

MassMotion

MassMotion

Help Guide

Oasys

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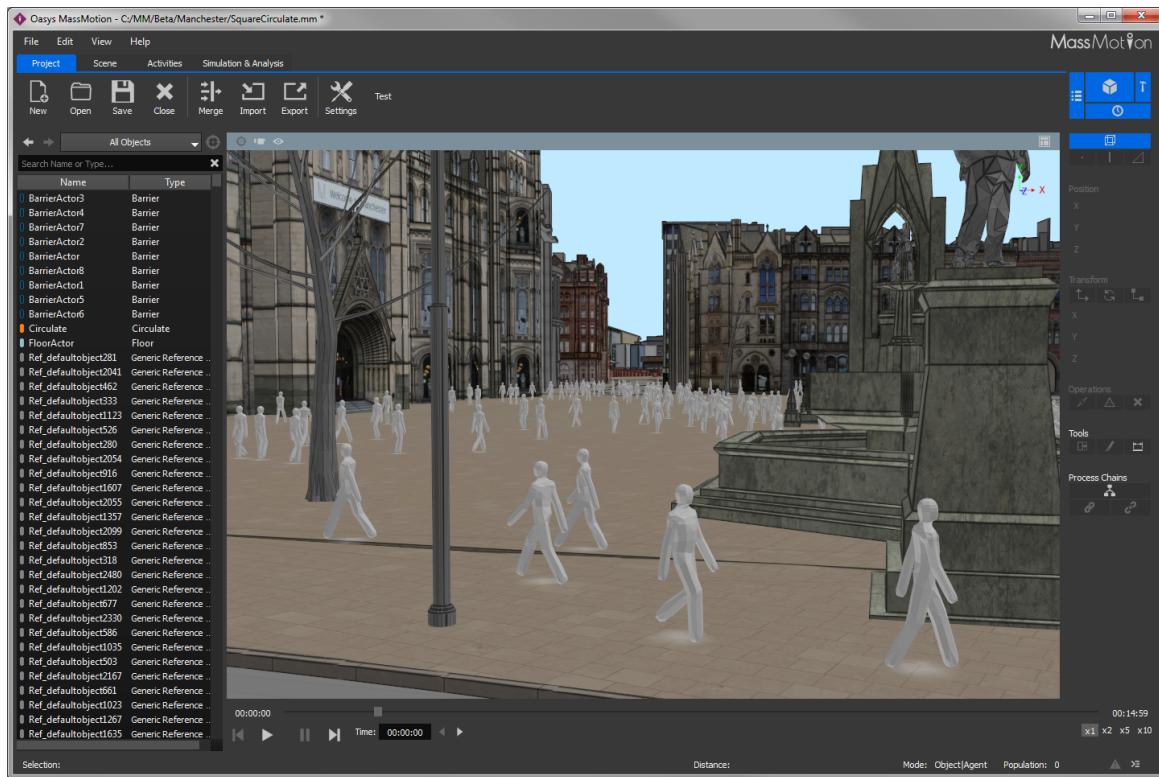
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Part I

1 Welcome to MassMotion



The field of pedestrian planning is rapidly growing as design professionals respond to a world where population density is increasing. This leads to greater emphasis on the efficiency and safety of commercial buildings, performance venues, schools, transit facilities and public areas. The process of understanding how people will move through and occupy a finished project is both challenging and fascinating.

MassMotion is developed to enable design and planning professionals to rapidly test and analyse the movement of people in many kinds of environments. To do this MassMotion provides users with a suite of tools for creating and modifying 3D environments, defining operational scenarios, executing dynamic simulations and developing powerful analyses.

A range of introductory videos are provided on the [Oasys product page](#) to enable users to quickly begin modeling and simulating with MassMotion. To unlock the full potential of the MassMotion toolset users are encouraged to review the [User Guide](#) and to consult the [Reference](#) as necessary.

Part II

2 What's New in 9

MassMotion 9 adds a wide range of new features. There is support for working with 2D drawings, the ability to import a greater variety of 3D file formats, improved geometry editing, and expanded control over operations during a simulation.

MassMotion 9 can import Sketchup, AutoCAD, Microstation or image files. Imported [2D drawings](#) can be edited and then converted directly into scene objects. The tools for turning imported geometry into scene objects have been expanded (see [Generating Objects from Geometry](#)). It is also possible to [trace](#) over existing geometry and use that to create new objects.

A new 'snap' system provides the ability to snap objects to points/lines ([Transforming Objects](#)). This system also makes it possible to change the local axis for rotations and translations ([Changing the Reference Frame](#)).

A new [Trip Matrix](#) event can create agents using an origin/destination matrix. The ability to specify a series of scheduled times within the [Broadcast](#), [Server Access](#), [Vehicle](#) and [Gate Access](#) events means fewer event objects are required. [Gates](#) can be opened or closed independently for each direction. [Servers](#) can be opened or closed at either end using a new [Server Access](#) event.

MassMotion 9 introduces greater control over when events become active including in response to changing conditions in the scene. For example a gate can be closed when the population on a floor reaches a certain threshold (see [Triggering Events](#)). New [actions](#) have been added, including a 'Do Until' action which can be used to cancel existing agents tasks when a condition is met. Tests are used in [new ways](#) including to control access across gates or to determine server contact time. And [new tests](#) have been added which look at more than just agent properties but extend to conditions in the environment.

For more details on what has changed in version 9 see [List of Changes](#).

2.1 List of Changes

2D Drawing

- Import and heal [2D drawings](#).
- Create floors, links, stairs, ramps, escalators, portals, barriers [directly from 2D drawings](#).
- [Trace](#) over complex geometry, drawings, or imported images to create simplified objects.

Geometry Editing

- Align objects and components with other elements in the scene using object snap (see [Transforming Objects](#)).
- Change local frame of reference for translation/rotation/scale using manipulator snap (see [Changing the Reference Frame](#)).
- Edit imported reference geometry like any other object.
- Protect reference geometry from inadvertent editing through a new 'locked' property.
- Imported reference geometry is deleted instead of hidden when converting to MassMotion objects (see [Application Preferences](#)).

Geometry/Image Import

- Import 2D dwg files.
- Import Sketchup files.
- Import image (jpg, png) files as textured rectangles to be used as references or decoration.

Dynamic Events

- [Control events](#) based on changing conditions in the scene through the use of [Triggers](#).

Creating Agents

- New [Trip Matrix](#) event for origin/destination based demand.
- Specify a table based schedule for [Gate](#), [Server](#) and [Broadcast](#) (formerly Action) events.
- Use collections in [Timetable](#). Profile, token, portal, and gate entries can now be the name of a collection containing profiles, tokens, portals, or gates.

Gate Control

- Gates can be set to default open or closed.
- Gate events can both open and close gates
- Gate events can apply to a single direction.
- Gate events can apply selectively to agents using agent tests.

Server Control

- Use new [open server](#) event to open/close access to a server, or hold/release agents after processing.
- Use tests to control contact times, allowing them to change over the course of a simulation.
- Use new ways to [distribute agents](#) across servers: largest available capacity, smallest distance, smallest cost.

Vehicle Event

- Limit boarding access to [vehicle cars](#) based on car capacity.
- Specify and/or show through passengers.
- Control pre-arrival time for alighters, boarders, and through passengers.

Agent Tests

- Test population counts in areas or on servers using 'Area Population'.
- Test whether or not an event is actively operating on the scene (creating agents, opening gates, etc.) using 'Event Active'.
- Test whether gates or servers are open or closed using 'Gate State' or 'Server State'.
- Test whether agents are in a greater variety of area types including regions, floors, links, stairs, ramps, and escalators using 'In Area'.
- Use tests in new ways (see [Where Tests are Used](#)).

Agent Actions

- Give agents a series of tests to execute until a condition is met using 'Do Until'.
- Repeat the same action and task until a condition is met using 'Repeat'.
- Delay execution of an action until after a task is complete using 'Apply Action'.
- Control how long agents wait using duration, target time, or a new test.

Auto Save

- Projects are automatically saved at intervals. Manage auto save from application preferences.

Simulation

- There have been changes to how density is calculated, and the default relationship between density and speed. For more information see [Speed at Density](#).

Analysis

- Hide empty rows or columns in the [Origin/Destination](#) table query.

Batch Execution

- Automatically execute and export queries using the new command line options '-query', '-queryall', and '-csvseparator' (see [Console Simulation Window](#)).

Name Changes

The following objects have been renamed:

Old Name	New Name
Reference Model	Transform
Analysis Region	Volume
Action event	Broadcast
Reference Time	Time
Agent Action	Action
Agent Test	Test

General

It is now possible to view the status of events from a simulation run using the [Event Observer](#).

2.2 Changes to Agent Movement

Each new major version of MassMotion can contain improvements to low level [Agent Movement](#). If continuity of results is important for a particular model, it is recommended that that model always be simulated using the same version.

Improved Density Calculation

The density around an agent is based on the amount of available space and the number of neighbouring agents. Previous versions of MassMotion used a ray based method to approximate available space. In 9 the available space is measured directly by counting the open points on a floor or link [obstacle map](#). This method leads to a more accurate measure of density, especially in confined areas and when in proximity to barriers with complex shapes.

Speed Density Relationship

The speed density relationship has been adjusted to bring flow rates at high density closer in line with Fruin targets. See [Changes to Flow Rates](#) for a comparison of flow rates between different versions of MassMotion.

Escalators

The default width of a 1m tread escalator has been extended to 1.15m to match the distance between handrails. Pedestrian shoulders are not constrained by tread width but are free to extend out to the handrails. The best way to account for this in MassMotion is to model geometry based on the distance available at shoulder height.

The default escalator tread speed has been reduced to 0.65m/s. [Movement](#) at this tread speed has been tuned to produce the practical flow rate of 100 ppl/min [1]. Movement has not been tuned at tread speeds or widths other than the defaults. The table below shows flow rates for a variety of widths and tread speeds.

Note that escalators modeled using the 8.5 defaults of 1m width and 0.85m/s tread speed will achieve flow rates around 94ppl/min rather than the target 100ppl/min when simulated in version 9.

Speed	0.5m/s	0.65m/s	0.8m/s
Width			
1m	84	96	105

1.15m	99	112	122
1.25m	109	128	131

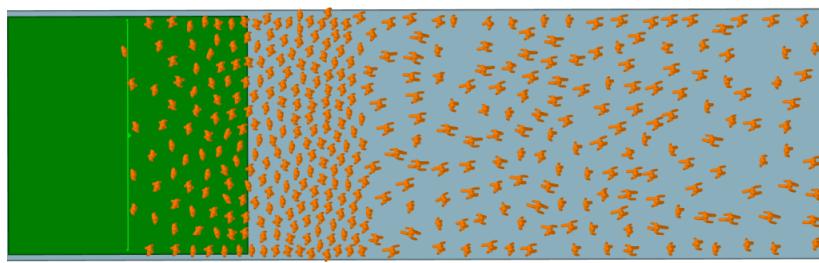
Escalator Flow Rates (ppl/min) in 8.5 (default properties shaded green)

Speed Width	0.5m/s	0.65m/s	0.8m/s
1m	79	89	96
1.15m	91	100	105
1.25m	99	108	115

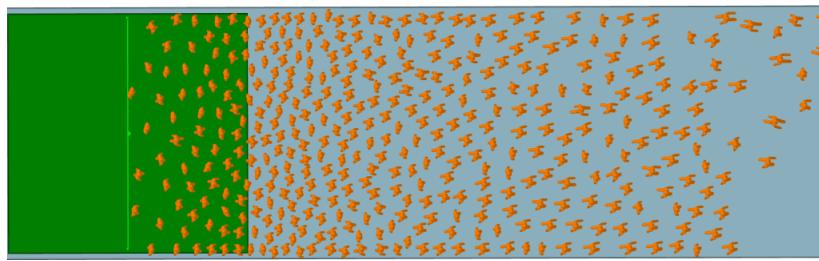
Escalator Flow Rates (ppl/min) in 9.0 (default properties shaded green)

Crowd Dispersion

Changes have been made to improve how quickly agents will move from an area of high density to an area of lower density. The images below show the results from a project in which 400 agents are created instantly in a 10mx10m square and then move from left to right. The agents in version 9 are more likely to disperse forward into the open space, creating a more even density gradient.



MassMotion v8.5



MassMotion v9

[1] CBSE Guide D, 2015, Section 2.5.4, Table 2.8.

2.3 Changes to Flow Rates

The following tables show flow rate changes from version 8.5 to 9.0. Tests were performed using the default agent [profile](#) with demand at LOS F. All flow rates are in people per minute, with the expected values based on Fruin guidelines [1].

Links (Length 2m)

Width (m)	Expected [1]	v8.5	v9.0
1.0	82	82	83
1.5	123	129	122
2.0	164	176	163
3.0	246	267	246

Stairs Up (30 degrees)

Width (m)	Expected [1]	v8.5	v9.0
1.0	56	58	56
1.5	84	89	83
2.0	112	118	112
3.0	168	176	166

Stairs Down (30 degrees)

Width (m)	Expected [1]	v8.5	v9.0
1.0	56	61	56
1.5	84	91	83
2.0	112	127	112
3.0	168	191	166

[1] Fruin, John J. Pedestrian Planning & Design, Revised Edition Chapt. 4, Elevator World, 1987

Part III

3 User Guide

The user guide provides a brief introduction to MassMotion. It describes some of the key concepts and outlines basic project workflow. It is intended to be used in combination with the introductory video tutorials available at <http://www.oasys-software.com> and the comprehensive [Reference](#) section.

3.1 Installation

The most up to date version of MassMotion may be downloaded at <http://www.oasys-software.com>.

3.1.1 System Requirements

MassMotion is a high performance 64bit multi-threaded application that is capable of effectively utilizing very high specification equipment. It is particularly important when running simulations that have very high concurrent agent counts (25,000+) that CPU core counts are maximised for processing speed and that solid state storage is provided for efficient database transactions. GPU performance is important for highly detailed 3D environments and for 3D playback of high agent count environments.

MassMotion uses Windows Media technology for generating videos and images. On some versions of Windows (N/KN) the Windows Media Feature Pack may need to be downloaded and installed separately.

Recommended Minimum Specification:

- Windows 64bit OS (Windows 7 & later)
- 8-core Intel or AMD workstation/server class CPU
- 16GB of RAM
- OpenGL 4 workstation GPU from NVIDIA or AMD
- 500GB Solid State Hard Drive
- 2 1680x1050 display monitors
- 3-button mouse

Minimum Specification:

- Windows 64bit OS (Windows 7 & later)
- Dual-core Intel or AMD workstation/server class CPU
- 4GB of RAM
- OpenGL 3.0 compatible GPU
- 500GB Hard Drive
- 1280x1024 display monitor
- 3-button mouse

3.1.2 Licensing

MassMotion licensing can be per machine, networked, or site based. For information on how to purchase MassMotion please visit <http://www.oasys-software.com>.

Standalone Licenses

Standalone licenses may only be installed on one computer at a time. Users may switch the license from one machine to another by deactivating it on the current machine and then activating it on the new one. This licensing scheme does not require an active internet connection to function, although an internet connection is required for initial activation and transfer.

To activate or move your license see <http://www.oasys-software.com/support/licensing.html> for details.

Shared & Virtual Licenses

Shared licenses may be utilized by any machine within an organization, provided that the total number of concurrently active MassMotion users does not exceed the number of shared licenses within the organization. This is the required licensing option for virtual machines.

To activate your license see <http://www.oasys-software.com/support/licensing.html> for details.

University Licenses

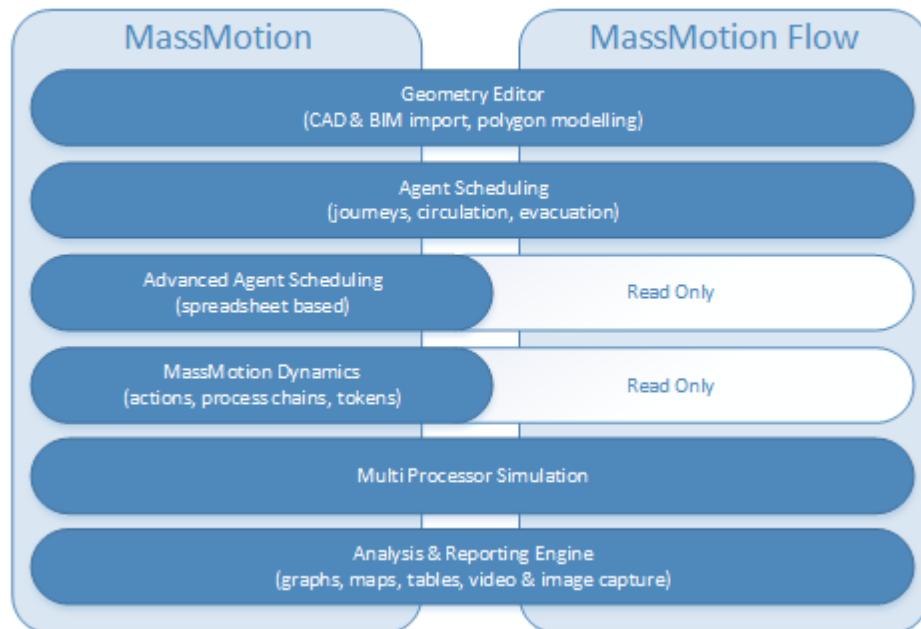
Site licenses are typically used by educational institutions and licensing is controlled by designated IP address. Any machine that connects to the internet using the IP address will be granted a 60 day license that will be automatically renewed each time MassMotion is launched while the machine is connected to the internet through the designated network.

To activate your license see http://www.oasys-software.com/company/university_licensing.html for details.

3.1.3 MassMotion & Flow

Oasys offers two crowd simulation products: MassMotion and Flow. The project files (.mm) and results databases (.mddb) from each version may be opened and used in the other. The two versions are differentiated by the extent of the authoring and agent scheduling features available as per the diagram below. While Flow can run simulations or analyse projects with actions, complex events, and process modeling, only MassMotion can create or edit those components.

MassMotion Product Features Map



3.2 How MassMotion Works

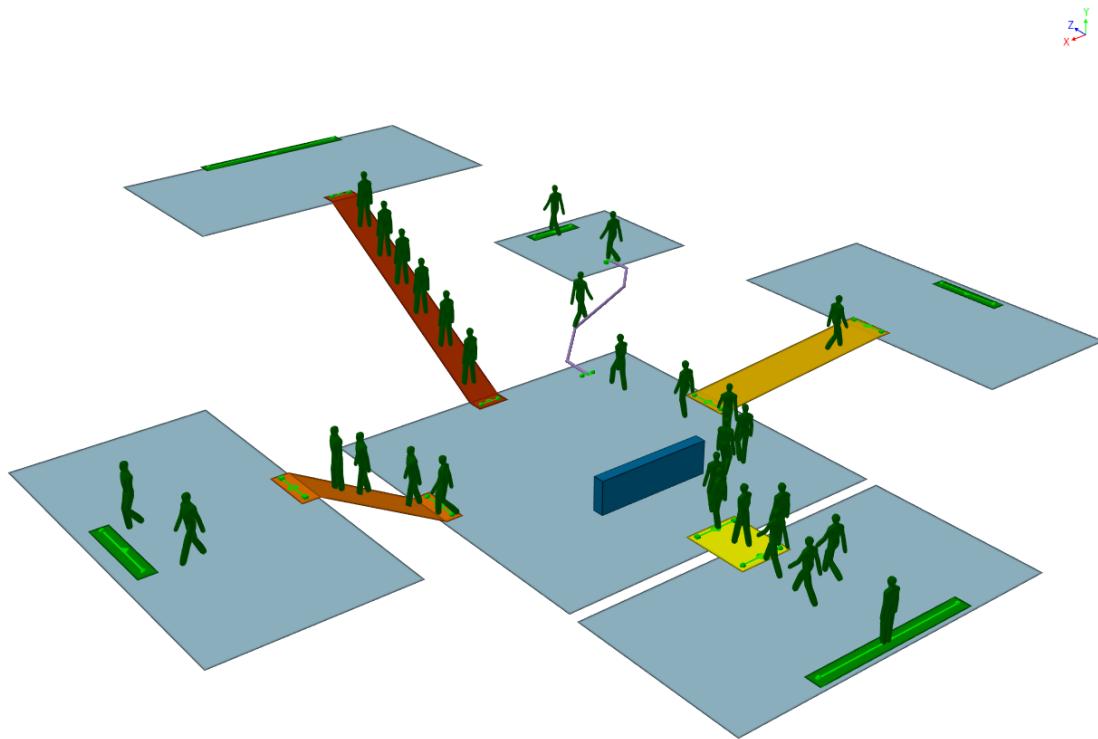
This section provides a brief introduction to some of the main concepts in MassMotion. [The Scene](#) covers topics related to the simulation environment and [People as Agents](#) describes the representation of people.

3.2.1 The Scene

MassMotion models real world spaces by breaking those spaces down into component parts and classifying the parts according to function. People in a MassMotion simulation know to walk around an obstruction because it has been marked as a barrier. Speed of movement is reduced when walking up a surface because that surface has been marked as a stair.

The way in which classified objects are arranged can have a large impact on how people navigate a space, affecting their speed, their movement patterns, and their route choices.

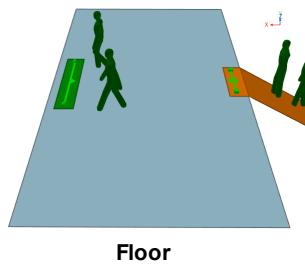
The basic elements of a scene are: [floor](#), [link](#), [stair](#), [ramp](#), [escalator](#), [path](#), [portal](#), and [barrier](#).



MassMotion Scene

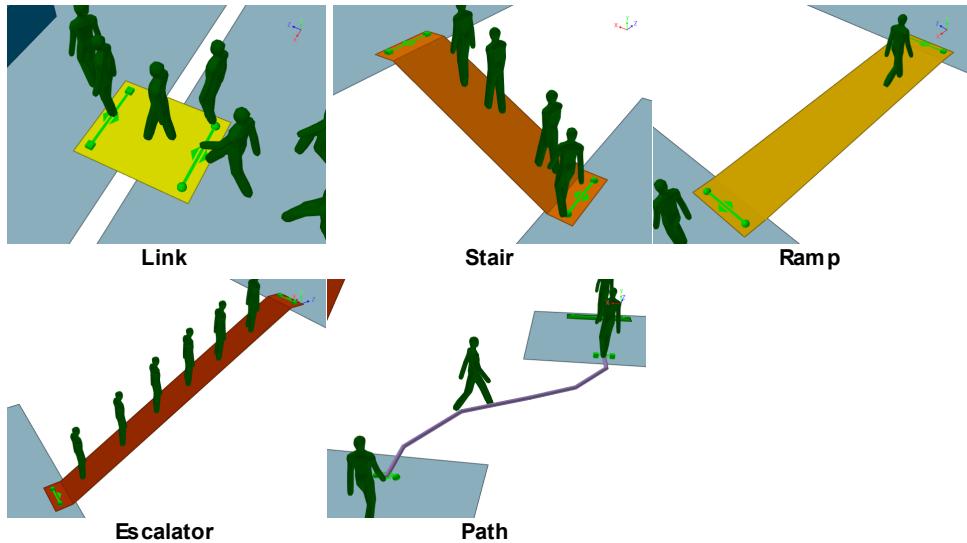
Floors

[Floors](#) are the most fundamental scene object. They represent the spaces (rooms, hallways, plazas, sidewalks, train platforms) which define the program areas of a design. Each floor defines a separate and distinct walkable area, with pedestrian movement constrained by the floor boundary.



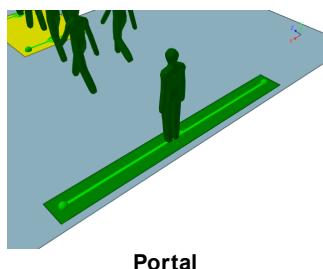
Connections Between Floors

People may only move between floors where they are connected by [connection objects](#). [Links](#) represent simple flat doorways or turnstiles. [Stairs](#), [ramps](#), and [escalators](#) connect floors at different elevations. [Paths](#) connect floors at any elevation and restrict movement to single file. Connection objects also act as decision points in [the route network](#).



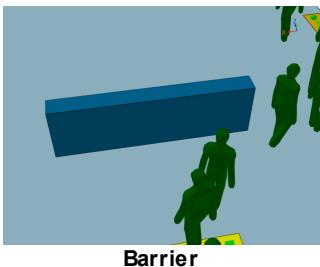
Entrances and Exits

[Portals](#) serve two main functions: they mark areas where people can enter the simulation and they represent [destinations](#) to which people can be sent.



Obstructions

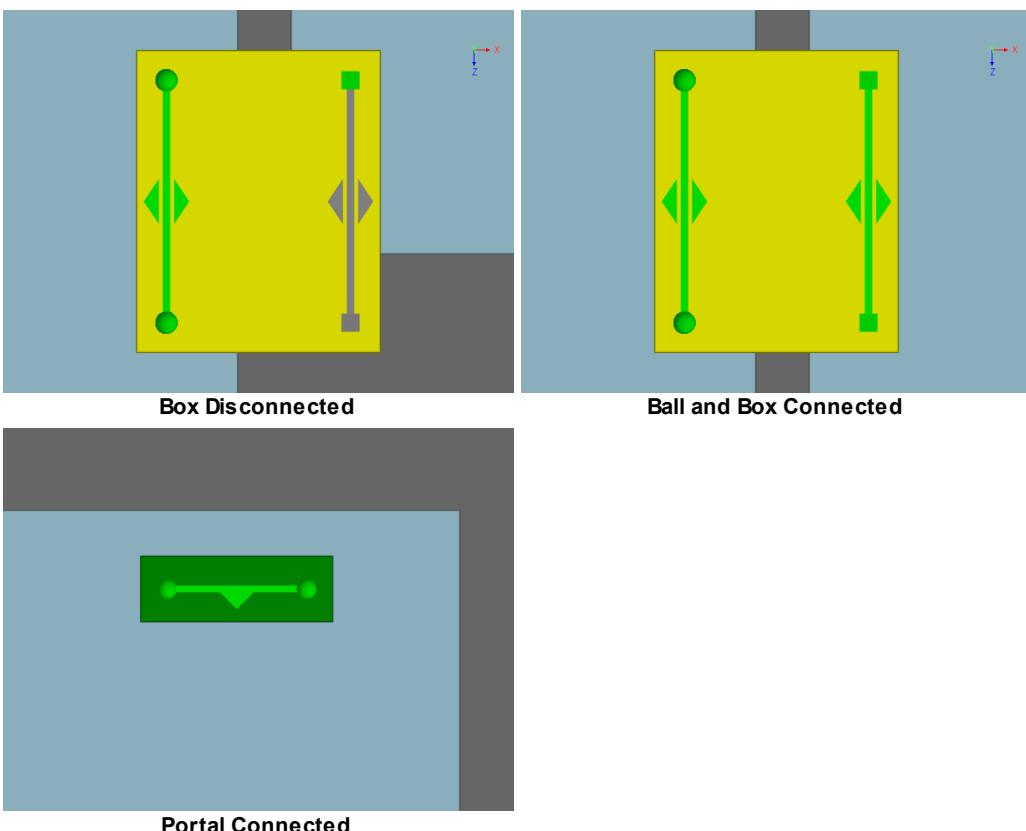
[Barriers](#) represent walls, columns, tables, benches, and anything else that can constrain movement on a floor.



Barrier

3.2.1.1 Connecting Objects Together

Each [connection object](#) (ie. [link](#), [stair](#), [ramp](#), [escalator](#) or [path](#)) has a box goal line at one end and a ball goal line at the other. [Portals](#) have a single goal line. It is the goal lines which connect an object to the underlying floor. Arrows on either side of a goal line indicate the possible directions of travel over the connection.



Physical Requirements

Goal lines must be above the floor but no higher than 0.4m.

Each end of the goal line must be at least 0.2m from the edge of the floor. For [connection objects](#), this means that they must overlap the floor by at least 0.4m. For [portals](#), the centre-line of the portal

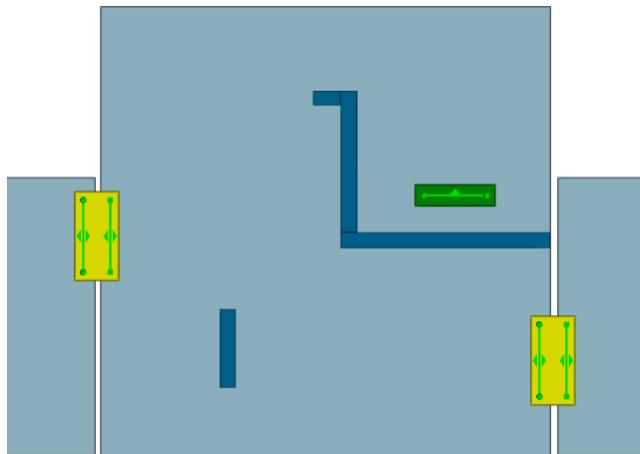
must be 0.2m from the edge of the floor.

3.2.1.2 Determining Walkable Space

Walkable space on a [floor](#), [link](#), [stair](#), [ramp](#), or [escalator](#) is represented through surface maps. A surface map is a 2D grid. Red values indicate areas not on the walkable object or blocked by an obstacle. Black, white, or grey areas represent useable space. Surface maps are created automatically for each object in the scene during simulation initialization. Understanding surface maps can help with understanding how people in MassMotion navigate a space.

Surface maps can be viewed by right-clicking on an object and choosing the 'Display' menu, or they can be exported as part of the simulation results (see [Generated Simulation Files](#)).

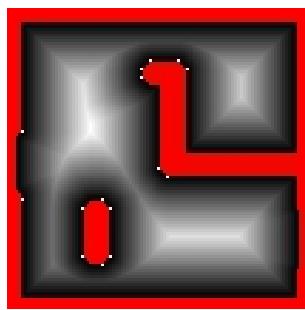
Simple Scene



A room with one portal and two links

Obstacle Maps

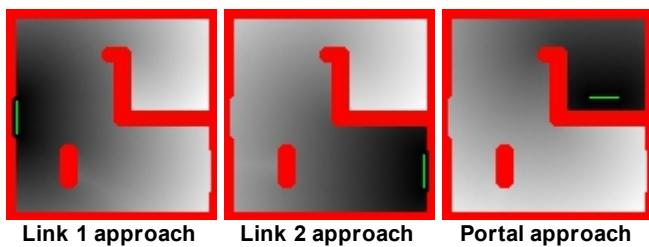
Obstacles are included if they intersect any part of the floor, or are within 0.4m of the top of the floor. Any portion of an obstacle that is below the floor or above the 0.4m cutoff is ignored. Floor edges and included obstacles are marked as red and are unavailable for walking. The shaded regions represent the normalized distance to the nearest obstacle, with black as a distance of 0 and white the farthest distance.



Obstacle map of room

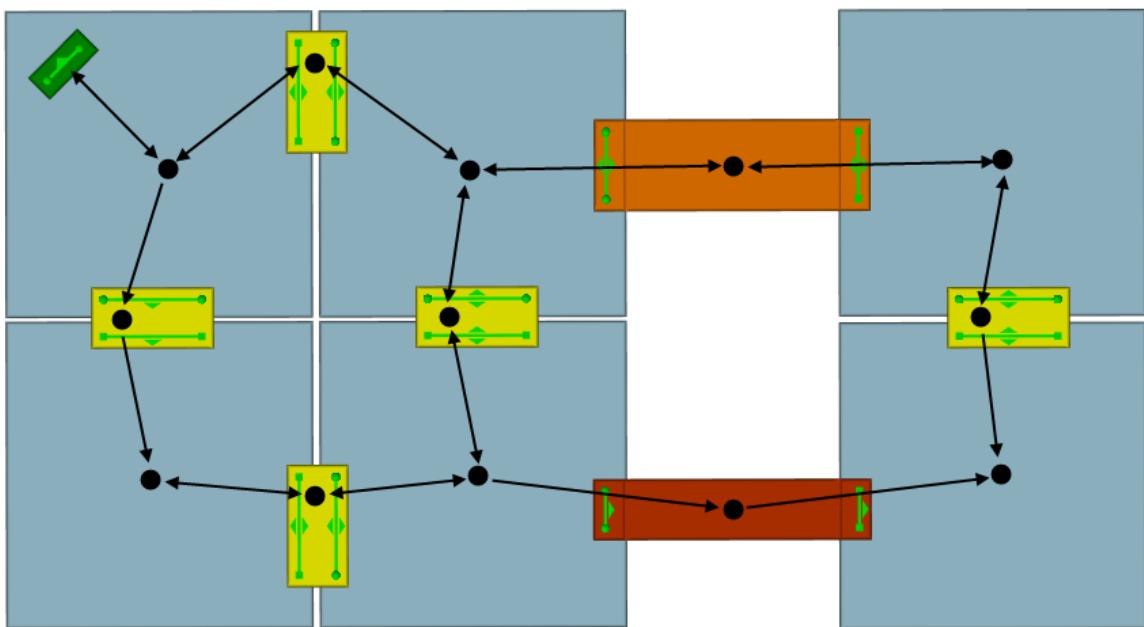
Approach Maps

As with the obstacle map, an approach map represents unavailable areas in red. The shaded areas describe distance to a single goal line on the walkable surface. For the simple room above, there are three goal lines and so three approach maps. In each case black represents a distance value of 0, and white represents the furthest distance from the goal line.



3.2.1.3 The Network

The arrangement of [floors](#), [connection objects](#) (ie. [links](#), [stairs](#), [ramps](#), [escalators](#) and [paths](#)) and [portals](#) is termed the network. The network describes all possible routes available when navigating the scene. In the diagram below, black circles represent nodes in the network. When a person is on a node, the arrows leading from the node represent possible route options.



3.2.1.4 Destinations

A destination is represented by a [portal](#). People in the scene can be asked to seek out a particular destination and will then use the network to determine the best available route.

Route options are constructed during simulation initialization. The tracing algorithm begins at the destination portal and moves through all available connections, marking the shortest route to every other object in the scene. This information is stored in the form of a cost tree. There is a separate cost tree for each possible portal destination in the scene. The cost tree is then used by people when [navigating the network](#) to assist them in finding the shortest route to a particular portal.

3.2.2 People as Agents

Every person in a MassMotion simulation is an autonomous agent. Each agent has the ability to monitor and react to its environment according to a unique set of characteristics and goals. Agents are created and placed in the [scene](#) using [events](#).

Characteristics

The physical characteristics and personality of an agent are defined by its agent [profile](#). The profile defines a distribution of values for properties such as size, speed, and any preference for various route options.

Scheduling

Agents are placed in the scene through [events](#). All events will specify one or more starting locations for the new agents. Some events like the [Journey](#) will specify a single entry time, while others like the [Vehicle](#) will specify a repeating cycle of entry times. Some events like the [Journey](#) will give a single task (seek this portal than exit), while others like [Evacuate](#) will give a series of tasks to be executed in order (wait for 20 seconds, then evacuate the train platform zone, then seek the street portal).

Behaviour

When placed in the scene, agents are given one or more tasks to accomplish. The agent will execute its tasks in order, relying on two independent intelligence systems: Navigation and Movement.

Scene Interaction	
Task	The task system determines the goals or purpose of an agent. An agent is always attempting to execute its current task.
Navigation	The navigation system is responsible for determining how best to accomplish a task. When seeking a particular portal, the agent must evaluate its surroundings and determine the best route to that portal. This determination is based on an awareness of the environment, both in terms of the distances involved and a limited sense of congestion at some of the near decision points. Once a route has been chosen, that choice is periodically re-evaluated as the agent progresses along the route.
Movement	Once the agent has chosen where to go, its movement system guides the agent across the floor towards its choice. This system relies on a modified version of the Social Forces ¹ algorithm. A series of forces are generated based on the direction the agent wants to go, the location and movement of neighbouring agents, and the position of nearby obstacles. These forces are summed at every time step and used to determine the agent's heading and velocity.

[1] Dirk Helbing and Péter Molnár Social force model for pedestrian dynamics II. Institute of Theoretical Physics, University of Stuttgart, 70550 Stuttgart, Germany, January 1995

3.2.2.1 Agent Tasks

Each agent in the simulation maintains a list of tasks or "things to do". The agent is only capable of working on one task at a time, and the task currently being considered is said to be the *active* task. Each frame, the agent determines what to do and how to do it based on the active task. Once the active task is complete, the agent will move on to the next task in its list. Tasks are always executed in order.

Giving Agents New Tasks

Agents can be assigned new tasks using [Actions](#). When an agent receives one or more tasks from an action, those tasks are pushed in front of any currently active tasks and executed in order. The agent will return to the deferred tasks when all of the new tasks have been completed.

Types of Tasks

For a complete list of available tasks, please see the task giving actions in [Agent Actions](#). Typical tasks include:

- Moving to a portal destination.
- Moving to and entering a process chain.
- Evacuating a zone.
- Waiting in an area for some duration.
- Executing a sequence of sub tasks (in order).
- Exiting the simulation.

3.2.2.2 Agent Navigation

Agent navigation makes use of [the scene network](#), assessing route options and planning the best path to a given [destination](#). When choosing between a number of available routes, agents will consider the network objects connected to the current [floor](#), and select the object with the best route cost. The chosen route is called the local target. The choice of target is periodically re-evaluated as the situation on the floor changes. Once the agent has reached the target and transitioned onto a new floor, the routes leading off of that floor are evaluated and the next local target selected.

Agents are only aware of route options off of their immediate floor. Any congestion or surprise conditions on downstream floors are not factored into the local choice.

Costing Routes

A local target is chosen based on a comparison of the cost of each possible route off of the current floor. A number of components are considered. Distance values are converted into time by dividing by the agent speed. Component time values are then summed to produce a total cost for the route.

Route Cost Components	
Downstream Horizontal Distance	The shortest possible horizontal distance from the target to the goal.
Weighted Downstream Vertical Displacement	The vertical displacement measured along the route that was traced to measure the downstream horizontal distance. Components of the vertical displacement are multiplied by a factor based on object type (stair , escalator , ramp , etc.) [1].
Near Horizontal Distance	The horizontal distance from the agent to the target.
Queue Time	The expected time it will take to queue for the target, calculated using the number of people queuing in front of the agent and the expected flow rate onto the target. Agents are only aware of queuing for objects leading off of their current floor.
Opposing Flow	A penalty time based on the magnitude of the oncoming flow across the target.

Route Cost Components	
Closed Penalty	A penalty time if the target is currently closed to the agent (See Connection Objects for information on gates and priority access).
Backtrack Penalty	A penalty time if the agent has already used the target (bias against backtracking).

Stochastic Elements

There are two areas where [randomness](#) is introduced into the navigation process: agent personality and choice variability.

Each agent is assigned a unique personality based on a set of costing weights. These weights are applied to the various cost components when evaluating routes. The weights are calculated from distributions defined in the agent's [profile](#). An agent with a high queue cost weight and a low horizontal distance weight will tend to avoid large queues in favour of longer uncongested options.

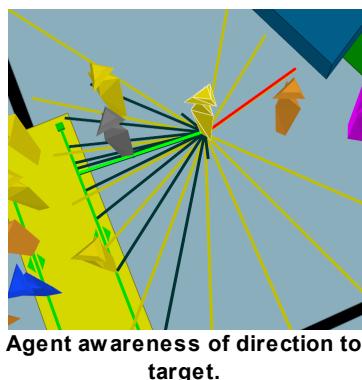
Each route choice is assigned a small random factor. This factor will be different for each agent each time the agent steps onto the floor. As a result, agents will on occasion choose slightly less than optimal routes ensuring that not all agents make the same choice when routes are very close in cost.

[1] Business Case Development Manual, Transport For London, May 2013, Appendix E 3.1

3.2.2.3 Agent Movement

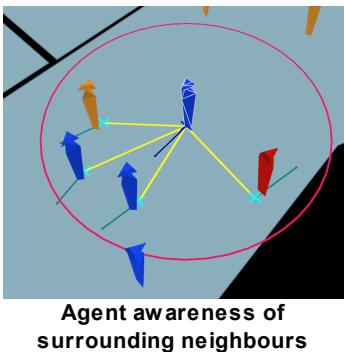
Finding the Target

Agents moving towards a local target will determine the direction to that target by looking at the [approach map](#) for the target's goal line. The agent extends feelers out in various directions and measures the distance to the target along each of the feelers. The feeler that ends up closest to the target goal line is taken as the direction to goal.



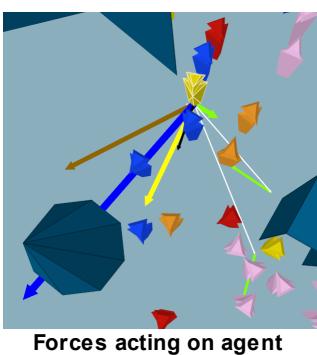
Neighbours

Each agent is aware of other agents that are within a particular range. This range changes with the speed of the agent and the local density. Other agents inside the awareness range are called neighbours. An agent is aware of the location, speed, and size of its neighbours.



Social Forces

The social forces algorithm generates a series of forces based on the agent's desired target, the presence of neighbouring agents, and the location of obstacles. These forces are summed together and used to modify the agent's acceleration.



Component Forces	
Goal	Force required to nudge agent so that it is at its desired speed heading towards its target.
Neighbour	Repulsive force from each neighbour within range.
Cohesion	Force pushing towards centroid of neighbours with similar targets.
Collision	Force pushing agent away from collisions with oncoming neighbours.
Drift	Force pushing agent in bias direction when faced with oncoming agents in narrow spaces.
Orderly Queuing	Force pushing agents towards the middle of a target when approaching.
Corner	Force pushing agents to hug a corner or swing wide.

It should be noted that obstacles do not result in a repulsive force of their own, but are used to constrain other forces. When component forces are summed, the resulting net force is reduced such that it does not push the agent into a barrier.

Agent Speed

The agent's desired speed is the speed at which the agent will walk when on flat ground in an uncongested environment. This speed is assigned through the agent's [profile](#) when the agent is

created.

The actual speed of an agent at any given time depends on a number of additional factors.

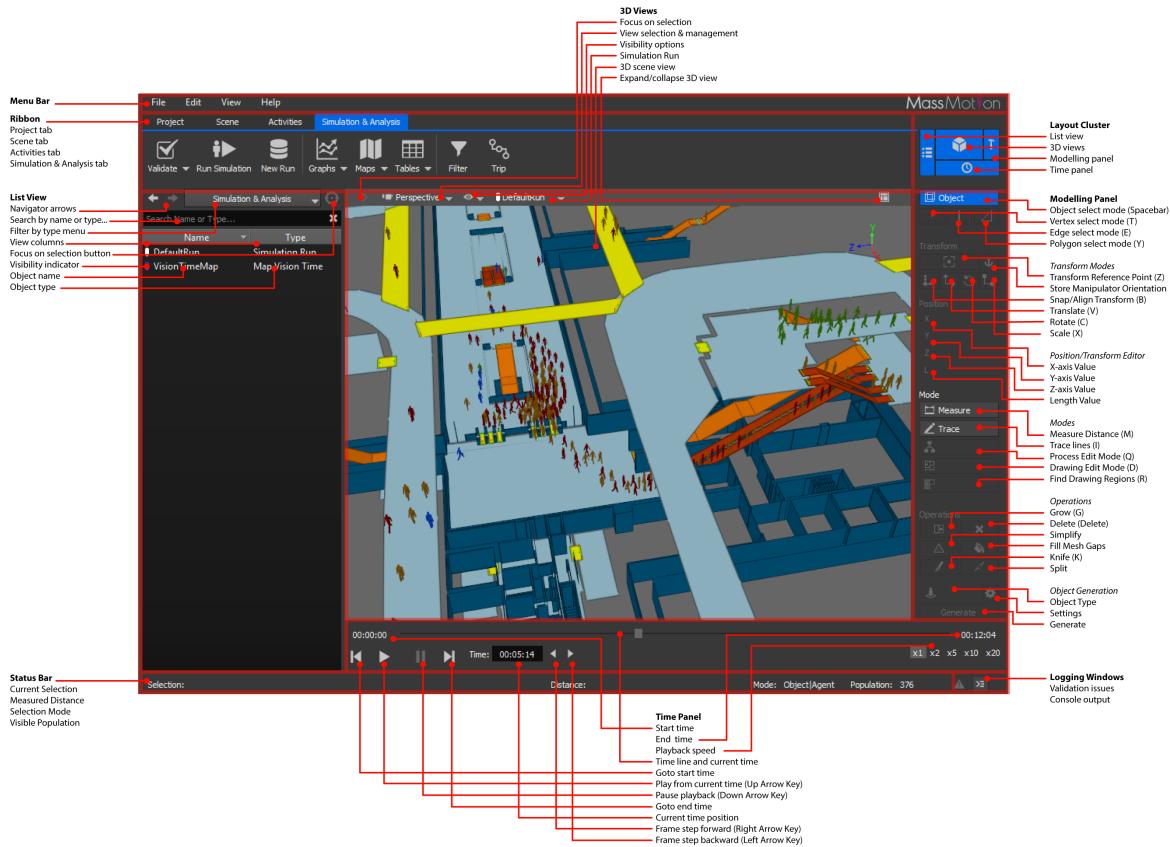
Factors Influencing Agent Speed	
Density	In order to simulate the reduced stride length and reduced mobility of people in crowded spaces, agent speed is reduced as density increases. The exact relationship between speed and density has been tuned to match the data in John Fruin's Pedestrian Planning & Design [1]. This relationship can be disabled in the agent's profile.
Object Type	<p>Escalator: Agent speed is set to exactly match the escalator speed property.</p> <p>Floor or Link: Agent speed is not altered.</p> <p>Path or Server: When immediately behind another agent, speed is reduced to match the agent in front.</p> <p>Ramp or Stair: Agent speed is modified based on whether travel is in the up or down direction. See the object reference pages for more information.</p>
Object Speed Limit Property	Objects have a property for capping agent speed. Any agent on the object with a speed above the cutoff will have their speed reduced to the cutoff. Agents below the cutoff are unaffected.

[1] Fruin, John J. Pedestrian Planning & Design, Revised Edition Chapt. 4, Elevator World, 1987

3.3 User Interface Overview

3.3.1 Main Window

The following image enumerates some of the more important features in the MassMotion main user interface.



Main Menu

The main menu provides commands for opening and saving the project, importing or exporting content, controlling object selection, changing which windows are visible, and accessing help. See [Main Menu Bar](#) for more information.

Ribbon

The ribbon is a tabbed toolbar which provides buttons for performing high level operations. The project tab provides buttons for managing the project and importing or exporting content. The scene and activities tabs provide buttons for creating scene and activity related objects. The analysis tab provides buttons for validating the project, running a simulation, and creating analysis objects.

List View

The list view provides a mechanism for accessing the objects in the project by name or type. A filter at the top controls the type of object displayed. The search bar can be used to find objects by name or type. The capsule drawn beside each object displays information on the type, colour, and status of the object. See [List View](#) for more information.

Scene View

The [3D scene view](#) is a graphical representation of the scene objects in the project. The camera can be moved by holding down the 'S' key while dragging the left or right mouse buttons. It is possible to select objects by clicking on them or dragging over them with a selection box (see [Selection](#)).

The camera button at the top provides a variety of preset cameras and the ability to save or recall custom viewpoints. The eye button provides options for controlling how the scene is rendered, from different agent representations, to wireframe mode, to whether or not agents should be hidden when on a hidden floor. The focus button will focus the view on the current selection.

Tool Panel

The [tool panel](#) contains a number of controls for interacting with the scene view. It displays and controls the current selection mode. It displays and controls the position, translation, rotation, and scale of the current selection. It also contains buttons for operating on the geometry of the selected object, measuring the distance between points in the scene, and tracing lines to generate new objects.

Time Panel

The [time panel](#) is used to control the playback of data from one or more simulation runs. It is only available when the project has a simulation run with valid data.

Status Bar

The status bar provides information about the current selection and agent population and has buttons for showing the console and issue windows. See [Main Status Bar](#) for more information,

3.3.2 Objects

Much of the data in a project is represented in the form of objects. The MassMotion interface is designed around viewing and managing these objects. Some objects have a physical presence. These objects are referred to as [scene objects](#) and are visible in the graphical [scene view](#). All objects are displayed in the [list view](#).

Properties

Each object contains a list of properties. These properties can be modified using the [property window](#) which is available through the object's right-click menu, or by double-clicking on the object in the scene or list views. Objects which share common properties can have those properties edited in batch all at once using [object multi-edit](#).

Some properties can refer to other objects (See [Choosing Objects](#)).

A property can be either valid or invalid based on its value. The validity of a property is displayed by the property indicator beside it. These indicators can be used to reset a property to its default value, or to copy values from one property to another (either by right-clicking or dragging the indicator). In some cases a property will be shown as valid but still fail validation. This occurs when the cause of the problem is only uncovered by checking against other objects or property values.

Common Object Properties	
Selected	All objects can be selected .
Hidden	Objects that have been hidden will not appear in the scene view and will display an outline only for the type capsule in the list view . All scene objects can be hidden. Hiding a collection will hide all of its member

	objects. Hiding a map will remove any textures that it has applied in the scene.
Disabled	Some objects can be disabled. A disabled object will not be included in simulations and will be shown as grey in the scene and displayed with a grey type capsule in the list view .

3.3.3 Selection

The selection is a list of objects or object components chosen by the user for a particular purpose. Objects can be selected in the [scene view](#), [list view](#), or individual choosers. The selection mode, which toggles between selecting objects, faces, edges, or vertices, can be changed through [keyboard shortcuts](#) or buttons in the [tool panel](#).

Select Here, Selected Everywhere

The selection status of an object or object component is a property of the object and so visible in all parts of the user interface. If an object is selected in the [list view](#), it will show as selected in the [scene](#). This behaviour can be leveraged when choosing objects. If a dialog is presented which asks for an object, but the user is unsure of the name of the object, the object can be selected in the scene, and that choice will automatically be reflected in the dialog. Similarly, if a user is unsure about which object a dialog is describing, that object can be selected in the dialog, then the scene 'focus' button can be used to view the selected object graphically.

Selection Mode

The default selection mode is 'Object|Agent'. In this mode, entire objects or playback agents can be selected. The component selection modes are only available when one or more objects are selected. The component selection modes allow for the selection of face, edge, or vertex components of the selected object(s). The selection mode can be changed from the [tool panel](#) in the Main Window or using [keyboard shortcuts](#).

Selecting in the Scene View

In the scene view, an object can be selected by clicking on it with the left mouse button. Holding down CTRL will add each subsequent object to the selection. A selection box can be used by left-clicking and dragging the mouse. If the mouse is dragged from left to right, only those objects or components which are entirely inside the box will be selected. If the mouse is dragged from right to left, all objects or components which intersect with the box will be selected. See [3D Scene View](#) for more information.

3.4 Project Workflow

There are three main stages to working with a project: [authoring](#), [simulation](#), and [analysis](#). The evolution of a project is often iterative, with results from simulation or analysis leading back to authoring changes and additional simulation runs.

3.4.1 Authoring

Authoring involves the recreation of a physical space in the simulation environment. This representation is referred to as the scene. Authoring also includes the construction of events for creating agents and controlling operations.

3.4.1.1 Modeling Strategies

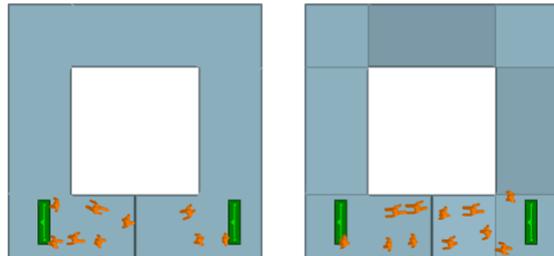
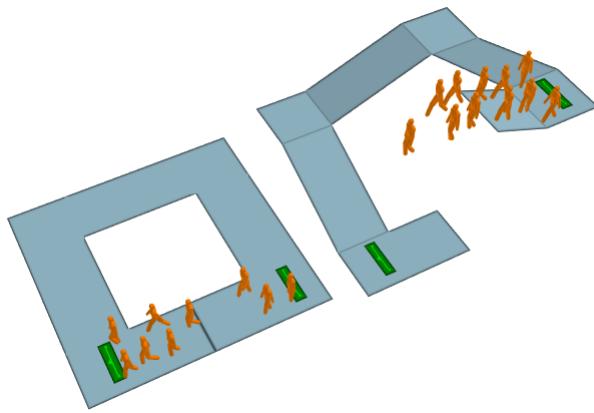
The contained sections detail strategies for modeling real world objects in MassMotion.

3.4.1.1.1 Floors

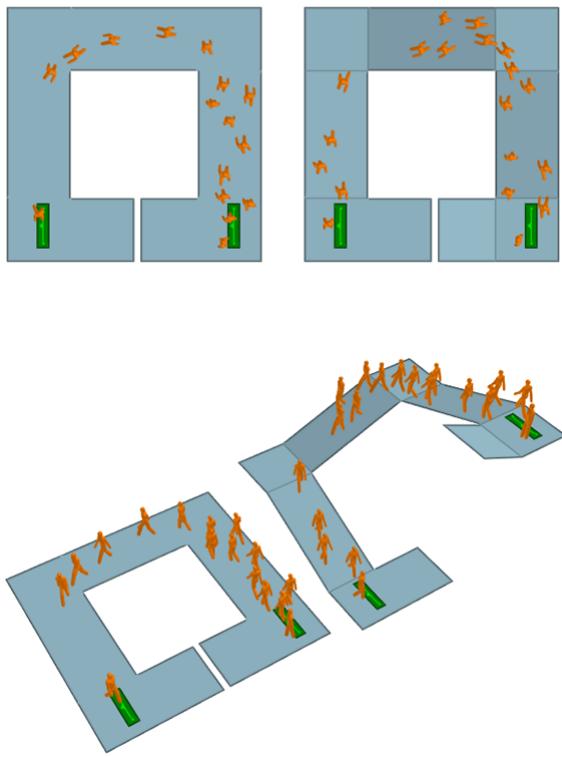
[Floors](#) are the basic building block of MassMotion scenes. They represent the spaces (rooms, hallways, plazas, sidewalks, train platforms) which define the program areas of a design. Each floor defines a separate walkable area, with agent movement constrained by floor boundaries.

No Overlap

During simulation, floors are used to create [walkable space](#) data structures. These data structures are 2D and do not record variations in height. A floor that changes elevation and overlaps with itself will be seen by agents as a continuous surface.



When the floors above are corrected such that there is a gap between the two portals (as shown below) the agents are then presented with one unambiguous route from the entry to exit portal in both the flat and sloped configurations.



Slopes on Floors

Agents walking unobstructed on a floor will always move at the same horizontal speed regardless of the slope of the geometry. In the images above, the agents on both the flat and sloped configurations will take the same time to reach the exit. Agents will adjust their vertical position by tracking top surface of a walkable object, but this has no impact on their horizontal speed. It is recommended that [stairs, escalators, or ramps](#) be used to model changes in elevation.

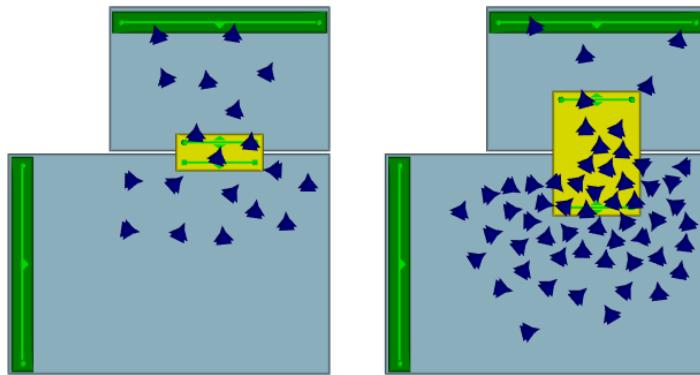
Size

The size of floor objects is not explicitly constrained in MassMotion but there are a number of factors that should be considered. During the simulation there are a number of data structures that are automatically constructed which describe the [walkable space](#) of the object. The size of these data structures is directly related to the size of the object's geometrical bounding box. If there are very large floors in a scene there may be noticeable increases in simulation setup times and in some extreme cases may cause memory to exceed local RAM capacity which can lead to slow simulations or crashes.

3.4.1.1.2 Connection Objects

Connection objects are used to provide access between pairs of floors. They act as decision points, providing options for agents during route selection (see [The Network](#)). They can be used as statistic collection points for [graphs](#) or [tables](#). The available connection objects are [escalators](#), [links](#), [paths](#), [ramps](#) and [stairs](#).

As described in [Connecting Objects Together](#), connection objects must be a reasonable distance above the target floor and must overlap the floor by at minimum 0.4m. The overlap distance should be minimized as large overlaps can negatively impact agent movement.



The same number of agents pass over the link with small floor overlap (left) and large floor overlap (right). The extra overlap makes it difficult for agents to smoothly transition from floor to link and will reduce flow.

All connection objects share a set of common properties:

Direction

Connection objects may allow agents to enter from either direction or restrict access to only a single direction.

Gates

All connection objects can be configured to be gated. Gated connections that are closed do not let agents enter unless opened by an [event](#). Available events which open gates are [open gate events](#) and [vehicle events](#). Agents will use the object's "Cost of waiting" to determine how a closed gate will impact their route selection. Agents that are already on the connection when the gate closes will not be prevented from exiting the object.

Flow Limits

Connection objects can be configured to limit the flow of agents entering the object. When demand exceeds the specific limit, agents are held at the object goal line until there is available capacity.

Priority Flow

Priority flow sets whether agents traversing a connection object can have priority. If agents traversing a connection object have priority, agents moving in the opposite direction will yield and wait until there are no more agents with priority.

Delay on Enter and Exit

Agents can be set to pause while entering or exiting a connection object.

Banks and Perimeters

Each connection object can be added to a single [bank](#) and/or a number of [perimeters](#). Banks and perimeters control how the link is used by the agent when navigating the network.

3.4.1.1.3 Complex Spaces

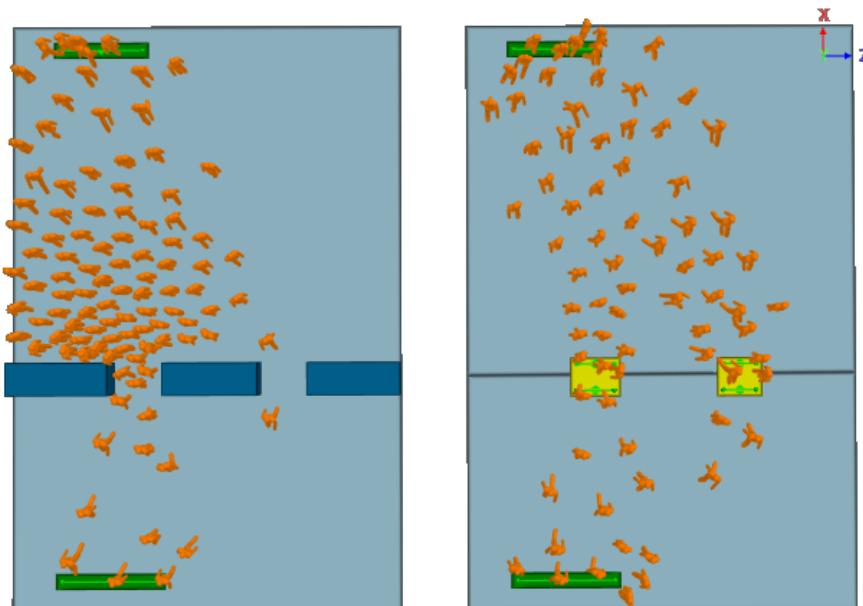
Splitting Floors

When a person navigates the network, they are constantly choosing a path from a set of possible routes. These routes can be represented as a series of goal lines. It describes all possible routes through the scene with each scene object representing a node or choice point along the route. Agents are continuously evaluating the cost of available nodes when determining the optimal route to

a goal. Costs are calculated from factors such as horizontal distance, vertical distance, local queuing, and oncoming traffic.

Adding Network Choice to Reduce Congestion

In the image below, the same layout is modeled in two different ways. On the left, two narrow channels are created by placing barriers on a single floor. On the right, the single floor has been split in two with links representing the narrow channels. On the left there is no network and so no navigation is required. The navigation system will choose the portal as destination and rely on the movement system to carry it across the floor. While the movement system is aware of the resulting congestion and will keep agents from colliding with one another, it will always take the shortest path to its goal which in this case means always using the left channel. On the right the navigation system must choose between the two links and will take congestion into account when making that choice. When queuing builds at the left link agents will choose to avoid it by taking the right.



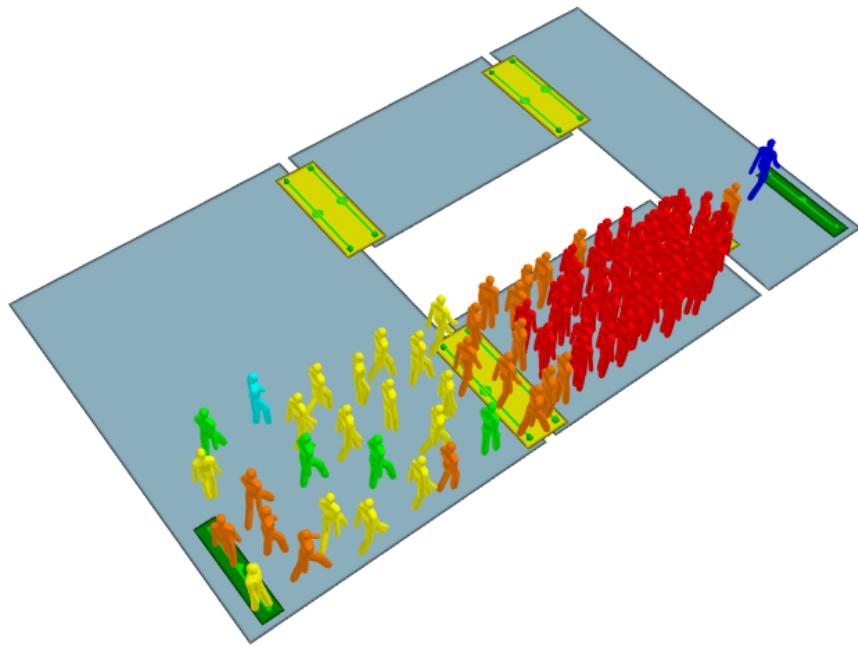
Left: Agents are not aware of congestion at the left opening as it occurs in the middle of the floor and are not even aware of the right channel as an option. **Right:** Agents are aware of congestion at the left link and can choose to take the right, resulting in more balanced loading.

This process of splitting floors to ensure agents fully consider route implications is useful in a number of situations including:

- Narrowing due to barriers (as above)
- Bifurcation of routes due to a barrier or void in a floor (as with stairs/escalators in the middle of train platforms)
- Heavy flows compressing around an obstruction despite available space (as with jogs in corridor alignments)

Reducing Network Choice to Reduce Congestion

While splitting floors and introducing additional links can increase the amount of choice in a network, there are counterbalancing factors to consider. Agents are only able to perceive congestion associated with links that are connected to their current floor. In the image below it can be seen that agents will continue to select the nearest route despite the fact that the narrow link in the connecting corridor has become congested and the alternate route has become more efficient. This should be considered when deciding when and where to split up complex spaces.



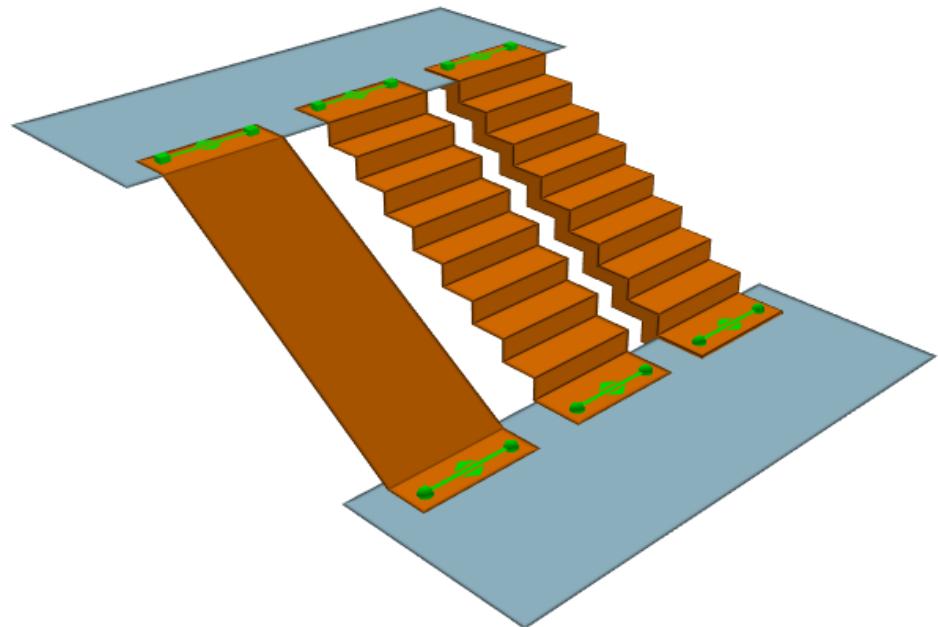
3.4.1.1.4 Vertical Circulation

Stairs, ramps, and escalators (vertical circulation elements or VCEs) are link objects that connect floors of different heights using a sloped vertical transition. They have much the same best practice guidelines that are described in the [Connection Objects](#) guide and in the [Connecting Objects Together](#) section.

The slope of VCEs must be between 0 and 50 degrees from level. Steeper slopes may result in agents not being able to track the surface during simulation

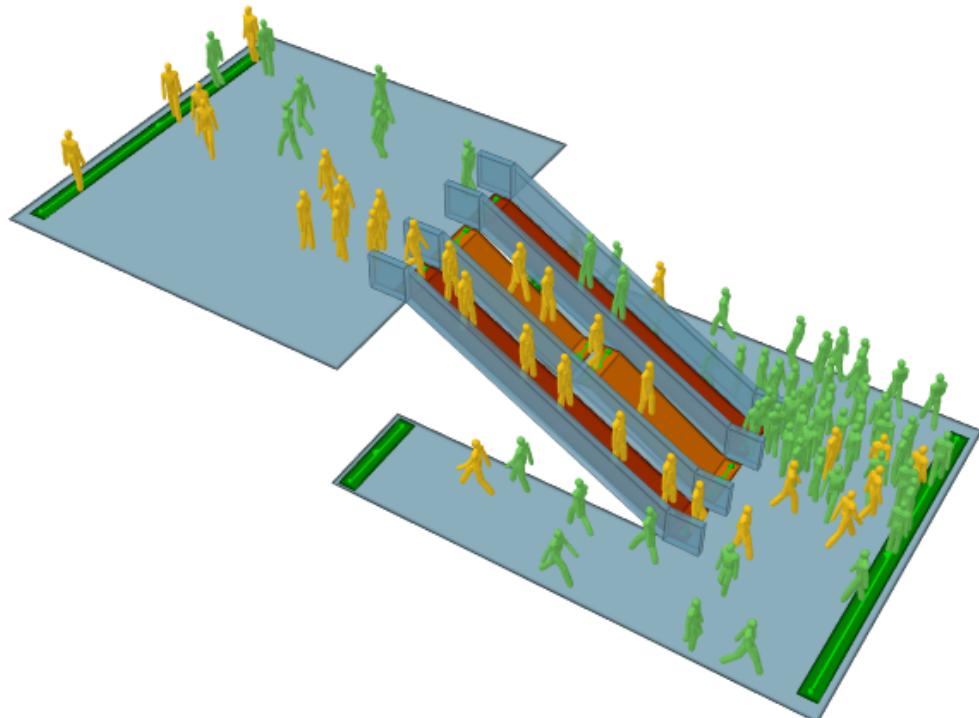
Geometry

The geometry of VCEs can be as detailed as the user likes. All the stair objects in the image below are functionally equivalent and the agents will traverse them in the same way. As with [floors](#), the geometry may not overlap itself. The slope must be between 0 and 50 degrees from level as agents will have trouble tracking surfaces at a larger grade.



Common Configurations

Escalators and stairs are often constructed in sets with one or more of each type located in close proximity to one another. The image below shows a configuration common in transit stations where a stair and a set of down/up escalators are arranged in the middle of a platform. As in the real world, the agents will perceive the escalators to have a greater utility than the stairs and queues will form for the escalators before there is substantial traffic on the stairs.



Banks of Vertical Circulation Elements

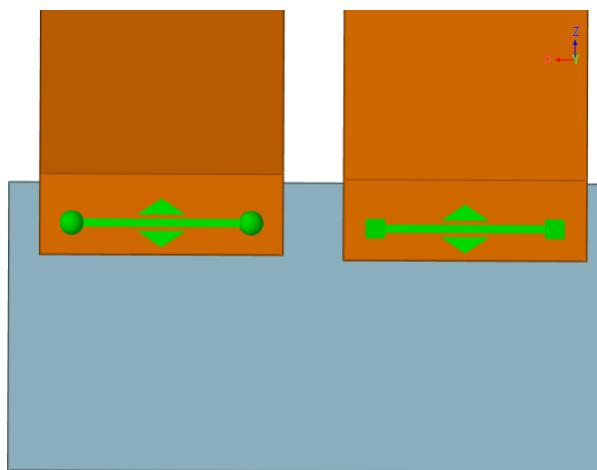
When multiple stairs, escalators, or ramps are positioned beside one another, have the same directionality, and bridge the same two floors, they should be banked to ensure agents make use of all available elements. In Figure 2, the two escalators are in opposite directions, while the stair is bidirectional. Because an object can only be part of one bank, it is not possible to bank the stair with both escalators. A single bank should be created for the stair and whichever escalator is likely to see the most traffic during the simulation. Please see [Banks](#) for more information.

3.4.1.1.4.1 Switchback Stairs

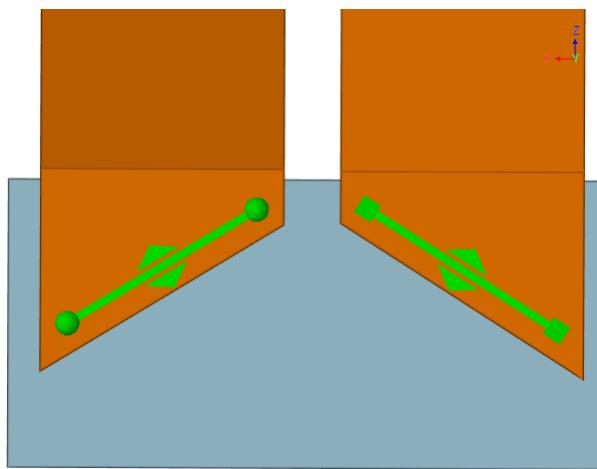
Switchback stairs such as those commonly found in the evacuation cores of buildings present a set of unique challenges. These stairs are generally narrow, with constrained landing areas where agents must make abrupt changes in direction.

Geometry

If flow rates on switchback stairs are not at the desired level, angle the ends of the stair landings to help guide agents in a smooth transition from one stair to the other.



Initial switchback stair landing



Modified switchback stair landing

Note that if goal lines are placed at too great an angle to one another, the outside corners of the landings will present such acute angles that agents can have trouble squeezing onto the landings along the outside edges. Moderate angles like those demonstrated above are recommended.

Properties

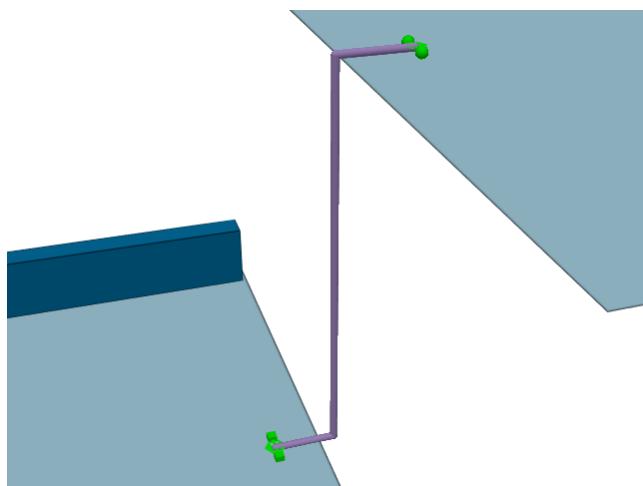
Given a demand at or below level of service D, switchback stairs process agents at a rate roughly equal to similarly sized straight stairs. For level of service E or F, there can be a 10% drop in processing rates despite the geometric adjustments described above. To achieve the same rates as straight stairs even in high density situations, set the switchback stair property for agent body radius to a value of 0.2m.

3.4.1.1.4.2 Ladders

A ladder can be modelled using a [path](#).

Geometry

Ensure that the final line segments on either end of the path are flat.



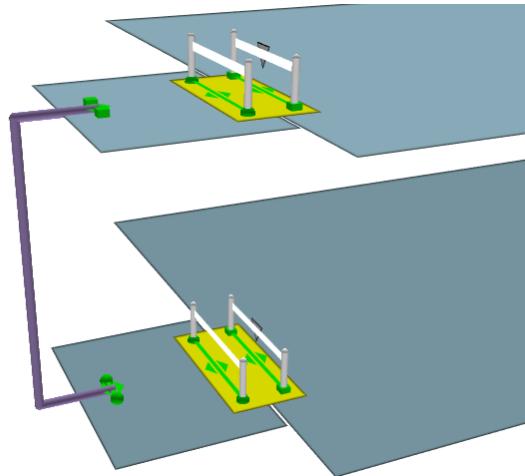
A ladder modelled using a path.

Properties

If the ladder is only to be used in one direction, set the path to the desired direction. If two-way travel is required, enable priority access. If there is a clear priority direction, set the priority direction appropriately and ensure that the option 'Primary will yield' is checked so that agents will only use the path in one direction at a time.

3.4.1.1.4.3 Elevators

There is no built in object type for elevators, but elevators can be approximated using a combination of gated links, floors, and paths.



An elevator can be modelled using a combination of floors, gated links, a path, and a gate event.

Floors, Links, and Path

Create a small floor for each level at which the elevator will stop. Connect these elevator floors to their levels with gated links. Connect each elevator floor to the floors above and below using a path. The paths will allow agents to travel between levels while the gated links will control access to the elevator, opening when the elevator is at a particular floor.

Ensure the path directionality is set to bidirectional. The elevator links must be gated. Set priority access to give priority to agents leaving the elevator.

Gate Event

Create separator boarding and alighting gate events for each of the elevator doors. Use triggers to open the door in the alighting direction some interval after the door on the floor above or below closes. Use triggers to open the door in the boarding direction at the same time as the lighting direction, but then close it when the population on the elevator car reaches a maximum count or a set number of people transition through the door.

Alternative Simplified Gate Event

Create a separate gate event to control each elevator link. For each gate event, add the corresponding gated elevator link, enable cycling, set the on duration to be the time the elevators doors will remain open, and the off duration to be the time it takes the elevator to leave the floor and return.

3.4.1.1.5 Turnstiles

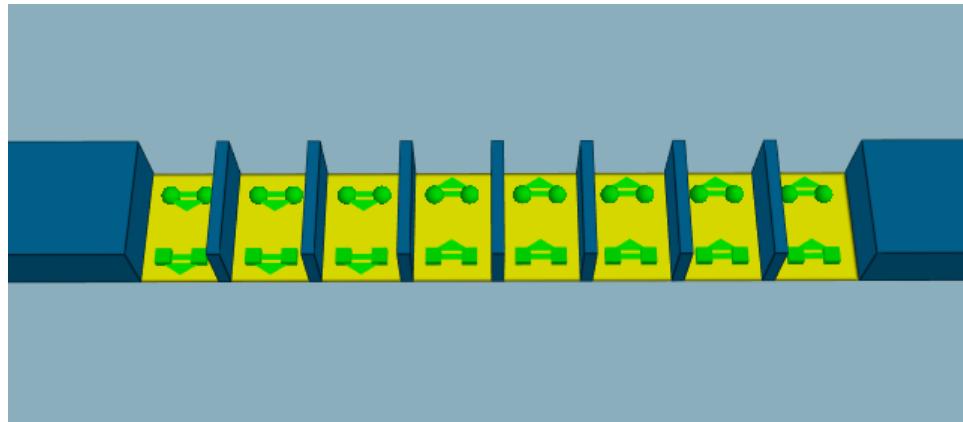
MassMotion is used extensively for analyzing transit stations, and the modelling of turnstile geometry and related agent behaviour is a common requirement. There are a number of factors which should be considered when modelling turnstiles.

Geometry

The geometry of the turnstiles will be similar to [Doors](#). In order to achieve the desired flow rates

across the links, consider the following steps:

1. Determine the centre to centre dimension of the real world turnstiles and use that for the width of the link.
2. Make the width of the separating barrier geometry as narrow as is practically possible.
3. At the end conditions, extend the width of the barrier geometry to prevent agents from ending up beside their target links.



A set of 0.68m wide turnstiles with barriers 0.1m wide

Object Properties

If the turnstiles are to be used in one direction only, set that direction in the link property window. If the turnstiles are to be bidirectional, enable priority access and set the priority direction to bidirectional. In this case it is recommended that priority 'move aside' be turned off so that agents do not move to block one turnstile when waiting for access to another.

The limit flow property can be used to ensure the processing rate does not exceed operational expectations. An additional delay on exit can be used to simulate the brief pause from dealing with fares or navigating the turnstile. Delay on exit is recommended over delay on enter so that paused agents do not interfere with the limit flow control over inbound flow rates.

If the turnstile widths are exceptionally narrow (less than 0.6m) or if the turnstile is not aligned with the scene axes, it may be necessary to also do the following:

1. For each turnstile object, set the traversal type property (on the agent behaviour tab of the link's property window) to ignore barriers. This will free up space for the agents along the edges of the link surface.
2. For each floor on either side, set the physical map resolution to 0.05m or even 0.02m. This will enhance the resolution of the edge/barrier condition on the approach to the turnstile channels and provide more effective width within the approach channel.
3. Reduce the agent radius for each turnstile. MassMotion agents are represented as cylinders and are unable to move sideways to fit through narrow gaps as people can in real life. Reducing agent radius can serve to approximate 'squeezing' through narrow openings.

Banks of Turnstiles

Turnstiles are often positioned in groups bridging the same two floors. To ensure that agents use all available turnstiles and consider all turnstiles equally, links in the same direction should be banked. Please see [Banks](#) for more information.

3.4.1.1.6 Collections

A [collection](#) is a group of one or more objects. Some collections, such as banks, perimeters, and zones, have a particular function within the simulation. All collections can be used to help manage a scene or perform [analysis](#).

Visibility

When a collection is shown or hidden, all members are shown or hidden. This can be useful for quickly controlling which elements of a scene are visible. In an office tower, there might be one collection for each floor or level. Showing/hiding levels then is just a matter of showing/hiding the appropriate collections.

Intelligent Member Selection

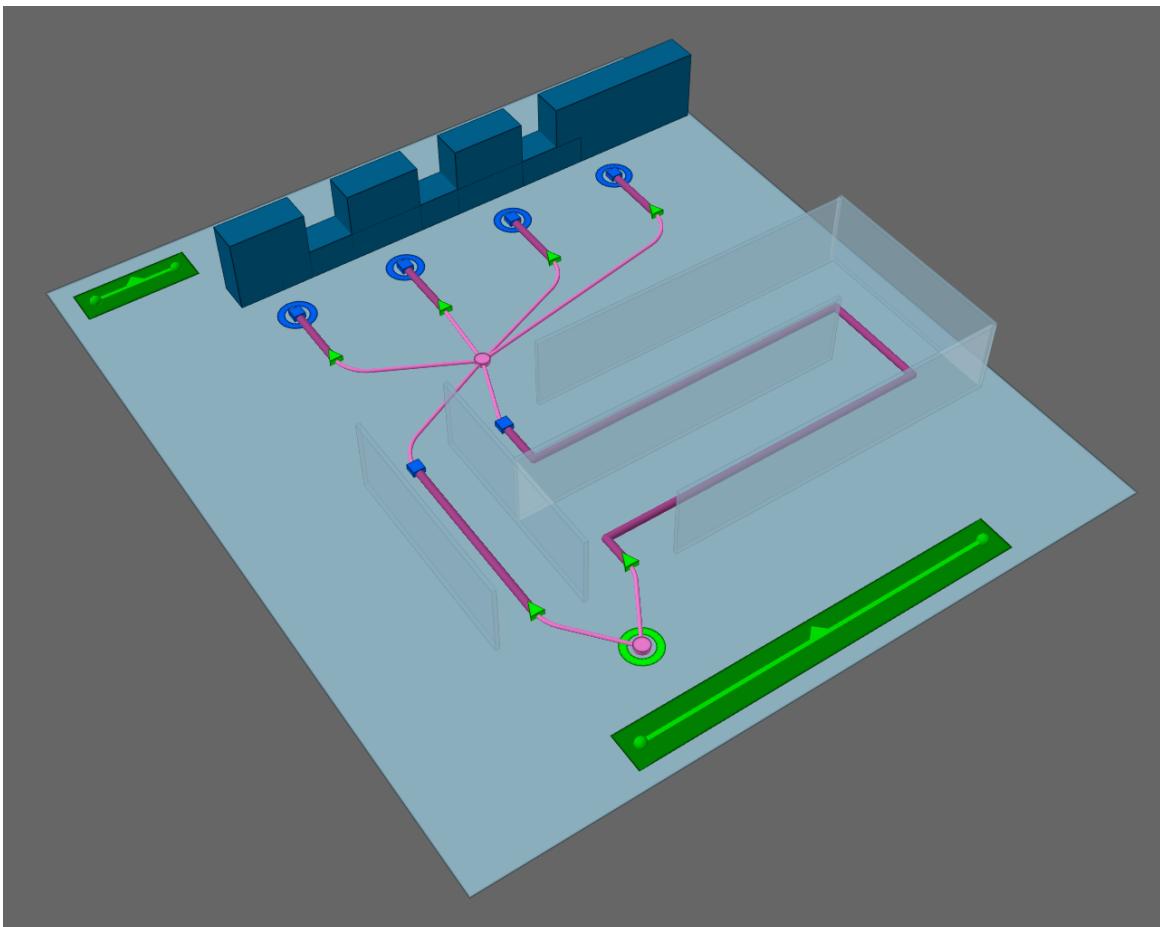
A collection can be specified as an input to many objects (for instance the entrance portals in a journey event). The object will pull only those members from the collection that make sense in the particular context. If a single collection contains all of the floors, door links, and portals associated with a train car, that same collection can be used to specify the gates in a gate event and the portal origins in a journey event.

Please see [Collections](#) for more information on referencing collections from other objects.

Collection Type	
Bank	A bank is a collection of connection objects (ie. links , stairs , ramps , escalators and paths) that bridge the same two floors and are spatially close to one another. When an agent chooses a route through a bank, it selects which of the bank members to take based only on near distance and queue cost, ignoring any downstream costs. This can be useful for maximizing flow through a set of turnstiles. See Bank for more information.
Collection	A general purpose collection with no special purpose beyond the grouping of member objects. See Collection for more information.
Perimeter	A perimeter is a collection of connection objects (ie. links , stairs , ramps , escalators and paths) marking a boundary around a special area. Routes that cross this boundary more than once are disallowed. By adding all turnstile links to a perimeter, routes leading into and out of the fair paid area will be permitted, but through-traffic agents will be prevented from taking shortcut through the fair paid area. See Perimeter for more information.
Zone	A zone is a collection of floors, links, stairs, ramps, escalators, or paths. Zones are used primarily for evacuations where agents inside a zone can be instructed to prioritize leaving the zone before heading to any other destination. This is useful in scenarios where agents evacuating a subway station must first evacuate the platform before worrying about evacuating the station. See Zone for more information.

3.4.1.1.7 Ticket Desks

The definition of ticket desks or similar processes is a common task in MassMotion. Pictured below is a standard multi-fare airline-style ticketing/check-in configuration:



Ticketing Layout

Ticketing layouts are constructed using [servers](#) that are [chained together](#) to represent the flow of people from one process component to the next. In the above configuration there are two accumulator queues for business and economy passengers which feed into 4 service positions. The two accumulator queue entrance points should be connected together such that agents can be sent to a single dispatch entry point for the entire process chain.

It is good practice to setup [barriers](#) around the queues (as in the real world) to ensure that circulating people don't try to pass through the queuing areas.

Properties

Agents are assumed to have either a business or economy [token](#) assigned through earlier [actions](#). To manage access control, the server objects representing the accumulator queues are set to require the appropriate token, for example, business tokens for the business class queue.

The accumulator queues should be set to infinite capacity and contact times of zero. This will allow agents to continue queuing regardless of occupancy and they will only stop at the queue exit points if the downstream service positions are all busy. This is an automatic consequence of the connection between both the exit points of the accumulator servers and the entry points to the service position servers.

The capacity of the service position servers should be set to 1 to ensure that once the position is occupied, no other agents will be released from the accumulator queues until the position becomes free again. The contact time for the service positions should be set to correspond to the range of times that it typically take to process a passenger. The service positions may be set to prefer

business or economy tokens which means the position will prioritize the release of agents with the designated token from the accumulator queues. If no preferred token agents are queuing the positions will then accept other agent types.

3.4.1.2 Building the Scene

The physical environment in a MassMotion project is defined by scene geometry which is contained in one or more scene objects. The objects each have a particular purpose in a simulation based on their type (see [Modeling Strategies](#)).

It is possible to create new [default objects](#) with standard shapes and then [edit the geometry](#) to create the desired scene. It is also possible to [import content](#) from another application, and then [convert the imported objects and/or drawings](#) into MassMotion objects of the appropriate type.

3.4.1.2.1 Creating Default Objects

New MassMotion objects can be created through the ribbon buttons in the Scene tab at the top of the [main window](#), or through the right click menu in the [3d scene view](#).

Newly created objects come with a default geometry which can then be [edited](#) to match requirements.

3.4.1.2.2 Selecting Object Components

To select an object for editing, click on the object with the left mouse button. To select components for editing, first select the object and then change the selection mode in the top right of the main window. This will display the components of the selected object which can themselves be selected using the left mouse button.

It is not possible to select a new object when in component selection mode. First return to object mode, add the new object to the selection, then return to the component selection mode.

The following lists show object types and their corresponding components.

3d Mesh Objects

- Face
- Edge
- Vertex

Line Objects

- Edge
- Vertex

Drawing Layers

- Line
- Point

3.4.1.2.3 Importing Geometry or Drawings

Geometry, drawings, or images can be imported from files using the Import button in the 'Project' tab or the Import section of the 'File' menu. See [Import Files](#) for information on supported file formats.

Imported geometry is referred to as [reference geometry](#) and is primarily used to [generate MassMotion objects](#). It can also be used as a visual aid during playback or for recorded videos. Imported geometry is not used directly during simulation or analysis.

IFC Geometry

The contents of IFC files are imported as [IFC geometry](#), where IFC type information is retained. This type information can be used to automatically [generate](#) corresponding MassMotion objects.

3d Geometry

All non-IFC geometry is imported as [generic geometry](#). This can also be used to generate MassMotion objects but the user must specify the target object type.

2d Points/Lines

All 2d elements within a file are imported as [drawing layer](#) objects. Drawing layers can be used separately or merged together. The lines and enclosed spaces/regions within a drawing can be used to [generate](#) MassMotion objects.

Images

Image files can be imported as textures which are automatically placed on a 2d rectangle. These textured surfaces can then be used to trace new objects.

3.4.1.2.4 Creating Objects from Geometry or Drawings

MassMotion objects can be generated from traced lines or [imported geometry or drawings](#) using the right-click 'Generate' menu commands or the 'Generate' button in the [tool panel](#).

Tracing new Objects

Lines can be traced over existing drawings, imported images, or 3d objects. For information on using traced lines to generate objects see [Tracing New Objects](#).

Generating from Reference Geometry

Imported reference geometry objects can be used to generate new scene objects. When working with Ifc geometry, the target type for a given source object can be determined automatically. See [IFC Geometry](#) for a mapping of source Ifc type to MassMotion type.

When a specific target type is chosen, a transformation is applied to the source object. The transformation is based on the source and target types. See [Generating From Generic Geometry](#) for a list of the default transformations. It is also possible to customize the transformation operations through the [Generate Options](#).

When a new object is generated from reference geometry, the source object is deleted. This behaviour can be changed through the [Application Preferences](#).

Generating from Drawing Lines/Regions

The lines and empty spaces within drawing layer objects can be used to generate objects (see [Generating From Drawings](#)). Drawing lines can be extruded out of the plane to form barriers, expanded in plane to form a link, or spanned (between two lines) to form stairs or escalators. Voids enclosed by drawing lines can also be used to generate floors or barriers. The voids are called regions, and once found can be selected and used to generate objects like any other component (see [Finding Regions](#) for information on regions and [Healing Drawings](#) for editing lines to ensure good region construction).

Copying Reference Geometry, Faces, or Regions

The 'Convert' context menu available when right-clicking on selected reference geometry will convert the selected objects into a new object of the specified target type. The source geometry will not be modified. The same operation can be applied to mesh faces or drawing regions through the 'Copy to' context menu.

Projecting Objects onto Drawings

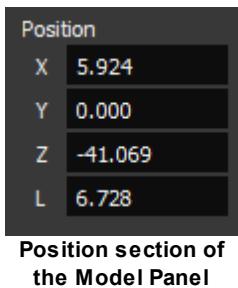
Drawing layers can be used to create objects from the spaces between reference geometries (eg. floors from surrounding walls). 3d geometry can be projected onto a new horizontal drawing layer through the 'Generate' right-click menu. The new drawing layer can then be used to generate other objects as required.

3.4.1.2.5 Editing Geometry or Drawings

Geometry or drawings can be edited either by moving the entire object, or by manipulating individual components of the object.

Many of the tools for editing geometry have [shortcuts](#) for quick access.

3.4.1.2.5.1 Setting Position and Length



Setting Positions

The position of objects or object components can be set to a specific location using the 'Position' section in the Main Window's [tool panel](#). This is useful when a number of vertices need to be along the same line or at the same height.

In the case of objects, the position of the object centroid is displayed. In the case of object components, the position of the vertices connected to the components is displayed.

Setting Length

The 'Positions' section of the Main Window's [tool panel](#) can also be used to set the length of an edge. This is useful when a stair or door is required to be a certain width. Select the appropriate edges and enter the desired length in the L field.

3.4.1.2.5.2 Geometry Manipulation

Translating, Rotating, Scaling

Objects or components can be moved around the scene using the transform [manipulators](#). These manipulators are available under the 'Transform' section of the [tool panel](#).

Select an object or component, select the transform, rotate, or scale manipulator, then either enter numbers directly or drag the manipulator to achieve the desired transform. In the case of the translate or rotate manipulator, the 'Shift' key can be held to snap movement to discrete increments.

In the case of translation, the axis arrows can be used to translate along a particular axis. Clicking between two axes will drag within the plane defined by the two axes (a yellow square indicates the plane of translation).

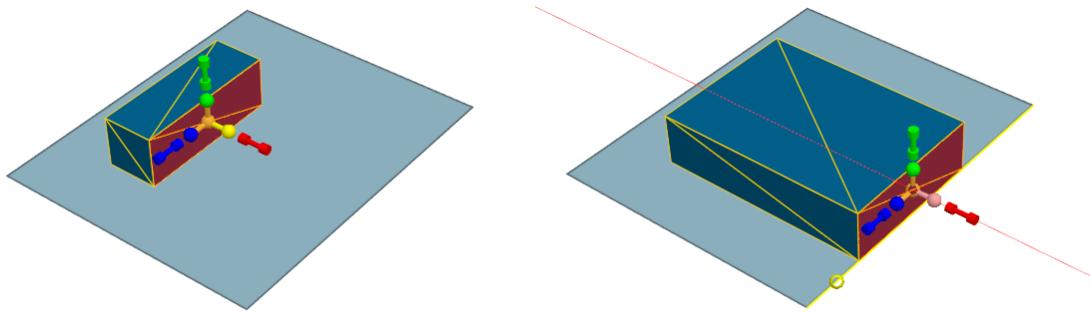
When scaling, the axis arrows can be used to scale only in a particular direction. Clicking between two axes will scale uniformly within that plane (both directions will scale equally). Clicking away from the manipulator (such that the entire manipulator is yellow) will scale equally in all directions.

Snapping

Objects or components can be moved in relation to each other using the [object snap](#) manipulator. This manipulator is also available under the 'Transform' section of the [tool panel](#).

Select an object or component, select the snap manipulator, then drag the manipulator to achieve the desired transform. The manipulator is comprised of the orange centre ball; the red, green and blue axis balls; and red, green and blue alignment barbells. The centre ball can be used to 'translate' to vertices, edges, edge midpoints or points on faces of other objects. The coloured axis balls perform the same operation, but 'constrained' to a specific axis direction. The alignment barbells are used to rotate the manipulator and selection so that the axis is parallel to a particular edge.

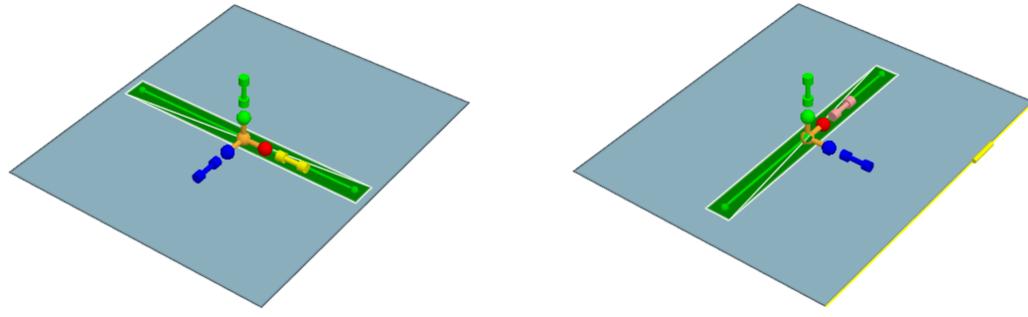
The vertex, edge or face being snapped to will be highlighted in yellow.



Before X constrained position snap

After X constrained position snap

Note: Without the X-constraint, the faces would not have moved only in the X direction and may end up elsewhere on the floor's edge.



Before alignment snap

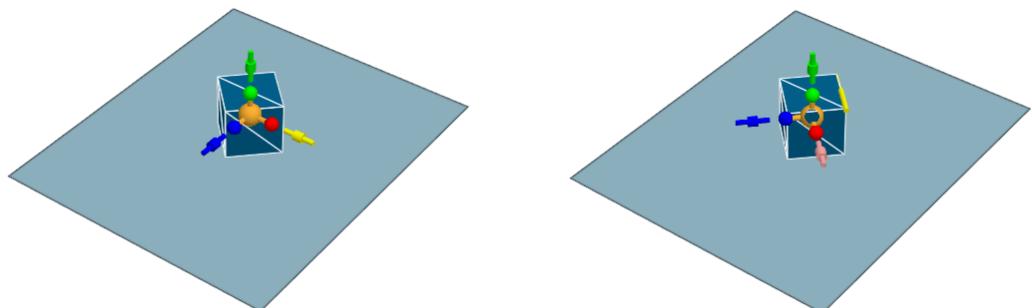
After alignment snap

See [Manipulator Tips and Tricks](#) for more uses of object snap.

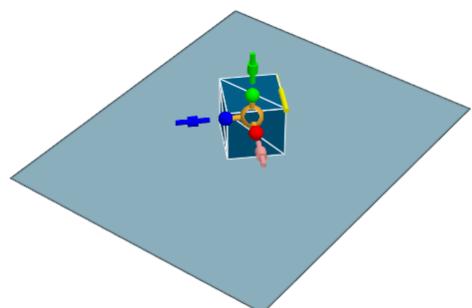
Off-axis Operations

For off axis and uncentered operations, the manipulator snap sub-mode can be used to reposition or realign the manipulator with respect to the selected objects or components. Once repositioned the manipulator will retain its position and orientation for subsequent object transformations.

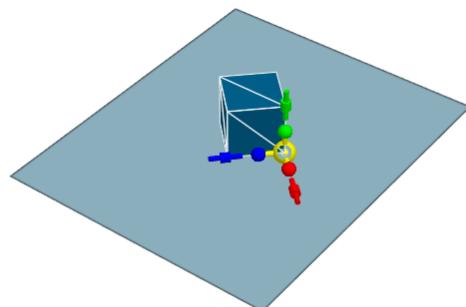
The following images show how to use manipulator snap to bring an off-axis barrier flush with a floor's edges. The first step is to use manipulator snap to re-orient the manipulator until it is aligned with the barrier, and then to move the manipulator to the barrier corner. Once the manipulator is positioned correctly, object snap can be used to position the barrier corner on the target floor corner and then to rotate the barrier until it is aligned with the floor.



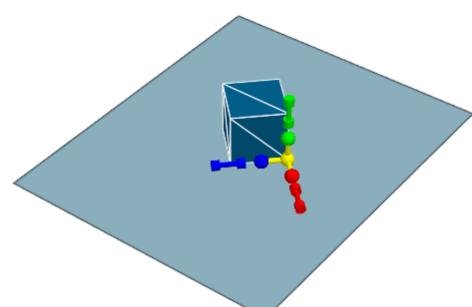
1) Before manipulator snap



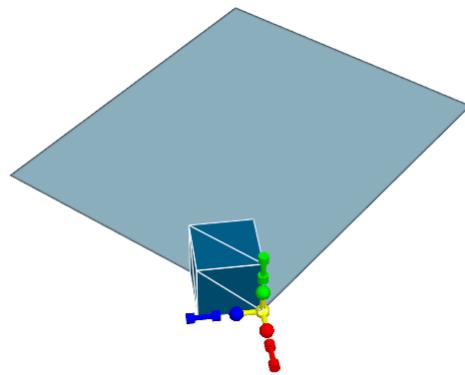
2) After manipulator alignment



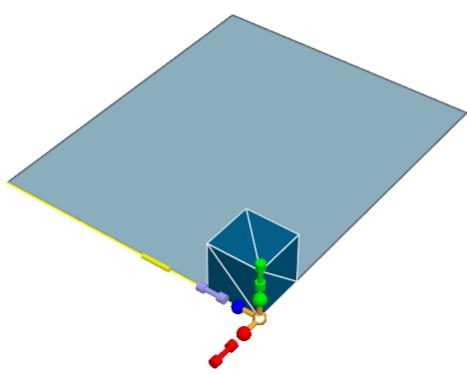
3) After manipulator reposition



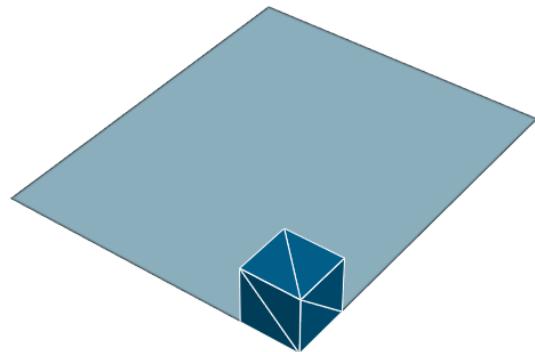
4) Before object snap



5) After position snap



6) After alignment snap

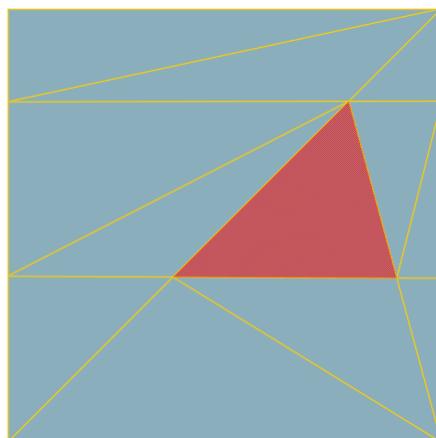


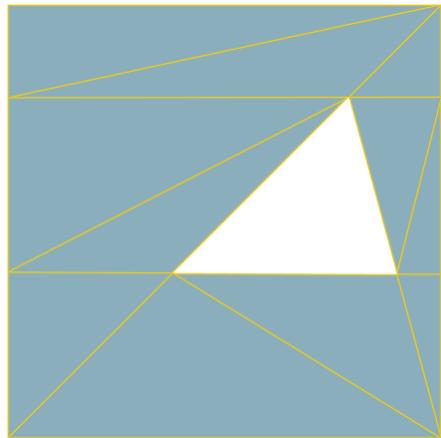
7) Barrier now flush with floor edges

See [Manipulator Tips and Tricks](#) for more uses of manipulator snap.

3.4.1.2.5.3 Common Operations

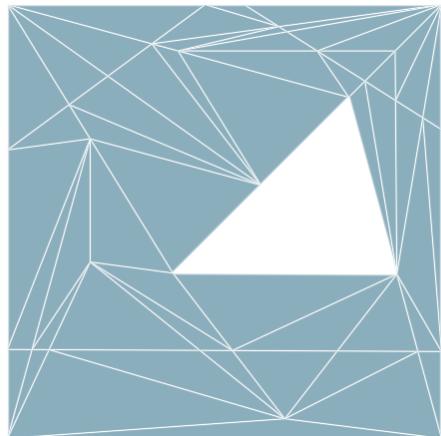
Select an object or component and hit the delete key or use the delete button in the [tool panel](#) to delete the selection.



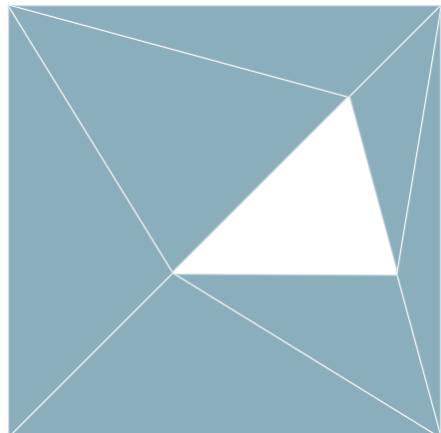


After deletion of selected face

If an object has been sliced, split, or grown many times, there can sometimes be an excess of faces. Use the 'Simplify' command in the [tool panel](#) or object right-click menu to reduce the object to its simplest form. The overall shape of the object will not be altered.

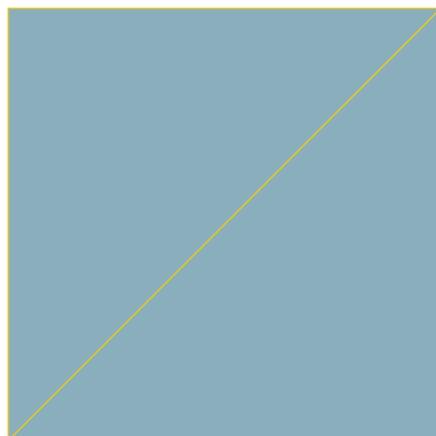


Before simplify

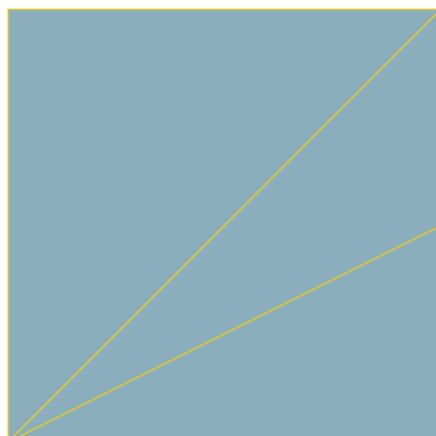


After simplify operation on object

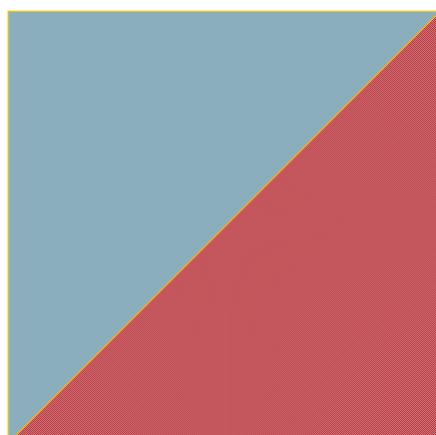
Edges or faces can be split to provide additional edges or vertices for manipulation. Select one or more faces or edges and use the 'Split' button in the [tool panel](#) or component right-click menu.



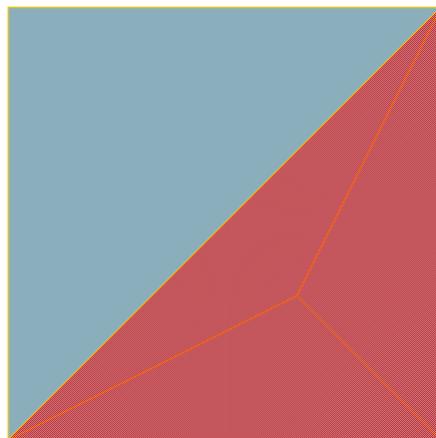
Before split edge



After split operation on the selected edge



Before split face



After split operation on the selected face

3.4.1.2.5.4 Mesh Operations

Select the edges of a hole or gap in a 3d mesh object. Use the fill command, accessible from the right click menu, to repair the mesh. Fill can be performed on both edges and vertices.

It is useful to [simplify](#) after this process.

Fill by Edges

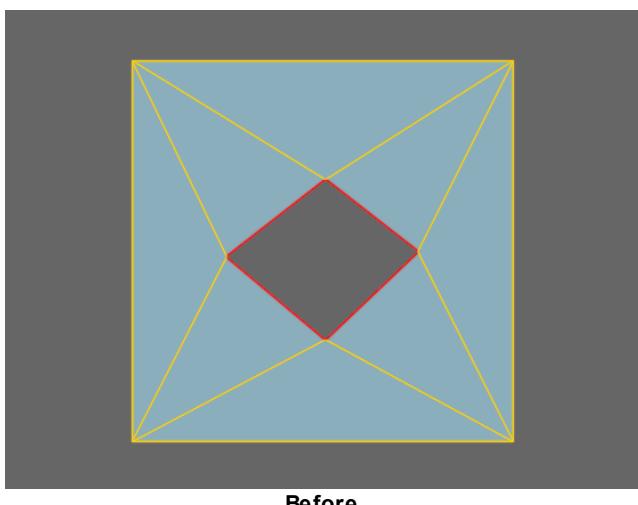
To fill a mesh using edges, select a series of connected edges outlining the hole or gap to be filled. The selected edges must be on the same plane.

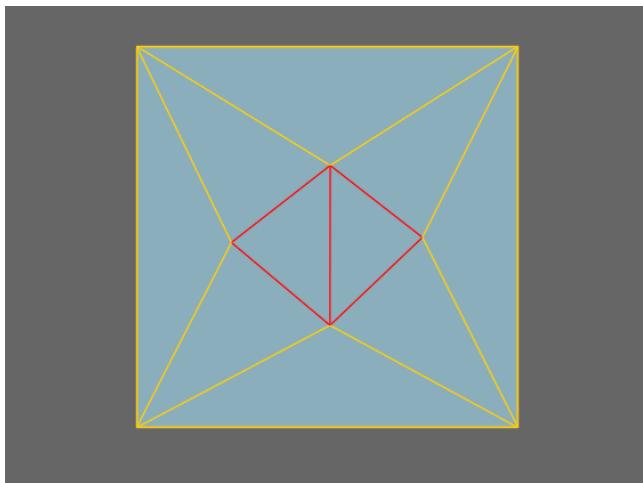
Note: Any two connected edges are on the same plane. This can be used to fill in complex, non-planar gaps.

Fill by Points

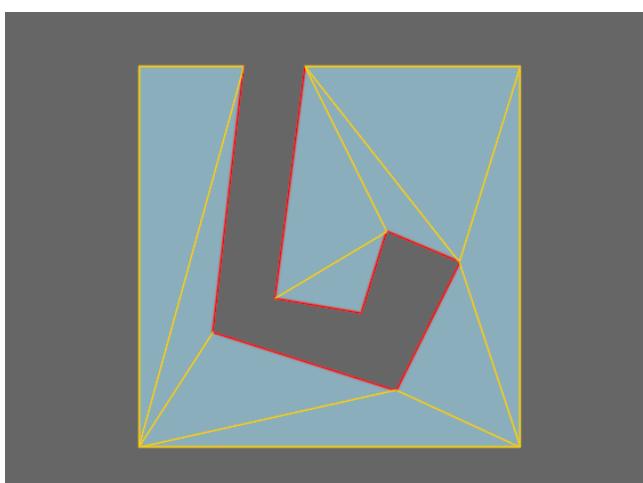
Filling a mesh can also be done by selecting points on the outline of a hole or gap.

This is equivalent to selecting the edges which connect the vertices.

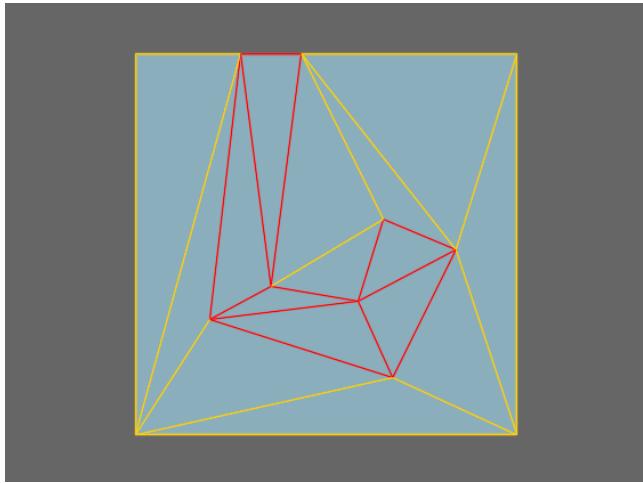




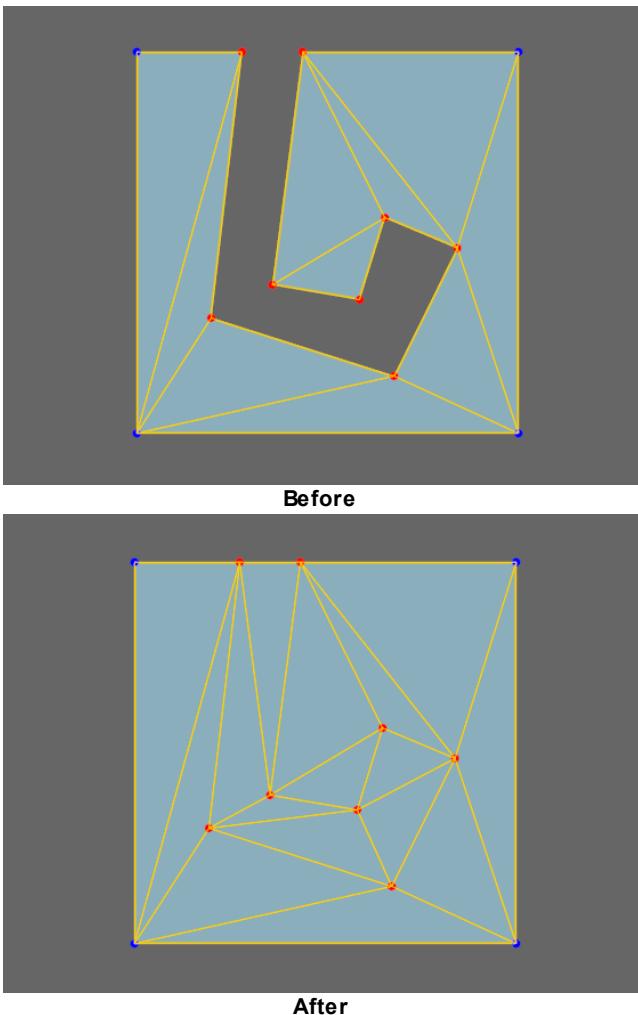
After



Before

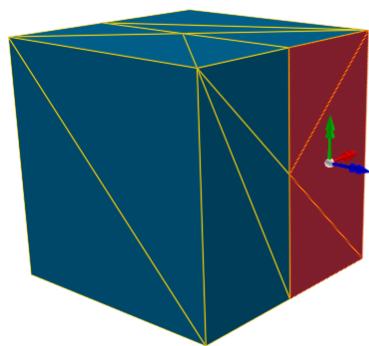


After

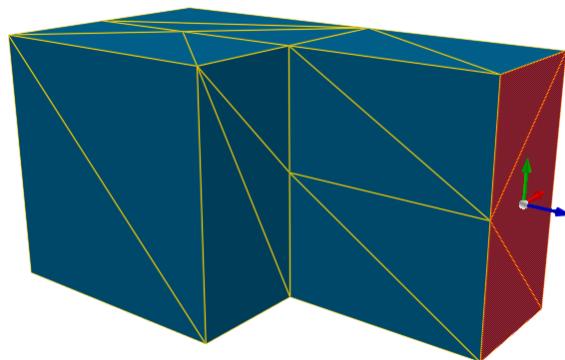


The grow manipulator can be used on mesh objects to extrude one or more edges or faces. In the case of line based objects like paths, end vertices can be grown to extend the line.

Select an edge (mesh object), or face (mesh object) and use the 'Grow' button in the [tool panel](#). The grow manipulator is shown similar to the translate manipulator. The first drag will create a duplicate of the selected component and begin a translation operation.



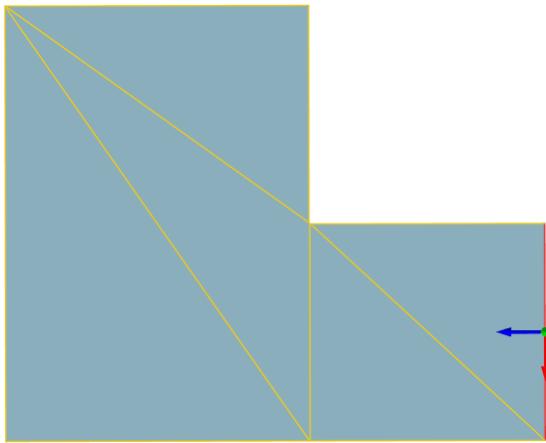
Before grow faces



After grow operation on the selected faces



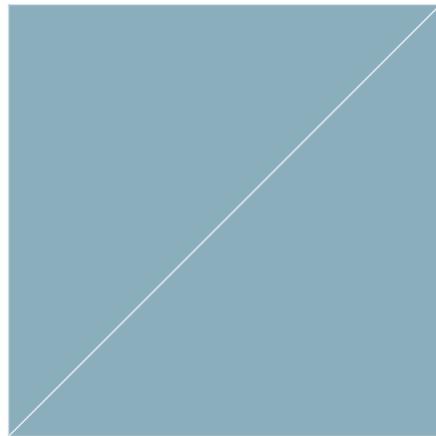
Before grow edge



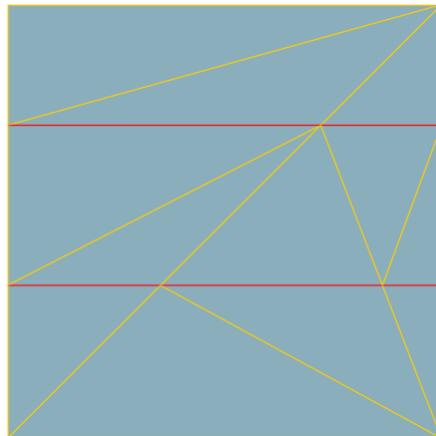
After grow operation on the selected edge

The slice tool is used to create new edges in an object along a user defined line. Select an object in the scene and then enable the knife tool in the [tool panel](#). Drag a line across the object where the slice is to be made. The new edges can be useful for isolating a section of an object. The new section can then be deleted to create a hole or grown to produce an extrusions.

Note that only selected objects that are actually contacted by the line will be cut.



Before slice



After two horizontal knife operations on the object.

3.4.1.2.5.5 Working with Lines

Some objects such as [paths](#) and [servers](#) are represented as a series of connected line segments. The points and line segments within a line can be edited just like the edges and vertices of a 3d mesh.

To add segments to the start or end of a line, select the end vertex and use the 'Grow' (hotkey G) command to extend the line.



Before grow vertex



After grow operation on the selected vertex

3.4.1.2.5.6 Healing Drawings

Drawings can be used to create geometry either from the lines within the drawing or the empty spaces (called [regions](#)) enclosed by those lines (see: [Copying and Converting Geometry](#)).

When empty spaces are not completely enclosed, some healing may be required before they can be treated like regions. See: [Drawing Commands](#) for a full list of commands available.

Delete Unwanted Detail

Examine each drawing layer and delete those that do not contain information useful for generating scene objects. Electrical systems, duct work, labeling, grid lines... anything that does not contribute to the definition of the physical space.

Extra lines within a drawing layer can also add unnecessary complexity to regions, subdividing a space further than is useful. Delete unwanted lines before finding regions.

Merge Multiple Drawings

Some drawing operations are only possible when editing a single drawing. If the information needed to define a floor/door/stair is spread over multiple drawing layers, consider merging those layers into a new combined layer. A standard merge will delete the source layers. To preserve the source layers use the right-click context menu to select 'Generate - > Merged Drawing'.

Close Gaps

See [Drawing Commands](#) for a full list of commands that can be used to help ensure [regions](#) are well formed. Each of these commands is available through the right-click menu when editing a drawing in the 'Lines' selection mode.

- **Add Line:** Obvious gaps can be filled by selecting two points on either end of the gap and adding a line between them with 'Add Line'.
- **Extend and Fuse:** Select two lines that are almost touching and use 'Extend and Fuse' to extend the lines until they intersect. The two lines will be joined by a new point at the intersection location.
- **Merge Points:** Points that are very close together can be merged into a single point using 'Merge'.

Performance Tips

If the 'Find Regions' operation is taking a long time to complete, try selecting only a subset of lines within the drawing layers. Only those lines selected will be used to construct regions.

Merge multiple drawing layers into one to take advantage of region caching. Regions are cached

when operating on a single drawing layer.

3.4.1.3 Creating and Controlling Agents

3.4.1.3.1 Scheduling & Events

[Events](#) are objects which create agents or modify the scene during a simulation. Events can be set to turn on at a specified time, or use [Triggers](#) to turn on or off in response to changing conditions in the scene.

Creating Agents Using Events

All agent related events will place agents in the scene at specified portal locations. Once placed in the scene, agents are given one or more tasks to accomplish. Many events give only a single task, usually to seek one portal. Some events will give a series of tasks that are to be executed in order.

Events that Create Agents	
Journey	Create a single wave of agents, each with a single origin and a single destination, where the origins and destinations are assigned from a set.
Circulate	Create agents which move some number of times between a set of "circulation" portals.
Evacuate	Create agents, tell them to wait for a specified period, then evacuate the scene through one of a set of destinations.
Timetable	Create agents, assign agent tasks, and open gates based on a series of coordinated text input files. Suitable for modeling train schedules, flight schedules, bus schedules, university lectures, or intersection gate timings.
Trip Matrix	Create a wave of agents, each with a single origin and destination, where the origins and destinations are assigned from an origin/destination matrix.
Vehicle	Create a series of vehicle arrivals. Gates can be opened at each arrival to control access to the vehicle area. Boarding and alighting agents can also be created for each arrival.

General Events

General events do not create agents. They modify the scene or existing agents during the simulation or provide information to other events.

General Events	
Broadcast	Applies an action to agents at a specified time.
Gate Access	Opens or closes gated connection objects .
Server Access	Opens or closes access to servers .
Time	This virtual event does nothing to the scene, but can be used by the reference times of other events to refer to a common time.

3.4.1.3.2 Actions

While traditional origin-destination based pedestrian simulators model the flow of people from A to B, MassMotion can target a sub population mid-route and direct those individuals to accomplish any number of alternate [Tasks](#).

Actions are operators that can be selectively applied to agents as they move through the scene. Actions can be applied as an agent enters the simulation, as it transitions between links and floors, as it enters or exits zones, as it reaches destination portals, as it finishes processing at a server, or through the use of triggered broadcast events. Possible operations include changing the agent colour, giving the agent a new goal, or instructing the agent to wait for a specific interval.

For a full list of available operations, see [Agent Actions](#). For information on how to apply actions to agents, see [Where to Use Actions](#). For details on the order in which actions are applied to an agent, see [Order of Action Execution](#).

3.4.1.3.3 Tests

[Tests](#) are Boolean operations that will return true or false when applied to an agent. Tests are used throughout the scene to control how events and other control mechanisms interact with agents. The most common use for tests is in determining whether or not [Actions](#) will be applied to a particular agent, but they are also used in [Process Chains](#) and many [Events](#).

For a full list of where tests can be used see [Where to use Tests](#).

3.4.1.3.4 Triggers

[Triggers](#) can be used to control when events turn on or off. Most events will use triggers implicitly in the setting of their start and/or end conditions. It is also possible to create standalone named trigger objects which can then be referenced by multiple events.

The most basic triggers fire at a specific time. This time can be absolute or set relative to the simulation start or a reference [Time](#).

More advanced triggers will fire when certain conditions in the scene are met. This could be based on the population in an area, a count of the number of people crossing through a door, the changing of a gate from open to closed, or any number of logical combinations of these. It is possible to have the same event fire multiple times during a simulation, once for each time the trigger conditions are met.

For a full list of available triggers, see [Triggers](#). For information on using triggers to drive events, see [Triggering Events](#).

3.4.1.3.5 Process Chains

A process chain provides a mechanism for modeling the progression of agents through a series of capacity constrained stations or servers. Agents can be distributed evenly across a number of servers, wait in single file for their turn at each server, be held for a specified period of time by the server, then be released when downstream servers have the available capacity to receive the agents. Process chains are ideal for designing security, ticketing, or other processes which are evaluated on their throughput efficiency and wait times.

Definition

A process chain is a series of one or more servers connected together and has one or more start

points (green circles) through which agents may enter the chain, and one or more end points (blue circles) where agents are released from the chain. The most basic process chain (shown in Figure 1-1) consists of a single server with one start point and one end point.

The most simple compound process chain (shown in Figure 1-2) consists of two servers connected together, with a single start point, a single end point, and a single internal connection. Agents following the internal connection from one server to another will only proceed to the connected server when it has the available capacity. If there is no available capacity, agents will wait at the upstream processor, potentially blocking other agents from accessing the upstream processor.

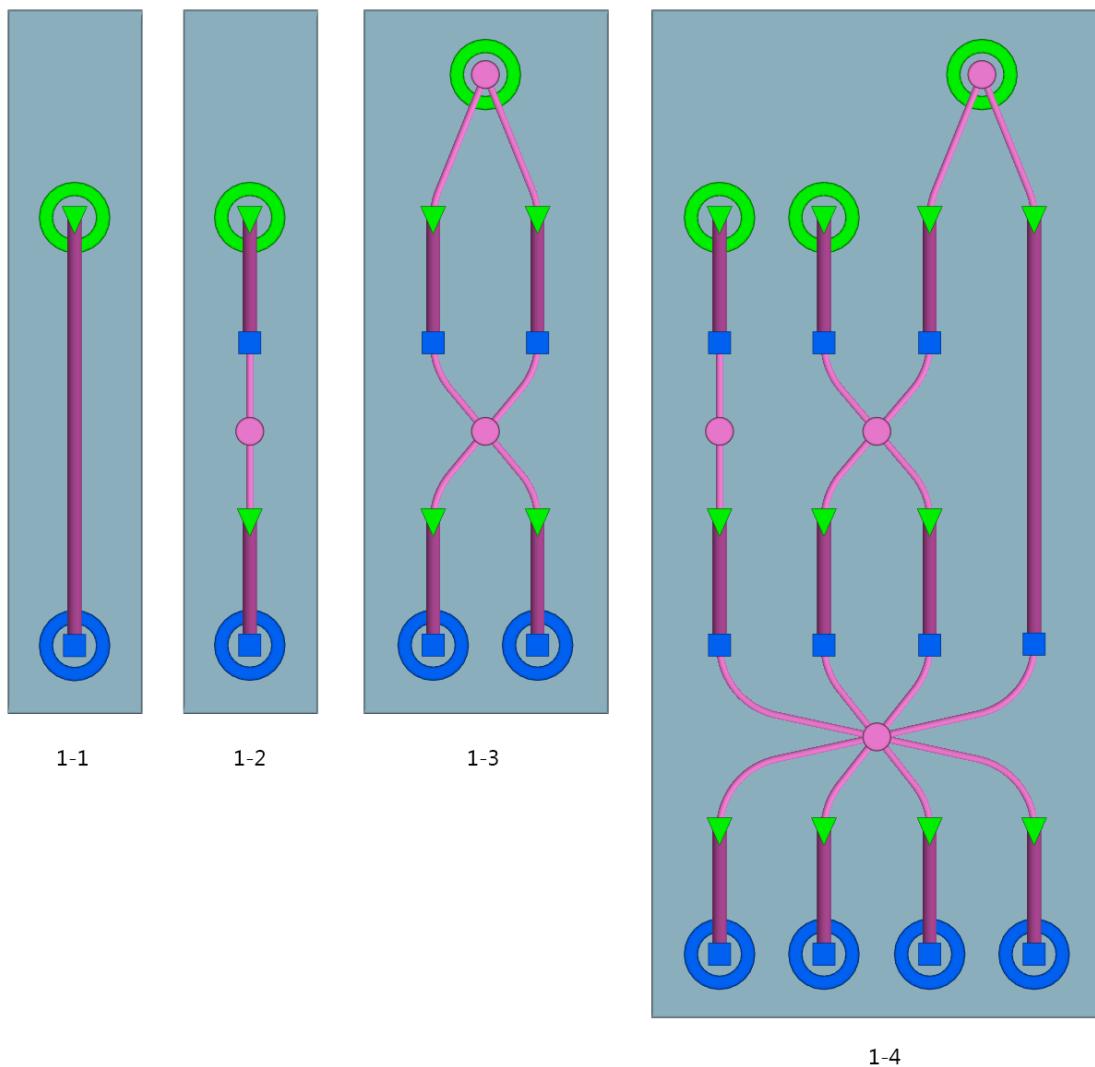


Figure 1

Servers

Servers form the core building blocks of a process chain. Each server is composed of an input buffer line (green triangle at entry point and purple path geometry) and a terminating process node (blue square at exit point). Agents walk and queue along the input buffer until they reach the process node and will only leave the server once processing is complete. The amount of time taken to process a single agent can be specified through the server properties. The server can also limit access to

specific agents based on token possession, and limit the maximum number of agents permitted in the input buffer. A single server is shown in Figure 1-1. For more information on server construction and properties, see [Servers](#).

Dispatches

Dispatch objects are automatically created when server objects are connected to each other. The dispatches are represented by pink discs with pink connector lines indicating which server objects are connected through the dispatch. Within the context of a dispatch, upstream servers are referred to as sources and downstream servers as sinks. Figure 1-3 shows how server entry points can be grouped together using a dispatch and also how successive groups of server exit points and entry points can be connected in a many-to-many configuration via a single dispatch. Figure 1-4 shows how multiple levels of servers may be connected using many servers and dispatches to define complex operations. The dispatch objects control the distribution pattern of agents (random or shortest queue) from sources to sinks. For more information on dispatch properties please see [Dispatches](#).

Creating Process Chains

Creating process chains is done by entering the "Process Chain Edit" mode. This can be done by either clicking on the  icon in Model Panel on the right hand side of the main window or by using the hot-key "Q". In edit mode, all server start and end points and all dispatches in the model will be outlined in yellow circles. These yellow circles may be connected together by selecting the circles and clicking the  Connect icon in the Model Panel. Dispatches will automatically be created between server start and end points as needed. To disconnect process elements from a process chain, click the  Disconnect icon in the Model Panel. Connecting and disconnecting process chain elements may also be done by right clicking the selected 3D objects and selecting the appropriate item in the pop-up menu. To exit "Process Chains Edit" mode click on the  icon in Model Panel on the right hand side of the main window or press the hot-key "Q".

Sending Agents to Process Chains

Process chain entry points (server or dispatch) are identified by green circles. Agents can be directed to a single entry point using the "Task: Seek process start" [action](#). Once an agent is tasked with seeking a process chain entry it will navigate the scene using the standard route choice algorithms until it reaches the floor with the process chain, at which point it will attempt to enter and follow the chain.

If the entrances to servers in the chain are left unconnected, separate actions are required to explicitly send agents to the individual entry servers. If the servers are connected by a single entry dispatch, all agents can be sent to that single dispatch, and then the dispatch will distribute agents across the connected servers. For example, in Figure 1-4 there are three start point entries into the process chain (two servers and one dispatch). Agents can be explicitly directed to any of the three using actions. However, those agents that are directed to the third start point will be evenly distributed across the third and fourth server.

Movement Within a Process Chain

Agents that enter a server cease to navigate via the [normal crowd movement](#) algorithms and will instead advance along the input buffer in a strictly ordered fashion. When in transit between two internal servers, agents will employ normal crowd movement behavior, attempting to avoid obstacles and each other, but will not engage in any route selection or wayfinding. For this reason all servers in a process chain must be located on the same [floor](#).

Measuring Counts and Times in a Process Chain

Please see [Analysis Objects](#) for information on the various metrics available for measuring the performance of process chains.

3.4.2 Simulation

Once authoring has reached a stage where the scene contains a viable network and there are events for generating agents, the project can be simulated. See [running a simulation](#) for information on how to launch a simulation. See [simulation data](#) for information on the data produced by a simulation.

Validation

When a simulation is launched, the project is automatically validated. Validation involves verifying that all objects and their properties are in a consistent state, that all object references can be resolved, and that the resulting simulation network will be well formed. Any errors must be addressed before proceeding with a simulation.

Validation can also be performed manually using the Validate button in the analysis tab of the main window's ribbon.

Compiling

When starting a simulation, a copy of the project is created and compiled into an optimized form. It is the optimized copy which is used for the simulation, meaning that changes in the authoring environment have no impact on a simulation that is already running.

Compilation involves converting the various object properties into raw data, resolving references between different objects, generating obstacle and approach maps for walkable objects, converting object goal lines into network waypoints, building the network, constructing cost trees for each destination in the scene, and creating a new database file.

Execution

The simulation can be run either in console mode or debug mode (see [Running a Simulation](#)). Both methods make use of all available processors on the machine. The [console window](#) provides text based feedback on the simulation. The [debug window](#) contains a graphical scene view and provides a mechanism for interrogating agents and objects as the simulation progresses. Both methods make use of all available processors on the machine, but a console simulation will execute much faster than a debug.

Review

Once a simulation is complete, the results can be played back or analysed through queries using the [Analysis](#) system.

3.4.2.1 Simulation Data

Each iteration of a simulation is associated with a [simulation run](#) object in the project. The simulation run is connected to a [database file](#) on disk and is the handle through which MassMotion accesses the data for both playback and analysis.

All of the simulation data is stored in a single mmdb file. This is a standard SQLite database file and can be interrogated using any third party SQLite tool. Many of the [analysis queries](#) provided by MassMotion are convenience wrappers for the execution of raw SQL queries. Agent position information is packed into an optimized form and difficult to read directly, but all other information can be extracted directly from the database with a basic understanding of SQL. For example, tables exist in this database to indicate what floors agents were on at every instant, and what tokens they were holding. A separate tool for [extracting and exporting agent positions](#) is available from the main window.

Local Storage Recommended

The performance of simulation execution, playback, and analysis queries can all be negatively affected by slow database access times. As a result, it is recommended that simulation runs point

only to local drives and not use a USB or network drive. SSD drives give the best performance, but note that the results database for a large model can be 100 GB or more. A rule of thumb is that 1 agent for 1 hour will take approximately 1 MB; therefore, a 2 hour simulation with a sustained population of 10 000 agents will result in a database approximately 20 GB in size.

Recovering a Project

The database file referenced by the simulation run contains not just the results of the simulation, but a copy of the project used as input to the simulation. The original project can be recovered by opening the mmdb database file as if it were a regular project file (*.mm) using the Open button in the main window's project ribbon.

3.4.3 Analysis

Each time a simulation is executed the results are recorded in a [simulation run](#). Tools are provided in MassMotion for playing back the simulation or extracting data from the run in the form of a query. Queries can be customized for a particular project, saved, and re-applied to additional runs.

Playback

The results from a simulation run can be reviewed through playback. It is possible to view agents from multiple simulation runs at the same time. For more information see [Playback](#).

Queries

Analysis queries take the form of [Graphs](#), [Tables](#), or [Maps](#). Graphs display information such as population counts or flow counts over time. Tables provide summary information about a particular population of agents. Maps represent spatial information such as density by painting colours directly onto the 3D scene objects.

Agent Filters

[Agent filters](#) allow for further customization of simulation run playback or queries by separating out specific sub-populations of agents. Agent filters can isolate agents that entered at a particular portal, or who are on a specified floor, or who have ever crossed a certain link. The filters can then be fed into maps, graphs, tables, or general playback to customize the query or playback output.

Reporting

Simulation run data can be exported to text files, images, or videos. For information see [Reporting](#).

3.4.3.1 Playback

A simulation can be reviewed in the scene view through the main window's [playback controls](#). The run will populate the view with agents as they were at the specified time in the recorded simulation.

Each simulation run in the project will play back a separate population of agents. When all simulation runs are shown, the different populations are presented over top of one another. This can be very useful when comparing populations from runs with slightly different setups. To choose a single simulation run for playback, use the source button at the top of the [3D scene view](#). Hidden simulation runs can still be used to drive queries but will not have any impact on the visual scene during playback.

Gate state is only displayed when a single simulation run is visible. If multiple simulation runs are showing, then gates will be drawn in white to indicate possible conflicting sources.

The colour of agents is taken from the colouring in the simulation. The colouring can be changed through the properties of the [simulation run](#) object. Agents can be set to a single colour in order to distinguish the populations of one run from the population of another, or the agents can be coloured by density. It is also possible to use an agent filter to colour a sub population.

The current time and count of agents shown in the scene can be displayed in the [3D scene view](#) by enabling the appropriate scene view overlay.

3.4.3.2 Reporting

Data can be exported from MassMotion in a number of different ways:

Graph and Table Data

When a table or graph query has been created and evaluated, the resulting data can be exported to a text CSV file using the 'File' button in the graph or table properties window.

Graph Images

When a graph query has been created and evaluated, the resulting data can be exported to an image file using the 'File' button in the graph properties window. Use the style options in the property window to control general graph formatting.

Scene Images and Videos

The [Movie and Image Export](#) window can be used to generate both snapshot images of the 3D scene view and videos of simulation playback. The export window is available from the 'Analysis' tab of the [Main Window](#) ribbon.

Agent Positions

The [Agent Position Export](#) window can be used to export agent positions to a CSV text file. The export window is available from the 'Analysis' tab of the [Main Window](#) ribbon.

Alembic

The [Alembic Export](#) window can be used to export agent playback information to alembic files. These files can be loaded into 3rd party applications like Softimage or 3ds Max to produce high quality renderings of the simulation.

3.5 Troubleshooting

A complex project will almost always encounter issues in setup or design. MassMotion provides a number of tools to help identify and resolve authoring related issues.

3.5.1 Auditing

Auditing an object will identify all properties that have non default values. This can sometimes uncover properties that were unintentionally modified or values that are incorrect. Audit results can be presented either by object or by property. Object auditing is available through an object's right-click menu. See the [Issue Window](#) for information on how to review any resulting issues.

3.5.2 Validation

Validation verifies general project integrity. Invalid property values in objects will be reported. Missing or incorrect references between objects will be flagged. All issues are collected and presented using the [Issue Window](#).

Full simulation validation is automatically executed when launching a new simulation. The project can also be manually validated using the Validate button in the Simulation & Analysis tab of the main window ribbon. Individual objects can be validated through the object's right-click menu.

Validation Types	
Quick Simulation	Examine all simulation objects and check properties for missing or incorrect values. This will also do simple tests to ensure basic route network connectivity.
Full Simulation	Perform a quick simulation validation, then construct the simulation network in full and report on any errors. This will also examine the relationship between objects and flag any circular or incorrect references.
Analysis	Examine all analysis objects and check properties for missing or incorrect values.
Entire Project	Same as a full simulation and analysis validation.
Object (right-click)	Perform a quick validation on the selection object(s), checking properties for missing or incorrect values.

3.5.3 Observing Agents or Objects

The observer windows display information about a particular agent or object for a given simulation run.

Observing Agents

The [Agent Observer](#) window can be used to interrogate the history of an agent from a particular simulation run. It displays lifetime information such as the starting portal, ending portal, creation event, route taken, and action history. It also displays some dynamic information such as speed, state, and density.

A focused observer window is available through the right-click menu on a playback agent. To open a generic agent observer window and enter the agent ID manually, use the 'View -> Window' menu or right-click and 'Observe' a simulation run object.

Observing Events

The [Event Observer](#) window can be used to determine when an event was active in a simulation. It will display the time at which an event became active and the type of activity it was engaged in.

3.5.4 Finding Object References

The 'Find' command in an object's right-click menu will search a project for objects that relate to the selected object(s). For example it is possible to find all members of a collection, or find all events that reference a particular gate, find the reference geometry used to generate a stair, or find all actions that use a particular token. This can be useful when determining why a gate is opening at an unexpected time or which events are creating agents at a given portal.

3.5.5 Debugging a Simulation

[Running a simulation](#) in debug mode provides more than just a graphical view of what is going on. It also gives access to many of the low level properties used by agents in their decision making. It can reveal why agents are being deleted or making unexpected decisions.

In the simulation launch dialog, specify a breakpoint time to have the debug simulation automatically pause when it reaches that time.

Object Properties

The right panel of the [Debug Simulation Window](#) shows the compiled properties of the selected object. See [Object Properties](#) for a detailed list of these properties. Agent properties are particularly useful when tracking down why an agent is being deleted or not behaving as expected. The task panel shows the list of tasks in the agent's to-do list, including the current active task. The action panel shows a history of all actions that have been applied to an agent and summarizes the results.

Agent Display Options

Enable specialized display options on a per agent basis to gain a better understanding of why an agent is behaving in a particular manner. The display options are available from the right-click menu for an agent in the debug scene view. 'Route Costing' will display perceived costs for the various route options the agent is considering. 'Neighbourhood' will indicate the neighbours that an agent is aware of. 'Surface Probe' will show the direction in which the agent believes it should move to reach its target. 'Social Forces' draws arrows representing the various forces acting on the agent. These options are described in detail in the [Simulation Scene View](#).

Obstacle Maps

Enable the display of an object's obstacle map to visualize the walkable space on a floor, link, stair, ramp, or escalator. Areas marked in red are unavailable to agents either because they are off the floor or covered by a nearby barrier. Sometimes barriers that don't look like they should be having an impact on an area will still cut a link in two or block access to a stair. Use an object's right-click menu to display the obstacle map.

Dumping Surface Maps

In the [project settings](#), enable the dumping of surface maps. When the simulation is compiled, all approach maps and obstacle maps will be written out as images to a debug folder in the simulation run results folder. Examine images for those objects that are involved in a problem and verify that goal lines appear as expected and that there aren't any unexpected barriers interfering with walkable space.

3.5.6 Using Analysis to Diagnose Issues

The [Analysis](#) system of queries and agent filters can be very useful for verifying the integrity of a project or tracking down the cause of any problems.

The [Origin/Destination](#) table is useful for quickly making sure the expected number of agents are entering and leaving at the expected places. The [Agent Path](#) map will trace the route taken by a set of agents. The [Agent Summary](#) table can indicate which agents failed to exit the simulation cleanly.

When diagnosing issues with agent route choice, the [Static Cost](#) map can help understand cost or distance gradients throughout the scene. Unintentional distance penalties on links, forgotten one way stairs, or accidentally virtual floors will all present as discontinuities in the map.

The 'Has end state' [Agent Filter](#) can be useful for isolating those agents that were deleted with errors, or that unexpectedly remained in the simulation after completion. Use the filter within a [Simulation Run](#) to only show those agents that have been deleted, or use in combination with an [Agent Path](#) to examine the path problem agents took through the scene.

The 'Selected agents' [Agent Filter](#) can also be useful for limiting a query to only the selected agents.

3.5.7 Auto Save

MassMotion will periodically save the current project to a temporary folder. These project files are automatically deleted when MassMotion exits. If MassMotion is still running or stops unexpectedly due to a crash, the project files remain in the folder and can be opened like any other project. Auto save can be disabled or configured through the [application preferences](#).

On Microsoft Windows the default location of the auto save folder is:

C:\Users\<%USER%>\AppData\Local\Temp\Oasys\MassMotion

Part IV

4 Reference

The reference section provides details about the individual components of MassMotion. It is intended to work in concert with the [User Guide](#). The core of the reference section is the [Objects](#) subsection, which contains detailed descriptions of the various properties of both objects that are part of the simulation (such as floors and schedules) and analyses that are used to query the results of the simulation.

4.1 Project

4.1.1 Project Settings

The project settings includes critical information such as the timing of simulation runs and location of results. The project settings are available from the project tab of the main window's ribbon.

General tab	
Runtime: Start Time	Sets the starting time of the simulation. Values are in hh:mm:ss. See Working with Time .
Runtime: Duration	Sets the duration of the simulation. Values are in hh:mm:ss. See Working with Time .
Simulation: Random Seed	Sets the seed of the project. The project seed governs several project variables, such as the distribution of agent speeds and where and when agents are created. See Randomness .
Simulation: Population Multiplier	Modifies the global population by a set factor. This scales the number of agents produced by all events . This can be a fractional value of less than one or greater than one.
Results Working Folder	Sets the folder where the default simulation run and analysis outputs will be sent.

Custom Views tab	
Main window	This window shows the list of all custom views. Custom views are created from the 3D scene view .
Show	Shows the selected custom view in the main viewport.
Rename	Renames the selected custom view.
Delete	Deletes the selected custom view.

Debug files such as surface map images or route cost spreadsheets are placed in a 'debug' folder alongside the simulation run's results database file.

Debug tab	
Simulation	Enables creation of debug surface maps for every object in the scene.

Debug tab	
Diagnostic Files: Surface Maps	
Simulation Diagnostic Files: Route Costs	Enables creation of route cost spreadsheets for every portal in the scene.

4.1.2 Merging Projects

MassMotion includes functionality for merging data from another project file into the currently open project, through the File -> Merge menu entry. This will attempt to take all [Objects](#) and the [Project Settings](#) from the file and import them into the current project. A dialog window will be shown to indicate what data will be merged and allow for the resolution of any conflicts.

Objects

- Any objects that exist in the file but not in the current project will be added to the current project as a new object. If file objects happen to have the same name as objects in the current project, the file objects will be renamed by adding a numerical suffix.
- If the same object exists in both the file and current project, and both versions are equal (same name, geometry and properties), the file object is ignored.
- If the same object exists in both the file and current project, and the versions are different, then there is a conflict with that object, and the user must resolve the conflict manually.

Project Settings

If the project settings from the imported project are different in any way from the current project, they will be marked as in conflict and must be resolved.

Resolving Conflicts

There are three options for dealing with object or settings conflicts:

- **Use existing** will use the version from the current project and ignore the file.
- **Use imported** will use the version from the file, overwriting the current project.
- **Advanced** allows the user to choose between 'Use existing' and 'Use imported' for settings and conflicted objects on an individual basis.

4.1.3 Importing and Exporting Objects

Objects can be imported and exported using the File menu or buttons in the 'Project' tab of the main window's ribbon, and can also be exported while [editing object properties](#). Exported objects include both geometry and properties. References between objects are maintained provided all referenced objects are either included in the export, or are already present in the destination project (for instance, when exporting/importing between different versions of the same project).

When an imported .mmxml file contains objects with the same name as existing objects, the newly imported objects will be renamed by adding a numerical suffix. In some situations, importing objects will lead to a conflict with objects currently in the project. In this case the [Merging Projects](#) window will be used to resolve the conflicts.

4.1.4 Files

MassMotion Files

File Type	Description
-----------	-------------

.mm	The standard MassMotion project file. Contains all objects and the project settings .
.mddb	<p>The results of a MassMotion simulation.</p> <p>A simulation run is used to access a mddb file from within the project. A simulation also produces several other files as listed in Generated Simulation Files.</p> <p>The file can be queried as an sqlite database for information about agents or used to recover a project by opening it as if it were a mm project file. See Simulation Data for more information.</p>
.mmxml	Exported MassMotion objects. See Importing and Exporting Objects for more information.
.mmxsi	A project exported from the Softimage workbench using MassMotion 7.

Import Files

MassMotion can import geometry from a variety of sources as [Reference Geometry](#), which can be used to create other [scene objects](#). See [Importing Geometry](#) for more information.

Export Files

MassMotion's [analysis tools](#) can export data for further processing. All [tables](#) and [graphs](#) can export their datasets to a .csv file, and graphs can additionally be exported as an image. [Agent Position Export](#) can be used to output the position of agents from a simulation run to a .csv file. [Movie and Image Export](#) can be used to produce images and movies in various formats. [Alembic Export](#) can be used to export animated agent models for use in animation/visualization packages.

4.1.5 Upgrading Older Projects

Projects saved using an older version of MassMotion will automatically be upgraded to version 9 when opened. No user intervention is required. Projects saved in version 9 cannot be opened in an older version of MassMotion.

Simulation Results

Database files are not compatible between versions. Older simulation runs cannot be used for playback or analysis and will have to be rerun using version 9.0.

Converting Workbench Object(s)

Some objects created in the MassMotion 7 Softimage workbench cannot be authored in MassMotion 9. These objects will import into a version 9 project and can be used to execute a simulation, but cannot be modified. To change the behaviour of these objects they must be converted into comparable MassMotion 9 objects. Some information may be lost in the conversion. To convert an object right click on it in the main window list view and select "Convert Workbench Object(s)" or use the button in the workbench object's properties window.

Workbench Object	MassMotion Object	Notes
Workbench Schedule	Journey	<p>Start time, demand curve, population count, profile, actions, origins, destinations are all converted with no loss.</p> <p>Agent colours are specified using a rule generated from the origin/destination avatar assignment from the workbench</p>

Workbench Object	MassMotion Object	Notes
		<p>schedule.</p> <p>Avatar assignment is lost during conversion and all agents use the same avatar from the specified profile.</p>
Workbench Evacuation	Execute Action	An inline action is created to mimic exactly the behaviour of the workbench evacuation event. Agents are given a wait task, a seek best portal task, and then an exit simulation task. No information is lost in the conversion.

MassMotion 7

- Goal line tolerances were tightened. Some links, stairs, ramps, escalators, or portals that validated in version 6 may have to be adjusted in version 7.
- Unique names enforced. In version 6 it was possible to have objects of different types with the same name. As of version 7 all objects must have a unique name regardless of type.

MassMotion 8

- Validation errors must now be resolved before a simulation can execute.
- Old style process chains with connected server port groups will automatically be converted to the new dispatch process chain style.

MassMotion 9

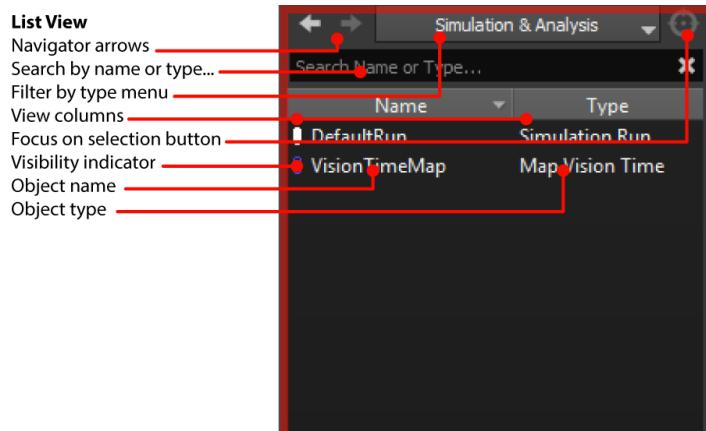
- The 'effective width' property has been removed from [Connection Objects](#). This property only affected agent perception of queue costs and was seldom used.

4.2 User Interface

4.2.1 Main Window

4.2.1.1 List View

The list view presents the name and type of all objects in the project. The list can be filtered to display only objects meeting certain criteria.



The list view has built in filters accessible through the "Filter by type menu". Alternatively, right clicking on objects in the list view or scene view and using a "Find" command will create a custom

filter presenting only the found objects.

UI Element	Description
Navigator Arrows	Go backwards and forwards through the history of displayed objects.
Search by name or type...	Search objects by name or type. Objects will only be shown if either the object's name or its type contains the given text.
Filter by type menu	Filters the list by objects of a certain type. Categories of objects can be used, such as all collections or all analysis objects .
View columns	The column headers can be used to sort objects by name or type.
Focus on selection button	Filters the list to display all currently selected objects.
Visibility Indicator	Each object has an indicator which shows its colour and visibility. Hidden objects will have only an outline as an indicator. Disabled objects will have a small grey dot.
Object Name	Each object's name. The name can be edited by selecting one or more objects and pressing the 'F2' key.
Object Type	Each object's type.

4.2.1.2 3D Scene View

The 3D scene view shows the spatial arrangement of all [scene objects](#). Decorators display the status of various objects.

Right clicking on objects in the scene view produces a menu which allows users to manipulate the scene. Additional controls can be found in [Keyboard and Mouse Controls](#).



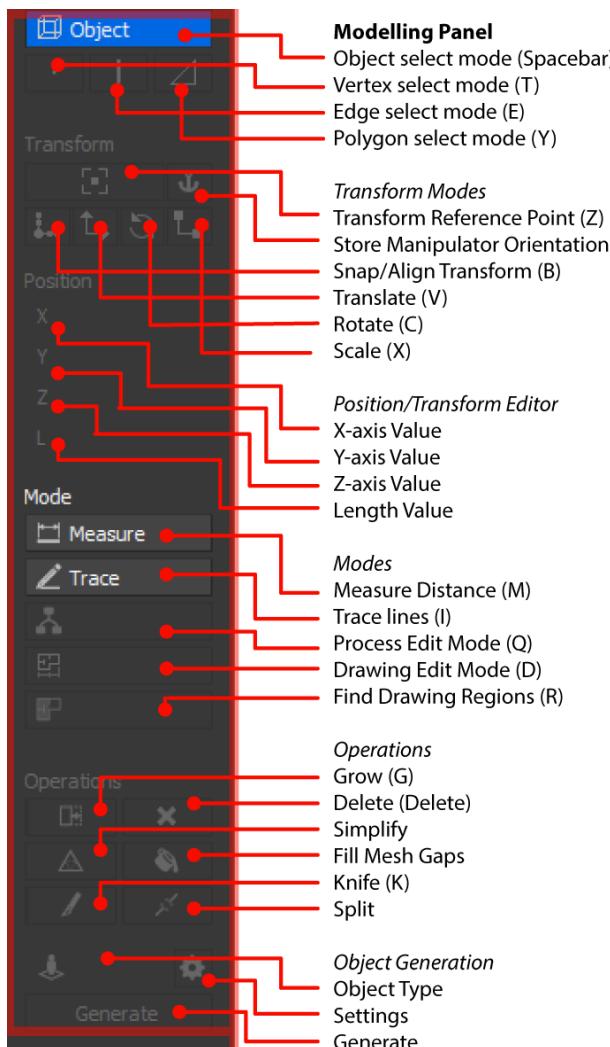
UI Elements	
Focus on selection	Centre and zoom in on the currently selected object(s).
View selection & management	<p>Change the camera between perspective and various orthographic views. Custom views can be saved and applied in this menu as well.</p> <p>Perspective: The default perspective view. Side/Top: Orthogonal views. Camera can be panned and rotated horizontally. Front/Back/Left/Right: Orthogonal views. Camera can be panned but not rotated.</p> <p>The following views can be activated by right clicking an agent and selecting an agent camera:</p> <p>First Person: See from the perspective of an agent. Following: Camera follows and turns with an agent. Track: Camera follows an agent.</p> <p>Custom: User saved views can be saved and loaded. Custom views can be renamed and deleted in the project settings.</p>
Visibility options	<p>Change the appearance of objects in the scene view. These settings are very useful when setting up the scene to export a movie or image.</p> <p>Render Type: Switch between Shaded and Wireframe representations.</p> <p>Agents: Change the appearance of agents. See below for a description of agent appearance options.</p> <p>Decoration: Toggle the visibility of all decorations of a given type in the scene view. Decorations can be turned on or off for specific objects by right clicking on</p>

	<p>an object and using the 'Display' menu.</p> <p>Overlay: Toggle the appearance of overlays which display information such as the current simulation time and visible population. It can also be used to hide the reference axes which appear at the top right, and the legend which can be displayed when maps are shown in the scene.</p> <p>Show Geometry Edges: Toggle the drawing of edges on unselected objects. Only affects shaded rendering.</p> <p>Show Selection Highlights: Toggle the highlighting of selected objects. The highlighting shows the outlines of selected objects even when occluded by others.</p> <p>Show Drawing Layer Titles: Toggle the display of drawing layer titles.</p> <p>Hide Agents On Hidden Floors: Agents on hidden floors and other geometry will not be shown.</p>
Simulation run	Change the data source driving playback within the view (see Simulation Run).
3D scene view	A graphical representation of all visible scene objects. See Keyboard and Mouse Controls for information on moving the camera.
Expand/ collapse view	Expand and collapse scene views. By default, only one scene view is displayed, but three are available. If only one view is visible, clicking this button will shrink that view so all three are shown. If all three views are visible, clicking any one of them will expand it to be the only one shown.

Agent Appearance	
Animated	The default animated avatar with articulated arms and legs.
Debug	A low resolution simple peg. The size of the peg will change with the radius of the agent.
Show Custom	<p>For a project containing advanced features, agents can be assigned custom geometry.</p> <p>This option enables the display of agents using that geometry. If the project does not contain custom agent geometry, the animated or debug agents are used.</p>

4.2.1.3 Tool Panel

The tool panel provides tools for manipulating scene objects. Many of these tools can be accessed using [keyboard and mouse controls](#).



Selection Mode	
Object select	Cancel any interaction modes and return to object selection mode. See Selecting Object Components .
Vertex select	Allow the selection of vertices for any selected mesh or line object. See Selecting Object Components .
Edge select	Allow the selection of edges for any selected mesh or line object. See Selecting Object Components .
Polygon/ Face select	Allow the selection of faces for any selected mesh object. See Selecting Object Components .

Position/ Transform	
Transform Manipulator	Move the manipulator independent of the selection, changing the location or orientation of snap, translate, rotate, or scale. See Changing the Reference Frame .
Store Manipulator Orientation	Store a custom manipulator orientation as the new default. See Storing the Manipulator Orientation .
Snap	Enable snapping selected object/components. See Transforming Objects .
Translate	Enable translation of selected objects/components. See Transforming Objects .
Rotate	Enable rotation of selected objects/components. See Transforming Objects .
Scale	Enable scaling of selected objects/components. See Transforming Objects .
X/Y/Z/L Values	Allows for direct editing of the position or length of selected objects or components. When using the manipulator these can be used to precisely manipulate selected objects/components. See Transforming Objects .

Modes	
Measure	Measure the distance between two points. Additional measurement points can be added by holding the shift key. The total distance is displayed in the Distance section of the Main Status Bar .
Trace	Trace over existing objects or drawings and use the lines/regions to generate new objects. See Tracing New Objects .
Edit Process	Edit the connections between servers. See Process Chains .
Edit Drawings	Edit the lines and points inside a drawing. See Working with Drawings .
Find Regions	Find enclosed regions inside selected drawings and use them to generate new objects. See Generating From Drawings .

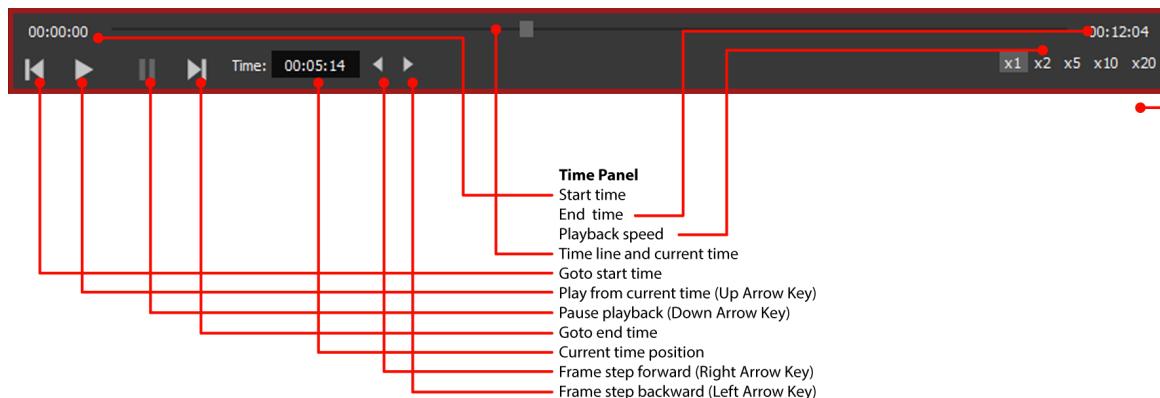
Operations	
Grow	Extrude a selected edge or face. See Extrude (Grow) .
Delete	Delete selected objects or components.
Simplify	Merge edges and faces to reduce geometric complexity without changing the object shape. See Editing Geometry .
Fill Mesh Gaps	Add faces to close any holes or gaps in a mesh. See Fill .

Knife	Cut selected objects along a cutting plane. See Slice .
Split	Subdivide a selected edge or face. See Editing Geometry .

Object Generation	
Target Type	Change the type of object generated. See Creation Widget .
Options	A toggle button which displays the ' Generate Options ' window for editing operations used when generating objects. See Creation Widget .
Generate	Generate a new object of the target type using the current selection (hotkey 'N'). See Creation Widget .

4.2.1.4 Time Panel

The time panel displays the current time and can be used to [play back](#) simulations in the [scene view](#).

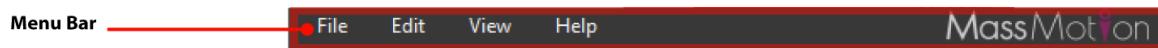


UI Element	Description
Start Time	The simulation's start time. See Project Settings for more information. If multiple simulation runs have different start times, the earliest one is used.
End Time	The simulation's end time. See Project Settings for more information. If multiple simulation runs have different end times, the latest one is used.
Playback Speed	How quickly playback runs. 1x is "real time" and higher values effectively "fast forward" through playback.
Timeline and current time	A slider which indicates playback progress. The slider can be repositioned to change the current time.
Go to start time	Sets the current time to the start time.
Play from	Plays back simulations from the current time. MassMotion simulations are

current time (Up arrow)	calculated and recorded in 0.2second increments. When playback is active the animation system will use linear frame interpolation to provide the smoothest possible representation of the currently selected playback speed in the 3D views.
Pause playback (Down arrow)	Pause playback.
Go to end time	Sets the current time to the end time.
Current time position	Displays the current time. Can be edited to skip to a specific moment.
Frame step forward	Advance the current time by 1 simulation frame (no frame interpolation is applied)
Frame step backward	Move the current time back 1 simulation frame (no frame interpolation is applied)

4.2.1.5 Main Menu Bar

The MassMotion Application Menu is available from the menubar at the top of the MassMotion window.



File	
New	Create a new empty project.
Open	Open either a previously saved MassMotion project file (.mm), a project exported from the Softimage workbench (.mmxsi), or a project contained in a MassMotion results database (.mddb).
Open Recent	Open a project from a list of recently used project files.
Save	Save the project as a .mm project file. Note that this will save as a new file if the project was initially opened from a Softimage export (.mmxsi).
Save As	Save the project as an alternative .mm project file with a new name.
Close	Stop all running simulations and close the current project.
Merge	Merges the open MassMotion project with data from another MassMotion project file (.mm), a project exported from the Softimage workbench (.mmxsi), or with project data contained in a MassMotion results database (.mddb). See Merging Projects for more information.
Import	Import either: <ul style="list-style-type: none"> • Objects exported from other projects (.mmxml) (see Importing and Exporting Objects). • Analysis objects from MassMotion 6.0 or 6.1 projects (Analysis.xml) (see Importing and Exporting Objects).

	<ul style="list-style-type: none"> • Avatar geometry • Reference geometry exported from other CAD/geometric authoring applications.
Export	<p>Export:</p> <ul style="list-style-type: none"> • Objects for import into other MassMotion projects (.mmxml) (see Importing and Exporting Objects). • Geometry to neutral file formats such as Collada (.dae) for import into other CAD/geometric authoring applications • Agent positions data in a simple text file (see Agent Position Export). • Alembic animation data for rendering agent movement in applications like Softimage or 3ds Max (see Alembic Export). • A movie or image generated from the current project (see Image and Movie Export).
View Auto Saves	Open an explorer window showing the location in which projects are automatically saved.
Exit	Stop all running simulations and quit the application.

Edit	
Undo	Undoes the previous command. Can be stepped back multiple times.
Redo	Steps forward if the Undo command is used. Can be used multiple times.
Select All	Select all objects in the project.
Select Inverse	Select all objects other than those in the current selection.
Deselect All	Deselect all objects currently selected.
Project Settings	Edit the Project Settings .
Application Preferences	Edit the application preferences .

View	
List View	Toggle display of left-hand side list view showing list of all existing object(s) in the project.
Scene View	Toggle display of all 3D scene views .
Time View	Toggle display of bottom pane time panel with playback controls (See Playback).
Context View	Toggle display of right-hand side pane with contextual tools for operating on currently selected objects; see tool panel for details.
Other Windows	Toggle the display of additional windows:

	Console: Show a console window with MassMotion diagnostic output. Issues: Show the Issue Window with the most recent list of warnings, errors, or audit information; see Validation for details Observe Agents: Display information about a particular agent from a particular run (see Agent Observer).
Close All Windows	Closes any pop-up properties or analysis windows.
Show All	Unhide all objects.
Show Selected	Unhide all selected objects.
Hide Selected	Hide all selected objects.
Hide All But Selected	Hide all objects that are not part of the current selection (leaving only selected objects visible).
Hide Maps On Selected	If any of the selected surface objects have been covered by an analysis map texture, the map texture is removed (does not apply to textured reference geometry)
Hide Maps On All	Remove all analysis map textures from all surface objects in the scene (does not apply to textured reference geometry)

Help	
Show Help...	Display the MassMotion user guide.
Keyboard Controls...	Display the user guide page describing keyboard shortcuts and controls.
Licensing...	Open the license manager.
Check for Updates	Check for more recent releases of MassMotion.
Graphics Driver Diagnostics	Displays the current OpenGL version as well as any issues detected; MassMotion requires OpenGL version 3.0 or higher for full functionality. If you are having problems with graphics not being displayed properly, or crashes when attempting to open or create a project, please include this diagnostic information in any support request.
About MassMotion...	Display information on the current version of MassMotion.

4.2.1.6 Main Status Bar

The main window status bar is at the bottom of the main window.



Main Status Bar

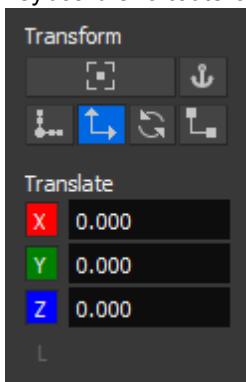
Selection	Displays the name of the object currently selected. If more than one object is selected the number of objects selected is displayed. If object components are selected, the number of components is displayed.
Distance	Displays the length of the edge currently selected, along with the component horizontal and vertical lengths. If more than one edge is selected, the total length of all edges is displayed. If two vertices are selected, the distance between the vertices is displayed. If the measure tool is active, the total distance measured is displayed. If two straight lines from Drawing Layers are selected, it shows the angle between them if they were connected end to end. In all cases the number is in metres or degrees.
Mode	The current selection mode: object, face, edge, vertex.
Population	The total of all agents from all connected simulation runs that are alive at the current time. This counts includes hidden agents, ignoring the simulation run filter and visibility state of the simulation run.
Issue Window	Show the issue window including the most recent list of issues or audits.
Console Window	Show the console window.

4.2.2 Manipulator

The manipulator is a tool used to transform objects or object components (vertex, edge, face, drawing). The manipulator has 4 modes for [transforming objects](#): **Object Translate**, **Object Rotate**, **Object Scale** and **Object Snap**. There are additionally two sub-modes: one for [changing the reference frame](#) of the manipulator and another for [growing objects](#)

Each mode will generally allow the user to independently transform in each of the X, Y and Z axes. These axes are coloured red green and blue respectively.

The manipulator will appear in the scene at the centroid of the current selection when accessed via keyboard shortcuts or via the Transform section of the [tool panel](#):



The top four buttons can be used to open the manipulator in a given mode or to close it if that mode is already active.

The X, Y, and Z buttons can be pressed to disable an axis and prevent it from changing. The three entries beside them can be used to enter precise values for a transformation (ie.

Translating along Z by exactly 4m).

The bottom left button enables the manipulator snap sub-mode.

The bottom right button toggles saving the axis alignment (see below: Saving the Axis Alignment).

See [Editing Geometry](#) for examples of use.

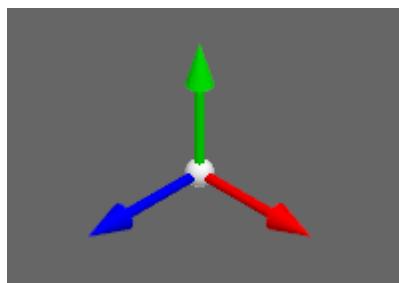
Keyboard Shortcut Summary

Shortcut	
V	Object translate
C	Object rotate
X	Object scale
B	Object snap
G	Start component grow sub-mode
Z	Start manipulator snap sub-mode
1	Enable/disable X axis
2	Enable/disable Y axis
3	Enable/disable Z axis
Shift	Rotate: Constrain the rotation to 15 degree increments Snap: Reverse the axis alignment direction

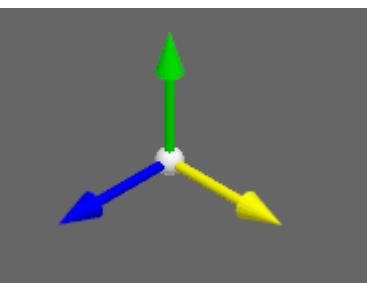
4.2.2.1 Transforming Objects

Object Translate (Shortcut: V)

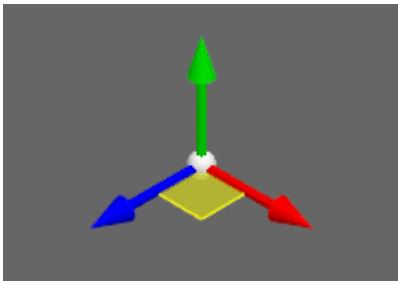
This mode is used to move the current selection along an axis or a plane. The axes can be adjusted via [manipulator snap](#) for off-axis translations.



Object translate mode



Translating along the X axis



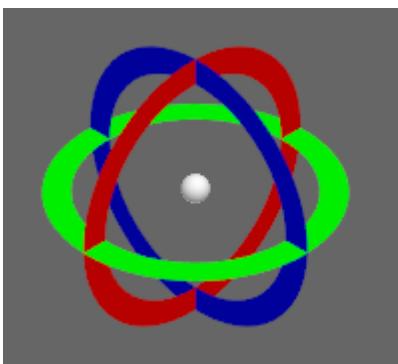
Translating on the XZ plane

Element	Control
Axis sticks	Click and drag along the axis to translate in that direction.
Between two axis sticks	Click and drag on the axes' common plane to translate.

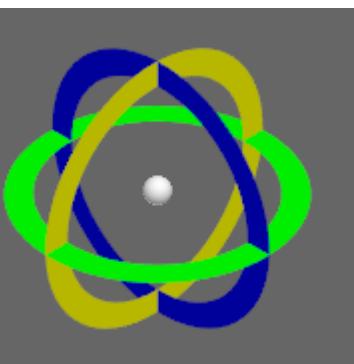
Object Rotate (Shortcut: C)

This mode is used to rotate the current selection about the manipulator centre. The centre of rotation can be adjusted via [manipulator snap](#). The axes can also be adjusted for off axis rotations.

Holding shift will constrain the rotation to 15 degree increments.



Object rotate mode

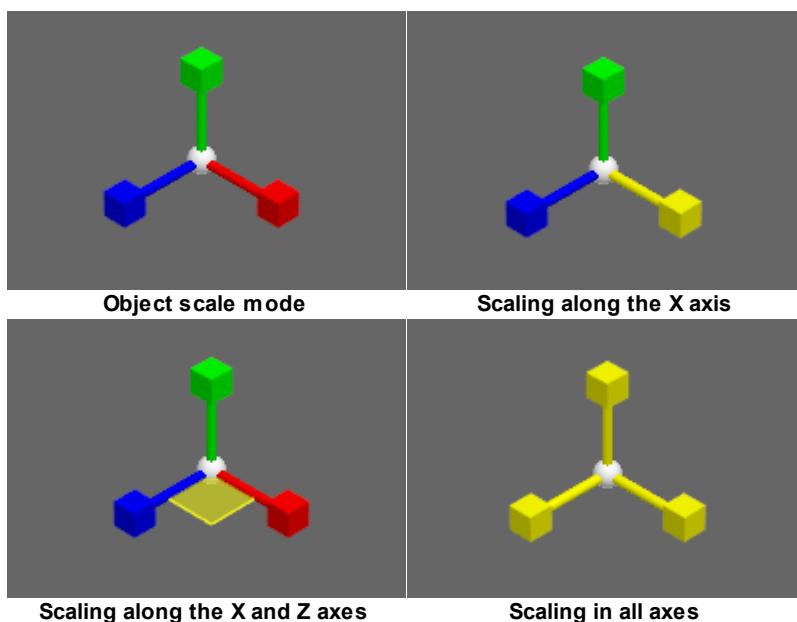


Rotating about the X axis

Control	Function
Ring	Click and drag around the centre to rotate.

Object Scale (Shortcut: X)

This mode is used to scale the current selection about the manipulator centre. This can be used to both stretch and shrink an object/component. The axes can be adjusted via [manipulator snap](#) for off-axis scaling.

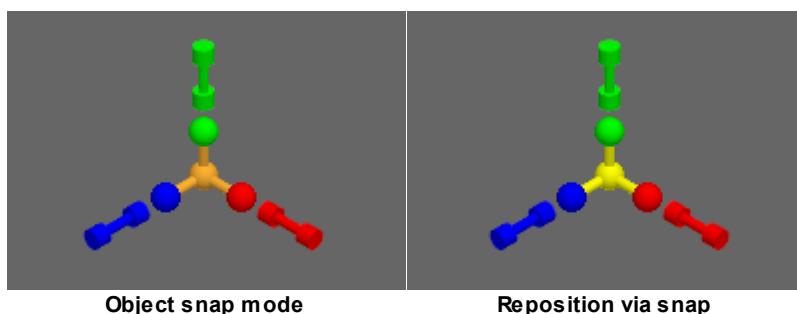


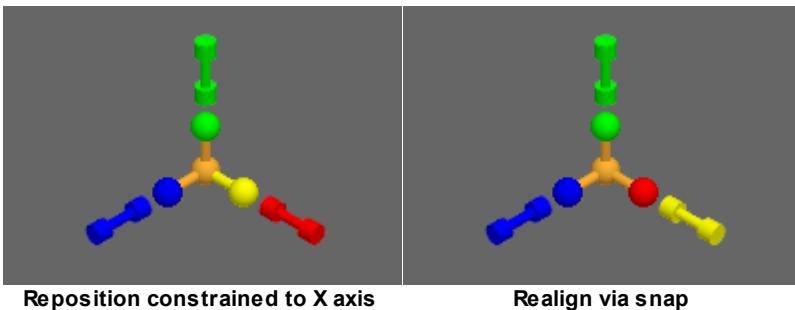
Control	Function
Axis sticks	Click and drag along the axis to scale in that direction.
Between two axis sticks	Click and drag towards/away from the manipulator centre to scale equally in both axes.
Elsewhere	Click and drag towards/away from the manipulator centre to scale equally in all axes.

Object Snap (Shortcut: B)

This mode is used to reposition or realign the current selection with respect to other objects and components. Unlike the other modes, this mode has two clickable elements per axis as well as a clickable orange centre ball. It is often practical to reposition the manipulator with [manipulator snap](#) before any operations.

When snapping components, a silhouette will appear showing the original geometry. Snapping to the silhouette will return the manipulator to its starting position, providing a convenient way to cancel the operation.





Control	Function
Orange centre ball	<p>Click and drag to another element in the scene. This will move the manipulator centre and all selected objects/components.</p> <p>Valid targets are:</p> <ul style="list-style-type: none"> • Another object's vertex, edge, face component • Another object's drawing or shape component (see: Drawings) • The midpoint of an edge or drawing line shape <p>When snapping components to each other, components of selected objects are also valid targets. However, only components which will not change as a result of the operation can be targeted.</p> <p>For example, when snapping the corner of a floor, the adjacent edges and face are not valid snap targets:</p> <p>The snapped move can be constrained by disabling various axes. For example, disabling Y will disable motion in the Y direction. This can be used to reposition objects at different elevations.</p>
Axis coloured balls	<p>Click and drag to another element in the scene. This will move the manipulator centre and all selected objects/components. The motion will be constrained to the selected axis. For example, dragging the green Y ball will only change the elevation of the selection. A coloured guide line will be drawn to indicate the axis constraint.</p> <p>Valid targets are:</p> <ul style="list-style-type: none"> • Another object's vertex, edge, face component • Another object's drawing or shape component (see: Drawings) • The midpoint of an edge or drawing line shape
Barbells	Click and drag to an edge or drawing line. This will rotate the manipulator so that the selected axis is aligned to the edge/line with all the selected objects following

Control	Function
	<p>its motion. The axis can be aligned to an edge in either direction. Hold shift to reverse the alignment to the other direction.</p> <p>Valid targets are:</p> <ul style="list-style-type: none"> • Another object's edge • Another object's drawing or shape component (see: Drawings) <p>This will likely lead to the manipulator not being aligned to the global axes. This can be reset by closing and reopening the manipulator. Alternatively, the new alignment can be preserved (see Saving Reference Frame).</p>

4.2.2.2 Changing the Reference Frame

Manipulator snap can be used to change the centre of rotation or scaling, to work in an off-axis model, or to align two different objects and bring them flush with each other.

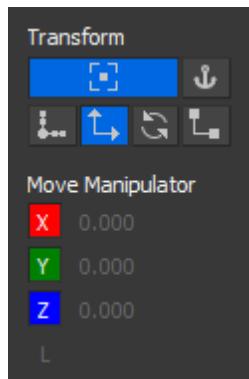
Changes made to the local reference frame persist for as long as the manipulator remains open. Once the manipulator is closed its position and orientation are reset to their default. See [Storing the Manipulator Orientation](#) for information on how to change the default orientation of the manipulator.

See [Tips and Tricks](#) for additional use cases for manipulator snap.

Manipulator Snap (Shortcut: Z)

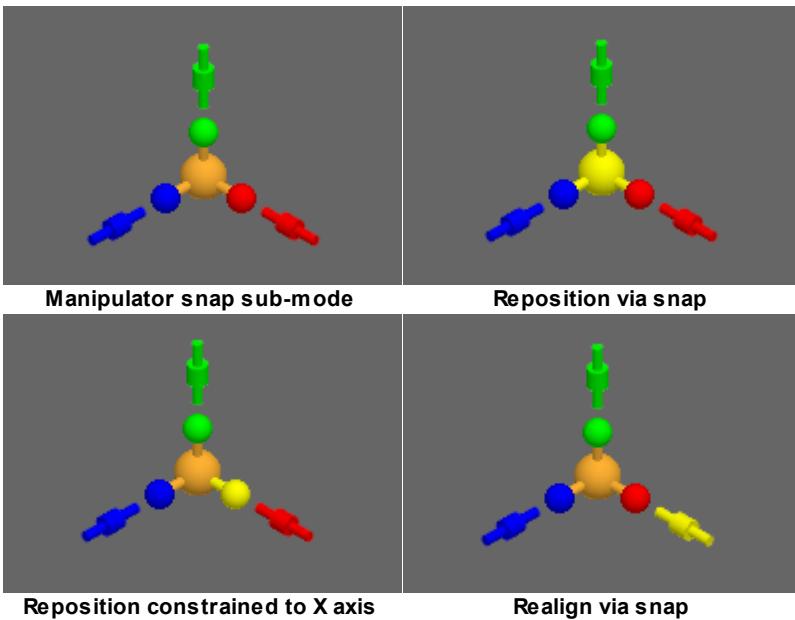
The manipulator snap sub-mode allows users to reposition and realign the manipulator without modifying any of the selected geometry. Its controls are almost identical to the object snap with a clickable centre orange ball and two clickable elements per axis.

Manipulator snap can be toggled on/off by pressing the 'Z' key in any manipulator mode. Pressing 'Z' without a manipulator will open an object snap manipulator in the manipulator snap sub-mode.



Transform section of the Model Panel indicating translate with manipulator snap sub-mode

See: [Geometry Manipulation](#) or [Tips and Tricks](#) for examples of use.

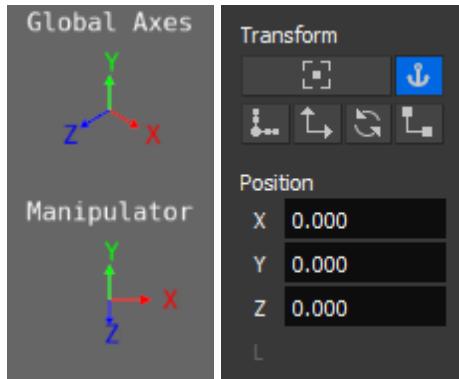


Control	Function
Orange centre ball	<p>Click and drag to another element in the scene. This will move the manipulator centre there.</p> <p>Unlike Object Snap, components of selected objects can be targeted. Valid targets are:</p> <ul style="list-style-type: none"> • Any object's vertex, edge, face component • Any object's drawing or shape component (see: Drawings) • The midpoint of an edge or drawing line shape <p>The snapped move can be constrained by disabling various axes. For example, disabling Y will disable motion in the Y direction.</p>
Axis coloured balls	<p>Click and drag to another element in the scene. This will move the manipulator centre there while constraining the motion to the selected axis. For example, dragging the green Y ball will only change the elevation of the selection. A coloured guide line will be drawn to indicate the axis constraint.</p> <p>Valid targets are:</p> <ul style="list-style-type: none"> • Any object's vertex, edge, face component • Any object's drawing or shape component (see: Drawings) • The midpoint of an edge or drawing line shape
Rolling pins	<p>Click and drag to an edge or drawing line. This will rotate the manipulator so that the selected axis is aligned to the edge/line. The axis can be aligned to an edge in either direction. Hold shift to reverse the alignment to the other direction.</p> <p>Valid targets are:</p> <ul style="list-style-type: none"> • Another object's edge • Another object's drawing or shape component (see: Drawings) <p>This will likely lead to the manipulator not being aligned to the global axes. This can be reset by closing and reopening the manipulator. Alternatively, the new</p>

alignment can be preserved (see [Saving Reference Frame](#)).

4.2.2.3 Storing the Manipulator Orientation

Storing the manipulator orientation is useful when working with several off-axis objects which share the same alignment. Toggling the "Store Manipulator Orientation" button in the [Tool Panel](#) on will store the current orientation. Whenever the manipulator is closed and reopened, the stored orientation is used instead of the global axes.



The scene will show the stored axes as well as the global axes.

The anchor button is toggled on, indicating a new orientation has been stored.

Resetting the reference frame to the default frame aligned with the coordinate axes can be done by toggling the "Store Manipulator Orientation" button off.

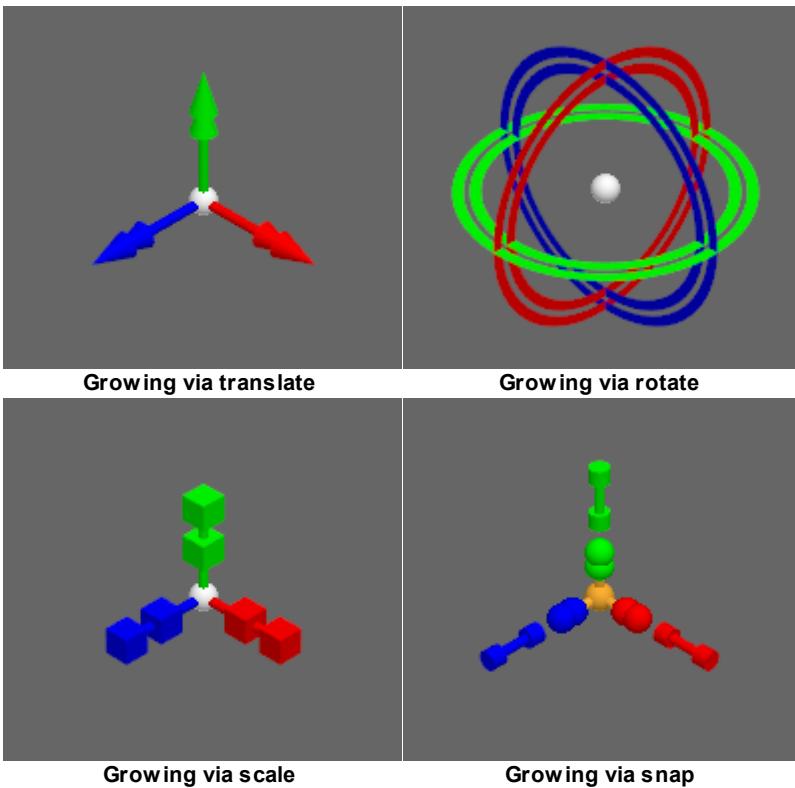
4.2.2.4 Growing Objects

Component Grow (Shortcut: G)

When editing components, starting a grow will not change the selected components, but instead create an extrusion and modify the new components. The grow sub-mode can be easily identified by the doubling of particular manipulator elements.

Grow can be toggled on/off by pressing the 'G' key in any manipulator mode. Pressing 'G' without a manipulator will open an object translate manipulator in the grow sub-mode.

See: [Geometry Manipulation](#) or [Tips and Tricks](#) for examples of use.

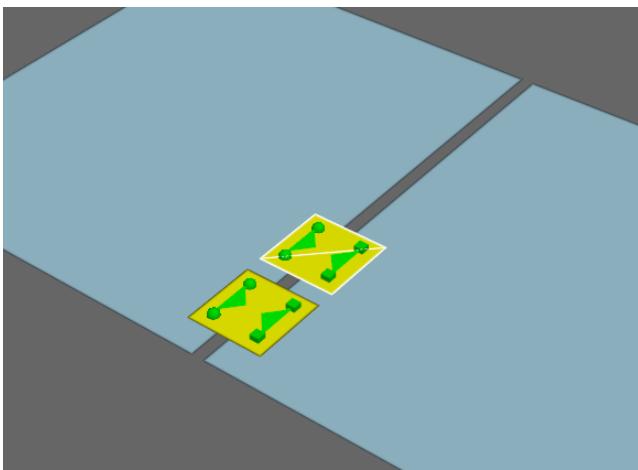


4.2.2.5 Tips and Tricks

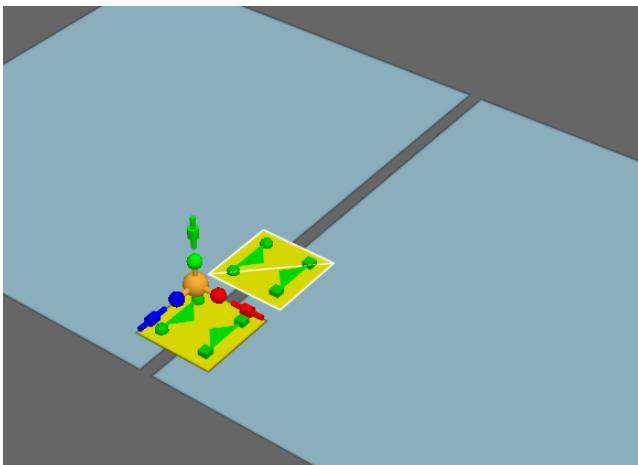
See [Geometry Manipulation](#) for simple uses of object and manipulator snap such as aligning off-axis geometry.

Evenly spaced links

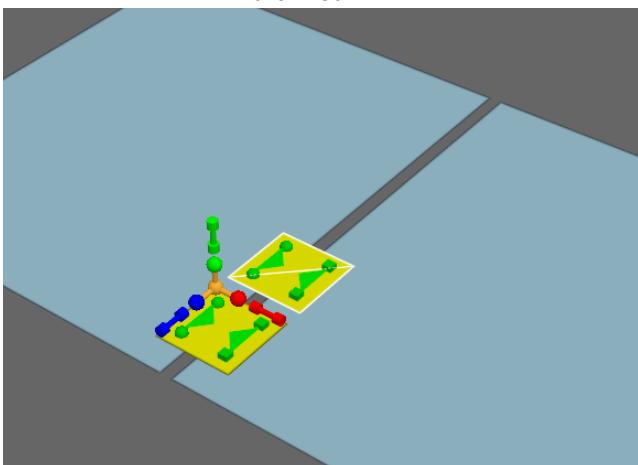
Duplicating an object (Ctrl-D) while the manipulator is open will preserve the current position of the manipulator while selected the new objects. This can be combined with object snap to create evenly spaced links:



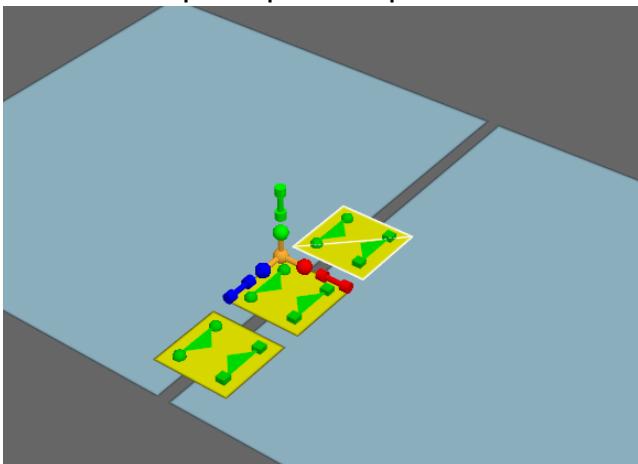
1) Two links with the desired spacing. Select the "second" link in the row



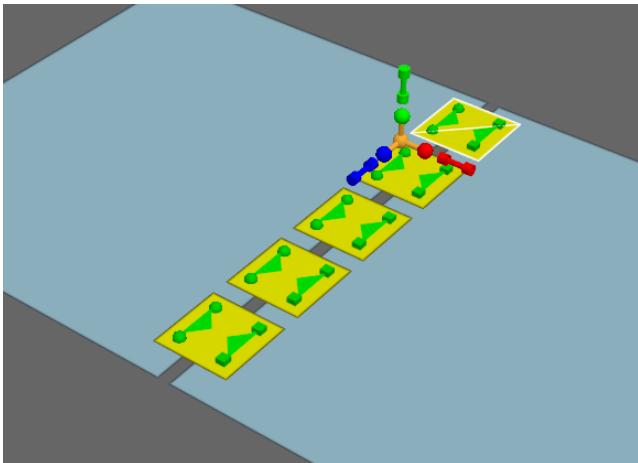
2) Using manipulator snap, position the manipulator on the first link



3) Duplicate the link and switch to object snap. The manipulator position is preserved.



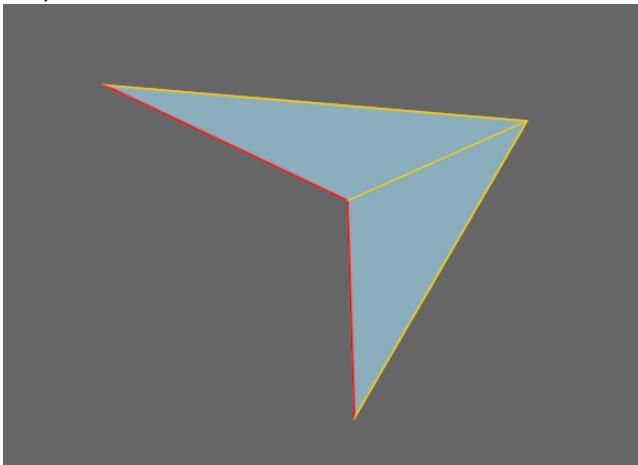
4) Snap to the same position on the second link. This ensures even spacing.



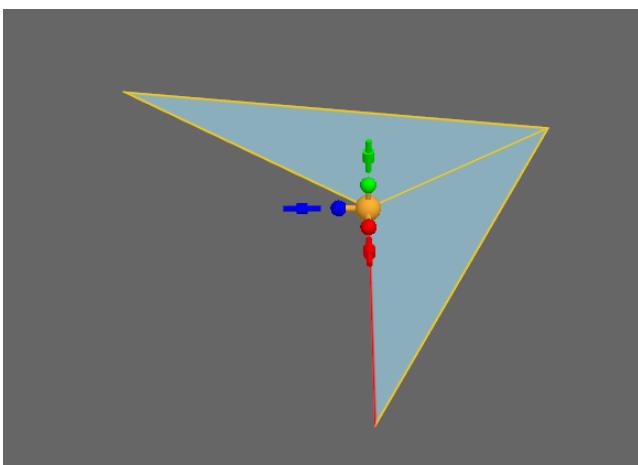
5) Repeat this process as many times as required.

Straightening an edge

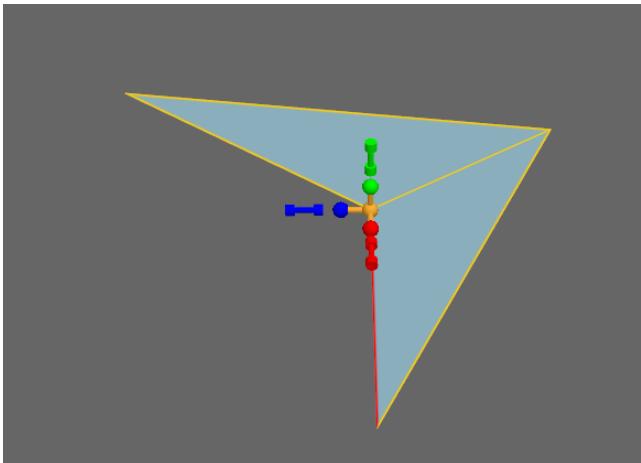
Straightening the edges of a floor (perhaps to simplify geometry) can be done with component level snaps:



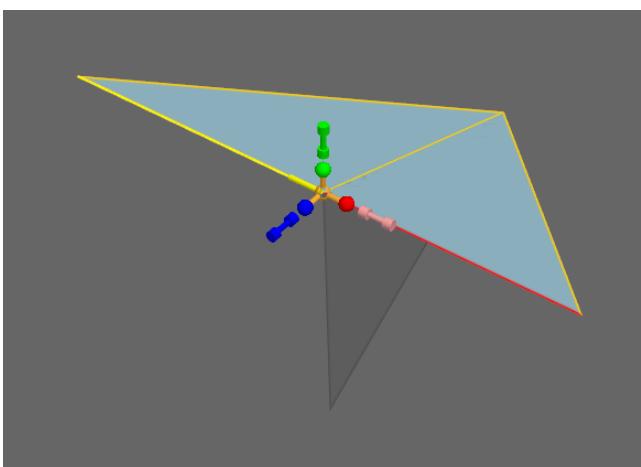
1) Aligning these two edges.



2) Select one edge and use manipulator snap to reposition and realign the manipulator.



3) Switch to object snap.

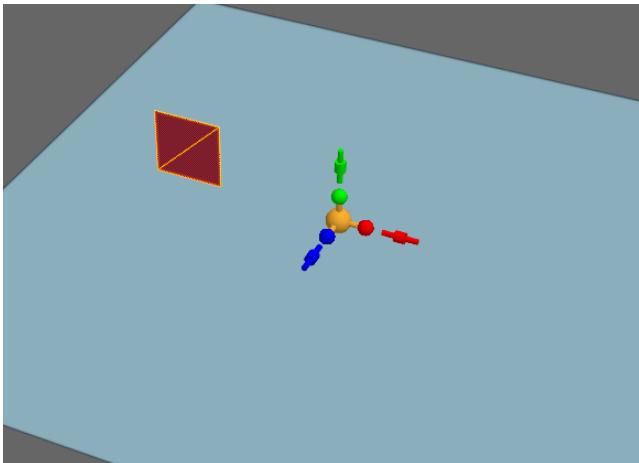


4) Align the edge to the other edge. You may need to hold shift to toggle the align direction.

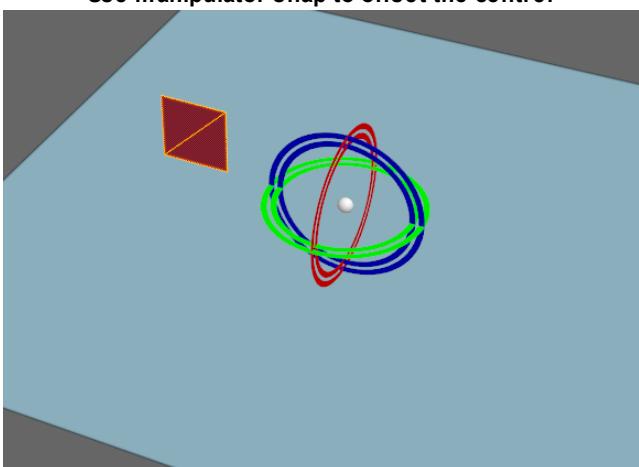
Note: The shadow is the silhouette of the pre-snap geometry.

Scale/Rotate Grow

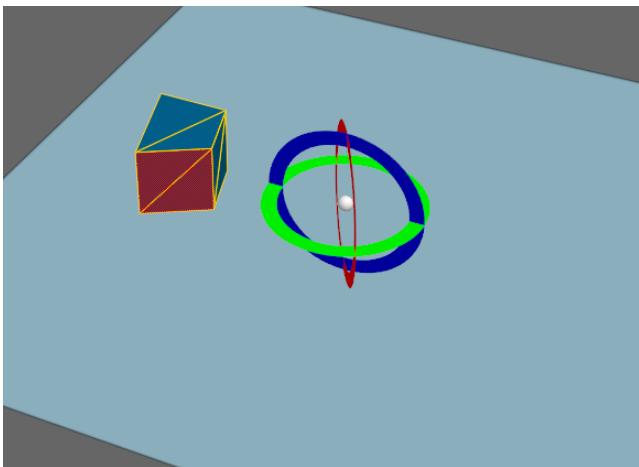
Scale and rotate grow are not typically useful functions, but can be useful with the manipulator snap. For example, it can be used to create a round barrier:



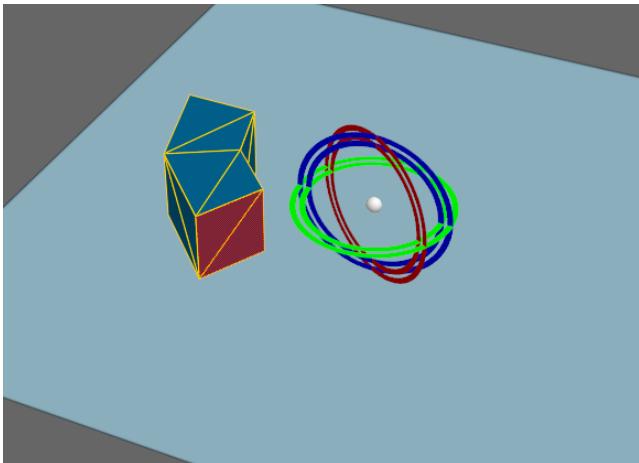
1) Starting with the faces of a square barrier selected.
Use manipulator snap to offset the centre.



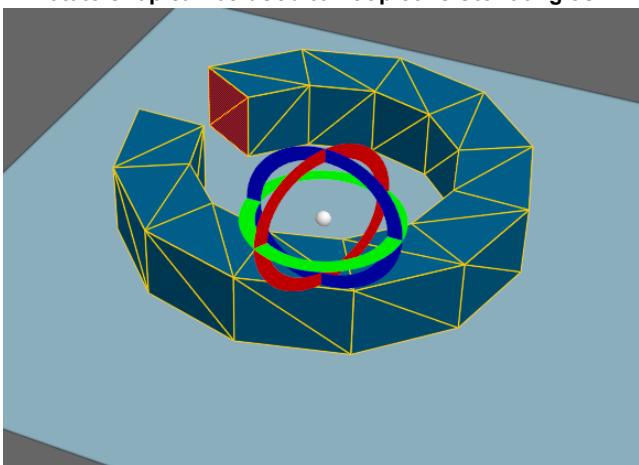
2) Switch to object rotate with grow enabled.



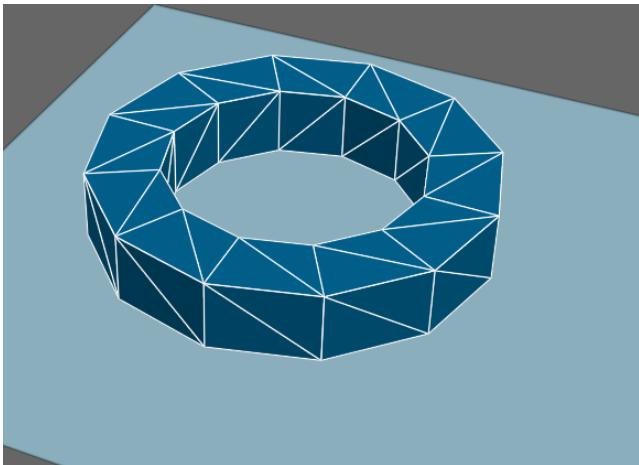
3) Perform the rotate/grow. Hold shift to lock into 15
degree increments.



4) Grow the next segment. If using irregular angles, rotate snap can be used to keep consistent angles.



5) Continue the process.



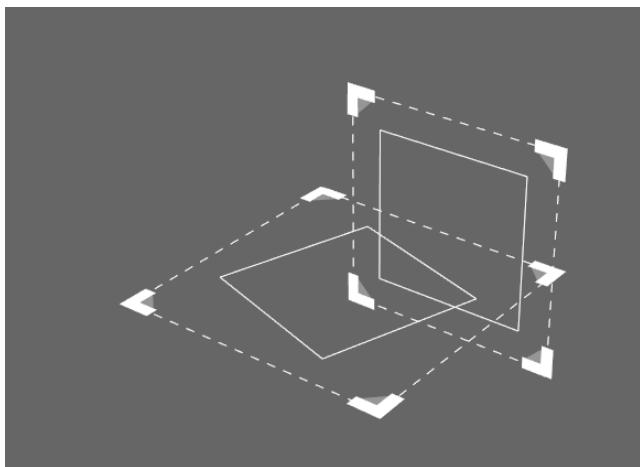
6) Final product.

If using irregular angles, you can use a process similar to the evenly spaced links described above.

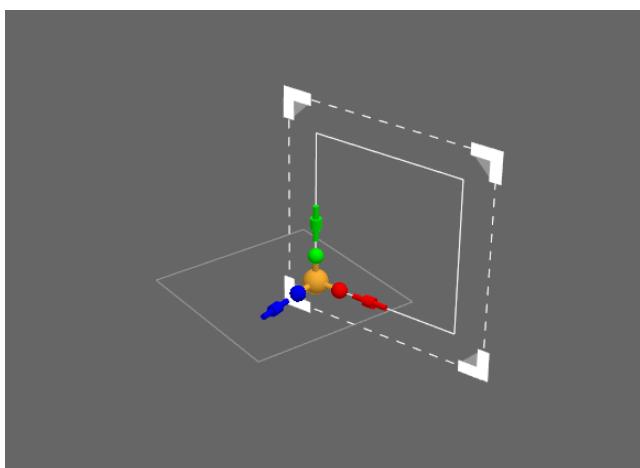
Arranging section and plan drawings

Like 3d scene geometry, imported drawings can be snapped to. This makes it easier to align

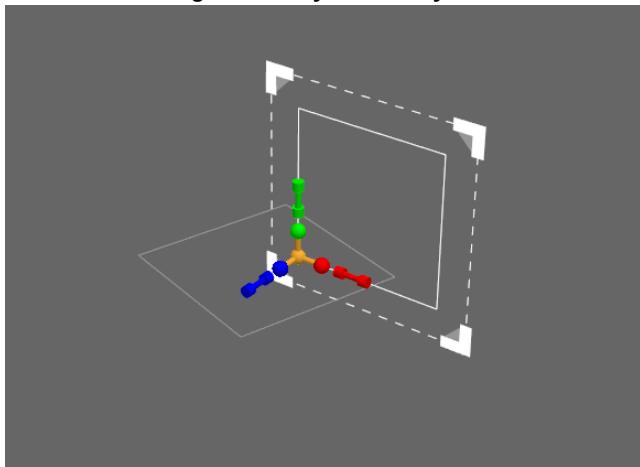
sections and plans with each other.



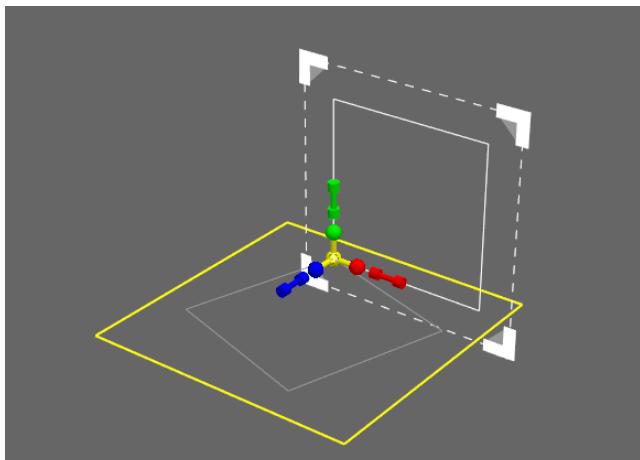
1) A plan and a section drawing.



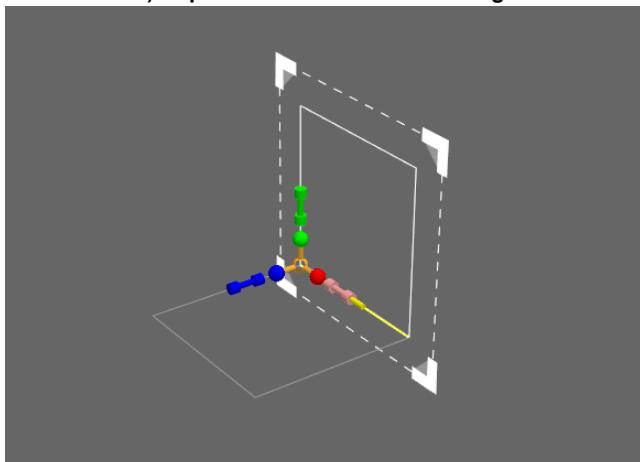
2) Select the section drawing. Use manipulator snap to move the manipulator to a feature common to both drawings. Possibly a walkway corner.



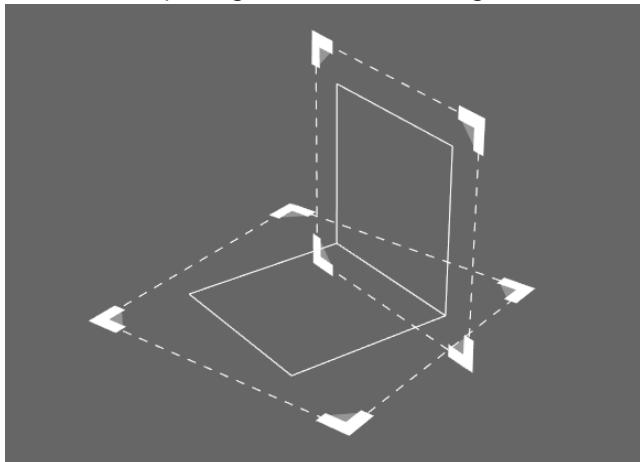
3) Switch to object snap.



4) Reposition the section drawing.



5) Realign the section drawing.



6) The plan and drawing are now correctly positioned.

4.2.3 Importing Files

MassMotion can import 3d objects, 2d drawings, images, or exported MassMotion objects through the import button in the project ribbon of the [Main Window](#) or the through the 'File' menu. See [Import File Formats](#) for a list of supported file formats.

During import a prompt will appear with [options](#) for controlling how the file will be handled. Not every file format will ask for every option. All imported objects are grouped under a single [Transform](#)

collection which can be used to scale, rotate, or translate the imported geometry as a group.

3d objects are imported as either [Generic Geometry](#) or [IFC Geometry](#) while 2d objects or layers are imported as [Drawing Layers](#). Images are imported as a rectangle with the image projected onto it.

4.2.3.1 Import File Formats

MassMotion can import the following file formats:

3d Objects	
3ds	3D Studio Scene
dae	COLLADA
dgn	Bentley Systems' Microstation
dwg	AutoCAD Drawing Database
dxf	Drawing Exchange Format
fbx	Autodesk FBX
ifc	Industry Foundation Classes
obj	Wavefront 3D Object
skp	Sketchup

2d Drawings	
dgn	Bentley Systems' Microstation
dwg	AutoCAD Drawing Database
skp	Sketchup

Images	
bmp	Microsoft Windows Bitmap
jpg/jpeg	Joint Photographic Experts Group (JFIF)
png	Portable Network Graphics

MassMotion Objects

mmxml	MassMotion exported objects
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4.2.3.1.1 dgn

DGN files can be imported as both drawing layers and generic geometry. Support for various elements is listed in the table below:

Type	Supported DGN Elements	Unsupported DGN Elements
2d elements (imported as drawing layer)	arcs, planar splines, conics, ellipses, lines, planar line strings, quad grid, quad list, triangle grid, triangle list, 2d shapes, closed 2d splines	non-planar line strings and splines
3d elements (imported as generic geometry)	3d shapes, closed 3d splines	
Other		dimensions, linear patterns, text

4.2.3.1.2 dwg

DWG files can be imported as both drawing layers and generic geometry. Support for various elements is listed in the table below:

Type	Supported DWG Elements	Unsupported DWG Elements
2d elements (imported as drawing layer)	lines, circles, arcs, ellipses, planar polylines, planar splines, regions	non-planar polylines and splines
3d elements (imported as generic geometry)	meshes, polyface meshes, polygon meshes, solids, faces, regions	NURBs based geometry (ie. surfaces and 3d solids)
Other		dimensions, hatches, leaders, text, wipeouts

Note: Regions will be imported as both a drawing layer for its outline and a generic geometry for the filled area.

Imported 2d elements will be grouped into drawing layer objects by the layers from the source DWG file.

4.2.3.1.3 dxf

DXF 3D object support in MassMotion is currently limited to explicit mesh geometry definitions. DXF files that represent geometry through ACIS definitions are not yet supported.

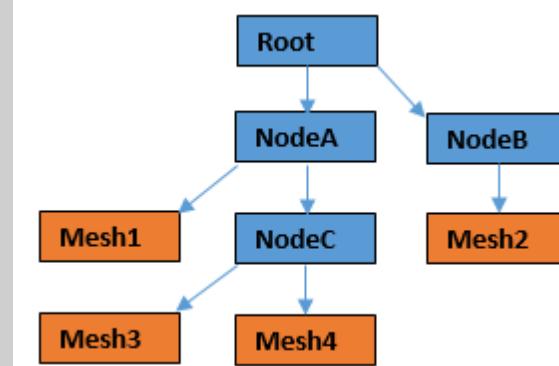
4.2.3.1.4 fbx

FBX files created with AutoCAD use a very old version of the file format and may not be read correctly by MassMotion. To upgrade AutoCAD exported .fbx files it is recommended to use the [FBX 2013.3 Converter](#) which is available free of charge from Autodesk.

4.2.3.2 Import Options

Importing a file will present the following options:

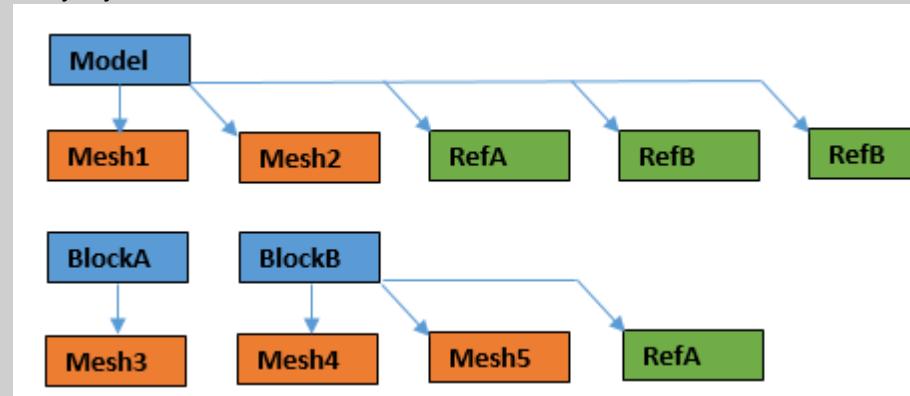
Option	File Formats	Effect
Geometry - Import	.dgn, .dwg, .dxf, .skp	<p>Options:</p> <ul style="list-style-type: none"> • All Objects: Import both drawing layers and generic geometry • Meshes Only: Import only generic geometry • Drawings Only: Import only drawing layers
Geometry - Include Reference Attachments	.dgn	DGN files may reference other DGN files. These files can be imported together with the specified file.
Geometry - NURB Quality	.3ds, .fbx	<p>Choose the level of detail when importing NURBs.</p> <p>MassMotion only supports mesh geometry and so other forms of geometry such as NURBs will be converted into a mesh upon import. This is the number of subdivisions between the control points of the surface.</p> <p>Users will be prompted for this before importing regardless of whether the file contains a NURB or not. If there are no NURBs, this option has no effect.</p>
Geometry - Group faces	.skp	<p>Sketchup files may only contain planar elements (line sketches and faces oriented in 3d). For complex files, this restriction can lead to a very large number of objects on import. To reduce this amount, faces can be grouped together with the following options:</p> <ul style="list-style-type: none"> • Group faces by layer and appearance: Faces with the same layer and sharing the same texturing and colour properties will be combined into a single object. • Group faces by layer: Faces with the same layer will be combined into a single object. Texturing and colour are discarded. • Don't group faces: No grouping is performed. Texturing and colour are preserved. This may create a very large number of objects.
Object Names - Prefix	.3ds, .dae, .dgn, .dwg, .dxf, .fbx, .obj, .skp	Add a prefix to the names of every imported object. This is useful when searching for objects
Object Names - Naming Scheme	All except images	3ds, dae, fbx, and obj files are internally organized such that geometry is associated with a node. Each node then has a 'parent' up to the 'root' node, forming a tree like structure:



These file formats give the following naming scheme options:

- Full name: Use the geometry name and the names of every node up to the root node. The above example will create four objects named: Root_NodeA_Mesh1, Root_NodeB_Mesh2, Root_NodeA_NodeC_Mesh3, Root_NodeA_NodeC_Mesh4
- Root name: Use only the root node's name. The above example will create four objects named: Root_0, Root_1, Root_2, Root_3
- Leaf name: Use the geometry name and an optional number of nodes. The above example with a leaf depth of 2 will create four objects named: NodeA_Mesh1, NodeB_Mesh2, NodeC_Mesh3, NodeC_Mesh4
- Root and leaf name: Use the geometry name, the root node's name and an optional number of nodes. The above example with a leaf depth of 2 will create four objects named: Root_NodeA_Mesh1, Root_NodeB_Mesh2, Root_NodeC_Mesh3, Root_NodeC_Mesh4

dgn, **dwg**, **dxf**, and **skp** files are internally organized using layers and blocks. A drawing file is typically a 'model space' block which represents the entire model and possibly contains other user defined blocks. Blocks contain meshes (and other geometry elements) as well as references to other blocks. The meshes are also organized into one or more layers.



These file formats give a number of options to name imported objects based on the imported object's layer, name, original block and type (drawing or mesh).

For example, Mesh3 will be imported 3 times, once via BlockA referenced by the Model block and twice via BlockB. The <Layer>_<Block>_<Name> option will give the names: Layer0_BlockA_Mesh3_0, Layer0_BlockA_Mesh3_1, Layer0_BlockA_Mesh3_2.

Image - Size	Images only	Imported images can have their imported dimensions set either as fixed size per pixel or by directly setting the width and height.
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4.2.4 Generating Objects from Geometry

It is possible to generate new [scene objects](#) from [traced lines](#), [reference geometry](#), [drawing layers](#), or the faces or edges of other objects. There are two primary methods for generating objects: The right-click '[Generate](#)' Context Menu, and the [Creation Widget](#) in the bottom of the [tool panel](#).

When working with IFC, it is possible to automatically generate new objects based on the IFC type. See [Generating From IFC](#) for the mapping between IFC type and scene object type.

4.2.4.1 Creation Widget

The creation widget is in the bottom right of the [tool panel](#) in the main window. It configures the process of generating objects from source geometry or [traced lines](#).

The 'Generate' button (or hotkey 'N') will use the selected source geometry or traced lines to generate an object of the specified target type. The transformation applied to the source will depend on the source type and the target object type. It is possible to customize this transformation using the [Generate Options](#) window which can be accessed through the button beside the 'Generate' button.

Once options have been set for a given source/target pair, those options will be used any time a source of that type is used to generate an object of the target type. Options are saved for each possible source/target pair.

Property	Description
Target Type	The type of object to generate.
Options	A toggle button which displays the ' Generate Options ' window for editing operations used when generating objects.
Generate	Generate an object of the target type from the selected geometry (hotkey 'N').

4.2.4.1.1 Generate Options

The Generation Options window can be used to customize the way in which objects are generated from the [Creation Widget](#) or 'N' hotkey. The window is available through the main window's 'View -> Windows' menu, the settings button in the [tool panel](#), or the 'Advanced' entry under 'Generate' in an object's right-click context menu.

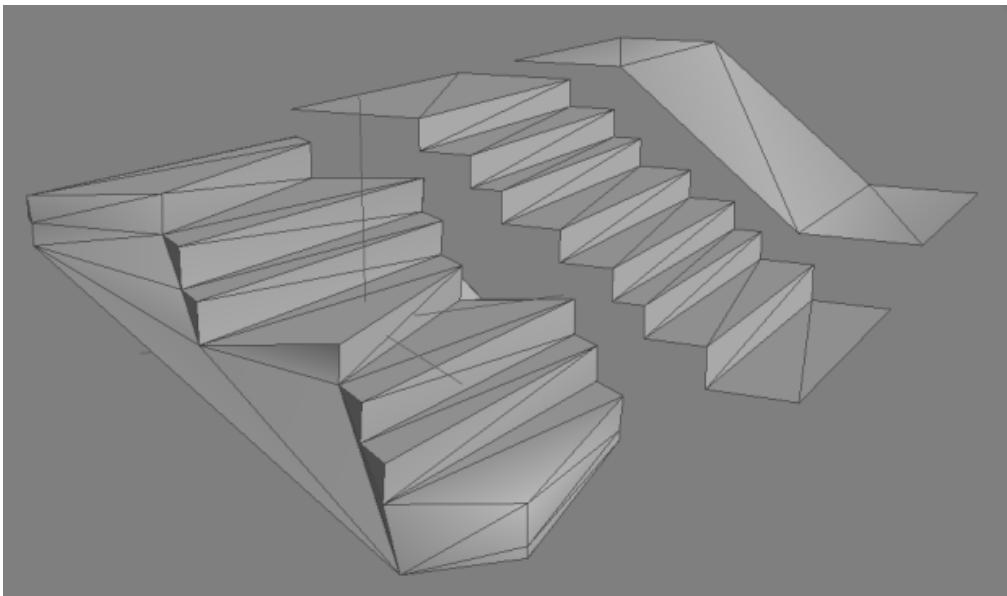
Options are saved for each possible source/target pair.

Property	Description
Target	The type of object generated.
Source Type	The source component used to generate the target (Reference geometry, face, edge, region, line).

Property	Description
Conversion Type	The transformation applied to the source geometry (see below).
Specify distance	If checked, conversions that ask the user for a value will instead use the supplied value.
Translate up	If checked, the targeted geometry will be translated up the specified distance.
Add landings with length	If checked, landings of the specified length will be added to the target geometry. This can in some cases modify the target geometry and should be used with caution.
Extend width	Extend the target geometry by the specified distance on either side.
Extend length	Extend the target geometry by the specified distance on either side.
Cleanup	Determines how source and target geometry is handled after the target is generated.

Conversion Type	Source	Description
Copy	Object, Face, Region	Target geometry will be a copy of the source.
Bottom surfaces	Object, Face	Use only the top surfaces for the target geometry.
Top surfaces	Object, Face	Use only the bottom surfaces for the target geometry.
Bottom of bounding box	Object, Face	Construct a 'best fit' bounding box around the source geometry and use the bottom surface of that box.
Top of bounding box	Object, Face	Construct a 'best fit' bounding box around the source geometry and use the top surface of that box.
Extrude up / out of plane	Face, Region, Edge, Line	Extrude or grow the selected component upwards (or out of the plane in the case of drawings).
Expand to rectangle	Edge, Line	Expand or stretch the edge/line into a rectangle (in the plane in the case of drawings).
Span two edges	Edge, Line	Create a surface between the two selected edges/lines.
Ifc door to link	Object, Face	
Smooth VCE	Object, Face, Region	Find the top and bottom of the selected geometry, add landings if necessary, and replace the geometry between the landings with a smooth surface.

Conversion Type	Source	Description
Stepped VCE	Object, Face, Region	Find the top and bottom of the selected geometry, add landings if necessary, then use the top surfaces only between the landings.



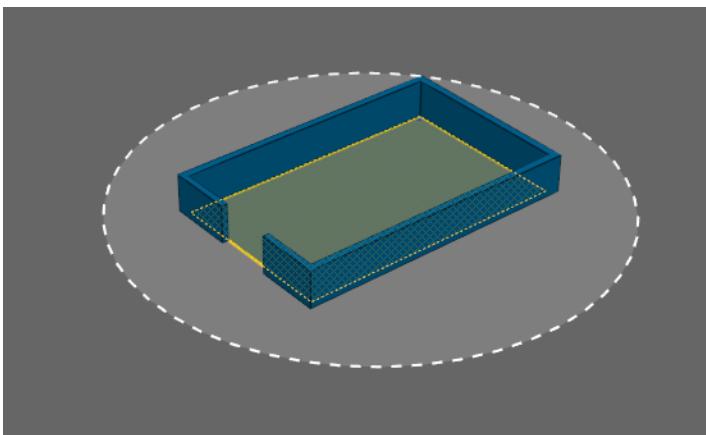
Example of applying the default 'Stepped VCE' and 'Smooth VCE' operations to an imported stair.

4.2.4.2 Tracing New Objects

It is possible to create new simplified objects by tracing over existing geometry in the scene. The 'Trace' mode is available through a button in the main window [tool panel](#) or the [keyboard shortcut 'I'](#).

Trace Mode

In trace mode, a series of lines are drawn by clicking on points in the scene. Each new point creates a line joined to the last. Once there are two non collinear lines, a tracing plane is formed and all subsequent points are projected onto this plane.



Tracing the inside of a room to create a floor. The yellow lines are the traced lines. The green area is enclosed by the lines.
The circle indicates the tracing plane.

Generating Objects

Traced lines can be used to generate objects using the 'Generate' button in the [Creation Widget](#). When the lines completely enclose one or more areas, those areas are used to generate the object. When the traced lines do not enclose any areas, the lines themselves are used. Once lines or areas have been used to generate an object, the lines and areas are deleted.

The transformation operations applied to the lines or areas are taken from the drawing layer line or drawing layer region settings in the [Generate Options](#) dialog.

Tracing Within Drawings

It is possible to simulate tracing by [drawing new lines](#) within an existing [drawing layer](#) object. This involves selecting an existing drawing layer, or creating a new drawing layer and positioning it at the appropriate location. Lines drawn in this way persist within the drawing layer and so can be modified or used more than once.

4.2.4.3 Generating From IFC

When [generating objects](#) from [IFC Geometry](#), the right-click 'Generate -> Auto' option will attempt to choose a target MassMotion type from the source IFC Type. The table below outlines the mapping between types.

IFC Type	IFC Geometry Type	Auto-converts to
Space	IfcSpace	Floor
Slab Floor	IfcSlab_Floor	None - must be explicitly specified
Slab Base	IfcSlab_Baseslab	None - must be explicitly specified
Slab Landing	IfcSlab_Landing	Floor
Slab Unrecognized	IfcSlab_Unrecognized	None - must be explicitly specified
Elevator	IfcTransportElement_Elevator	None - must be explicitly specified
Escalator	IfcTransportElement_Escalator	Escalator
Moving Walkway	IfcTransportElement_MovingWalkway	Escalator
Unrecognized Transport Element	IfcTransportElement_Unrecognized	None - must be explicitly specified
Door	IfcDoor	Link
Stair	IfcStair	Stair
Stair Flight	IfcStairFlight	Stair

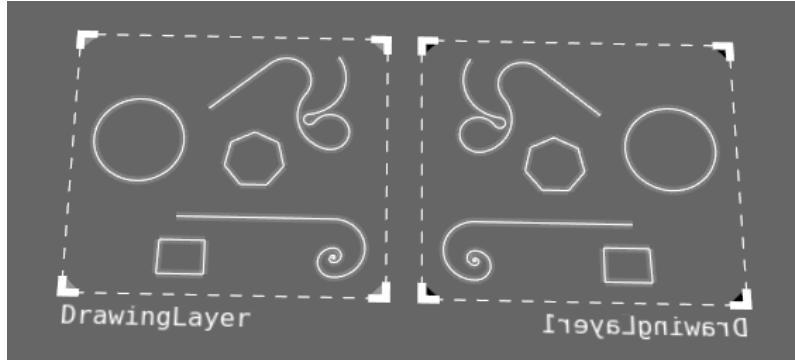
Wall	IfcWall	Barrier
Wall Standard Case	IfcWallStandardCase	Barrier
Railing	IfcRailing	Barrier
Column	IfcColumn	Barrier
Furnishing Element	IfcFurnishingElement	Barrier
Plate	IfcPlate	None - must be explicitly specified
Building Element Proxy	IfcBuildingElementProxy	None - must be explicitly specified
Ramp	IfcRamp	Ramp
Ramp Flight	IfcRampFlight	Ramp
Other	IfcElement	None - must be explicitly specified

4.2.4.4 Generating From Drawings

[Drawing layers](#) can be used to create objects, but only through selection of the drawing lines or the enclosed [regions](#) defined by those lines. See [Working with Drawings](#) and [Drawing Commands](#).

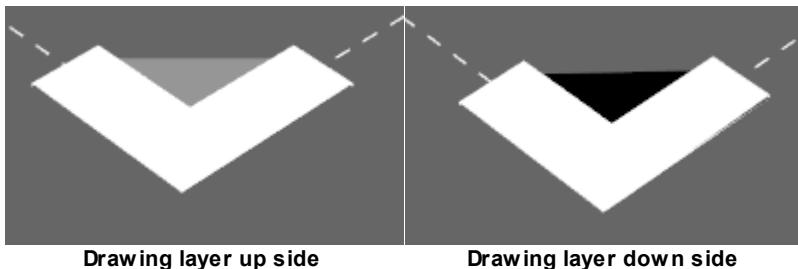
Drawings have an implicit "up" or "normal" direction. When extruding geometry from the drawing, this is the direction that will be used (negative values can be used to extrude in the opposite direction).

The direction is indicated by the title of the drawing. Display of the title can be toggled off in the [scene view](#).



The title appears correct on the "up" side and mirrored on the "down" side.

The direction is also indicated by the corners of the drawing object. The "up" side of the drawing will have light grey corner triangles and the "down" side will have black triangles:



Drawing layer up side

Drawing layer down side

Lines

When generating from lines, new objects will typically be extruded up out of the plane of the drawing, expanding into surfaces in the plane of the drawing, or constructed as a span between two selected lines. Objects can be generated using the '[Generate' Context Menu](#)', or from the [Creation Widget](#).

Regions

When generating from [regions](#), it may be necessary to first ensure that all regions are fully closed (see [Healing Drawings](#)). A '[Copy to](#)' command from the right click menu will create an exact copy of the selected region(s), while a '[Generate](#)' command will apply appropriate transformations.

4.2.4.5 'Generate' Context Menu

The 'Generate' context menu is available when right-clicking on a selection of [reference geometry](#) objects, mesh faces, mesh edges, drawing lines, or drawing regions. The menu will contain a list of object types. Choosing a type will then apply a transformation to the source geometry and create a new object of the target type.

The transformation applied to the source geometry depends on both the selection mode and the target type of the new object. The following subsections describe the default transformations. It is not possible to change the default transformations when generating from the context menu. To apply custom transformations use the [Creation Widget](#).

4.2.4.5.1 From Reference Geometry

The following transformations are applied when generating a new object from selected [Reference Geometry](#) objects. A description of the transformations can be found in [Generate Options](#).

Target Object	Transformation
Floor	Copy
Barrier	Copy
Portal	Top surfaces, translate up 0.02
Link	Top surfaces, translate up 0.02
Stair	Stepped VCE, translate up 0.02
Escalator	Smooth VCE, translate up 0.02
Ramp	Smooth VCE, translate up 0.02

<u>Cordon</u>	Copy
<u>Volume</u>	Copy
<u>Visual</u>	Copy
<u>Drawing Layer</u>	Project onto drawing

4.2.4.5.2 From Mesh Faces

The following transformations are applied when generating a new object from selected mesh faces. A description of the transformations can be found in [Generate Options](#).

Target Object	Transformation
<u>Floor</u>	Top surfaces
<u>Barrier</u>	Extrude up
<u>Portal</u>	Top surfaces, translate up 0.02
<u>Link</u>	Top surfaces, translate up 0.02
<u>Stair</u>	Stepped VCE, translate up 0.02
<u>Escalator</u>	Smooth VCE, translate up 0.02
<u>Ramp</u>	Smooth VCE, translate up 0.02
<u>Volume</u>	Extrude up
<u>Visual</u>	Copy
<u>Drawing Layer</u>	Project onto drawing
<u>Generic Geometry</u>	Copy

4.2.4.5.3 From Mesh Edges

The following transformations are applied when generating a new object from selected mesh faces. A description of the transformations can be found in [Generate Options](#).

Target Object	Transformation
<u>Expanded Floor</u>	Expand to rectangle

<u>Expanded Portal</u>	Expand to rectangle, translate up 0.02
<u>Expanded Link</u>	Expand to rectangle, translate up 0.02
<u>Expanded Generic Geometry</u>	Expand to rectangle
<u>Extruded Barrier</u>	Extrude up
<u>Extruded Cordon</u>	Extrude up
<u>Extruded Generic Geometry</u>	Extrude up
<u>Spanned Floor</u>	Span two edges
<u>Spanned Portal</u>	Span two edges
<u>Spanned Link</u>	Span two edges, translate up 0.02
<u>Spanned Stair</u>	Span two edges, translate up 0.02, add landings of length 0.5
<u>Spanned Escalator</u>	Span two edges, translate up 0.02, add landings of length 0.5
<u>Spanned Ramp</u>	Span two edges, translate up 0.02, add landings of length 0.5
<u>Spanned Generic Geometry</u>	Span two edges
<u>Drawing Layer</u>	Project onto drawing

4.2.4.5.4 From Drawing Lines

The following transformations are applied when generating a new object from selected drawing lines. A description of the transformations can be found in [Generate Options](#).

Target Object	Transformation
<u>Expanded Floor</u>	Expand to rectangle
<u>Expanded</u>	Expand to rectangle, translate up 0.02

Portal	
Expanded Link	Expand to rectangle, translate up 0.02
Expanded Generic Geometry	Expand to rectangle
Extruded Floor	Extrude up
Extruded Barrier	Extrude up
Extruded Link	Extrude up, translate up 0.02
Extruded Stair	Extrude up, translate up 0.02, add landings of length 0.5
Extruded Escalator	Extrude up, translate up 0.02, add landings of length 0.5
Extruded Ramp	Extrude up, translate up 0.02, add landings of length 0.5
Extruded Cordon	Extrude up
Extruded Visual	Extrude up
Extruded Generic Geometry	Extrude up
Spanned Floor	Span two edges
Spanned Barrier	Span two edges
Spanned Portal	Span two edges
Spanned Link	Span two edges, translate up 0.02
Spanned Stair	Span two edges, translate up 0.02, add landings of length 0.5
Spanned Escalator	Span two edges, translate up 0.02, add landings of length 0.5
Spanned Ramp	Span two edges, translate up 0.02, add landings of length 0.5
Spanned	Span two edges

<u>Generic Geometry</u>	
<u>Drawing Layer</u>	Project onto drawing

4.2.4.5.5 From Drawing Regions

The following transformations are applied when generating a new object from drawing layer [regions](#). A description of the transformations can be found in [Generate Options](#).

Target Object	Transformation
<u>Floor</u>	Copy
<u>Barrier</u>	Extrude up
<u>Portal</u>	Copy
<u>Link</u>	Copy
<u>Stair</u>	Stepped VCE, translate up 0.02
<u>Escalator</u>	Smooth VCE, translate up 0.02
<u>Ramp</u>	Smooth VCE, translate up 0.02
<u>Cordon</u>	Copy
<u>Volume</u>	Copy
<u>Generic Geometry</u>	Copy

4.2.4.6 'Copy to' Context Menu

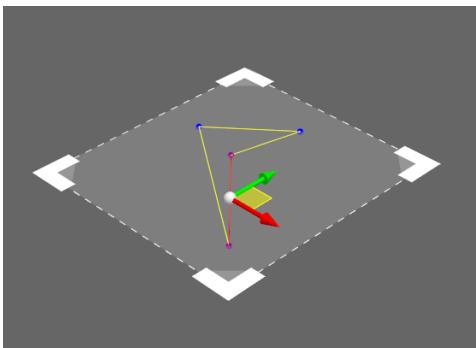
The 'Copy to' context menu is available when right-clicking on a selection of mesh faces or drawing regions. In either case, a new object of the specified type is created with an exact copy of the selected geometry.

4.2.5 Working with Drawings

A drawing layer object can be translated, scaled and rotated much like any other 3d object in the scene. Adding or editing points or lines within a drawing can be done from within the 'Edit Drawing' mode.

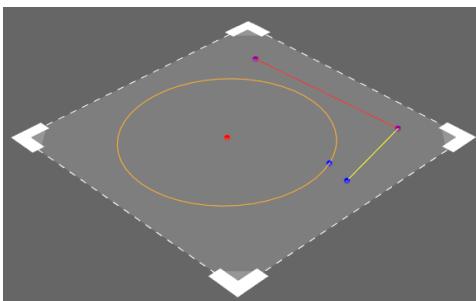
Editing a Drawing

To enter 'Edit Drawing' mode, select a drawing layer object and the use the 'Edit Drawing' mode button in the [tool panel](#) or use the 'D' shortcut key. Lines and points can then be selected and edited. The [manipulator](#) will be available but will be restricted to 2 dimensions.



Translating drawing elements in the plane

The points and lines are highlighted in red when selected, much like vertices, edges and faces for other scene objects. The connected lines of a point will additionally be highlighted in orange and the connected points of a line will be highlighted purple. This can help identify points that are conceptually but not physically connected to a line as in the case with the centre point of a circle.



Selecting the centre point of a circle highlights the circle orange. Selecting a straight line turns its end points purple. Unselected points and shapes are blue and yellow respectively.

Regions

Regions are empty spaces within a drawing that are completely enclosed by lines. Regions can be used to generate floor, barrier, or other scene objects. See [Finding Regions](#) for more information.

4.2.5.1 Adding Shapes

To add shapes or lines to a drawing begin by entering 'Edit Drawing' mode (see [Working with Drawings](#)). Lines can only be added when editing a single drawing. It is not possible to add shapes or lines when multiple drawings are being edited at the same time.

Adding Straight Lines

Straight lines can be added between two existing points by selecting the two points, right clicking on them, and selecting the 'Add line' command.

New straight lines can also be drawn directly using the [Draw Lines](#) mode.

Adding Shapes

New shapes can be added to a drawing when in 'Line' selection mode by right clicking on empty space within the drawing plane and selecting one of the 'New Lines' commands.

Shape	

Circle	Creates a single circular line with one centre point and a point on the radius.
Ellipse	Creates a single elliptical line with one centre point and then a point on each of the major and minor axis.
Square	Creates four straight lines connected to form a square.

4.2.5.2 Drawing Lines

To draw new lines in a drawing layer, select a single drawing and enter 'Draw Lines' mode. 'Draw Lines' mode is accessible through the 'L' hotkey, the drawing object right-click context menu, or through a button in the [tool panel](#) when in 'Edit Drawing' mode.

Note it is not possible to draw lines when multiple drawing layers are selected.

If there is geometry below the drawing layer, the mouse will snap to faces, edges, or points to allow for exact tracing. If there is some distance between the snap target and the drawing layer, the location of the new point and line will be taken from the projection of the snap location onto the drawing plane.

Element	Action
Single Line	A) Left click once to create the first point, and left click again to create the second point joined to the first by a line. B) Click and drag anywhere in the drawing plane.
Continuous Line	After drawing the first line segment, hold SHIFT while drawing subsequent lines to create a continuous series of connected line segments.

4.2.5.3 Drawing Commands

Object Commands

These commands accessible via right clicking on a drawing layer, or in some cases through buttons on the [tool panel](#). Some commands will only operate when specific number of drawings are selected.

Command	Effect
Generate -> Merged Drawing	Create a new drawing that combines the selected drawings. Do not delete the originals. If the drawings are not on the same plane, the drawings will be projected to the plane of the first selected drawing.
Merge	Create a new drawing that combines the selected drawings and delete the original drawings. If the drawings are not on the same plane, the drawings will be projected to the plane of the first selected drawing.
Edit Lines	Changes the selection mode to 'Lines' so that the lines and points of the drawing can be edited.
Find Regions	Combine all selected drawing layers and use the lines to find

	<p>enclosed areas. These areas are presented as regions that can then be used to generate scene objects (see Finding Regions).</p> <p>Only drawing layers on the same plane are combined together when finding regions.</p>
Simplify	Remove any duplicate lines or unnecessary points in the selected drawings. No points are moved.

Line/Point Commands

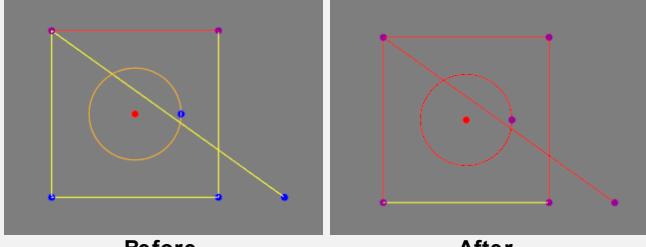
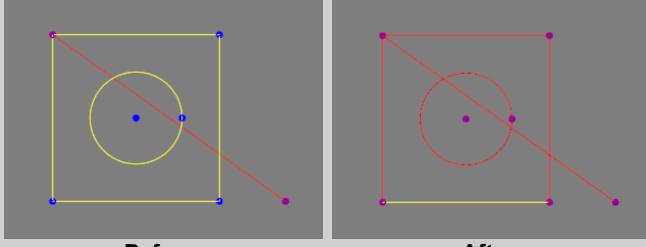
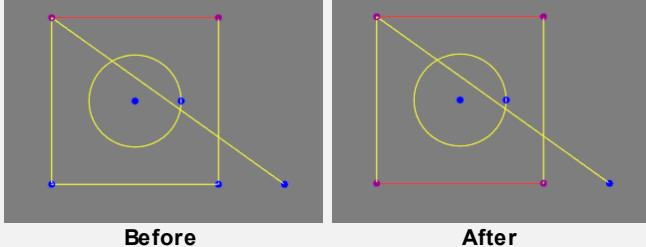
These commands operate on a selection of points and/or lines within a drawing layer. Some commands will only operate on certain types of lines such as straight lines or line chains.

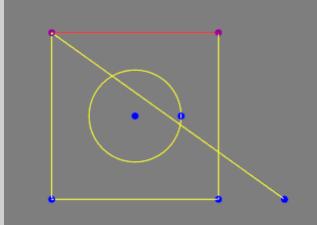
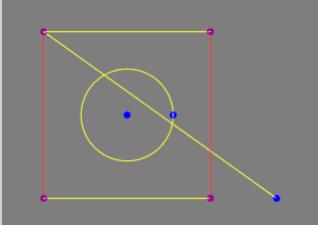
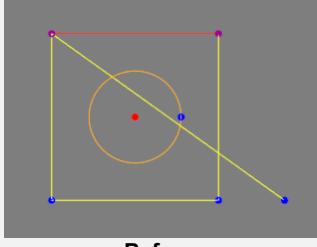
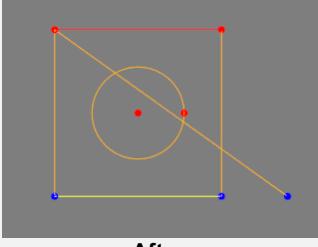
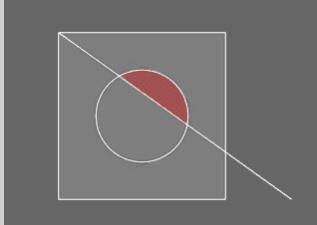
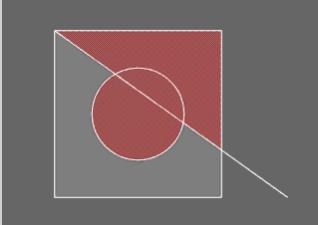
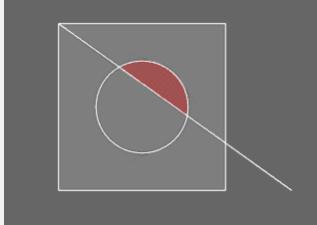
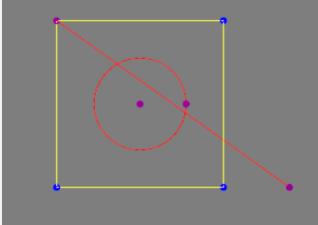
Command	Target	Effect
Delete	Points, lines	Deletes the selected points and lines. If points are deleted, any connected lines are also deleted. If lines are deleted, any points no longer connected to another line are also deleted.
Discretize	Lines	Split the lines each into a number of straight line segments.
Duplicate	Lines	Creates a copy of the lines and its connected points in the same drawing. This is useful for creating repeating patterns.
Extend and Fuse	2 or more straight lines	Extend the selected straight lines until they intersect with each other then fuse them. See: Fuse. Shortcut: 'U'
Explode	Points, lines	Breaks a point related to multiple lines into several points, effectively disconnecting the lines. If a point is used multiple times by the same lines, it will also be split. Exploding a line will explode all the points it's connected to.
Extract	Points, lines	Remove the selected points and lines from the current drawings and use them to create new drawing layer objects.
Find Regions	Lines	Combine all selected lines from all selected drawing layers and use them to find enclosed areas. These areas are presented as regions that can be used to generate scene objects (see Finding Regions).
Fuse	2 or more straight lines	This is used to connect lines together where they cross. Add points where the selected lines intersect and split the lines at those points.
Merge	2 or more points, 2 or more straight lines	Merges nearby points into each other. Any lines connected to the selected points will be connected to the merged points. If there are straight lines selected, sufficiently "parallel" lines will be merged into a single line. Two straight lines will be merged if they are close to each other and if both of the shorter line's end points are close enough to the longer line projected to infinity. For both merging points and straight lines, a tolerance can be

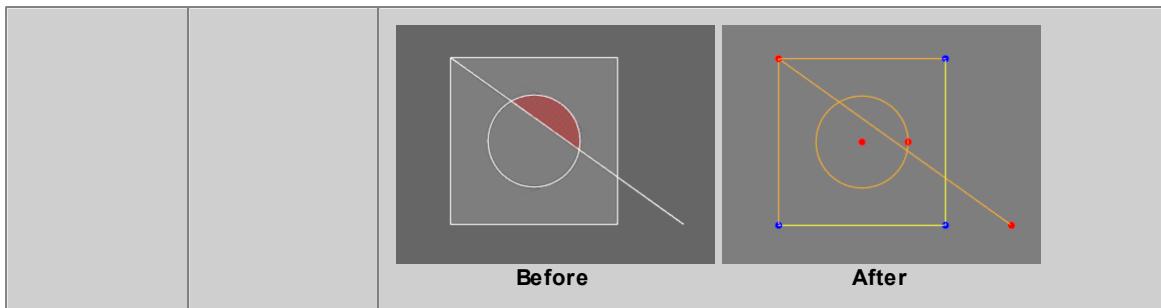
		specified. This operation may cause lines to shift around.
Simplify	Points, lines	Remove duplicate lines and unnecessary points. No points are moved.
Split	Straight lines, circles, circle arcs	Splits the lines in two. Circles and circle arcs will be split into circle arcs.

Component Selection Commands

These commands are accessible via right clicking.

Command	Target	Effect
Select: Connected Lines	Points and Lines	Select all lines which are connected to selected points or are connected to a point connected to the selected lines.
		 <div style="display: flex; justify-content: space-around; width: 100%;"> Before After </div>
Select: Intersecting Lines	Lines	Select all lines that intersect with the selected lines. Lines that touch at end points count as intersecting. Lines that share a connected point but do not actually cross are not counted.
		 <div style="display: flex; justify-content: space-around; width: 100%;"> Before After </div>
Select: Parallel Lines	1 Straight Line	Select all straight lines that are parallel to the selected line.
		 <div style="display: flex; justify-content: space-around; width: 100%;"> Before After </div>
Select:	1 Straight	Select all straight lines that are perpendicular to the selected

Perpendicular Lines	Line	line. The initial line is deselected.
		 Before  After
Select: Connected Points	Points and Lines	Select all points which are connected to a selected line or are connected to a line connected to a selected point.
		 Before  After
Select: Connected Regions	Regions	Select all regions which are adjacent to the selected regions. Corner adjacency is not counted.
		 Before  After
Select: Connected Lines	Regions	Select all lines which define the selected regions.
		 Before  After
Select: Connected Points	Regions	Select all points connected to lines which define the selected regions.



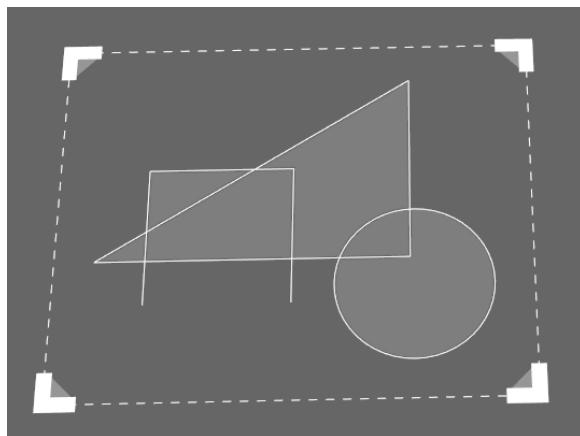
4.2.5.4 Finding Regions

Drawing regions are areas in a drawing layer that are fully enclosed by lines. Once found, regions can be selected and used to generate scene objects such as floors, stairs, or barriers. To fill the regions in a drawing select a drawing then enter the "Find Regions" mode from the [tool panel](#) or press the 'R' shortcut key.

Lines do not need to be connected together to enclose a region, but can be simply crossing or touching. However, if lines do not completely enclose a space, the space cannot be filled and no region is created. See [Healing Drawings](#) for techniques on how to identify and close gaps surrounding regions.

It is possible to select and use a subset of lines for region calculations. When working with large or complex drawings this can greatly reduce the time it takes to find and display regions.

When multiple drawings are selected, all drawings which share the same plane are combined into a temporary drawing for region calculations.



Performance Tip

Regions calculated for a single drawing are cached and can be reused provided the lines in the drawing are not edited. It is not possible to cache regions calculated across multiple drawing layers or for a subset of lines. In some cases it can be advantageous to extract lines into a new drawing or merge multiple layers into a single drawing so as to take advantage of the caching.

4.2.6 Editing Object Properties

Object properties can be edited using the Properties Window. This dialog is available through the object's right-click menu, or by double-clicking on the object in the scene or list views. Objects which share common properties can have those properties edited in batch all at once using [object multi-edit](#).

Properties Window Toolbar	
File	For some query types, this allows the results to be saved to an image or CSV file. For agent actions , the action graph image can be exported. Additionally, for any object type, this allows the current object(s) to be exported to an XML file for use in another project.
Select	Select the objects currently being edited (useful for then finding them in the scene or choosing them elsewhere in the user interface).
Multi	Choose which objects are currently being edited (see Editing Multiple Objects for details).
Generate/Evaluate	Used by graph , map , and table queries to calculate results.
Help	Display the help page for the inspected object.
Arrow	For table and graph queries which generate data, the arrow will show or hide the results.

Object Header

The header consists of a colour swatch, object name, and object indicator. This header is visible for all object types regardless of the properties.

Object Header	
Colour Swatch	The object colour can be modified by clicking on the colour swatch. Left click to bring up the colour chooser. Right click to pick a specific colour or reset to the object's default colour. See Working with Colours .
Name	Valid object names must begin with a letter then be followed by any combination of letters, numbers, underscores, or dashes.
Object Indicator	The object indicator displays the status of the object. If all properties in the object are valid the indicator will be green. Red indicates that at least one property is invalid. Right-clicking on the indicator can be used to reset all object properties to their default values.

Properties

Below the name field is a list of properties for the particular object being inspected. Beside each property is an indicator. The indicator changes colour depending on the state of the property: • green for valid, ■ red for invalid.

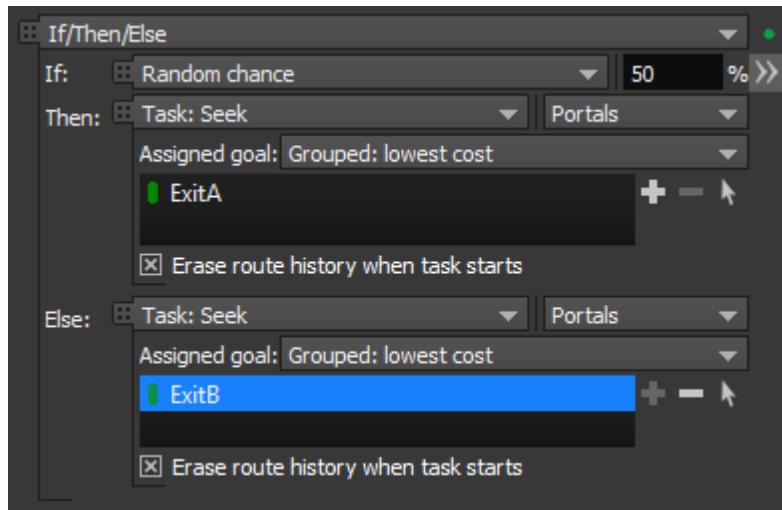
It is possible to reset a property to its default value, copy the value, paste a value, or set the value from another source object, all through the right-click menu of the indicator.

Property values can be copied within an object or even between objects by dragging the indicator of the source property onto the destination property.

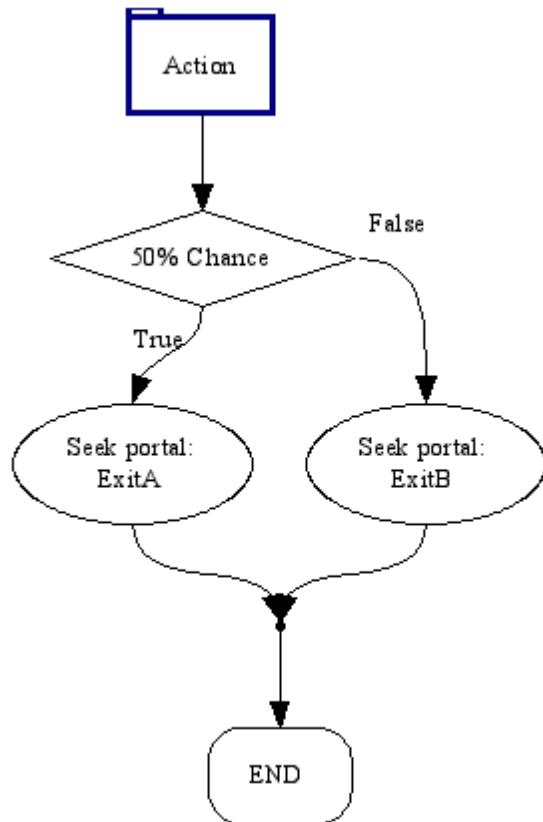
Action Properties

Many objects can apply actions to agents (see [Where to Use Actions](#)). For action properties, additional information is available by toggling the arrow button below the indicator.

If the action is valid, a flow diagram will be displayed which shows how the action functions. If the action is invalid, a list of errors will be displayed.



An action property. The arrow is on the right, below the indicator.



Flow diagram of the action.

4.2.6.1 Editing Multiple Objects

MassMotion supports editing the properties of many objects simultaneously. Select multiple objects and then use the right-click menu to select 'Properties'. Or inspect the properties of a single object, then use the 'Multi' button at the top of the window to add objects to the current session.

The editor dialog allows editing of any properties that the chosen objects all have in common. When editing objects of similar type all properties are available. If multi-editing a floor and link, only shared properties such as the map resolution can be modified. In all cases, setting the value of a property will set that value on all objects.

Editing Names

When inspecting the properties of multiple objects, the name entered will be applied to all objects being edited. Numeric suffixes will be added as needed to ensure that all names remain unique. For instance, if three objects are selected, then:

- Entering a name of 'NewName' will result in the objects being renamed to 'NewName', 'NewName1', and 'NewName2'
- Entering a name of 'NewName1' will result in the objects being renamed to 'NewName1', 'NewName2', and 'NewName3'
- Entering a name of 'NewName10' will result in the objects being renamed to 'NewName10', 'NewName11', and 'NewName12'

Property Indicators

The small coloured property indicators to the left of each property field are especially important when

editing multiple objects. Different colours and shapes of the property indicator indicate different states:

Indicator appearance	Meaning
● Green circle	All edited objects have the same valid value for this property.
▲ Yellow triangle	All edited objects have valid values for this property but they are not all the same.
■ Red square	All edited objects have invalid values for this property.
▣ Split yellow/red square	Some edited objects have invalid values for this property and some have valid values.

Right-clicking on the property indicator allows the property value from a specific object to be copied to all edited objects. 'Set from' brings up a dialog allowing any one of the currently-edited objects to be selected; that object's value for the current property will then be copied to all other objects. 'Set from any' works the same way but allows any object in the current project to be chosen.

4.2.7 Choosing Objects

Working with MassMotion frequently involves the choosing of one or more objects such as the [simulation run](#) used by a given query or the set of origin [portals](#) for a [circulate event](#). In both cases MassMotion provides a variety of ways to choose the object(s).

Single Objects

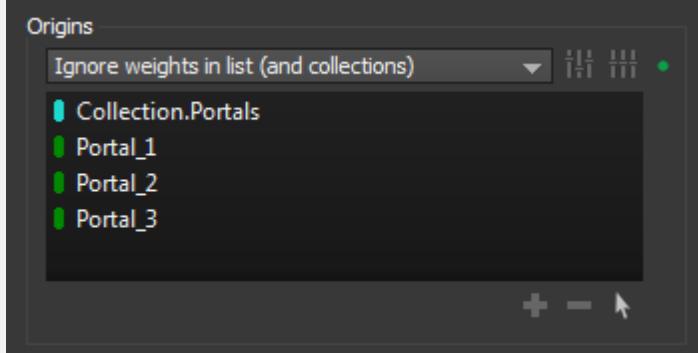
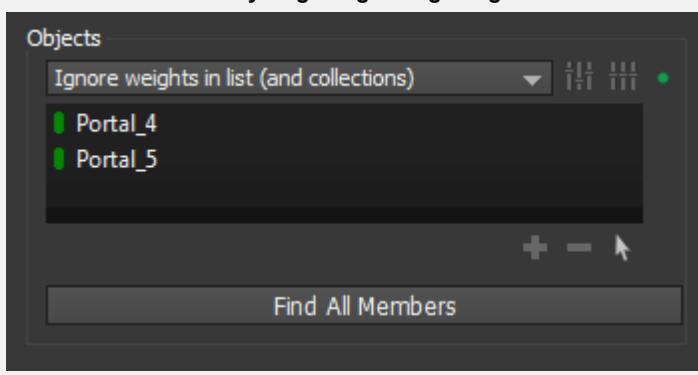
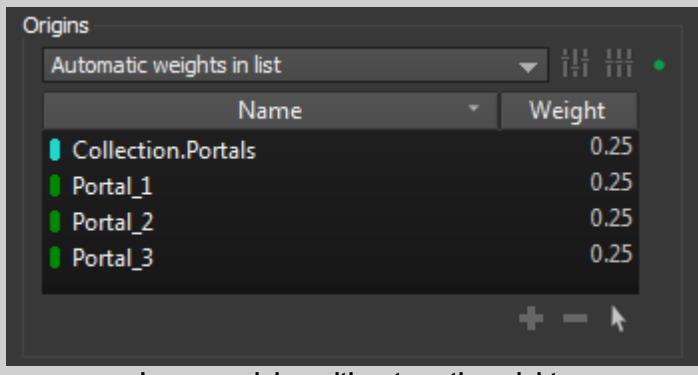
Clicking on the 'mouse cursor' icon beside a single-object field (or on the field itself if it is blank) will bring up a dialog with a list of all valid objects for that field. Alternatively, if the desired object has already been selected elsewhere, the 'crosshair' icon beside the field can be used to choose that object. For instance, a [simulation run](#) could be selected in the list view on the left side of the main window and then the crosshair could be used to choose that simulation run.

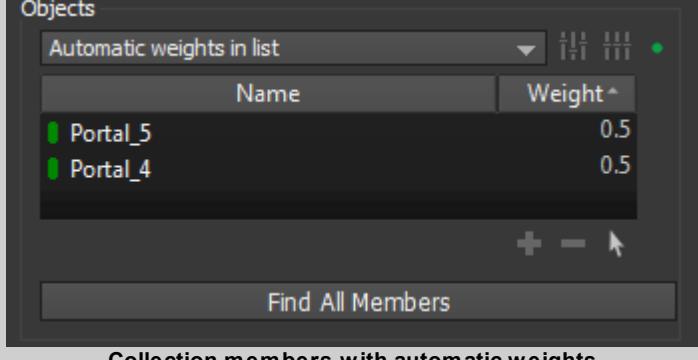
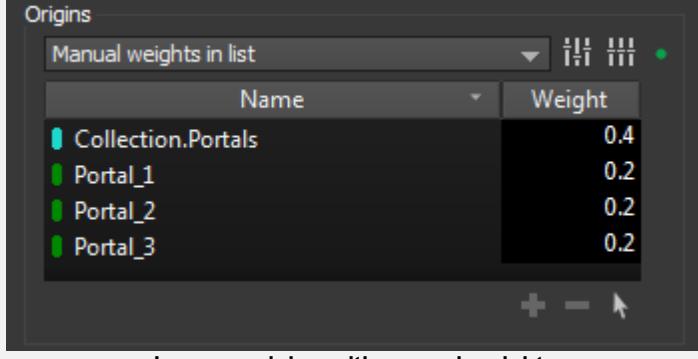
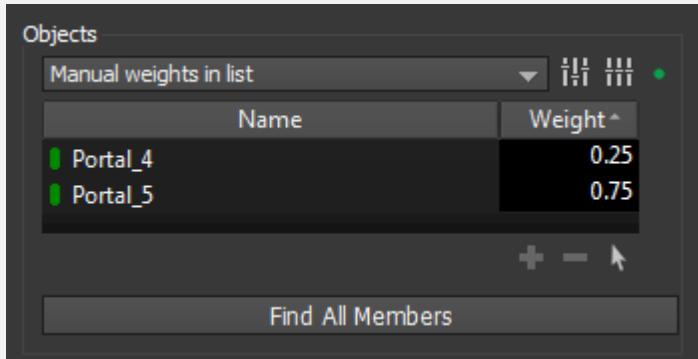
Multiple Objects

Similar to single objects, clicking on the mouse cursor icon or in an empty multi-object field will bring up a separate selection dialog. The two arrows in this dialog can be used to move valid objects between the **Available** and **Selected** columns. Alternatively, objects that are currently selected can be directly added or removed to or from the chosen objects field using the plus or minus buttons. For instance, one or more links could be selected in the 3D view and then added or removed from a bank by using the plus and minus buttons.

In some cases, the order of chosen objects is important, such as when defining a [trip](#). In these cases the multi-object field will additionally have up and down arrows that can be used to change the order of selected objects.

Finally, chosen objects can sometimes have weights assigned to them, such as the origin [portals](#) in a [journey event](#). In the following table, assume that three individual portals and one collection of two portals have been set up. There are then three options for how to assign and use weights:

Description	Meaning
All equally likely	<p>All individual objects in the list, and all member objects of any collections in the list, are merged into a single large set and weighted equally. In the example below, each individual portal would have a weight of 0.2 since there are a total of 5 portals.</p>  <p>Journey origins ignoring weights</p>  <p>Collection members ignoring weights</p>
Automatic weights	<p>Each item in the list is weighted equally; in the example below the three top-level portals and the collection would each have a weight of 0.25. For any item that is a collection, the collection's weight is then divided between the collection's individual member items based on each item's weighting within the collection. Again in the example below, the two portals inside the collection would both have a weight of 0.125 (half of 0.25 each).</p>  <p>Journey origins with automatic weights</p>

Description	Meaning																
	<p>Objects</p>  <table border="1"> <thead> <tr> <th>Name</th> <th>Weight</th> </tr> </thead> <tbody> <tr> <td>Portal_5</td> <td>0.5</td> </tr> <tr> <td>Portal_4</td> <td>0.5</td> </tr> </tbody> </table> <p>Collection members with automatic weights</p>	Name	Weight	Portal_5	0.5	Portal_4	0.5										
Name	Weight																
Portal_5	0.5																
Portal_4	0.5																
Manual weights	<p>Each item in the list is assigned a manual weight; the two 'equalizer' buttons can be used to quickly set all weights equal or normalize them (force the sum to 1 while keeping the same relative proportions). For any item that is a collection, the manual weight assigned to the collection is then divided between the collection's individual member items based on each member's weighting within the collection.</p> <p>In the example below, the three top-level portals would keep their weights of 0.2 each while the two portals within the collection would end up with weights of 0.1 and 0.3 (one-quarter and three-quarters of 0.4 respectively).</p> <p>Origins</p>  <table border="1"> <thead> <tr> <th>Name</th> <th>Weight</th> </tr> </thead> <tbody> <tr> <td>Collection.Portals</td> <td>0.4</td> </tr> <tr> <td>Portal_1</td> <td>0.2</td> </tr> <tr> <td>Portal_2</td> <td>0.2</td> </tr> <tr> <td>Portal_3</td> <td>0.2</td> </tr> </tbody> </table> <p>Journey origins with manual weights</p> <p>Objects</p>  <table border="1"> <thead> <tr> <th>Name</th> <th>Weight</th> </tr> </thead> <tbody> <tr> <td>Portal_4</td> <td>0.25</td> </tr> <tr> <td>Portal_5</td> <td>0.75</td> </tr> </tbody> </table> <p>Collection members with manual weights</p>	Name	Weight	Collection.Portals	0.4	Portal_1	0.2	Portal_2	0.2	Portal_3	0.2	Name	Weight	Portal_4	0.25	Portal_5	0.75
Name	Weight																
Collection.Portals	0.4																
Portal_1	0.2																
Portal_2	0.2																
Portal_3	0.2																
Name	Weight																
Portal_4	0.25																
Portal_5	0.75																

4.2.8 Working with Colours

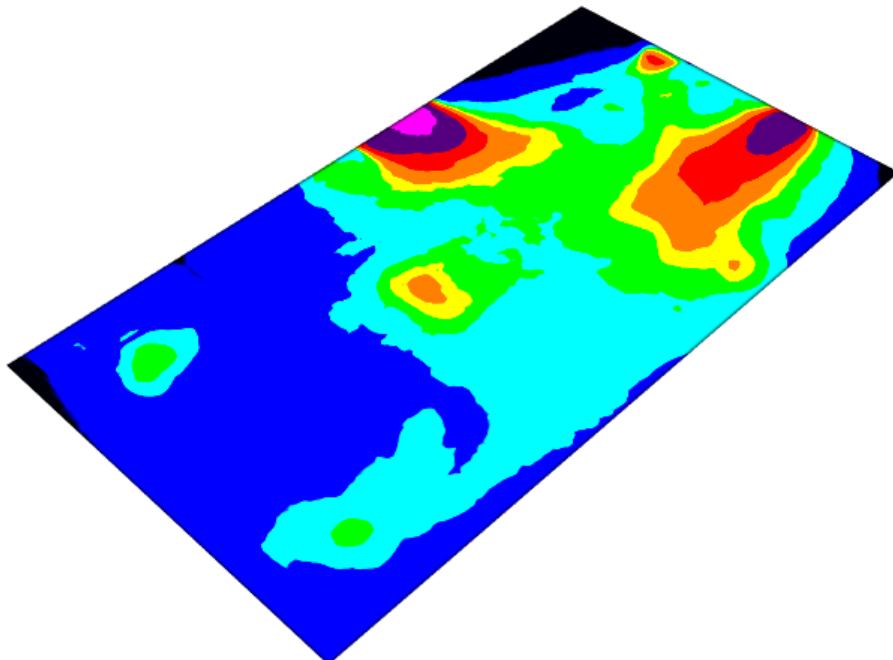
Individual Colours

Colour 'swatches' are used throughout MassMotion wherever a colour should be specified (such as the colour of an object in the 3D scene, or the colour of an individual series in a [graph](#)). In all such cases, the colour swatch shows a preview of the colour and can be clicked to bring up a full-featured colour dialog. Note that transparency can be set if desired by changing the 'Alpha channel' in the colour dialog; an alpha channel value of 255 is fully opaque while a value of 0 is fully transparent (invisible).

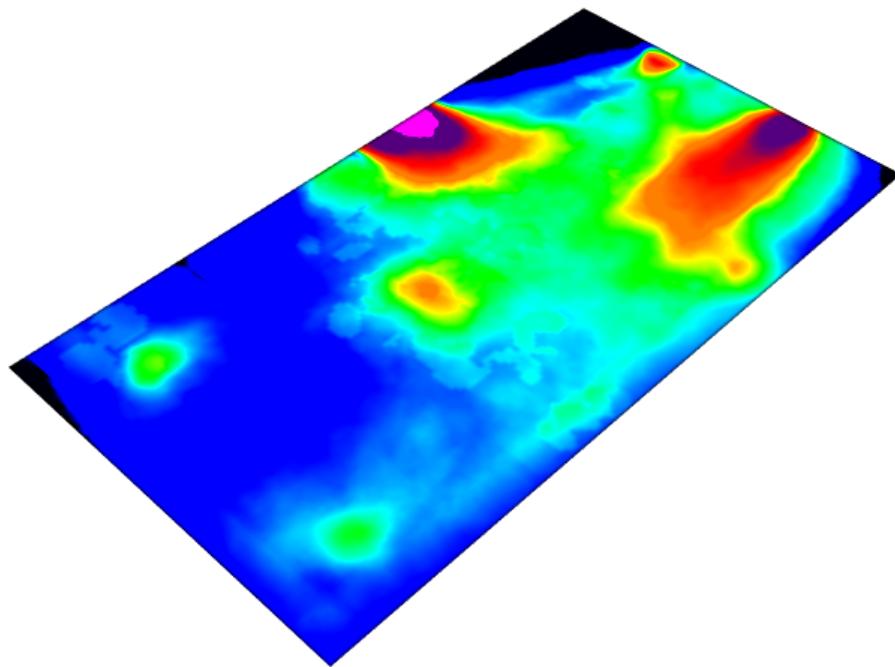
Alternatively, the swatch can be right-clicked to select from a small number of built-in colours or reset the colour to its default value (e.g., light blue for a [floor](#)).

Colour Contours and Gradients

It is sometimes necessary to define a mapping between numerical values (such as time or density values) and colours, such as in some [map queries](#). For instance, the Fruin and IATA standards described in [LOS Colour Mapping](#) define colours associated with different ranges of agent density. In MassMotion, custom colour mappings can be defined by specifying a list of colours with cutoff values in between colours. In most cases, these cutoff values and colours can then be visualized as either discrete colour bands with sharp contours, or as smooth gradients.

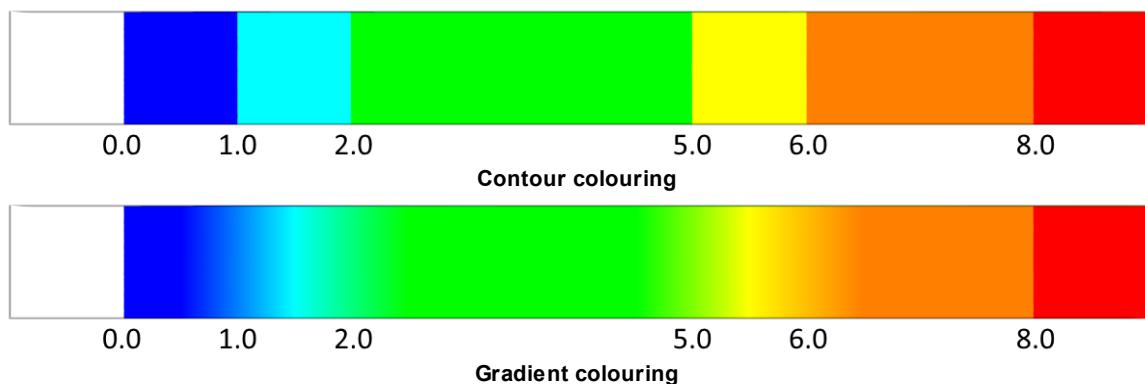


Contour colouring



Gradient colouring

The number of colours is always one more than the number of cutoff values. The first colour is used for all values less than the first cutoff value and the last colour is used for all values greater than the last cutoff value. If sharp contours are used, the second colour is used for all values between the first and second cutoff value, the third colour is used for all values between the second and third cutoff values, and so on. If a gradient is used, colour values are smoothly interpolated across each cutoff value except for the first and last, which remain as sharp cutoffs. For example, the images below show the relationship between numerical value and colour for cutoff values of 0.0, 1.0, 2.0, 5.0, 6.0 and 8.0. In the images above, note that the black and pink contours remain sharp even in the gradient version. (In many cases the lower sharp cutoff will not be visible since it typically has an associated cutoff value of 0.0, and often no values are less than or equal to 0.0.)



The gradient behaviour is designed so that it is obvious (via a sharp edge) when a value falls outside of the expected range. To avoid the sharp cutoff at each end of a gradient, the recommended method is typically:

- At the lower end, make the first two colours the same. In the above example, blue could be used for both 'less than or equal to 0.0' and 'between 0.0 and 1.0'. Note that this means it will no longer be possible to tell the difference between a small value and 'no data'.
- At the upper end, add an extra cutoff value and associated colour; the cutoff value chosen should

be one that you do not expect to ever reach. In the above example, a cutoff value of 12.0 could be added with an associated colour of bright pink. This will cause the orange and red to blend together over the cutoff value of 8.0; however, if the measured value (density, distance, time, cost etc.) ever exceeds 12.0, a sharp cutoff to bright pink will be visible, perhaps indicating a dangerously high population density or unacceptable time to exit during an evacuation.

The repeated-colour technique can also be used at the upper end, but the technique recommended above has the advantage of clearly indicating when the simulation has exceeded expected bounds.

4.2.9 Working with Time

Working with MassMotion often involves specifying individual times, durations, or time ranges, such as the time a particular event should fire or the time range over which a group of agents should enter the simulation. Times and durations can either be entered explicitly in the form HH:MM:SS or using a variety of shortcuts as shown in the table below:

Entered text	Resulting time
0	00:00:00
5	00:00:05
10s	00:00:10
2m	00:02:00
90s	00:01:30
1.5h	01:30:00
12:15	12:15:00
0:1:5	00:01:05
-30m	-00:30:00 (useful for specifying offsets, see below)

Note that:

- Combined shortcuts such as 1h30m are not supported but can be entered as 90m or 1.5h instead.
- A single number is interpreted as a count in seconds, but a time such as 1:30 is interpreted as hours and minutes.

Time Ranges

Where a simple time range is required, it can be specified as:

Description	Meaning
All available	The entire simulation
All before	From the beginning of the simulation to the specified time
All after	From the specified time to the end of the simulation

Description	Meaning
Specified interval	From the specified start time, for the specified duration

Time References

In several places, times can be entered as either absolute or relative to another time. These can be specified as:

Description	Meaning
Absolute	A specific time in HH:MM:SS form. This is relative to midnight (00:00:00) on the start day of the simulation. For instance, if the start time of the simulation (from the project settings) is set to 08:30:00, an absolute time of 00:30:00 is actually before the start of the simulation; an absolute time of 09:00:00 should be used in this case instead.
Event start	A specified offset from the start of a specified event (negative offset values can be used if necessary).
Simulation start	A specified offset from the start time of the simulation.
Simulation end	A specified offset from the end time of the simulation (in this case, a negative offset value should probably be used).

Time Reference Ranges

In some places, time ranges can be specified using time references (as above) instead of simple times. In these cases the following options are possible:

Description	Meaning
All simulation	The entire simulation
Between start and end	Starting from one specified time reference, continuing until a second specified time reference
Over duration	Starting from one specified time reference, continuing for a specified duration
Scheduled	Specified using a series of intervals. Starting from the beginning of an interval and continuing for the duration of the interval. Repeating for each interval. Interval start times are relative to the starting time reference.

4.2.10 Triggering Events

Events can be used to create agents, apply actions to agents, or modify the state of scene objects. An event that is engaged in any of these activities is said to be **active**. An event can become active multiple times during a simulation.

Events can become active at a specified time for a specified interval, or they can be set to become active in response to changing conditions in the scene. Once an event becomes active, it will remain active until done or turned off. An event cannot restart once active. An event can become active again immediately after ceasing to be active.

[Triggers](#) are the mechanism by which events can be turned on and off. A trigger will 'fire' when a certain condition is met. The most basic triggers are time triggers which fire at a specified time. A more complicated trigger is the area population trigger which will fire continuously whenever the population in an area is above or below a target threshold. Triggers can be combined together using logic to create complex combinations of conditions.

Simple Start Trigger

Some events like the [Journey](#) will become active whenever the starting trigger fires. The journey will then create agents over the specified duration. If the starting trigger fires again while the journey is active, that firing is ignored. Once the journey has completed creating all agents, it will cease to be active. The next time the starting trigger fires the journey will again become active and create the specified number of agents.

Trigger Range

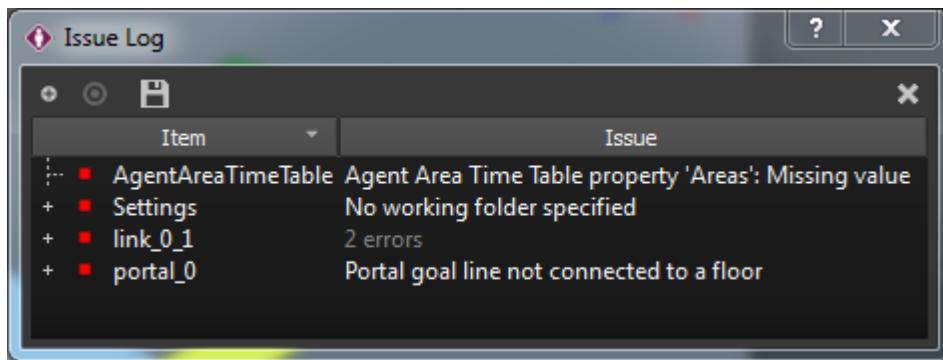
Events like the [Gate Access](#) will specify an active range using a trigger range. The trigger range will specify a starting trigger and an end condition. The gate event will open/close the gates when the start trigger fires, leave the gates open/closed while active, then return the gates to their original state when the end condition is met. While active, the start trigger is ignored. Once the end condition has been met and the event is no longer active, the start trigger can again fire and cause the event to become active.

Trigger Range	
All simulation	The event will become active at the start of the simulation and remain active until the end of the simulation.
Between start and end	The event will become active when the start trigger fires. Once active, the event will remain active until the end trigger fires. Any firings by the start trigger while active, or by the end trigger while inactive are ignored.
Over duration	The event will become active when the start trigger fires and remain active for the specified interval.
Scheduled	The event will become active according to the table of intervals. The scheduled times are with respect to the firing of the start trigger. The event is considered active from the firing of the start trigger to the completion of the final interval. Any firing of the start trigger while the event is active is ignored.
Whenever	The event will be active any time the condition is satisfied, and will not be active when the condition is not satisfied.

4.2.11 Issue Window

The issue window lists the results of a [validation](#) or [audit](#). In the case of validation the window shows potential errors in any object or the project settings. The issue window can be accessed from the bottom right of the [main window](#), listing the results of the last validation.

A similar issue log panel is available at the end of a simulation, listing any issues which arose during the course of the simulation.



Issues are grouped by the objects they are related to, and individual issues for each object and further details can be seen by expanding listed items. All issues can be expanded at once using "Toggle expansion" button.

When an issue or audit result references one or more objects, those objects can be highlighted in the [list](#) and [scene](#) views using the "Select subject" bullseye button. The contents of the issue window can be saved to an external CSV file.

4.2.12 Keyboard and Mouse Controls

Project Controls	
Ctrl-A	Select all from view. Select visible objects in the 3D scene view or the current members of the list view .
Ctrl-Z	Undo
Ctrl-Y	Redo
Ctrl-S	Save

Camera Manipulation Controls	
Pan	Press and hold the 'S' key, then press and hold the left mouse button while moving the mouse. Alternative: Hold the middle mouse button while moving the mouse.
Rotate	Press and hold the 'S' key, then press and hold the right mouse button while moving the mouse. Note rotations are done around the current focus object. To change the focus object, select the object and press the 'F' key. Alternative: Hold the shift key and middle mouse button while moving the mouse.

Camera Manipulation Controls	
Zoom	Press and hold the 'S' key, then press and hold the middle mouse button while moving the mouse. Alternative 1: Hold the control key and middle mouse button while moving the mouse. Alternative 2: Scroll the mouse wheel.
A - Show All	Use the 'A' key to move the camera so that all visible objects and agents are framed within in the view.
F - Focus	Use the 'F' key to centre and zoom to frame within the view the currently selected object(s). The selection object(s) will become the new focus for any camera rotations.

Playback Controls	
Right Arrow	Advance one frame in playback.
Left Arrow	Rewind one frame in playback.
Up Arrow	Play/pause simulation playback.
Down Arrow	Pause simulation playback.

Object Selection Controls	
Left Click	Selects an object or agents in the scene. Click and drag to "box select" multiple objects. Dragging right will only select objects fully enclosed by the box, dragging left will select any object within or overlapped by the box.
Ctrl Key + Left Click	Hold this key while selecting objects to toggle (add/remove) objects in the current selection.
Shift Key + Left Click	Hold this key to add objects to the selection
E	While an object is selected, switch to edge selection mode. Only edges of selected objects can be selected.
T	While an object is selected, switch to vertex selection mode. Only vertices of selected objects can be selected.
Y	While an object is selected, switch to face selection mode. Only faces of selected objects can be selected.
Space	Return to object selection mode. Any manipulations will also be stopped.
Escape	Cancel or clear the current operation. Repeatedly pressing escape will walk back

Object Selection Controls	
	through active modes until in object select mode with no objects selected.
Mode Controls	
M	Opens the measure tool. See Model Panel tools for more information.
I	Opens the tracing tool. See Tracing New Objects for more information.
Q	Enter or exit process chain edit mode for editing the connections between servers .
D	While a drawing layer is selected, switch to drawing mode. Only points and lines of the selected drawing layer can be selected.
R	While a drawing layer is selected, switch to drawing mode and fill all regions of the drawing layer. If already in drawing mode with drawing lines selected, only fill regions using the selected lines.
Transform Controls	
X, C, V, B	Starts scaling, rotating, translation, or snap manipulations respectively. See Editing Geometry or Transforming Objects for more information.
Z	Starts manipulator snap for moving the selection frame of reference. See Editing Geometry or Changing the Reference Frame for more information.
Tool Controls	
Right Click	Open a context specific menu which can be used to modify objects, view their properties, find related objects or create new objects in the scene view . Object components have a separate context menu specific to the type of component.
Ctrl-D	Duplicate the currently selected object. The new object will be selected.
G	Starts a growing operation when a vertex, edge or face is selected. See Editing Geometry or Growing Objects for more information.
N	Generate a new object of a specific type from the current selection using the current generation options .
O	In trace mode, close the traced polygon by adding a new line between the previous line and the starting point (see Tracing New Objects).
K	Opens the slice (Knife) tool. See Editing Geometry for more information.
U	Applies Extend and Fuse to selected lines in a Drawing Layer . See Drawing Commands for more information.
Delete	Delete selected objects or components.

4.2.13 Application Preferences

MassMotion provides a number of preferences that apply to all projects. These preferences can be accessed under Preferences in the main window's Edit menu.

General	
Scene View: Background	Background colour to use when displaying scenes.
Scene View: Near clip distance	Minimum distance from the camera at which objects are visible. Decrease to avoid clipping objects, at the cost of rendering accuracy (objects will be more likely to appear to overlap each other).
Scene View: Far clip distance	Maximum distance from the camera at which objects are visible. Increase as necessary for very large scenes, at the cost of rendering accuracy (objects will be more likely to appear to overlap each other).
File Import/Export: List separator	Specify the default separator character to use when importing and exporting csv files. This will affect Timetable files, query data export, and agent position export .
Auto Save: Enable	When enabled, the current project will be saved to a temporary folder at regular intervals. See auto save for more information.
Auto Save: Interval	Specify the interval between auto saves.
Reset	Reset all general to MassMotion defaults.

Editing	
Object Creation: From objects	Specify the default action to take when converting one object to another.
Object Creation: From faces	Specify the default action to take when converting a series of object faces into another object.
Object Creation: From drawings	Specify the default action to take when converting a series of drawing components into a new object.
Undo: Stack size	Set the number of undo steps to remember. The larger the number the larger the memory footprint taken by the undo system. When modifying the geometry of large models each undo operation can hold a significant copy of the model in memory. Reducing the stack size can help reduce the amount of RAM required to edit a large project.

Movie/Image	
Appearance: Resolution	Default resolution to use for movie/image export.
Appearance: Background	Default background colour to use for movie/image export.

Movie: Quality	Default quality setting to use for movie/image export.
Movie: Frame rate	Default frame rate to use for movie/image export.
Overlay: Text	Default overlay text colour to use for movie/image export.
Overlay: Population count	Whether population count should be displayed by default during movie/image export.
Overlay: Time	Whether current time should be displayed by default during movie/image export.
Overlay: Map legend	Whether the map legend (if any) should be displayed by default during movie/image export.
Overlay: Map title	Whether the map title (if any) should be displayed by default during movie/image export.
Overlay: Reference axes	Whether the set of reference axes should be displayed by default during movie/image export.
Reset	Reset all movie/image preferences to MassMotion defaults.

4.3 Objects

As described in the [Objects](#) page of the user guide, a MassMotion project consists primarily of a set of objects. Objects can be classified as:

- [Scene](#): physical objects such as floors, which have a physical presence in the scene
- [Activities](#): create agents, modify agents, or perform operations on the scene
- [Analysis](#): queries and related objects that are used to analyze the results of a simulation

This section describes the properties of each individual type of object in detail.

4.3.1 Scene Objects

Imported Geometry

Scene Object Type	Description
Reference Geometry	Imported geometry from external sources. Reference geometry will come in as either a generic geometry (3d mesh), a drawing layer (2d drawings) or a special ifc geometry for IFC files.

Basic Objects

Scene Object Type	Description
Floor	Floors represent any flat area in which agents may walk.
Barrier	Obstacles that block agents from passing through.

Portal	Represents entrances into the simulation as well as agent destinations.
Escalator	A vertical connection object representing an escalator. Escalators must be unidirectional.
Server	Used to model queues and more complex agent behaviour.
Stair	A vertical connection object which represents a stair.
Visual	Cosmetic objects that enhance the look of the scene.

Connecting Objects

Scene Object Type	Description
Link	A connection object which connects floors horizontally. May represent a doorway or turnstile.
Stair	A vertical connection object which represents a stair.
Escalator	A vertical connection object representing an escalator. Escalators must be unidirectional.
Ramp	A vertical connection object which represents a ramp.
Path	A connection object constructed from a curve segment. Does not need to be horizontal.

Counting Objects

Scene Object Type	Description
Cordon	These objects represent boundaries in space that agents can cross.
Volume	These objects represent test volumes in space that may contain agents.

Decorative Objects

Scene Object Type	Description
Visual	Cosmetic objects that enhance the look of the scene but have no impact on the simulation.

Collections

Collections are containers of other objects. Some collections are used during the simulation and others are for modeling and analysis.

Scene Object	Description

Type	
Bank	Represents a set of nearby connections between two objects. Affects agents in simulation.
Collection	A general multi-purpose collection that can store any non-collection object.
Perimeter	A set of connections which cannot be crossed more than once. Affects agents in simulation.
Zone	A conceptual area in the simulation.
Transform	Created automatically to contain the reference geometry objects from an imported geometry file.

4.3.1.1 Collections

Collections are a versatile way of using and interacting with objects. Some collections have an impact on simulation execution. All collections can be used as simple containers for controlling scene object visibility in bulk or referencing a set of objects all at once.

Members of a collection can be selected using "Find -> Collection Members" in the right click menu or the "Find all members" button in the collection properties.

Collections as parameters

A collection can be chosen in most places where multiple objects are expected (such as the gated [links](#) for an [open gate event](#)). Choosing a collection is similar to individually choosing its various members. When a collection contains members that do not make sense for the given choice, those members are ignored. For instance, a [general collection](#) called "EastWing" might include a combination of links, floors and portals. Using that collection within an open gate event would only make use of the gated links, while all other members would be ignored.

The type of objects used from a collection will be indicated by appending a suffix to the collection name. For example, a [map query](#) choosing a [general collection](#) called "EastWing" will refer to the collection as "EastWing.Surfaces" in its properties.

List of collection suffixes

Suffix	Description
Areas	Area objects: walkable objects (floors , links , etc.) or volumes .
Connections	Connection objects (ie. links , stairs , escalators , ramps and paths).
Cordons	Cordons
ExitPortals	Portals which are set to be destinations.
Gates	Links and other connection objects which have gated access.
Portals	Portals
Profiles	Profiles

Servers	Servers
SimRuns	Simulation Runs
Surfaces	Paintable surfaces, used for map queries . Is usually only walkable objects, but the vision time map can also paint barriers.
TripPoints	Possible destinations for a trip (ie. areas , cordons , portals and servers). When used in a trip , reaching any of the members will count as fulfilling that stage of the trip.
Tokens	Tokens
Volumes	Volumes
Walkables	Walkable objects (floors , links , etc.).

Types of Collections

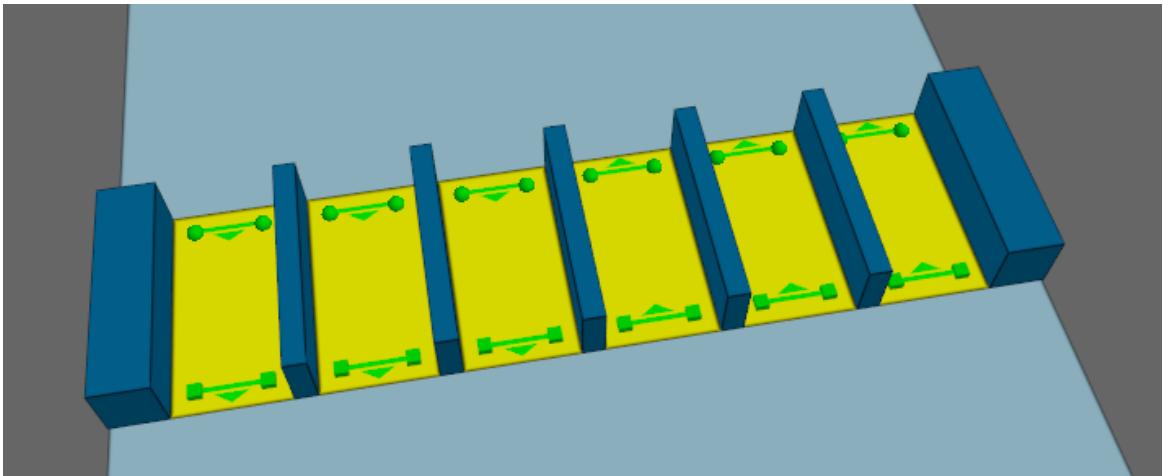
Collection Type	Description
Bank	A collection of connection objects which connect the same two objects. Banks help agents navigate clusters of similar and closely placed connections.
General Collection	A collection of any type of object except other collections.
Perimeter	A collection of connection objects encircling a conceptual area of interest. Agents cannot cross the same perimeter twice.
Zone	A collection of walkable objects which define a conceptual area in the simulation. Connected links and portals can be automatically included.
Reference Model	A collection of reference geometry objects which were imported from the same file. These are created automatically by importing geometry.

4.3.1.1.1 Bank

A bank is a collection that contains [connection objects](#) such as [links](#), [stairs](#), [escalators](#), [ramps](#) and [paths](#) that are close together and connect the same two floors. A bank groups the similar connections together and makes them appear as one choice to agents navigating the space.

During navigation, agents will attempt to choose the most convenient connection based on a number of factors including congestion, distance to the connection (near distance), and distance from the connection to the goal (downstream distance). In many cases this results in unequal distribution of agents along a set of very similar connections due to alignment of the incoming flow, unequal widths of links, or small (but largely irrelevant) differences in downstream distance.

When connections are banked, agents ignore downstream distance and focus exclusively on the remaining cost factors. This results in agents being better spread out over a large set of connections and improves flow across the bank.



A row of turnstiles. Two banks should be created, one for the three links on the left, and another for the three links on the right.

While the most common use of banks is for turnstiles or fare gate arrays, banks can also be useful for sets of vertical connections, such as stairs and escalators, where the objects are right beside one another. If both stairs and escalators are members of the same bank, agents will still prefer the escalators regardless of the bank.

Bank Properties

Properties	
Name	The name of the bank.
Objects	Members of the bank. These must be connection objects (ie. links , stairs , escalators , ramps and paths).

4.3.1.1.2 Collection

A general collection can store objects of any type except other [collections](#). They can be used as conceptual or spatial groupings of other objects. Objects can belong to more than one collection.

Collection Properties	
Name	The name of the collection.
Objects	Members of the collection. These may be any non-collections object. The weights of objects can be set here if set to manual. See Choosing Objects for more details.

4.3.1.1.3 Perimeter

Perimeters are collections of connection objects which reduce the number of available routes through a scene.

There are two common situations where this can be useful:

1. When the number of possible route permutations is so large that simulation initialization requires hours to complete. This usually occurs when there is a very large number of connections in the

scene.

2. When certain regions of the simulation should not be used as shortcuts by agents 'just passing through' (such as with fare paid zones in a transit station).

Perimeters can consist of [connection objects](#) (ie. [links](#), [stairs](#), [ramps](#), [escalators](#) and [paths](#)). When a route involves crossing a link that is a member of a perimeter, it is said to be a route which crosses that perimeter. A route will be considered invalid (and so hidden from agents) if it crosses the same perimeter more than once.

Connection objects maybe be part of several different perimeters.

Impact on available routes

Given a region of floors completely enclosed by members of a perimeter, access across the boundary to that region will be permitted only to those agents either originating inside the region or seeking a destination within the region. Agents wanting to simply pass through the region will be forced to go around. Figure 1 demonstrates the effect of perimeters on available routes through a network.

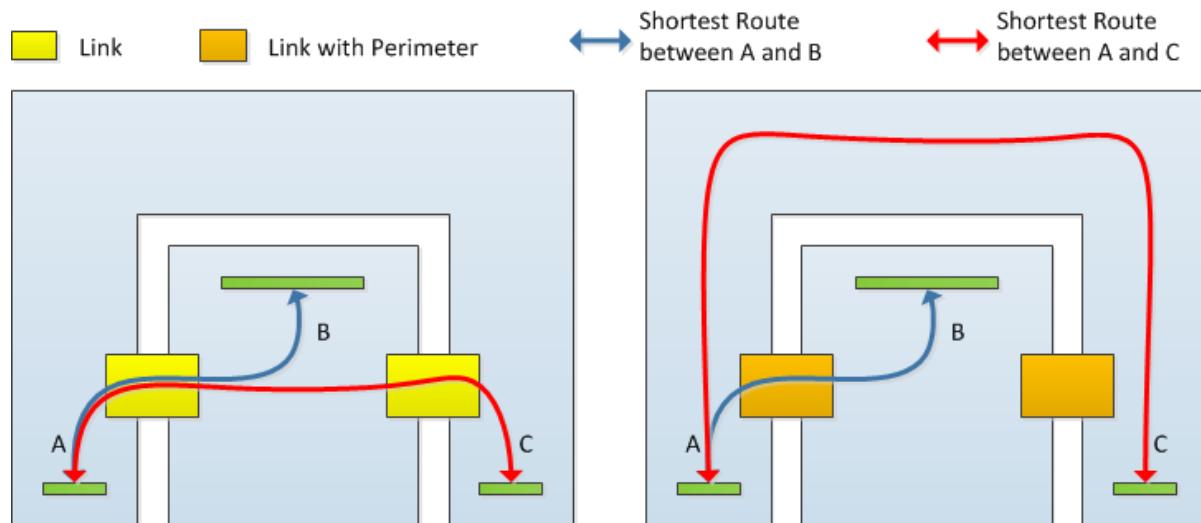


Figure 1: Example floor plan with and without a perimeter.

Care must be taken when constructing perimeters. It is important that all links that can be used to access an area are included in the perimeter. If there is a single link left out, the perimeter is said to have a hole, and will not be effective. The impact of a hole on a perimeter is shown in Figure 2.

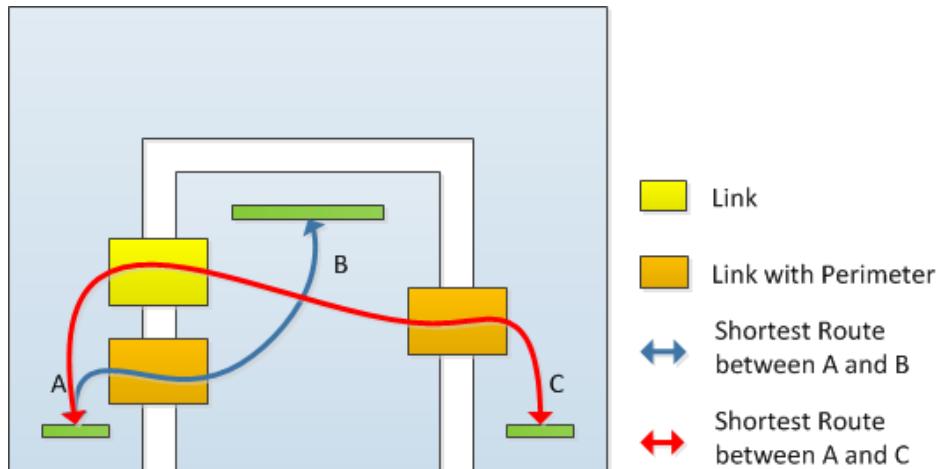


Figure 2: Example floor plan with incomplete perimeter.

Connection objects in series within a route should not be part of the same perimeter. For example, given a flight of stairs with two stairs connected by a simple floor landing, if both stairs are part of the same perimeter, the flight of stairs will become unavailable for use.

Perimeter Properties	
Name	The name of the perimeter.
Objects	Members of the perimeter. These must be connection objects (ie. links , stairs , escalators , ramps and paths).

4.3.1.1.4 Zone

A zone is a collection of objects that define a conceptual area in the simulation. Zones are specified using a set of primary members, but then will automatically include additional secondary members based on the "Type" property setting as described below. The areas in a zone do not need to be connected to one another. Objects may be members of any number of zones.

All members, both explicitly and automatically chosen, can be found by using the "Find All Members" button, or by right clicking the zone in the [list view](#) and using "Find: Collection Members".

Zones are required for use in [evacuation events](#).

Zone Properties	
Type	<p>Determines the manner in which members are specified.</p> <ul style="list-style-type: none"> • Chosen objects: Allows all walkable objects to be chosen as members. Automatically adds portals connected to member floors. • Chosen floors and interior connections: Allows only floors to be selected as members. Automatically adds portals connected to member floors as well as connections between any two member floors. • Chosen floors and all connections: Allows only floors to be selected as members. Automatically adds portals and connections touching any member floor.

Members	The explicitly chosen members of the zone. These may be floors , links , stairs , escalators , ramps and paths depending on the Type. Both the explicitly and implicitly chosen members of a zone may be selected by right-clicking on the zone in the List View and selecting Find->Collection Members.
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4.3.1.1.5 Transform

Transform collections can be used to move, scale, or rotate member objects all at once. Transforms are automatically generated when importing geometry and will contain all imported [reference geometry](#) or drawing layers from a single file. In the case of reference geometry the transform also contains texture information that is shared amongst members.

Adding or removing a member will not change the member's current size, position, or orientation. Deleting a transform will delete all associated member objects from the scene.

Reference Model Properties	
Bounding Box: Centre	The centroid of all member geometry in the transform.
Bounding Box: Size	The maximum extents of member geometry.
Transform: Scale	Apply a scale factor to all members. The dialog box provides a quick way of specifying a scale factor based on the original units used by the source modeling application when creating the member geometry.
Transform: Rotation	Apply a rotation to all members. The rotation is applied after the scale.
Transform: Translation	Apply a translation to all members. The translation is applied after scale and rotation.
Transform: Centre	Set a translation such that the bounding box centre is at the origin.
Transform: Reset	Does not move members. Return the scale to 1 and rotation and translation to (0,0,0) but keep all members at their current scale, rotation and translation.

4.3.1.2 Barrier

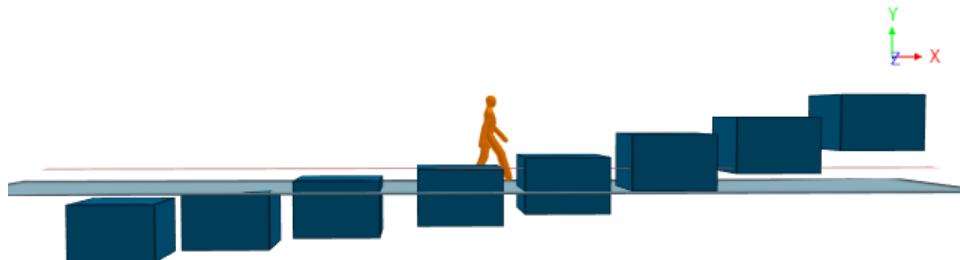
A barrier describes a region through which agents cannot pass. The default new barrier is a 1m x 1m x 1m cube which can be then edited to any size or shape.

Barrier geometry interaction with walkable geometry

The blocked region on a floor is determined using the volume of intersection between the floor and

the barrier. Those portions of the barrier that do not intersect with the floor are ignored. Those portions of the barrier that are more than 40cm above the floor are ignored.

Intersection tests are performed using the bounding box of the floor which is formed using the highest and lowest points on the floor (including the underside). If barrier walls or columns on a floor intersect with the underside of the floor above, they will impact agent movement on that floor. To avoid this, ensure that barriers for a lower floor terminate just below the upper floor.



1m tall barriers arranged at various heights relative to a floor. The red line marks the 0.4m cutoff. Measuring distance from floor to barrier top is -0.2, 0.0, 0.2, 0.4, 0.6, 1.0, 1.3, 1.7.



The resulting obstacle map shows the first and last barriers are below and above the cutoff. The 5th barrier has top and bottom beyond the cutoff so only the walls are included.

Notes on barrier geometry

- Barrier objects can be 3D volumes or 2D planes.
- Barriers can have a large impact on the time it takes to compile a simulation. Barriers that contain a large number of faces can take a long time to project onto the floor obstacle maps. Similarly, if an obstacle contains faces over a large area, then many floors will have to consider the barrier when generating their maps.
- Barriers must not completely block off links or portals on the same floor. Doing so may result in a large number of agents removed by error during simulation. If dividing the floor into unconnected areas is necessary, use separate floors for each area instead.

Properties

There are no properties for objects of this type.

4.3.1.3 Cordon

Cordon objects are used when performing analysis but have no impact on the simulation itself. Agents will ignore objects of this type. It is possible to create and use cordon objects for analysis on previously generated simulation runs without having to re-execute the run.

Notes on geometry

- Must be a single polygon mesh object or a collection of polygon mesh objects. There are no other restrictions on shape or orientation; cordons can be horizontal, vertical, curved or even closed volumes (in which case agents will be counted when passing into or out of the volume).
- During analysis, agents will be considered 'at' the cordon when the centre point between their feet crosses any surface of the cordon object.

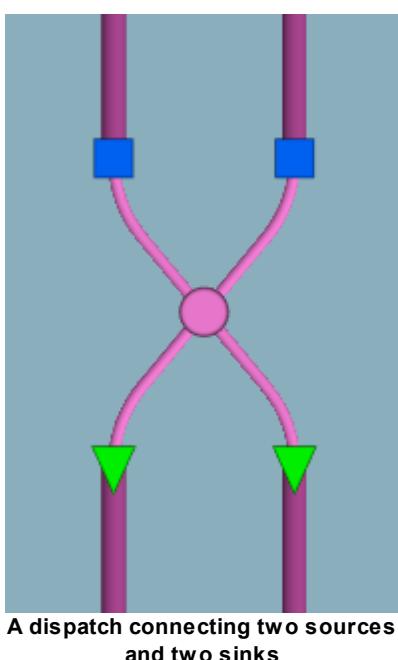
Properties

There are no properties for objects of this type.

4.3.1.4 Dispatch

Dispatch objects connect servers together into process chains and distribute agents across server inputs.

Dispatch objects are automatically created by connecting server entry and exit points together in the "Edit process chains" mode. Please refer to the overview of [Process Chains](#) for more information on how to connect server objects. **The location of dispatch objects has no effect on the movement of agents.**



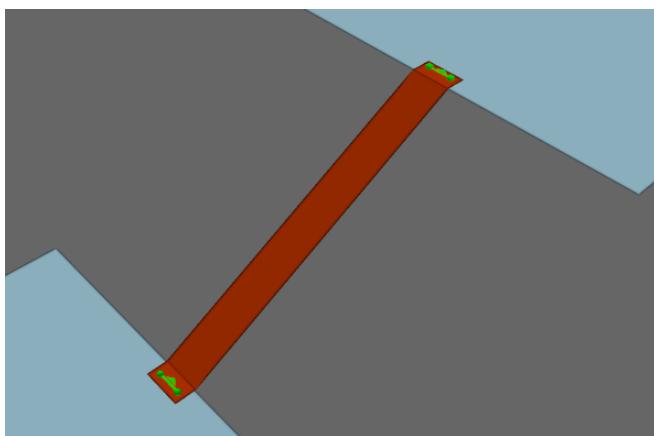
Dispatch Properties	
Assign Type	Defines the method used to distribute agents across downstream servers: Largest available capacity: Choose the server with the most space. If all servers have limited capacity this is the max capacity minus the current population. If any server is not set to limited capacity its capacity is

	<p>assumed to be infinite and it will always be chosen.</p> <p>Smallest cost: Choose the server for which processing will incur the lowest cost. Cost is calculated using the time it will take to walk to the server, the average time it will take to be processed by the server, and any time that will be spent waiting for agents already on the server. Processing time is taken from the average of the default contact time distribution (test distributions are ignored).</p> <p>Smallest distance: Choose the server that is closest to the agent.</p> <p>Smallest queue: Choose the server with the smallest queue.</p> <p>Randomly: Choose the server randomly.</p> <p>Note that preferred and required test restrictions for server access will be respected for all assignment methods.</p>
Sources	The list of connected upstream servers which feed into this dispatch. Sources can be added or removed using the multi-object chooser in the Dispatch properties page or via the connect and disconnect functions in the "Edit process chains" mode in the main application window.
Sinks	The list of connected downstream servers to which agents will be dispatched. Sinks can be added or removed using the multi-object chooser in the Dispatch properties page or via the connect and disconnect functions in the "Edit process chains" mode in the main application window.

4.3.1.5 Escalator

Escalators are a vertical [connection object](#). Unlike other connection objects, escalators must be unidirectional. They are most typically used to model real world escalators, but can be made fully horizontal to simulate moving walkways. The default new escalator is 4m tall, 7m long, and 1.15m wide, with 0.5m landings at each end where the ball connection will be at the bottom and the box connection will be at the top.

A change in elevation results in an additional vertical cost during agent route selection, however, escalators are less costly to traverse than [stairs](#) or [ramps](#).



An upwards escalator.

Restrictions on Geometry

- The escalator object itself should not include any handrails or other geometry that extends above the walkable surface. If these are desired, they should be added as separate [barrier](#) objects.
- The width of the escalator should include the distance between the handrails (for an escalator with 1m wide steps, this defaults to 1.15m).
- The escalator must have a flat landing area at each end; this should be at least 0.5m by 0.5m to allow construction of valid goal lines. Landings should be flat and approximately rectangular or trapezoidal.
- The geometry (including the landings) may have thickness, but only the top surface will be considered during the simulation.

In order to run a simulation, the escalator landings must be placed such that each goal line is between 0.01m and 0.20m above a floor, at least 0.20m from the edge of the floor. The two floors must be different (an escalator cannot be used to connect two portions of the same floor).

Impact on Agent Speed

Agent speed is modified to be exactly equal to the tread speed as specified in the escalator properties.

Properties

General Tab	
Direction	Defines the direction of the escalator. Escalators are always unidirectional (ie. either Ball to Box or Box to Ball).
Costs: Distance added	Defines any distance penalty or modified cost to be added to the escalator. A positive value will add a distance (and hence make the route less desirable for agents), and a negative value will remove a distance. Distance is measured in metres. See Agent Navigation for more information.
Costs: Queue multiplier	Increases the penalty for queuing. A higher number will increase the perceived time cost of queuing making agents more likely to seek alternate options when there is queuing. See Agent Navigation for more information.
Physical: Map Resolution	Determines the resolution of surface maps created for agent navigation. Smaller values describe escalator and barrier edges more accurately resulting in more precise walkable area definitions , but increase memory and processing requirements during simulation.
Physical: Effective Width	Defines how the width of the escalator's connections is calculated. The width is used to calculate queue times (how long it will take for a queue of agents to clear) and controlled flow if using people/minute/metre. Calculate from Geometry: The default setting where the width (m) is calculated from the vertices of the escalator edges. Specify Manually: Allows the effective width (m) of both the box and ball connections to be set to specific values. Note that this does not change the geometry of the link object, only agents' perception of the width of the object.
Tread Speed	Defines the speed of the escalator along the incline, measured in metres per second.

Access Tab	
Gate: Enable use as gate	Configures the object as a gate, closing the objects to all agents unless explicitly opened through events (see Open Gate Event).
Gate: Wait style:	<p>Sets the behaviour of agents waiting for the escalator when the gate is closed.</p> <p>Stand Still: Agents will stop moving after stepping onto a floor connected to the escalator.</p> <p>Spread Out: Agents will spread out on the floor after stepping onto a floor connected to the escalator.</p> <p>Focus On Target: Agents will move to and wait by the escalator.</p>
Gate: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Gate: Commit to wait	Sets whether agents will commit to the gate once it has been chosen. When checked agents will wait for this object regardless of changes in route costs elsewhere on the floor.
Limit Flow: Cap flow of entering agents	When enabled, the flow of entering agents is not permitted to exceed the specified rate. If demand exceeds capacity, agents are held at the goal line until there is available capacity.
Limit Flow: Rate type	<p>Sets whether the flow rate is calculated as people/minute or people/minute/metre.</p> <p>If using people/minute/metre, the effective width (general tab property) is used.</p>
Limit Flow: Max rate	Sets the maximum flow rate. Flow rate will be measured according to the rate type shown above.

Agent Behaviour tab	
Delay On Enter	<p>Sets how long an agent will be delayed before stepping onto an escalator. This can be set as a distribution in seconds, see Single Value Distributions for more information.</p> <p>If an escalator is gated and closes before the delay finishes, the agent will wait until the next time the escalator opens before attempting to step on again.</p>
Delay On Exit	Sets how long an agent will be delayed before stepping off an escalator. This can be set as a distribution in seconds, see Single Value Distributions for more information.
Traversal: Walk type	<p>Defines the manner in which agents will cross the escalator.</p> <p>Standard: Agents will consider other agents, barriers, and personal speed characteristics to calculate their trajectories.</p> <p>Ignore Barriers: As above with the exception that agents will ignore any</p>

	<p>barriers on the surface. This is the default for escalators.</p> <p>Virtual: Agents will move instantly across the surface to their intended goal, ignoring all obstructions on the surface. Commonly used for areas of a simulation environment where the agent route choices are important but crowding characteristics are not important.</p>
Body Radius: Set agent radius	If enabled the body radius for all agents on the surface will be changed to the specified value. This can be useful in areas where crowding conditions are governed by geometric or behavioural conditions outside of normal open space standards. Agents approaching the escalator will slowly (over a range of 2-3m) transition to the new radius to avoid instantaneous changes. This setting should be used with caution as a) it applies to all agents regardless of their profile settings, and b) agent movement has only been validated for radius values close to 0.25m.
Body Radius: Radius	Sets the agent radius in metres.

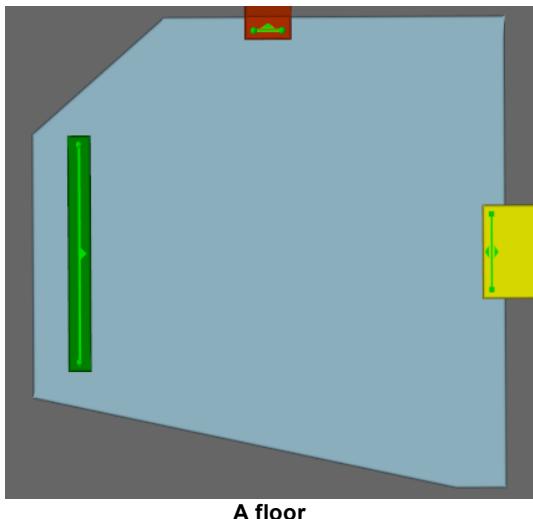
Actions Tab	
Ball: On enter	The action will be applied to all agents as they enter the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Box: On enter	The action will be applied to all agents as they enter the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Box: On exit	The action will be applied to all agents as they leave the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .

Collections Tab	
Bank	The bank which the escalator is a member of, if any. For more information, see Banks .
Perimeters	Perimeters which the escalator is a member of, if any. For more information, see Perimeters .

4.3.1.6 Floor

Floors are the most fundamental object types in a MassMotion environment. Floor objects are contiguous polygon mesh surfaces that define the extent of a "walkable" area. An agent's awareness of other agents, barriers, and route options is based on the floor on which they are standing. Most other scene objects must be connected to floor objects (portals, links, stairs, ramps, escalators).

The default new floor is a 10m x 10m flat square.



A floor

Restrictions on Geometry

- Floors may have thickness, although only the top surface will be considered during simulation.
- The floor surface must not overlap itself (the entire top surface of the floor must be visible from above).
- The floor surface should be continuous (a single floor should not have two or more disconnected parts) but may have holes.
- Floors must have dimensions of at least 2 agent widths by 2 agent widths (by default 1m x 1m).
- There is no maximum size for floors, however users should consider subdividing large ($>10,000\text{m}^2$) floors into logical areas.
- The floor surface is not required to be flat, but elevation changes are not considered for [Agent Movement](#), speed calculations, or [Agent Navigation](#).

If connected objects are completely separated by [barriers](#) on the floor, it is more appropriate to separate the floor into two separate floors. Agents attempting to traverse a floor between two links completely separated by a barrier will be removed from the simulation with an error.

Impact on Agent Speed

By default, agent speed is unaffected by floor traversal. Speed can be capped at a specific value by enabling the 'Limit Speed' property. See [Agent Profile](#) for information on agent speed.

Properties

General Tab	
Costs: Distance added	Defines any distance penalty or modified cost to be added to the floor. A positive value will add a distance (and hence make the route less desirable for agents), and a negative value will remove a distance. Distance is measured in metres.
Physical: Map resolution	Determines the resolution of surface maps created for agent navigation. Smaller values describe floor and barrier edges more accurately resulting in more precise walkable area definitions , but increase memory and processing requirements during simulation.

Agent Behaviour Tab	
Traversal: Walk type	Defines the manner in which agents will cross the floor. Standard: Agents will consider other agents, barriers, and personal speed characteristics to calculate their trajectories. This is the default for floors. Ignore Barriers: As above with the exception that agents will ignore any barriers on the surface. Used mainly for connection objects (links, stairs, escalators, ramps). Virtual: Agents will move instantly across the surface to their intended goal, ignoring all obstructions on the surface. Commonly used for areas of a simulation environment where the agent route choices are important but crowding characteristics are not important.
Body Radius	If enabled the body radius for all agents on the surface will be changed to the specified value (m). This can be useful in areas where crowding conditions are governed by geometric or behavioural conditions outside of normal open space standards. Agents approaching the floor will slowly (over a range of 2-3m) transition to the new radius to avoid instantaneous changes. This setting should be used with caution as a) it applies to all agents regardless of their profile settings, and b) agent movement has only been validated for radius values close to 0.25m.
Direction Bias	If enabled, the direction bias of agents on the surface will be changed to the specified value. This can be useful for corners or narrow spaces where the natural system wide direction bias is locally inappropriate. See Agent Profile for more information on Direction Bias.
Speed Limit	Enables a maximum threshold for agent speed (m/s). Agents traveling above the specified maximum will have their speed reduced to the maximum.
Speed Density	If enabled, agents will use the specified speed density relationship rather than the default provided by their profile. For more information on speed density, see the 'Movement' property in Agent Profile .

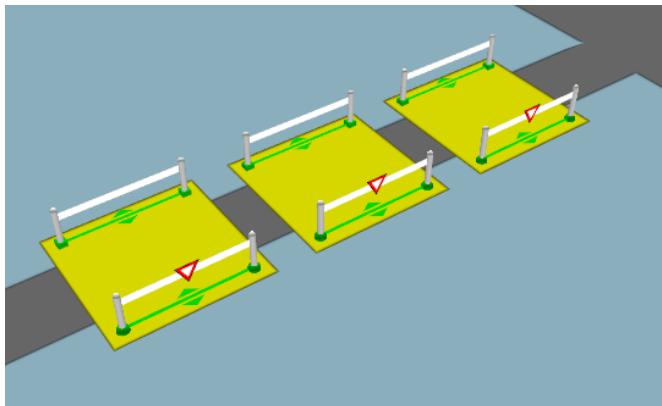
Actions Tab	
On enter	The action will be applied to all agents as they enter the object. For a description of the order in which actions are applied see Action Order of Execution .
On exit	The action will be applied to all agents as they leave the object. For a description of the order in which actions are applied see Action Order of Execution .

Collections Tab	
Zones	Zones which the floor is a member of, if any. For more information, see Zones .

4.3.1.7 Link

Links are the most basic type of [connection object](#). They act as bridges or doors through which agents may pass from one floor to the other. The default new link is a 1m x 2m flat rectangle.

Links will ignore changes in elevation and do not add any vertical route costs.



A series of gated links with priority flow enabled.

Restrictions on Geometry

In order to support properly formed goal lines, geometry used for links should be very close to flat and approximately quadrilateral (a rectangle, trapezoid or parallelogram) although they may consist of a large number of individual triangles. The link must be placed such that each goal line is between 0.01m and 0.20m above a floor, at least 0.20m from the edge of the floor. The two floors must be different (a link cannot be used to connect two portions of the same floor). Links must be at least 0.4m wide to allow proper generation of goal lines.

Impact on Agent Speed

By default, agent speed is unaffected by link traversal. Speed can be capped at a specific value through enabling the 'Limit Speed' property. See [Agent Profile](#) for information on agent speed.

Properties

General Tab	
Direction	Sets the direction in which agents can traverse the link. Two way: Agents may cross in both directions Unidirectional (ie. Ball to Box or Box to Ball): Agents may only cross in the specified direction.
Costs: Distance added	Defines any distance penalty or modified cost to be added to the link. A positive value will add a distance (and hence make the route less desirable for agents), and a negative value will remove a distance. Distance is measured in metres. See Agent Navigation for more information.
Costs: Queue multiplier	Increases the penalty for queuing. A higher number will increase the perceived time cost of queuing, which makes agents more likely to select alternative routes. See Agent Navigation for more information.
Physical: Map resolution	Determines the resolution of surface maps created for agent navigation. Smaller values describe link and barrier edges more accurately resulting in more precise walkable area definitions , but increase memory and processing requirements during simulation.

Physical: Effective width	Defines how the width of the link's connections is calculated. The width is used to calculate queue times (how long it will take for a queue of agents to clear) and controlled flow if using people/minute/metre. Calculate from Geometry: The default setting where the width (m) is calculated from the vertices of the link edges. Specify Manually: Allows the effective width (m) of both the box and ball connections to be set to specific values. Note that this does not change the geometry of the link object, only agents' perception of the width of the object.
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Access Tab	
Gate: Enable use as gate	Configures the object as a gate, closing the objects to all agents unless explicitly opened through events (see Open Gate Event).
Gate: Wait style:	Sets the behaviour of agents waiting for the link when the gate is closed. Stand Still: Agents will stop moving after stepping onto a floor connected to the link. Spread Out: Agents will spread out on the floor after stepping onto a floor connected to the link. Focus On Target: Agents will move to and wait by the link.
Gate: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Gate: Commit to wait	Sets whether agents will commit to the gate once it has been chosen. When checked agents will wait for this object regardless of changes in route costs elsewhere on the floor.
Limit Flow: Cap flow of entering agents	When enabled, the flow of entering agents is not permitted to exceed the specified rate. If demand exceeds capacity, agents are held at the goal line until there is available capacity.
Limit Flow: Rate type	Sets whether the flow rate is calculated as people/minute or people/minute/metre. If using people/minute/metre, the effective width (general tab property) is used.
Limit Flow: Max rate	Sets the maximum flow rate. Flow rate will be measured according to the rate type shown above.
Priority: Enable priority access	Enables a limited yield system where agents moving in one direction receive preferential access. This is useful for constrained geometry where the majority of the flow is in one direction, or for cases such as train doors where alighting passengers often have priority over those boarding.
Priority: Primary direction	Sets the direction in which agents will have primary access. The counter-flow direction will yield. One way (Ball to Box or Box to Ball): Agents moving in the counter-flow

	<p>direction will not enter the object when there are agents moving in the priority direction with priority access. If Primary will yield is set, agents traveling in the primary direction will yield if they arrive at the object while it is already being used by agents in the counter-flow direction. This is useful for scenarios such as ladders where usage should be restricted to one direction at a time.</p> <p>Two way: Agents in either direction can claim priority access. Priority access is maintained for a given direction until there are no more agents crossing in that direction.</p>
Priority: Capture range	Sets the distance in metres from which agents approaching the object can capture priority access.
Priority: Move aside	When enabled, agents in the counter-flow direction will move aside to accommodate the priority flow.
Priority: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Priority: Commit to wait	When enabled, agents that have chosen the object will continue to wait until they have access regardless of changes to costs in other routes on the floor.

Agent Behaviour tab	
Delay On Enter	<p>Sets how long an agent will be delayed before stepping onto a link. This can be set as a distribution in seconds, see Single Value Distributions for more information.</p> <p>If a link is gated and closes before the delay finishes, the agent will wait until the next time the link opens before attempting to step on again.</p>
Delay On Exit	Sets how long an agent will be delayed before stepping off a link. This can be set as a distribution in seconds, see Single Value Distributions for more information.
Traversal: Walk type	<p>Defines the manner in which agents will cross the link.</p> <p>Standard: Agents will consider other agents, barriers, and personal speed characteristics to calculate their trajectories.</p> <p>Ignore Barriers: As above with the exception that agents will ignore any barriers on the surface. Used mainly for connection objects (links, stairs, escalators, ramps).</p> <p>Virtual: Agents will move instantly across the surface to their intended goal, ignoring all obstructions on the surface. Commonly used for areas of a simulation environment where the agent route choices are important but crowding characteristics are not important.</p>
Body Radius	If enabled the body radius for all agents on the surface will be changed to the specified value (m). This can be useful in areas where crowding conditions are governed by geometric or behavioural conditions outside of normal open space standards. Agents approaching the link will slowly (over a range of 2-3m) transition to the new radius to avoid instantaneous

	changes. This setting should be used with caution as a) it applies to all agents regardless of their profile settings, and b) agent movement has only been validated for radius values close to 0.25m.
Direction Bias	If enabled, the direction bias of agents on the surface will be changed to the specified value. This can be useful for corners or narrow spaces where the natural system wide direction bias is locally inappropriate. See Agent Profile for more information on direction bias.
Speed Limit	Enables a maximum threshold for agent speed (m/s). Agents traveling above the specified maximum will have their speed reduced to the maximum.
Speed Density	If enabled, agents will use the specified speed density relationship rather than the default provided by their profile. For more information on speed density, see the 'Movement' property in Agent Profile .

Actions Tab	
Ball: On enter	The action will be applied to all agents as they enter the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On enter	The action will be applied to all agents as they enter the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .

Collections Tab	
Bank	The bank which the link is a member of, if any. For more information, see Banks .
Perimeters	Perimeters which the link is a member of, if any. For more information, see Perimeters .

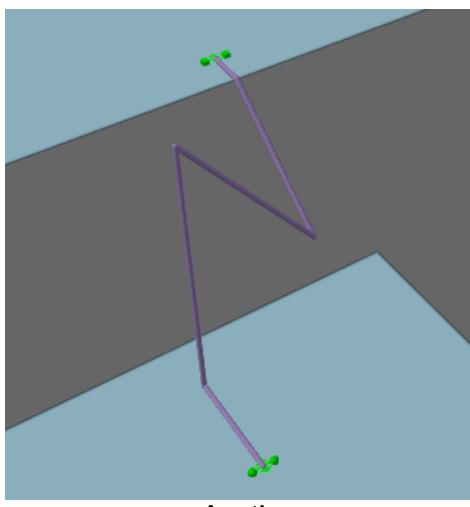
4.3.1.8 Path

Paths are [connection objects](#) consisting of a simple curve. There are no restrictions on the shape of the curve, and they may be vertical or even intersect themselves and other geometry.

The default new path is a 2m horizontal line segment. This line segment can be extended by growing the end vertices, or splitting the edge into multiple pieces. See [Editing Geometry](#) for more information on editing paths.

Agents can enter the curve at one end, follow along the curve in single file, and exit at the far end. While on a curve agents will either move at their desired speed or follow immediately behind the agent in front. Agents on the curve will ignore agents not following the curve or on the same curve but moving in the opposite direction. Agents not on the curve will attempt to avoid agents on the curve.

Agents on a path will see each other as cylinders with a radius equal to their body radius. Agents following behind another will maintain a "Queue Spacing" (set in Agent Behaviour) between the surfaces of the cylinders.



A path

Restrictions on Geometry:

- A path must contain a single curve object.
- Each end point of the curve must be positioned just *above* a separate floor.
- There are no restrictions on the path described by the curve provided that it is continuous.
- The final line segment at either end of the path should be roughly horizontal so as to produce valid goal lines.

Impact on Agent Speed

By default, agent speed is unaffected by path traversal. Agents will slow down to follow an agent that is immediately in front. Speed can be capped at a specific value through enabling the 'Limit Speed' property. See [Agent Profile](#) for information on agent speed.

Properties

General Tab	
Direction	Sets the direction in which agents can traverse the path. Two way: Agents may cross in both directions Unidirectional (ie. Ball to Box or Box to Ball): Agents may only cross in the specified direction.

Costs: Distance added	Defines any distance penalty or modified cost to be added to the path. A positive value will add a distance (and hence make the route less desirable for agents), and a negative value will remove a distance. Distance is measured in metres. See Agent Navigation for more information.
Costs: Queue multiplier	Increases the penalty for queuing. A higher number will increase the perceived time cost of queuing, which makes agents more likely to select alternative routes. See Agent Navigation for more information.
Physical: Effective width	<p>Paths are represented as lines, but the goal lines onto and off of the lines still have width.</p> <p>Defines how the width of the path's connections is calculated. The width is used to calculate queue times (how long it will take for a queue of agents to clear) and controlled flow if using people/minute/metre.</p> <p>Calculate from Geometry: The default setting where the width (m) is calculated from the goal line width.</p> <p>Specify Manually: Allows the effective width (m) of both the box and ball connections to be set to specific values.</p>

Access Tab	
Gate: Enable use as gate	Configures the object as a gate, closing the objects to all agents unless explicitly opened through events (see Open Gate Event).
Gate: Wait style:	<p>Sets the behaviour of agents waiting for the path when the gate is closed.</p> <p>Stand Still: Agents will stop moving after stepping onto a floor connected to the path.</p> <p>Spread Out: Agents will spread out on the floor after stepping onto a floor connected to the path.</p> <p>Focus On Target: Agents will move to and wait by the path.</p>
Gate: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Gate: Commit to wait	Sets whether agents will commit to the gate once it has been chosen. When checked agents will wait for this object regardless of changes in route costs elsewhere on the floor.
Limit Flow: Cap flow of entering agents	When enabled, the flow of entering agents is not permitted to exceed the specified rate. If demand exceeds capacity, agents are held at the goal line until there is available capacity.
Limit Flow: Rate type	<p>Sets whether the flow rate is calculated as people/minute or people/minute/metre.</p> <p>If using people/minute/metre, the effective width (general tab property) is used.</p>
Limit Flow: Max rate	Sets the maximum flow rate. Flow rate will be measured according to the rate type shown above.

Priority: Enable priority access	Enables a limited yield system where agents moving in one direction receive preferential access. This is useful for constrained geometry where the majority of the flow is in one direction, or for cases such as train doors where alighting passengers often have priority over those boarding.
Priority: Primary direction	<p>Sets the direction in which agents will have primary access. The counter-flow direction will yield.</p> <p>One way (Ball to Box or Box to Ball): Agents moving in the counter-flow direction will not enter the object when there are agents moving in the priority direction with priority access. If Primary will yield is set, agents traveling in the primary direction will yield if they arrive at the object while it is already being used by agents in the counter-flow direction. This is useful for scenarios such as ladders where usage should be restricted to one direction at a time.</p> <p>Two way: Agents in either direction can claim priority access. Priority access is maintained for a given direction until there are no more agents crossing in that direction.</p>
Priority: Capture range	Sets the distance in metres from which agents approaching the object can capture priority access.
Priority: Move aside	When enabled, agents in the counter-flow direction will move aside to accommodate the priority flow.
Priority: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Priority: Commit to wait	When enabled, agents that have chosen the object will continue to wait until they have access regardless of changes to costs in other routes on the floor.

Agent Behaviour Tab	
Queue Spacing	This determines how closely each agent will follow a previous agent. This can be set as a distribution in metres, see Single Value Distributions for more information.
Delay On Enter	<p>Sets how long an agent will be delayed before stepping onto a path. This can be set as a distribution in seconds, see Single Value Distributions for more information.</p> <p>If a path is gated and closes before the delay finishes, the agent will wait until the next time the path opens before attempting to step on again.</p>
Delay On Exit	Sets how long an agent will be delayed before stepping off a path. This can be set as a distribution in seconds, see Single Value Distributions for more information.
Traversal: Walk type	<p>Defines the manner in which agents will cross the path.</p> <p>Standard: Agents will consider other agents, barriers, and personal speed characteristics to calculate their trajectories.</p>

	<p>Ignore Barriers: Identical to 'Standard' for paths, as agents always ignore barriers when traversing paths.</p> <p>Virtual: Agents will move instantly to the other end of the path. When a path is virtual, route distance calculations ignore the internal geometry of the path and measure the straight line distance between the two path end points.</p>
Body Radius	<p>If enabled the body radius for all agents on the surface will be changed to the specified value (m). This can be useful in areas where crowding conditions are governed by geometric or behavioural conditions outside of normal open space standards. Agents approaching the path will slowly (over a range of 2-3m) transition to the new radius to avoid instantaneous changes. This setting should be used with caution as a) it applies to all agents regardless of their profile settings, and b) agent movement has only been validated for radius values close to 0.25m.</p> <p>Agents on a path will see each other as cylinders with a radius equal to their body radius and will maintain a space between each other set by their "Queue Spacing".</p>
Speed Limit	Enables a maximum threshold for agent speed (m/s). Agents traveling above the specified maximum will have their speed reduced to the maximum.
Speed Density	If enabled, agents will use the specified speed density relationship rather than the default provided by their profile. For more information on speed density, see the 'Movement' property in Agent Profile .

Actions Tab	
Ball: On enter	The action will be applied to all agents as they enter the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On enter	The action will be applied to all agents as they enter the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .

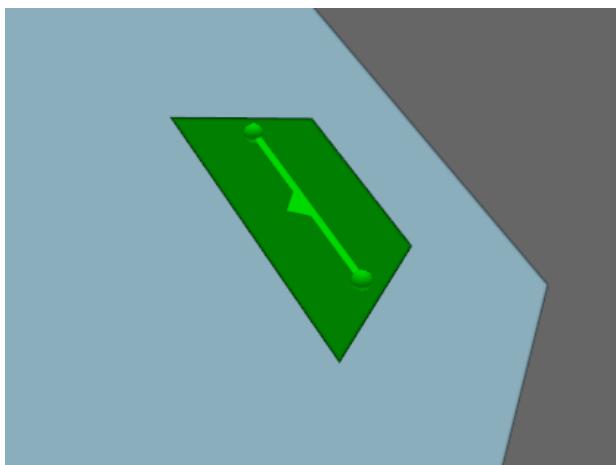
Collections Tab	
Bank	The bank which the path is a member of, if any. For more information, see Banks .

Perimeters	Perimeters which the path is a member of, if any. For more information, see Perimeters .
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4.3.1.9 Portal

Portals act as both entrances and destinations for agents in the simulation. All portals can serve as an entrance, specified through agent creation events. Portals are by default also enabled as destinations, allowing agents to seek them as intermediate destinations or final simulation exits.

Destination portals require additional time to initialize during simulations. If simulation initialization is too time consuming, consider changing some portals into "Entrance Only".



A portal

Restrictions on Geometry

- Portals must be flat.
- Portals must be approximately rectangular or trapezoidal, to allow proper construction of the goal line.
- Portals must be positioned between 0.01m and 0.2m above a floor and no closer than 0.2m to a floor edge.

Properties

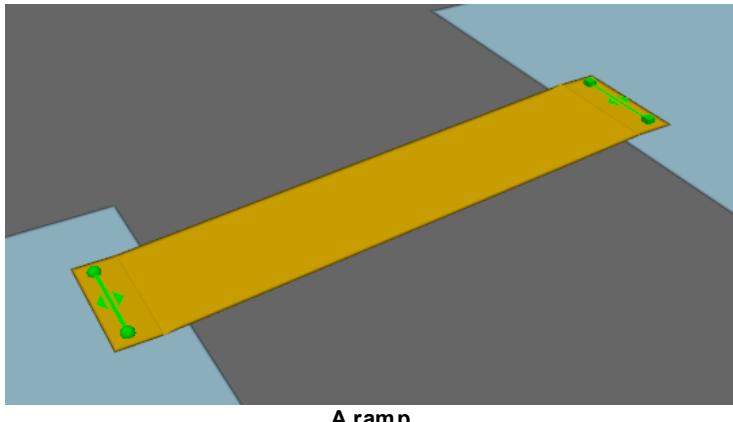
General Tab	
Network: Type	The role the portal will play in the network. Entrance and Destination: Agents may enter and exit the simulation at this portal as well as use it as a waypoint. Entrance Only: Agents may enter the simulation at this portal, but may not use it as a destination or waypoint.
Agent Placement: Distribute	Defines how newly created agents are placed in the simulation environment. Along Spawn Line: Agents appear randomly distributed on the longest midline of the planar, rectangular portal geometry. Inside Portal: Agents appear randomly distributed inside the planar, rectangular boundary of the portal geometry. On Floor: Agents appear randomly distributed inside the planar, rectangular boundary of the floor beneath the portal. Agents will only appear in valid

	unobstructed regions of the floor, but may appear on top of existing agents in areas of high density.
Agent Placement: Start Angle	Measured in degrees. Defines the orientation of the agents when they enter the simulation environment. This angle is visually represented by a triangle decoration on the portal's spawn line.

Actions Tab	
Entered simulation	The action will be applied to all agents as they enter the simulation through the portal. For a description of the order in which actions are applied see Action Order of Execution .
Arrived at waypoint	The action will be applied to agents that are seeking the portal as they arrive at the portal. For a description of the order in which actions are applied see Action Order of Execution .

4.3.1.10 Ramp

Ramps are [connection objects](#) that represent inclined surfaces and are used to connect two floors that are at different elevations. This change in elevation results in an additional vertical cost during agent route selection and can have an impact on agent speed during traversal. Ramps are less costly to traverse than stairs, but more costly than escalators.



Restrictions on Geometry

- The ramp object itself should not include any handrails or other geometry that extends above the walkable surface. If these are desired, they should be added as separate [Barrier](#) objects.
- The ramp must have a flat landing area at each end; this should be at least 0.5m by 0.5m to allow construction of valid goal lines. Landings should be approximately rectangular or trapezoidal.
- The geometry (including the landings) may have thickness, but only the top surface will be considered during the simulation.

In order to run a simulation, the ramp landings must be placed such that each goal line is between 0.01m and 0.20m above a floor, at least 0.20m from the edge of the floor. The two floors must be different (a ramp cannot be used to connect two portions of the same floor).

Impact on Agent Speed

By default, agent speed is modified as a function of the ramp angle and direction of travel (see table below). Speed can also be capped at a specific value through enabling the 'Limit Speed' properties. See [Agent Profile](#) for information on agent speed.

Direction of Travel	Angle X (degrees)	Percentage of Natural Speed
Up	$0 < X < 5$	100
Up	$5 \leq X < 10$	88.5
Up	$10 \leq X \leq 20$	Interpolated between 88.5 and 75
Up	$20 < X$	75
Down	Any	100

Properties

General Tab	
Direction	Sets the direction in which agents can traverse the ramp. Two way: Agents may cross in both directions Unidirectional (ie. Ball to Box or Box to Ball): Agents may only cross in the specified direction.
Costs: Distance added	Defines any distance penalty or modified cost to be added to the ramp. A positive value will add a distance (and hence make the route less desirable for agents), and a negative value will remove a distance. Distance is measured in metres. See Agent Navigation for more information.
Costs: Queue multiplier	Increases the penalty for queuing. A higher number will increase the perceived time cost of queuing, which makes agents more likely to select alternative routes. See Agent Navigation for more information.
Physical: Map resolution	Determines the resolution of surface maps created for agent navigation. Smaller values describe ramp and barrier edges more accurately resulting in more precise walkable area definitions , but increase memory and processing requirements during simulation.
Physical: Effective width	Defines how the width of the stair's connections is calculated. The width is used to calculate queue times (how long it will take for a queue of agents to clear) and controlled flow if using people/minute/metre. Calculate from Geometry: The default setting where the width (m) is calculated from the vertices of the ramp edges. Specify Manually: Allows the effective width (m) of both the box and ball connections to be set to specific values. Note that this does not change the geometry of the link object, only agents' perception of the width of the object.

Access Tab	
Gate: Enable use as gate	Configures the object as a gate, closing the objects to all agents unless explicitly opened through events (see Open Gate Event).
Gate: Wait style:	Sets the behaviour of agents waiting for the ramp when the gate is closed. Stand Still: Agents will stop moving after stepping onto a floor connected to the ramp. Spread Out: Agents will spread out on the floor after stepping onto a floor connected to the ramp. Focus On Target: Agents will move to and wait by the ramp.
Gate: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Gate: Commit to wait	Sets whether agents will commit to the gate once it has been chosen. When checked agents will wait for this object regardless of changes in route costs elsewhere on the floor.
Limit Flow: Cap flow of entering agents	When enabled, the flow of entering agents is not permitted to exceed the specified rate. If demand exceeds capacity, agents are held at the goal line until there is available capacity.
Limit Flow: Rate type	Sets whether the flow rate is calculated as people/minute or people/minute/metre. If using people/minute/metre, the effective width (general tab property) is used.
Limit Flow: Max rate	Sets the maximum flow rate. Flow rate will be measured according to the rate type shown above.
Priority: Enable priority access	Enables a limited yield system where agents moving in one direction receive preferential access. This is useful for constrained geometry where the majority of the flow is in one direction, or for cases such as train doors where alighting passengers often have priority over those boarding.
Priority: Primary direction	Sets the direction in which agents will have primary access. The counter-flow direction will yield. One way (Ball to Box or Box to Ball): Agents moving in the counter-flow direction will not enter the object when there are agents moving in the priority direction with priority access. If Primary will yield is set, agents traveling in the primary direction will yield if they arrive at the object while it is already being used by agents in the counter-flow direction. This is useful for scenarios such as ladders where usage should be restricted to one direction at a time. Two way: Agents in either direction can claim priority access. Priority access is maintained for a given direction until there are no more agents crossing in that direction.
Priority: Capture range	Sets the distance in metres from which agents approaching the object can capture priority access.

Priority: Move aside	When enabled, agents in the counter-flow direction will move aside to accommodate the priority flow.
Priority: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Priority: Commit to wait	When enabled, agents that have chosen the object will continue to wait until they have access regardless of changes to costs in other routes on the floor.

Agent Behaviour tab	
Delay On Enter	Sets how long an agent will be delayed before stepping onto an ramp. This can be set as a distribution in seconds, see Single Value Distributions for more information. If a ramp is gated and closes before the delay finishes, the agent will wait until the next time the ramp opens before attempting to step on again.
Delay On Exit	Sets how long an agent will be delayed before stepping off a ramp. This can be set as a distribution in seconds, see Single Value Distributions for more information.
Traversal: Walk type	Defines the manner in which agents will cross the ramp. Standard: Agents will consider other agents, barriers, and personal speed characteristics to calculate their trajectories. Most like the real world. Ignore Barriers: As above with the exception that agents will ignore any barriers on the surface. Used mainly for connection objects (links, stairs, escalators, ramps). Virtual: Agents will move instantly across the surface to their intended goal, ignoring all obstructions on the surface. Commonly used for areas of a simulation environment where the agent route choices are important but crowding characteristics are not important.
Body Radius	If enabled the body radius for all agents on the surface will be changed to the specified value (m). This can be useful in areas where crowding conditions are governed by geometric or behavioural conditions outside of normal open space standards. Agents approaching the ramp will slowly (over a range of 2-3m) transition to the new radius to avoid instantaneous changes. This setting should be used with caution as a) it applies to all agents regardless of their profile settings, and b) agent movement has only been validated for radius values close to 0.25m.
Direction Bias	If enabled, the direction bias of agents on the surface will be changed to the specified value. This can be useful for corners or narrow spaces where the natural system wide direction bias is locally inappropriate. See Agent Profile for more information on Direction Bias.
Speed Limit	Enables a maximum threshold for agent speed (m/s). Agents traveling above the specified maximum will have their speed reduced to the maximum.

Speed Density	If enabled, agents will use the specified speed density relationship rather than the default provided by their profile. For more information on speed density, see the 'Movement' property in Agent Profile .
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Actions Tab	
Ball: On enter	The action will be applied to all agents as they enter the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On enter	The action will be applied to all agents as they enter the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .

Collections Tab	
Bank	The bank which the ramp is a member of, if any. For more information, see Banks .
Perimeters	Perimeters which the ramp is a member of, if any. For more information, see Perimeters .

4.3.1.11 Reference Geometry

Reference geometry objects are created by [importing](#) content from external files. Standard 3d elements are imported as [generic geometry](#), 2d are imported as [drawing layer](#) objects, and IFC file content is imported as [IFC geometry](#).

These objects have no impact on simulation but they can be used to create MassMotion objects for simulation (see [Generating Objects from Geometry](#) for more information).

Imported reference geometry is automatically placed inside a [transform collection](#) which can be used to scale, rotate, and translate the imported geometry.

Reference Geometry Properties	
Lock Geometry	While enabled, the object's geometry cannot be directly manipulated or edited. It is still possible to delete a locked object or apply transformations using the containing Transform object.
Transform	Upon import, all objects from the same file are grouped in a transform

	collection which allows them to be translated, rotated and scaled together. The object can be removed from or placed in a different collection.
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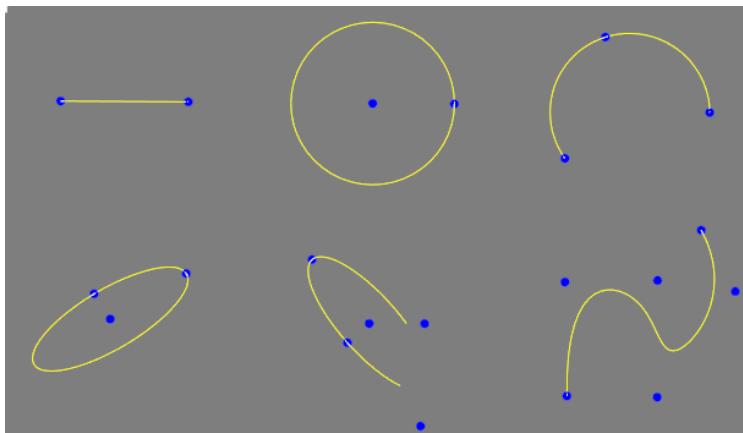
4.3.1.11.1 Drawing Layer

Drawing layers are a type of [reference geometry](#) which represents 2d elements on a common plane. Drawings consist of a series of points and lines. Lines can be connected together into line chains. Areas completely enclosed by lines can be filled to form regions. Lines and regions can then be used to quickly create other other [scene objects](#) via the right click menu. This can be done in "Edit Drawing" mode by extruding the lines from the drawing plane, or in "Find Region" mode by extruding enclosed [regions](#).

It is possible to translate, rotate and scale the entire drawing in 3d space, however, editing drawings components must be done on the 2d plane. See: [Working with Drawings](#).

Lines

Drawings are comprised of points and lines. Lines are connected to and defined by a certain number of points. It is possible for a point to be connected to multiple lines or to the same line multiple times. To separate lines which share a common point, or a point that is connected to many lines, use the [explode command](#).



Straight Line, Circle, Circle Arc
Ellipse, Ellipse Arc, Spline

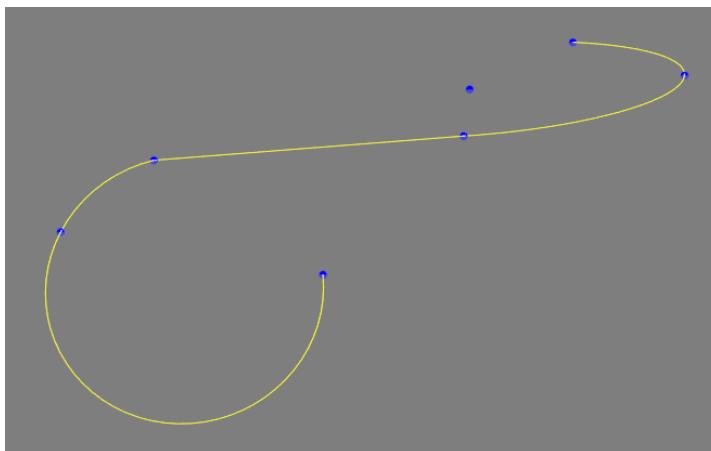
The types of lines are described below:

Line Type	Description
Straight Line	A straight line between two points.
Circle	A circle defined by a centre point and a point on the circle.
Circle Arc	A circle arc defined by the end points and a third point on the arc.
Ellipse	An ellipse defined by a centre point and two points on the ellipse. Given a centre O, and two points A and B, the ellipse is defined as any point where $P = (A-O) \cos(t) + (B-O) \sin(t)$ for any t. Note that A and B therefore do not define the semi-major and semi-minor axes.

Ellipse Arc	An ellipse arc defined by a centre point, two points on the ellipse (but not necessarily on the arc), and two points defining the start and end angles of the arc. The points defining the ellipse define the ellipse arc similarly to the points of the full ellipse. It is possible for none of the points to be on the line they define.
Spline	A spline can be defined by any number of points, but generally at least 4. Splines cannot be created within MassMotion, only imported. It is possible for none of the points to be on the line they define.

Line Chains

Lines, circle arcs and some ellipse arcs that have common end points are considered a line chain and are treated specially for some [editing commands](#) (eg. collapse to straight line).



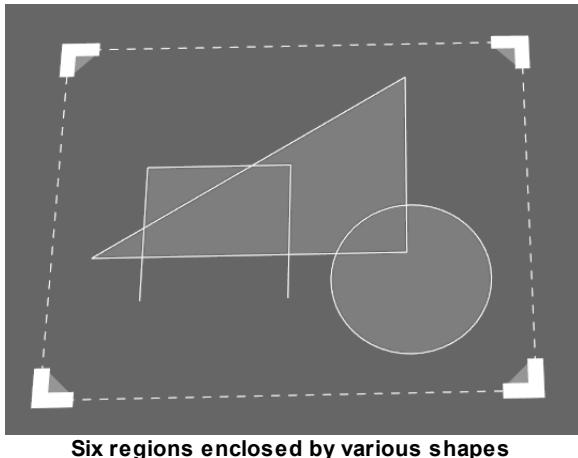
A line chain comprised of a circle arc, a straight line and an ellipse arc.

Ellipse arcs can only be part of a line chain if their start and end angle points are directly on the line itself. If working with ellipse arcs, it may be easier to discretize them to straight line segments.

A single line (straight line, circle arc, or valid ellipse arc) is considered to be a line chain as well. While collapsing a single straight line to a line will do nothing, collapsing a circle arc to a line will replace it with a straight line connecting its end points.

Regions

[Drawing Regions](#) are a special type of component generated by filling areas that are completely enclosed by lines. Regions can be accessed via region mode in the [tool panel](#) or via the shortcut key 'R'. Regions can be used to [generate scene objects](#).



Six regions enclosed by various shapes

4.3.1.11.2 Generic Geometry

Generic geometry is mesh geometry imported from other files and applications. See [Importing Geometry](#) for more information.

Generic geometry can be used to create scene objects for use in simulation and analysis. See [Generating Objects from Geometry](#) for more information.

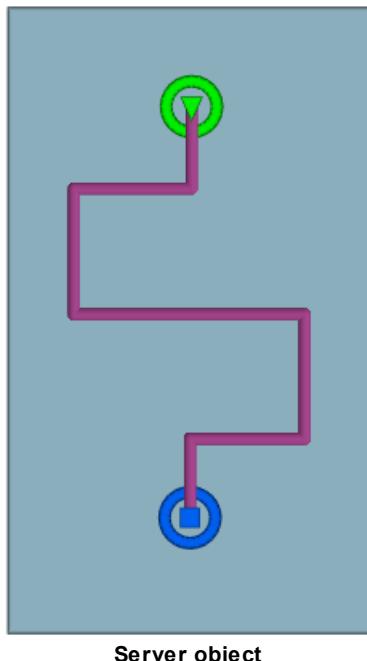
4.3.1.11.3 IFC Geometry

IFC geometry objects preserve the IFC type information taken from the source IFC file. This type information can be used to automatically convert IFC geometry into a suitable MassMotion [scene object](#). See [Generating From IFC](#) for more information.

4.3.1.12 Server

Servers model queuing behaviour and more complex interactions between agents and their environments.

A server is used for process modeling and is the basic building block of process chains. Each server has a conceptual entry point (green triangle) through which agents enter, and an exit point (blue square) through which agents leave the server. If the server has a process time other than zero, agents will be processed and held at the exit point for the specified duration. Server ports can be grouped together or connected to other ports to form process chains. For more information on process modeling and process chains see the introduction to [Process Chains](#).

**Server object**

To create a server use the "Server" button on the Scene tab of the main application window or right click in a 3D view and select Create-> Scene-> Server. Like [Paths](#) the default new server is a 2m horizontal line segment. This line segment can be extended by growing the end vertices, or splitting the edge into multiple pieces. See [Editing Geometry](#) for more information.

How Agents Use Servers

Agents can be directed to one or more servers through the 'Seek process chain' task given as an [agent action](#). When directed to a process chain agents will seek out the start of the chain, be dispatched to one of the servers in the chain, and then move through the chain passing from server to server until it reaches the end. See [server operations](#) for a description of how an agent will approach and be processed by a server.

Access

Whether or not a server is available to an agent depends on a number of factors including the server entry state, available server capacity, and whether or not the server is set to require or prefer particular types of agents. See [controlling agent access](#) for more information.

Notes on server geometry

- A server must contain a single curve object (even when the approach type is set to 'Ignore Line').
- All points on the curve must be just *above* the same floor object.
- Server ports can only be grouped with or connected to other servers that are on the same floor.

Properties

General Tab	
Approach	This determines how agents will move towards the server (target). If targeting any part of the server before the exit agents will then join the line and follow the line in single file. While on the server agents will move through barriers and other agents not on the server.

	<p>Standard walk to target: Use the traversal type of the floor to approach the server target (see below).</p> <p>Teleport to target: Instantly teleport to the server target (see below).</p> <p>Virtual: Join and follow the server from the agent's current position. The agent will queue at the server and be processed by the server all without moving. The agent will be free to move again once released by the server.</p>
Target	<p>Server entry: Agents will walk or teleport to the start of the server line.</p> <p>End of queue on server: Agents will walk or teleport to the end of the queue on the server. If the server is full agents will walk or teleport to the server entry. If there is no queue agents will walk or teleport to the server exit.</p> <p>Server exit: Agents will walk or teleport to the end of the server line.</p>
Processors	<p>Specify the number of agents that can be processed at the same time.</p> <p>This is only available when 'Approach' is set to 'Virtual' or 'Target' is set to 'Server exit' as in all other cases only one agent can physically access the processor at a time.</p>
Capacity	<p>Defines the maximum number of agents accepted by the server (not counting those being processed).</p> <p>Infinite: there is no constraint placed on the number of agents accepted by the server. All agents are free to approach.</p> <p>Finite: The server will only accept a certain number of new agents based on the input buffer's available capacity. Agents will not be permitted to approach the server until there is available capacity. The available capacity is calculated as:</p> $\text{"Available Capacity"} = \text{"Max Capacity"} - \text{"Count of Agents Waiting to be Processed"}$
Contact Time	<p>If enabled, agents will be held in the processing state for the given interval.</p> <p>Tests provide a flexible way for varying the processing time. Agents can be given different contact times depending on the time of day, population on the servers, or token possession. Tests are evaluated from top to bottom and an agent will use the distribution corresponding to the first test that evaluates to true. If no tests evaluate to true the fallback distribution is used.</p>
Access	
Entrance default	<p>The server entrance can be opened or closed using a server access event.</p> <p>Closed: The server entrance will start closed preventing agents from using the server.</p>

	Open: The server entrance will start open.
Require agents satisfy	When enabled the server will only be available to agents for which the test evaluates to true. Agents for which the test does not evaluate to true will see the entrance as closed.
Prefer agents satisfy	When enabled the server will accept all agents, but given a choice will always choose an agent for which the test evaluates to true.
Exit default	<p>The server exit can be opened or closed using a server access event.</p> <p>Closed: The server exit will start closed, holding agents that have been processed until the server is opened.</p> <p>Open: The server exit will start open, releasing agents after processing when there is downstream capacity.</p>

Agent Behaviour Tab	
Queue Spacing	This determines how closely each agent will follow a previous agent. This can be set as a distribution in metres, see Single Value Distributions for more information.
Speed Density	If enabled, agents will use the specified speed density relationship rather than the default provided by their profile. For more information on speed density, see the 'Movement' property in Agent Profile .

Actions Tab	
Done Processing	The specified action is applied to each agent immediately after the agent has been processed but before it leaves the server. If a task is given during this action the agent will abandon the current "Seek process chain" task before it is considered complete. The action is applied before the agent is considered by any server exit event test or downstream server's preferred or required test.
On Release	The specified action is applied to each agent as it leaves the server. If the server is the end of a process chain, the action is applied immediately after the agent has completed the current "Seek process chain" task.

Connections Tab	
Source	If the server is connected to an upstream Dispatch object it will be listed here. A source Dispatch can be removed, replaced or added here. Servers can only be connected to one source dispatch at a time.
Sink	If the server is connected to an downstream Dispatch object it will be listed here. A sink Dispatch can be removed, replaced or added here. Servers can only be connected to one sink dispatch at a time.

4.3.1.12.1 Server Operations

An agent can be directed to a process chain through a task given by the 'Seek process chain' [action](#). The agent will actually seek the floor that contains the process chain, choosing the lowest cost route through the network. Once on the floor the agent will immediately register with the process chain's initial dispatch. The task is completed when the agent has left an end server in the process chain. If the agent is interrupted and given a new task before reaching the process chain end it will restart at the beginning of the process chain when returning to the process chain task.

Dispatch

The [dispatch](#) will assign the agent to a downstream server. In the case where there is only one server the assignment is trivial. When there are multiple servers the method of assignment can be specified through a property of the dispatch object. Once an agent is assigned to a server it registers with that server and is included in the counts for that server.

Approach

Agents will only approach a server that has available capacity as defined by the input buffer capacity. If an agent has been dispatched to a server and there is no available capacity, the agent will stand in place until space becomes available. Once there is capacity, the agent is registered with the input buffer (regardless of whether or not it has reached the buffer line) and approaches the processor according to the approach type (see the "General" properties table in [server](#)). Once the agent is within close range of the processor it becomes available for processing. If there is no available processor capacity, agents that are ready for processing will stand in place until there is capacity.

Processing

When the agent begins processing it is removed from the input buffer but is still included in server capacity calculations. The processor may process multiple agents at one time according to the processor capacity. The amount of time spent processing each agent is based on the server's contact time. There is a common contact time distribution that is the default for all agents. Additional distributions can be specified on a per test basis. See the "General" properties table in [server](#) for more information on contact time.

After Processing

Once processed, an agent is ready to leave the server. What happens next depends on the situation:

<i>Server exit is closed (see server access event)</i>	The agent is held in place until the server exit is opened.
<i>Server is in the middle of a process chain and there is no downstream capacity</i>	The agent is held in place until there is available downstream capacity.
<i>Server is in the middle of a process chain and there is downstream capacity</i>	The agent registers with the next dispatch and awaits assignment to one of the next servers in the chain.
<i>Server is the end of a process chain</i>	The agent finishes the 'Seek Process' task and continues with its next task.

4.3.1.12.2 Controlling Agent Access

Opening/Closing the Entrance

Entry to a server can be opened or closed through the use of [server access](#) events. A server with a closed entry is not visible to agents and will be ignored during [dispatch](#). Once an agent has been dispatched to a server it will proceed to that server even if the entry is closed while the agent is in transit.

Restricted or Preferential Access

A server can be configured to give exclusive and/or preferential access to specific agents based on the results of one or more tests. Servers that require a specific test will only accept agents for which the test evaluates to true. Servers with a preferred test will accept any agent but when given a choice will always choose an agent for which the test evaluates to true.

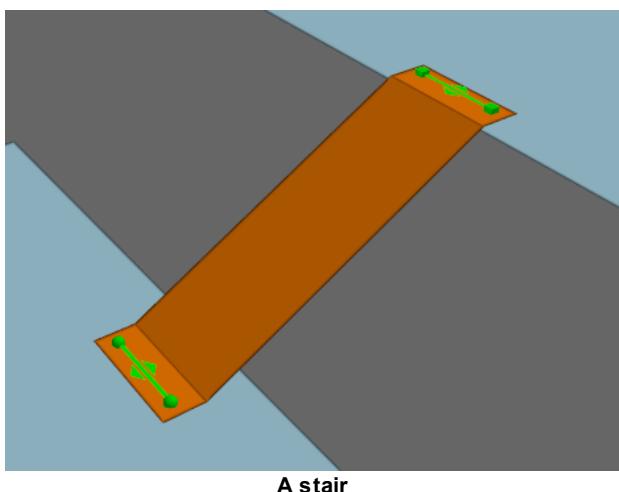
If an agent is sent to a group of servers that all require a test that does not evaluate to true for that agent, that agent will be removed from the simulation and the error logged.

If two servers are grouped and only one is set with either a preferred or required test, all agents that pass the test will be sent to that server. Only once the preferred or required server is at capacity will agents that pass the test be sent to the other server that does not have any restrictions.

Example: Use of required and preferred is typical of an airport check-in system, where the economy class and business class status is determined by possession of an economy or business token. The economy and business accumulator queues would require their respective tokens, while the check-in desks would prefer the same tokens. While the business queue would be restricted to agents holding the business token, the business check-in desk would be willing to accept economy token holders in the event that the business queue was empty.

4.3.1.13 Stair

Stairs are [connection objects](#) used to connect two floors that are at different elevations. This change in elevation results in an additional vertical cost during agent route selection and can have an impact on agent speed during traversal. Stairs are more costly to traverse than escalators and ramps.



Restrictions on Geometry

- The stair object itself should not include any handrails or other geometry that extends above the walkable surface. If these are desired, they should be added as separate [barrier](#) objects.
- The stair must have a flat landing area at each end; this should be at least 0.5m by 0.5m to allow construction of valid goal lines. Landings should be approximately rectangular or trapezoidal.
- The geometry (including the landings) may have thickness, but only the top surface will be

considered during the simulation.

In order to run a simulation, the stair landings must be placed such that each goal line is between 0.01m and 0.20m above a floor, at least 0.20m from the edge of the floor. The two floors must be different (a stair cannot be used to connect two portions of the same floor).

Impact on Agent Speed

By default, agent speed is modified as a function of the stair angle and direction of travel (see table below). Speed can also be capped at a specific value through enabling the 'Limit Speed' properties. See [Agent Profile](#) for information on agent speed.

Direction of Travel	Angle X (degrees)	Percentage of Natural Speed
Up	0 < X < 27	42.6
Up	27 <= X <= 32	Interpolated between 42.6 and 37.8
Up	32 < X	37.8
Down	0 < X < 27	57.4
Down	27 <= X <= 32	Interpolated between 57.4 and 49.8
Down	32 < X	49.8

Properties

General Tab	
Direction	Sets the direction in which agents can traverse the stair. Two way: Agents may cross in both directions Unidirectional (ie. Ball to Box or Box to Ball): Agents may only cross in the specified direction.
Costs: Distance added	Defines any distance penalty or modified cost to be added to the stair. A positive value will add a distance (and hence make the route less desirable for agents), and a negative value will remove a distance. Distance is measured in metres. See Agent Navigation for more information.
Costs: Queue multiplier	Increases the penalty for queuing. A higher number will increase the perceived time cost of queuing, which makes agents more likely to select alternative routes. See Agent Navigation for more information.
Physical: Map resolution	Determines the resolution of surface maps created for agent navigation. Smaller values describe stair and barrier edges more accurately resulting in more precise walkable area definitions , but increase memory and processing requirements during simulation.
Physical: Effective width	Defines how the width of the stair's connections is calculated. The width is used to calculate queue times (how long it will take for a queue of agents to clear) and controlled flow if using people/minute/metre.

	<p>Calculate from Geometry: The default setting where the width (m) is calculated from the vertices of the stair edges.</p> <p>Specify Manually: Allows the effective width (m) of both the box and ball connections to be set to specific values. Note that this does not change the geometry of the link object, only agents' perception of the width of the object.</p>
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Access Tab	
Gate: Enable use as gate	Configures the object as a gate, closing the objects to all agents unless explicitly opened through events (see Open Gate Event).
Gate: Wait style:	<p>Sets the behaviour of agents waiting for the stair when the gate is closed.</p> <p>Stand Still: Agents will stop moving after stepping onto a floor connected to the stair.</p> <p>Spread Out: Agents will spread out on the floor after stepping onto a floor connected to the stair.</p> <p>Focus On Target: Agents will move to and wait by the stair.</p>
Gate: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Gate: Commit to wait	Sets whether agents will commit to the gate once it has been chosen. When checked agents will wait for this object regardless of changes in route costs elsewhere on the floor.
Limit Flow: Cap flow of entering agents	When enabled, the flow of entering agents is not permitted to exceed the specified rate. If demand exceeds capacity, agents are held at the goal line until there is available capacity.
Limit Flow: Rate type	<p>Sets whether the flow rate is calculated as people/minute or people/minute/metre.</p> <p>If using people/minute/metre, the effective width (general tab property) is used.</p>
Limit Flow: Max rate	Sets the maximum flow rate. Flow rate will be measured according to the rate type shown above.
Priority: Enable priority access	Enables a limited yield system where agents moving in one direction receive preferential access. This is useful for constrained geometry where the majority of the flow is in one direction, or for cases such as train doors where alighting passengers often have priority over those boarding.
Priority: Primary direction	<p>Sets the direction in which agents will have primary access. The counter-flow direction will yield.</p> <p>One way (Ball to Box or Box to Ball): Agents moving in the counter-flow direction will not enter the object when there are agents moving in the priority direction with priority access. If Primary will yield is set, agents traveling in the primary direction will yield if they arrive at the object while it is already being used by agents in the counter-flow direction. This is useful</p>

	for scenarios such as ladders where usage should be restricted to one direction at a time. Two way: Agents in either direction can claim priority access. Priority access is maintained for a given direction until there are no more agents crossing in that direction.
Priority: Capture range	Sets the distance in metres from which agents approaching the object can capture priority access.
Priority: Move aside	When enabled, agents in the counter-flow direction will move aside to accommodate the priority flow.
Priority: Cost of waiting	Sets the penalty (in seconds) for agents waiting. If this penalty is too high agents will seek alternative routes to their goal. See Agent Navigation for more information.
Priority: Commit to wait	When enabled, agents that have chosen the object will continue to wait until they have access regardless of changes to costs in other routes on the floor.

Agent Behaviour tab	
Delay On Enter	Sets how long an agent will be delayed before stepping onto a stair. This can be set as a distribution in seconds, see Single Value Distributions for more information. If a stair is gated and closes before the delay finishes, the agent will wait until the next time the stair opens before attempting to step on again.
Delay On Exit	Sets how long an agent will be delayed before stepping off a stair. This can be set as a distribution in seconds, see Single Value Distributions for more information.
Traversal: Walk type	Defines the manner in which agents will cross the stair. Standard: Agents will consider other agents, barriers, and personal speed characteristics to calculate their trajectories. Most like the real world. Ignore Barriers: As above with the exception that agents will ignore any barriers on the surface. Used mainly for connection objects (links, stairs, escalators, ramps). Virtual: Agents will move instantly across the surface to their intended goal, ignoring all obstructions on the surface. Commonly used for areas of a simulation environment where the agent route choices are important but crowding characteristics are not important.
Body Radius	If enabled the body radius for all agents on the surface will be changed to the specified value (m). This can be useful in areas where crowding conditions are governed by geometric or behavioural conditions outside of normal open space standards. Agents approaching the stair will slowly (over a range of 2-3m) transition to the new radius to avoid instantaneous changes. This setting should be used with caution as a) it applies to all agents regardless of their profile settings, and b) agent movement has only been validated for radius values close to 0.25m.

Direction Bias	If enabled, the direction bias of agents on the surface will be changed to the specified value. This can be useful for corners or narrow spaces where the natural system wide direction bias is locally inappropriate. See Agent Profile for more information on Direction Bias.
Speed Limit	Enables a maximum threshold for agent speed (m/s). Agents traveling above the specified maximum will have their speed reduced to the maximum.
Speed Density	If enabled, agents will use the specified speed density relationship rather than the default provided by their profile. For more information on speed density, see the 'Movement' property in Agent Profile .

Actions Tab	
Ball: On enter	The action will be applied to all agents as they enter the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Ball: On exit	The action will be applied to all agents as they leave the ball side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Box: On enter	The action will be applied to all agents as they enter the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .
Box: On exit	The action will be applied to all agents as they leave the box side of the object. For a description of the order in which actions are applied see Action Order of Execution .

Collections Tab	
Bank	The bank which the stair is a member of, if any. For more information, see Banks .
Perimeters	Perimeters which the stair is a member of, if any. For more information, see Perimeters .

4.3.1.14 Visual

Visual objects can provide context to an environment or enhance the look of a scene. Visual objects are not used during simulation or analysis and have no functional impact on a project.

4.3.1.15 Volume

Volume objects are used to identify when agents are inside an arbitrary area. Volume objects do not need to be rectangular or even contiguous. Agents are considered inside a volume if they are inside any of the component parts of a volume.

Notes on geometry

- Must be a single polygon mesh object or a collection of polygon mesh objects.
- Agents will be considered 'in' the volume if the centre point between their feet is within any of the volumes defined by the meshes.

Properties

There are no properties for objects of this type.

4.3.2 Activities

Activity objects have to do with creating agents, defining agent characteristics and behaviour, and controlling elements of the scene.

Defining Agents

Object Type	Description
Profile	Used by events to define agent characteristics.
Avatar	An optional editable physical representation of an agent.
Token	Identifying markers held by agents.

Creating Agents

Object Type	Description
Journey	An event to create agents moving from one or more origins to one or more destinations.
Circulate	An event to create agents who move between "circulation" portals.
Trip Matrix	An event to create agents from an origin destination matrix.
Vehicle	An event that simulates the regular arrival and departure of a "vehicle" such as a subway car.
Evacuate	An event used to simulate evacuations. Agents are created and then evacuate the scene in specified ways.
Timetable	An event used to create large groups of agents and control the scene.

Controlling Agents and the Scene

Object Type	Description
Broadcast	An event which applies an agent action to change the behaviour of agents.
Gate	An event which opens/closes gated connection objects .

<u>Access</u>	
<u>Server Access</u>	An event which opens/closes the entrance and/or exit of servers.

Other Objects

Object Type	Description
<u>Action</u>	An operation that can be applied to an agent to modify its properties or assign it new tasks.
<u>Test</u>	A condition which can evaluate the scene or an agent and return true or false.
<u>Time</u>	A virtual event that can be used by <u>reference times</u> in other events and can help with coordinating the timing of multiple events.
<u>Trigger</u>	Used to control when events become active.

4.3.2.1 Actions

An action is an operation applied to an agent. The operation can modify agent properties or assign new [tasks](#). Actions can be applied to agents through events or when they transition between objects in the scene (see [Where to Use Actions](#)).

Modifying actions alter the agent immediately as the action is applied. Task giving actions create a new task for the agent to execute in the next frame. When a compound or named action results in multiple tasks, those tasks are collected into a group and executed by the agent in order.

Special Actions	
Do nothing	No action will be applied to the agent.
Named action	The action described by the action object will be applied to the agent.

Compound actions combine tests and other actions.

Compound Actions	
Choose action from set	Only one action from the specified list will be applied to the agent. The weight beside each action describes the likelihood that action will be chosen. The sum of the likelihood values is always normalized to 100% before the action is applied to an agent.

	A single action is always chosen, even if that action is 'Do nothing'.
Do tasks until	<p>Creates a do-until task which executes subtasks until a condition is met.</p> <p>Contains a 'do' action and 'until' condition. The 'do' action is applied as normal. Any tasks collected by the 'do' action are executed conditionally by the do-until task. If at any time during task execution the 'until' condition is met, the do-until and all subtasks are canceled and removed from the agent's task stack.</p> <p>Wait if done early: When enabled, a wait task is appended to the collected subtasks. If the agent finishes the 'do' tasks before the 'until' condition is met (or the 'do' action did not generate any tasks), the appended wait task will execute until the 'until' condition is met.</p>
If/Then	If the test evaluates to true, the 'Then' action is applied to the agent.
If/Then/Else	If the test evaluates to true, the 'Then' action is applied to the agent, otherwise the 'Else' action is applied.
List of actions	<p>Each action in the list is applied to the agent. If set to 'Given order' the actions are applied from top to bottom. If set to 'Random' the actions are applied in random order.</p> <p>Modifying actions are applied to the agent immediately in the order in which they are applied. The tasks from task giving actions are collected in the order in which the actions are applied and given to the agent as a group of tasks to be executed in that order.</p>
Repeat	<p>Creates a repeat task which applies an action multiple times.</p> <p>Contains a 'repeat' action and an 'until' condition. A repeater task is created which applies the specified action and executes any tasks collected. Once the collected tasks have been completed, the 'until' condition is checked. If the condition is not</p>

	satisfied at that time, the repeater task begins a new iteration, applying the specified action and executing any collected tasks. The repeater task is complete when an iteration finishes and the 'until' condition is met. Note that the 'until' condition is not checked during task execution but only when the tasks are complete.
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Modifying actions are applied immediately to the agent as the action is executed. Tests performed later in the action will notice property modifications enacted earlier in the action.

Modifying Actions	
Add avatar	Immediately change the avatar of the agent.
Add color	Immediately change the colour of the agent.
Add tokens	Immediately give the specified tokens to the agent. Agents can only hold one copy of a given token, and so any tokens already held by the agent are ignored.
Clear avatar	Immediately return the agent to its original or first assigned avatar. The first avatar assigned to an agent (whether through action or profile) is considered the agent's original avatar. Reset avatar actions will always return an agent to this original avatar. In the case where an agent does not have an avatar or is currently using the first assigned avatar, this action does nothing.
Clear color	Immediately return the agent to its original colouring.
Clear history	Immediately clear the agent's route history. The agent will forget any previous journeys and clear all backtracking penalties associated with routes already traversed.
Clear tasks	Immediately clear the agent's existing list of tasks. This has no effect on the tasks currently being generated by the action under execution. Those tasks will still be given to the agent after the action has finished executing.

Clear tokens	If the agent is currently holding any of the specified tokens, immediately remove them from the agent.
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Task giving actions create a task that is given to the agent for execution in the next frame. The agent will put aside the task it was previously executing and start on the new task(s). Once all new tasks have finished the agent will return to the original task that was interrupted by the action.

Task Giving Actions	
Apply Action	<p>Contains a sub action that is not executed immediately but is instead placed inside of a generated 'apply action' task. The sub action is applied to the agent when the task is executed.</p> <p>For example, if an agent is to seek a portal and then change colour once the portal has been reached, previous implementations would have required two separate actions: one to send the agent to the portal, and another placed on the portal itself to change the agent colour. With 'apply action' both the 'seek portal' and 'add colour' can be specified in the same instruction set, reducing the need for actions scattered throughout the scene.</p>
Evacuate zone	<p>The agent will navigate the scene, following the best cost route through the zone to a floor that is not a member of the specified zone. Best cost includes all standard route costing components such as horizontal distance and queuing. The task is complete once the agent has reached a floor that is not a member of the zone. Agents that are given this task when already outside of the zone will complete the task immediately.</p> <p>Erase Route History When Task Starts: If true, the agent will forget all previous journeys and there will be no backtracking penalties for routes traversed before the task began. If false, the agent will be biased against selecting routes traversed while executing previous tasks.</p>
Exit simulation	When executed, the agent will leave the simulation. The exit will be recorded as a 'success'. This is the normal method for removing agents from the simulation after

	they have completed their journeys/tasks.
Follow sign	<p>The agent will move towards and transition onto the specified adjacent floor, portal, link, stair, ramp, path, or escalator.</p> <p>Grouped: lowest cost: Agents will choose the object with the lowest route cost. Any object not connected to the current floor will be ignored. The agent will continuously re-evaluate its choice as conditions on the floor change. The task is complete once the agent has reached the chosen object.</p> <p>Sequence: in order: Agents will navigate from object to object in the order given. The first object must be connected to the current floor. Subsequent objects must be connected to one another in an unbroken chain. Collections can be used to specify a number of options for each 'leg' in the sequence. When a collection is used, agents will choose one object from the collection based on lowest cost. Objects in a collection that are not connected to the current floor are ignored. The task is complete when the agent has reached the final object.</p> <p>Single: by chance: Agents will be assigned one of the specified objects by chance. Objects that are not connected to the current floor will be ignored. The task is complete once the agent has reached the assigned object.</p>
Seek	<p>The agent will navigate the scene, following the best cost route to the specified destination. The task is complete once the agent has reached the destination. Possible destinations include:</p> <p>Or The agent will navigate the scene, following the best cost route to the portal through which the agent entered the simulation. The task is complete once the agent has reached its origin portal.</p>

	<p>Po rta ls: The agent will navigate the scene, following the best cost route to the assigned portal(s). The task is complete once the agent has reached the assigned portal.</p> <p>Grouped: lowest cost: Agents are given all portals and instructed to seek the portal with the lowest cost route. Agents will continuously re-evaluate route costs as they navigate the scene and alter their choice as conditions change. The agent can be assigned a single portal chosen by chance, or assigned all portals and instructed to seek the lowest cost from the group. See Choosing Objects for information on how weights are used in portal assignment.</p> <p>Single: by chance: The agent will be assigned a single portal by chance. Weights can be specified to alter the likelihood of each portal being assigned. See Choosing Objects for information on how weights are used in portal assignment.</p>
	<p>Pr oc es s sta rt: The agent will navigate the scene, following the best cost route to the start of the assigned process chain.</p> <p>It is possible to specify a number of process chain entries and have one assigned to the agent based on chance. However, if agents are to be distributed over many servers based on server availability or tokens,</p>

	<p>then the servers should be connected together into a single dispatch, and the dispatch specified in the seek process action (see Process Chains & Servers).</p> <p>Once the agent has reached the process chain start, it will enter the chain and continue through the chain until it reaches a chain end point. The task is complete once the agent has reached the chain end point and been processed by the last server.</p> <p>Note, if a 'Seek Process Start' task is interrupted by another task, agents will return to the beginning of the process chain when resuming the task.</p> <p>Erase Route History When Task Starts: If true, the agent will forget all previous journeys and there will be no backtracking penalties for routes traversed before the task began. If false, the agent will be biased against selecting routes traversed while executing previous tasks.</p>
Wait	<p>The agent will wait in place until the specified condition is met. The behaviour of the agent while waiting is determined by the specified wait style.</p> <p>For The agent will wait for the specified number of seconds. dur at: The wait timer starts when the agent begins executing the task. The wait timer is paused when the task is interrupted by other tasks and resumes from where it left off when the wait task resumes. The task is complete once the specified number of seconds have elapsed.</p>

	<p>Indefinitely: The agent will wait forever until the task is interrupted.</p> <p>Until time: The agent wait until the simulation reaches the specified time. The task is complete once the given time has been reached. The task will be completed in one frame if executed after the specified time.</p> <p>While true: The agent will wait until the given test evaluates to true.</p> <p>Style: The agent will wait according to the specified style.</p>
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4.3.2.1.1 Where to Use Actions

Actions can be applied in a number of ways. The following table lists the various locations within a project where user created custom actions can be referenced and so applied. In cases where multiple actions are applied, it is important to understand the [order of action execution](#).

Action Triggers		
Object	Property	Description
Profile	On birth	Applied to an agent newly created using the profile.
Journey, Circulate, Evacuate, Vehicle	On birth	Applied to an agent newly created by the event.
Execute Action	Action	Applied to every agent in the scene at the time specified, or as agents enter the simulation during the time the event is active. In the case where the event targets a zone, when the action is active agents will receive the action when they enter the zone.

Portal	Entered simulation	Applied to an agent when it uses the portal to enter the simulation.
Portal	Arrived at waypoint	Applied to an agent when it reaches a portal that it was seeking.
Floor	On enter	Applied to an agent once it has stepped onto the floor.
Floor	On exit	Applied to an agent once it has stepped off of the floor.
Link, Stair, Ramp, Escalator, Path	Ball: On enter	Applied to an agent once it has stepped onto the link at the ball goal line.
Link, Stair, Ramp, Escalator, Path	Ball: On exit	Applied to an agent once it has stepped off of the link at the ball goal line.
Link, Stair, Ramp, Escalator, Path	Box: On enter	Applied to an agent once it has stepped onto the link at the box goal line.
Link, Stair, Ramp, Escalator, Path	Box: On exit	Applied to an agent once it has stepped off of the link at the box goal line.
Server	Done processing	Applied to an agent once it has been processed by the server but before it has been released. Agents may be held at a server due to a lack of downstream capacity or a closed server exit. See server for more information.
Server	On release	Applied to an agent when it is released from a server.
Zone	On enter	Applied to an agent once it has stepped onto a member of the zone when coming from an object that is not a member of the zone.
Zone	On exit	Applied to an agent once it has stepped onto an object that is not a member of the zone when coming from an object that is a member of the zone.

4.3.2.1.2 Order of Action Execution

The order in which actions are applied is important, as test results in one action could be altered by the results of previous actions (such as giving or removing tokens). The following table describes the order in which actions are applied for various scenarios. In each case, actions are only applied if defined.

Order of Action Application	
Scenario	Order of Actions (if present)
A new agent is created and placed in the scene.	<ol style="list-style-type: none"> 1. Creation event 'Internal' (initial goal assignment) 2. Profile: 'On birth' 3. Creation event 'On birth' (including Timetable) 4. Timed execute action(s): 'Action' 5. Zone(s): 'On enter' 6. Floor: 'On enter' 7. Portal: 'Entered simulation'
An agent has transitioned from the ball side of a link onto a floor.	<ol style="list-style-type: none"> 1. Timed execute action(s): 'Action' 2. Link: 'Ball: On exit' 3. Zone(s): 'On exit' 4. Zone(s): 'On enter' 5. Floor: 'On enter'
An agent reaches its portal destination.	<ol style="list-style-type: none"> 1. Timed execute action(s): 'Action' 2. Portal: 'Arrived at waypoint'
An agent has finished being processed at a server.	<ol style="list-style-type: none"> 1. Timed execute action(s): 'Action' 2. Server: 'When finished'

4.3.2.2 Tests

Agent tests operate on a single agent at an instant in time, and return either true or false. Tests are used in [agent actions](#) to customize how the action is applied to an agent and in number of scene objects for controlling how properties are applied to agents. See [Where Tests are Used](#) for more information.

Special Tests	
Always true	Always returns true.
Named test	Returns the result of executing the specified agent test object.

Compound tests combine the results of other tests.

Compound Tests	
Not	Returns the inverse of the specified test.
Compound Test	Combines the results of the two tests using the specified logic, and returns the result.
All of	Returns true if all of the specified tests return true.
Any of	Returns true if any of the specified tests return true.
None of	Returns true if none of the specified tests return true.

Scene tests return true based on conditions within the simulation. The results will vary with time.

Scene Tests	
Area population	Return true when the combined population in the specified areas is within the specified range. Possible areas include floors, links, ramps, stairs, escalators, paths, volumes, and collections. The counts for each specified area are combined into a single total. If the same agent appears in multiple areas it will be counted multiple times.
Clock in time range	Returns true if the current simulation time is before/after the specified time.
Events active	Returns true if any/all/none of the specified events are actively engaged in the specified activity.
Gate state	Returns true if any/all/none of the specified gates are open/closed.

Random chance	Returns true the given percentage of the time.
Server capacity	Returns true when the combined available capacity for all specified servers is within the specified range.
Server population	Returns true when the combined population for all specified servers is within the specified range. Approach/Queuing: Count all agents at or heading towards the server. Queuing: Count agents currently queuing or being processed at the server.
Server state	Returns true if any/all/none of the specified servers are open/closed.

Static agent tests will always return the same result for a given agent and do not vary with time.

Static Tests	
Agent: Created by	Returns true if the agent was created by any of the specified events.
Agent: Entered at	Returns true if the agent entered the simulation at any of the specified portals.
Agent: Initial exit	Returns true if the agent was created with any of the specified portals as its initial exit/goal. The initial exit refers to the single and final portal destination assigned to the agent by the creating event. It does not consider any goals applied via actions or any intermediate or circulation goals assigned by an event. Not all agents will have an initial exit.
Agent: Uses profile	Returns true if the agent was created with any of the specified profiles.

Dynamic agent tests can produce different results at different times. They depend on temporal values or agent properties that can change from one frame to the next.

Dynamic Tests	
Agent: Has age	Returns true if the agent is currently younger/older than the specified age.
Agent: Has tokens	Returns true if the agent is currently holding all/any/none of the specified tokens.
Agent: In area	Returns true if the agent is currently in any of the specified areas. Valid areas include floors, links, ramps, stairs, escalators, paths, volumes, or

	collections.
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4.3.2.2.1 Where to use Tests

The following table lists the ways in which tests can be used.

Actions	
If/Then	Used to determine whether or not the action is applied.
If/Then/Else	Used to determine which action is applied.
Do Until	Can be used to determine when the Do Until task is done.
Task: Wait	Can be used to determine when the Wait task is done.

Events		
Broadcast	Apply to Agents	Controls whether or not the action is applied to an agent.
Gate Access	Apply to Agents	Controls whether or not the operation performed by the gate event is visible to an agent.
Vehicle	Boarding/Alighting Access	Controls whether or not agents can access the vehicle gates.

Scene Objects		
Server	Preferred/Required Access	Identify required or preferential conditions for access to the server.
Server	Contact Time	Specify a contact time duration for an agent.

4.3.2.3 Avatar

Geometry that can be used to represent different populations of agents during simulation playback. The avatar has no functional impact on simulation execution and is for visualization purposes only.

Avatar geometry can be edited using a special scene viewer which is accessible through the avatar object properties window. All of the tools available for [editing scene geometry](#) can also be used when editing avatars. It is important that the avatar centroid remain at the origin or it will not accurately reflect actual agent movement during playback.

Using Avatars

An agent is assigned a particular avatar through the agent's [profile](#). If no avatar is specified, the agent will use a default representation.

Viewing Avatars During Playback

By default MassMotion displays agents using the built in animated biped avatar. To view user specified static avatars, change the agent type in the 3D scene view's display menu.

4.3.2.4 Circulate

Circulate events create agents that will enter the simulation from one of the origin [portals](#), move between several circulation portals, then leave the simulation at one of the destination portals.

The same portal may be used as an origin, circulation and destination portal. Agents may visit the same circulation portal more than once.

With circulate events, the 'initial exit' refers to the destination portal specified in the arrive tab rather than the first circulation portal chosen by the agent.

Active

A journey is active over the interval for which it can create agents. This will depend on the population demand type. When using 'Instant' the event is active only for an instant. When using 'Random' or 'Evenly spaced', the event is active for the duration of the specified interval, including those frames when no agent is created. When using a 'Table', the event is active from when the start condition is met until the final interval in the table is complete. Once the event has finished creating agents it is no longer active, even if the created agents are continuing to circulate.

Properties

Agents Tab	
Timing: Start Time	The condition for starting the event. See Triggering Events for more information.
Population : Profile	The profile used to create agents. If a collection is specified, each agent will be assigned one of the profiles from the collection. A weighted collection can be used to alter the distribution of profiles amongst the population.
Population : Demand	<p>The number of agents the event will create and when they will be created relative to the event start time.</p> <p>Evenly spaced: The specified number of agents will arrive at a constant rate over the duration.</p> <p>Instant: The specified number of agents will arrive all at once at the event start time.</p> <p>Random: The specified number of agents will arrive according to the specified distribution over the duration. See Duration Distributions for information on arrival distributions.</p> <p>Table: Complex agent arrival is described by a series of rows. Each row contains the duration of an interval and the number of agents to create over that interval. The first interval starts at the event start. Subsequent intervals begin when the previous interval ends. Agents are created according to a uniform distribution within each interval.</p>
Origins	The portals at which agents will be created. Portals can be weighted to alter the

	distribution of agents across the set. See Choosing Objects for more details.
Destinations	<p>The portals from which the agent will be given its ultimate goal. The agent will pursue this goal once it has finished circulating. Despite the fact that agents will seek this goal after circulating, it is still referred to as the 'Initial exit' for the purposes of agent actions and tests.</p> <p>Single: by chance: The agent will be assigned a single portal by chance. Weights can be specified to alter the likelihood of each portal being assigned. See Choosing Objects for information on how weights are used in portal assignment.</p> <p>Grouped: lowest cost: Agents are given all portals and instructed to seek the portal with the lowest cost route. Agents will continuously re-evaluate route costs as they navigate the scene and alter their choice as conditions change.</p>

Circulate Tab	
Circulate (Type)	<p>Defines the end conditions for agent circulation. When using a time or duration limit, the agent will cease circulating immediately once the limit is reached regardless of whether the agent is currently waiting or in transit between circulation portals.</p> <p>For entire simulation: The agent will continue circulating amongst the portals until the simulation is complete.</p> <p>For count: The agent will circulate for the specified number of iterations.</p> <p>For duration: The agent will circulate for the specified duration (measured from the time the agent is created).</p> <p>For duration or count: The agent will circulate until the specified duration or for the specified number of iterations (see 'Wait After Count' below).</p> <p>Until time: The agent will circulate until the specified simulation time. Agents created after the time will proceed immediately to their destination.</p> <p>Until time or count: The agent will circulate until the specified simulation time or for the specified number of iterations (see 'Wait After Count' below).</p>
Duration	The duration for which agents will circulate. The duration is measured separately for each agent, relative to the time at which the agent was created.
Time	The time at which agents will stop circulating.
Count	The number of portals an agent will visit before considering the circulation finished.
Wait After Count	When the count and duration or end time are used together, this determines the agent behaviour when they finish the circulation count before the specified duration limit or end time. If true, agents will continue to wait at their last circulation portal. If false agents will ignore the incomplete duration or end time and proceed to their destination.
Circulation Portals	The portals agents should circulate between. Portals can be weighted to adjust their chances of being chosen when agents are determining the next leg in their circulation. See Choosing Objects for more details.

Dwell Tab

Wait at Start	Whether agents should wait at their origin portal before starting to circulate.
Wait Style	How agents should position themselves as they wait at a circulation portal. Spread Out: Spread out over the floor, near the portal. Stand Still: Stop moving as soon as the portal is reached.
Dwell Duration	When an agent reaches a circulation portal, the agent will wait or dwell at that portal for a period of time. The time is randomly generated according to a distribution as specified by the dwell duration rules. Agents will search through the rules from top to bottom and use the distribution corresponding to the first occurrence of their circulation portal (either directly or as a member of a specified collection). If the circulation portal is not contained within the dwell rules, the default bottom distribution is used.

Colours Tab	
Colours	<p>Event colour: Agents are assigned the same colour as the event object.</p> <p>Lighten event colour: Agents are assigned a lighter version of the event object colour.</p> <p>Darken event colour: Agents are assigned a darker version of the event object colour.</p> <p>Rule based: Agents are assigned a colour according to the colouring rules. Working from top to bottom, agents will use the first colour for which the test evaluates to true.</p> <p>Specified colour: Agents are assigned the specified colour.</p>

Actions Tab	
On birth	The action will be applied to all agents created by the event as they enter the simulation. For a description of the order in which actions are applied see Action Order of Execution .

Collections in circulate events

[Collections](#) can be used in the "Origins", "Destination" and "Circulation Portals" properties. The collections can be weighted, changing the distribution of agents going from/to various portals.

4.3.2.5 Evacuate

Evacuate events simulate the evacuation of agents from the scene. Agents created by an evacuate event will first wait a specified amount of time, then attempt to exit the simulation through the best of the destination portals.

If [zones](#) have been specified, agents will attempt to evacuate each zone in order before heading to the destination [portals](#). Once a zone has been evacuated, agents may re-enter previously evacuated zones, so generally, subsequent zones should contain prior zones. Agents created outside evacuation zones will simply head to their destination portals.

Only agents created by this event will evacuate the given zones or head to the destination portals.

Active

A journey is active over the interval for which it can create agents. This will depend on the population demand type. When using 'Instant' the event is active only for an instant. When using 'Random' or 'Evenly spaced', the event is active for the duration of the specified interval, including those frames when no agent is created. When using a 'Table', the event is active from when the start condition is met until the final interval in the table is complete. Once the event has finished creating agents it is no longer active, even if those agents have not yet completed their evacuation.

Properties

Agents Tab	
Timing: Start Time	The condition for starting the event. See Triggering Events for more information.
Population : Profile	The profile used to create agents. If a collection is specified, each agent will be assigned one of the profiles from the collection. A weighted collection can be used to alter the distribution of profiles amongst the population.
Population : Demand	<p>The number of agents the event will create and when they will be created relative to the event start time.</p> <p>Evenly spaced: The specified number of agents will arrive at a constant rate over the duration.</p> <p>Instant: The specified number of agents will arrive all at once at the event start time.</p> <p>Random: The specified number of agents will arrive according to the specified distribution over the duration. See Duration Distributions for information on arrival distributions.</p> <p>Table: Complex agent arrival is described by a series of rows. Each row contains the duration of an interval and the number of agents to create over that interval. The first interval starts at the event start. Subsequent intervals begin when the previous interval ends. Agents are created according to a uniform distribution within each interval.</p>
Origins	The portals at which agents will be created. Portals can be weighted to alter the distribution of agents across the set. See Choosing Objects for more details.

Evacuation Tab	
Timing: Pre-movement wait	How long agents will wait before beginning to evacuate. This can be set as a distribution in seconds, see Single Value Distributions for more information.
Timing: Wait style	<p>How the agents will position themselves before evacuating.</p> <p>Stand Still: The agents will stand by the portal at which they were created.</p> <p>Spread Out: The agents will spread out over the floor on which they were created.</p>
Zones	The zones in order of evacuation. Agents will evacuate zones in order, but are not prevented from re-entering previously evacuated zones.
Exits: Clear Route	Agents are biased against backtracking across objects they have already traversed. If unchecked, agents that have evacuated all zones will be biased

History	against re-tracing their steps when seeking the exit portals. If route history is cleared, agents forget where they have been and will have no problem backtracking if that is the best way to reach their exit portals.
Exits	<p>The portals from which the agent will be given its initial goal. The agent will pursue its initial goal once it has finished with the pre-movement wait and evacuated any specified zones.</p> <p>Grouped: lowest cost: Agents are given all portals and instructed to seek the portal with the lowest cost route. Agents will continuously re-evaluate route costs as they navigate the scene and alter their choice as conditions change. The agent can be assigned a single portal chosen by chance, or assigned all portals and instructed to seek the lowest cost from the group. See Choosing Objects for information on how weights are used in portal assignment.</p> <p>Single: by chance: The agent will be assigned a single portal by chance. Weights can be specified to alter the likelihood of each portal being assigned. See Choosing Objects for information on how weights are used in portal assignment.</p>

Colours Tab	
Colours	<p>Event colour: Agents are assigned the same colour as the event object.</p> <p>Lighten event colour: Agents are assigned a lighter version of the event object colour.</p> <p>Darken event colour: Agents are assigned a darker version of the event object colour.</p> <p>Rule based: Agents are assigned a colour according to the colouring rules. Working from top to bottom, agents will use the first colour for which the condition evaluates to true.</p> <p>Specified colour: Agents are assigned the specified colour.</p>

Actions Tab	
On birth	The action will be applied to all agents created by the event as they enter the simulation. For a description of the order in which actions are applied see Action Order of Execution .

Collections in open gate events

[Collections](#) can be used in the "Origins" and "Exits" properties. The "Origins" collections can be weighted, changing the distribution of agents created at those portals.

4.3.2.6 Broadcast

The action event is used to apply the specified action to agents within the simulation. The event can be applied selectively based on whether or not an agent passes a test or is in a specified zone.

When the event becomes active the action is applied to all agents currently in the simulation. While active, the action is applied to all agents as they enter the simulation. The action is only applied to a given agent once, even if properties of that agent change while the event is still active.

If a target zone is specified then only agents within the zone receive the action. When using a target zone, agents that enter the zone while the action is active will have the action applied as if it were a zone 'On enter' action. Once inside the zone, the action will not be re-applied to an agent even if properties of that agent change while the event is still active. However, if the agent leaves and then re-enters the zone, the action will be reapplied on entry.

If a target test is specified then only agents passing the test will receive the action.

Active

When active the broadcast event is applying the action to new agents as they enter the simulation or target zone.

Time	
Active	Conditions under which the event becomes active. For more information on controlling event timing see Triggering Events .
Area of Effect	If set, then only agents inside the specified zone will respond to the event. When the event first fires it is applied to all agents in the zone. It is also applied to each agent that enters the zone, for as long as the event remains active.
Apply to Agents	If set, then only agents that pass the specified test will receive the action. The test is used only when the broadcast event becomes active or agents enter an effected zone while the event is active. The action will not be applied to agents for whom the test becomes true while the event is active.
Action	The action that will be applied to agents. The action is applied after any actions related to agent creation, but before any actions received during the frame.

4.3.2.7 Journey

Journey events are the most direct way to populate a scene. They create agents at an origin portal and instruct them to seek a destination portal. Once the agent has reached the destination portal they automatically exit the simulation.

If multiple origins are specified, agents are given a random origin based on a distribution. If multiple destinations are specified, agents can either be given a random destination based on a distribution or told to seek the 'best' destination from the set.

The same portal may be used as both an origin and destination, however, agents that are given the same portal as both origin and destination will exit the simulation immediately after being created.

Active

A journey is active over the interval for which it can create agents. This will depend on the population demand type. When using 'Instant' the event is active only for an instant. When using 'Random' or 'Evenly spaced', the event is active for the duration of the specified interval, including those frames when no agent is created. When using a 'Table', the event is active from when the start condition is met until the final interval in the table is complete.

Properties

Agents	
Timing: Start	The condition for starting the event. See Triggering Events for more information.
Population: Profile	The profile used to create agents. If a collection is specified, each agent will be assigned one of the profiles from the collection. A weighted collection can be used to alter the distribution of profiles amongst the population.
Population: Demand	<p>The number of agents the event will create and when they will be created relative to the event start time.</p> <p>Evenly spaced: The specified number of agents will arrive at a constant rate over the duration.</p> <p>Instant: The specified number of agents will arrive all at once at the event start time.</p> <p>Random: The specified number of agents will arrive according to the specified distribution over the duration. See Duration Distributions for information on arrival distributions.</p> <p>Table: Complex agent arrival is described by a series of rows. Each row contains the duration of an interval and the number of agents to create over that interval. The first interval starts at the event start. Subsequent intervals begin when the previous interval ends. Agents are created according to a uniform distribution within each interval.</p>
Origins	The portals at which agents will be created. Portals can be weighted to alter the distribution of agents across the set. See Choosing Objects for more details.
Destinations	<p>The portals from which the agent will be given its initial goal.</p> <p>Grouped: lowest cost: Agents are given all portals and instructed to seek the portal with the lowest cost route. Agents will continuously re-evaluate route costs as they navigate the scene and alter their choice as conditions change.</p> <p>Single: by chance: The agent will be assigned a single portal by chance. Weights can be specified to alter the likelihood of each portal being assigned. See Choosing Objects for information on how weights are used in portal assignment.</p>

Colours Tab

Colours	<p>Event colour: Agents are assigned the same colour as the event object.</p> <p>Lighten event colour: Agents are assigned a lighter version of the event object colour.</p> <p>Darken event colour: Agents are assigned a darker version of the event object colour.</p> <p>Rule based: Agents are assigned a colour according to the colouring rules. Working from top to bottom, agents will use the first colour for which the condition evaluates to true.</p> <p>Specified colour: Agents are assigned the specified colour.</p>
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Actions Tab	
On birth	The action will be applied to all agents created by the event as they enter the simulation. For a description of the order in which actions are applied see Action Order of Execution .

Collections

[Collections](#) can be used in the "Origins" and "Destination" properties. The collections can be weighted, changing the distribution of agents going from/to various portals.

4.3.2.8 Gate Access

Gate access events are used to control agent access to various [connection objects](#). When agents encounter a gate that is closed they will either wait until the gate is opened or search for another route to their goal. [Escalators](#), [links](#), [paths](#), [ramps](#) and [stairs](#) must have gating enabled in their "Access" properties before they can be used in a gate event.

The gate event can be used to open or close the target object(s). Access can be specified for both directions or a single direction across the object. Access can also be controlled for a sub population of agents by specifying an agent test.

When multiple events act on the same gate object, the most recently applied event takes precedence.

A [vehicle event](#) is a convenient combination of an open gate event and a [journey event](#).

Active

When active the gate access event will be opening/closing the specified gates.

Properties

Properties	
Active	Conditions under which the event becomes active. For more information on controlling event timing see Triggering Events .
Timing: Cycle	If cycling is enabled, the event will alternate between on and off while active. If the event becomes active multiple times in the simulation, it will restart the 'On' timer each time it becomes active. On: The gate will open/close for this duration after becoming active (or until the event is no longer active). Off: The gate will return to its original state for this duration.
Command	Open: The gate will be opened for as long as the event remains active. If the gate is already opened then there is no change. Close: The gate will be closed for as long as the event remains active. If the gate is already closed then there is no change.
Direction	Determine the direction of travel affected by the event.
Gates	Gated connection objects that will be opened by the event. A connection object may be used by several different open gate events.

Apply to agents	If enabled, the event command will only apply to agents for which the specified test evaluates to true. For example, if the event command is set to close and a 'Has token' test is specified, only agents with the given token will see the gate as closed. .
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Collections in gate events

[Collections](#) can be used in the "Gates" property. All member links with gates enabled will be opened as if they were directly used.

4.3.2.9 Profile

Every agent is created with a set of unique properties that define the agent's physical characteristics and personality. The range of possible values for each agent is defined by the profile used to create that agent. See [Single Value Distributions](#) for more information.

Events which create agents will have a "Profile" property which determines which profile will be used.

Profile Properties

The general properties of the agent define radius, speed, and movement characteristics.

General Tab	
Profile	Select from a number of preset values for agent radius and speed [1][2].
Radius	<p>The size of each agent. Given the default value of 0.25m, each agent, measured from one shoulder to the other, will be 0.5m across.</p> <p>Note: care should be taken with this value. The simulation has been tuned to a value of 0.25m. While there are no theoretical limits, it is recommended that the practical body radius remain between 0.15m and 0.4m.</p>
Speed	<p>Each agent is assigned a desired speed according to the specified distribution. The agent will attempt to maintain this speed when moving freely in flat open space. See agent movement for information on other factors affecting agent speed.</p>
Movement (Speed Density)	<p>Controls the relationship between density and speed.</p> <p>Fruin commuter: Constrain agent speed based on density, resulting in flows tuned to match the data in John Fruin's Pedestrian Planning & Design [2].</p> <p>Unconstrained: Do not constrain agent speed by density. This will result in potentially unrealistically high flow rates.</p>
Avatar (optional)	<p>Defines the physical appearance of agents produced by this profile. If no avatar is specified the default appearance is used. By default each scene view displays agents using animated bipeds rather than static avatars. See avatar for information on viewing the static avatars during playback.</p>
Direction Bias	<p>When faced with an opposing flow, agents will tend to drift either left or right depending on local customs. The direction bias indicates the direction of drift. In agent movement the collision avoidance, drift, and corner forces are all affected by the direction bias. Available options are: Left Strong, Left Weak, None, Right Weak, Right Strong.</p>

The route choice properties determine how an agent will weight different cost factors. The greater the variation in a particular weight distribution, the greater the variation in decisions made by a given population. Please see [Agent Navigation](#) for a description of the cost components.

Route Choice Tab	
Horizontal	Applied to the horizontal distance cost component. The horizontal distance is the sum of the distances across all objects along the route to the goal.
Vertical	Applied to the vertical distance component. The vertical distance is the sum of weighted vertical displacements across all objects along the route to the goal. Weights applied to the vertical displacements are based on object type (see Agent Navigation for more information).
Queue	Applied to the queue cost component. Queue costs apply only to queues that form for objects leading off of the current floor.
Processing	Applied to the closed penalty cost component. This includes all penalties from from any gate or priority access 'wait when closed' penalties, delays, or controlled flow restrictions on objects leading off of the current floor.

Actions Tab	
On birth	The action will be applied to all agents created with the profile as they enter the simulation. For a description of the order in which actions are applied see Action Order of Execution .

[1] London Underground's Station Modelling with Legion Best Practice Guide 2 | 3 July 2009 – section 4.3

[2] Fruin, John J. Pedestrian Planning & Design, Revised Edition Chapt. 4, Elevator World, 1987 - Chapter 3

4.3.2.10 Server Access

Server access events are used to control agent ingress and/or egress to and from [server](#) objects. The same event can be used to open or close the entry onto a server or the exit from a server.

When the entry to a server is closed the server is unavailable to agents and will be ignored during [dispatch](#).

When the exit of a server is closed processed agents will remain on the server until the exit is opened. Agents held at the server exit can block other agents from being processed and are counted when determining the server's available capacity.

When multiple events act on the same gate server, the most recently applied event takes precedence.

Active

When active the server access event will be opening/closing the specified servers.

Properties

Properties	
Active	Conditions under which the event becomes active. For more information on controlling event timing see Triggering Events .
Timing: Cycle	If cycling is enabled, the event will alternate between on and off while active. If the event becomes active multiple times in the simulation, it will restart the 'On' timer each time it becomes active. On: The gate will open/close for this duration after becoming active (or until the event is no longer active). Off: The gate will return to its original state for this duration.
Command	Open: The server will be opened for as long as the event remains active. If the server is already opened then there is no change. Close: The server will be closed for as long as the event remains active. If the server is already closed then there is no change.
Target	Determine whether the entrance, exit, or both are opened or closed by the event.
Servers	Server objects that will be opened or closed by the event. A server may be used by several different server events.

Collections in server events

[Collections](#) can be used in the "Servers" property. All member servers will be opened/closed as if they were directly used.

4.3.2.11 Time

Reference times are virtual events that do not directly impact simulation. They are useful for representing significant times in a simulation such as a fire alarm or the end of a concert. If other dependent events refer to the reference time, then only the reference time need be modified to reflect operational changes. See time references in [Working with Time](#).

Active

The time event is active for the brief instant corresponding to the specified time.

Properties

Properties	
Timing: Start	When the reference event is considered to have started.

4.3.2.12 Timetable

Timetable objects allow for the rapid and potentially automated creation of large numbers of agents and coordinated events. They are suitable for modeling train schedules, flight schedules, bus schedules, university lectures, intersection gate timings, or any number of additional scenarios.

Timetables allow for the batch import of related agent schedules and/or events. Timetables are driven

by a series of comma separated (csv) text files. Once imported, the raw data is embedded in the timetable object and will be saved as part of the scene. The raw data is only processed on validation or simulation so there is little overhead associated with the amount of data or the number of entries.

Timetable files can be generated by hand, but will more often be generated by user written scripts or excel macros.

Different input files control different aspects of the timetable. One file specifies the creation of agents while another controls gate open events. It is possible to define time and location dependencies between the different files (so that a gate opens and agents are created at the same time) through the use of internal reference events. Reference events are not visible to scene elements outside of the timetable. Agents created with respect to a particular reference event are forever associated with that reference identifier and can be later targeted by other timetable events. It is also possible to create a very simple timetable that only executes gate events or only controls agent scheduling.

When inspecting a timetable object, the buttons at the top of the window allow for batch import/export/reload of the various timetable files. Each file type has a default name constructed from the name of the timetable and the file type. Default names are listed in the 'File Types' table below.

For information on each of the supported timetable files, see [Timetable Files](#).

Menu Bar Commands	
File: Import Timetable	Select a folder and import all contained files with the expected default names (see File Types below).
File: Export Timetable	Select a folder and export all file types that contain data. If file names are not specified the default file names are used.
File: Export Empty Timetable	Select a folder and export empty versions of all files using the default names (see File Types below).
Reload	Attempt to reload data from each file specified in the window. Entries where no file is specified will be ignored.

General Properties	
Base Path	This is the default location for input files managed by the timetable. If any specific file names are relative they are assumed to be in this path.
Profile	The default profile to use for agents created by the agent schedule file when no profile is specified in the file.

4.3.2.12.1 Timetable Files

Timetable files are all field separated (csv) text files. The separation character is by default a comma but can be set through the [Application Preferences](#). Blank lines in the file are ignored, as are leading and trailing spaces. Any line beginning with a '#' is considered a comment and is skipped.

File Types	
Reference Events	<p>Import, export, or clear the embedded reference event data. A reference event entry specifies a time, duration, and location. These events can be used by other sections of the timetable such as agent schedules, gate events, evacuation events, or action events.</p> <p>Default name: TimetableReferenceEvent.csv.</p> <p>See Timetable Reference Event File for more information.</p>
Agent Schedules	<p>Import, export, or clear the embedded agent schedule data. Each schedule entry creates a specified number of agents with particular origins and destinations.</p> <p>Default name: TimetableSchedule.csv.</p> <p>See Timetable Schedule File for more information.</p>
Curves	<p>Import, export, or clear the embedded curve data. Each curve entry defines an arrival profile or distribution that can be used by the agent schedules.</p> <p>Default name: TimetableCurve.csv.</p> <p>See Timetable Curve File for more information.</p>
Locations	<p>Import, export, or clear the embedded location data. Each location entry defines a collection of portals with corresponding distributions or membership weights. Locations can be used by reference events, agent schedules, or evacuation events.</p> <p>Default name: TimetableLocation.csv.</p> <p>See Timetable Location File for more information.</p>
Gates	<p>Import, export, or clear the embedded gate data. Each gate entry defines a collection of gate objects and can be referenced by gate events.</p> <p>Default name: TimetableGate.csv.</p> <p>See Timetable Gate File for more information.</p>
Gate Events	<p>Import, export, or clear the embedded gate event data. Each gate event entry will open a collection of gates for a specified interval. The gate event can be used on its own or in combination with the reference event.</p> <p>Default name: TimetableGateEvent.csv.</p>

	See Timetable Gate Event File for more information.
Evacuation Events	Import, export, or clear the embedded evacuation event data. Each evacuation event entry will broadcast a single evacuation over the specified interval. Default name: TimetableEvacuationEvent.csv. See Timetable Evacuation Event File for more information.
Action Events	Import, export, or clear the embedded action event data. Each action event entry will apply the specified action to agents over the specified interval. Default name: TimetableActionEvent.csv. See Timetable Action Event File for more information.

4.3.2.12.1.1 Timetable Reference Event File

The timetable reference event file is a comma separated (csv) text file defining one or more reference events. Each row corresponds to a single reference event. These events can be referenced by other input files within the same timetable. Reference events defined within the timetable may not be referenced from outside of the timetable. Reference event names must be unique and cannot be the same as any other objects within the project.

Reference events can refer to anything from an airplane departure to a train arrival to a university lecture. The end time of the event is calculated as Start Time + Duration.

Column Headers	
Reference Event Name	The name of a reference event. The name must be unique both within the file and across the entire MassMotion project. Other files within the timetable can refer to a reference event by name.
Start Time	The time associated with the reference event. The value must be either a single number indicating seconds, or a string of the form hh:mm:ss.
Duration (optional)	The duration from arrival to departure. The value must be either a single number indicating seconds, or a string of the form hh:mm:ss. If no value is specified a duration of 0 is assumed.
Location	Either the name of a location group (see Timetable Location File) or the name of a portal or collection of portals in the project.
Init Action (optional)	The name of an existing action in the project. The action will be applied to any agent created by a schedule that refers to this reference event. The action is applied after the agent has been given any optional tokens from subsequent columns.
Give Tokens... (optional)	Each subsequent column can specify a single token or collection of tokens

variable)	by name. The token or token collection must exist in the project. Agents created by a schedule that refers to this event will be given the specified tokens. The tokens are given before the Init Action is applied.
------------------	--

Example

See [Timetable Reference Event Example](#).

4.3.2.12.1.2 Timetable Schedule File

The timetable schedule file is a comma separated (csv) text file defining a number of schedules. Each row corresponds to a single schedule and will create a population of agents. The schedule can optionally refer to events in the reference event file or be used independently.

If the From or To fields reference locations, agents are created and sent to those locations. If the From or To fields refer to reference events, the agents are created and sent to the locations defined by those events.

The start time for a schedule is determined based on whether or not reference events were specified in the From or To fields:

- **From reference event, To reference event:** The start time is taken from the From reference event start time.
- **From reference event, To location:** The start time is taken from the From reference event start time.
- **From location, To reference event:** The start time is taken from the To reference event start time.
- **From location, To location:** The start time is assumed to be midnight on the day at which the simulation begins (so the time offset effectively becomes the start time).

Column Headers	
From	The location at which agents should be created. The location can be either the name of an existing portal in the project, the name of a collection of portals in the project, the name of a location from the Timetable Location File or the name of a reference event from the Timetable Reference Event File . If the location is from the location file or a project collection agents will be distributed across the member portals according to the associated distribution. If the location is the name of a reference event, the event location is used.
To	The goal location given to agents created by the schedule. The location can be either the name of an existing portal in the project, the name of a collection of portals in the project, the name of a location from Timetable Location File , or the name of a reference event from the Timetable Reference Event File . If the location is from the location file agents will be either sent to the portals according to the defined distribution, or told to seek the closest portal member depending on the settings in the location file. If the location is a project collection agents will be sent to the portals

	according to the collection weights. If the location is the name of a reference event, the event location is used.
Population	The number of agents created by the schedule.
Time Offset (optional)	A time value added to the schedule start time. The value must be either a single number indicating seconds, or a string of the form hh:mm:ss. If a reference event has been specified, this time is added to the reference event start time. If no reference event has been specified, this time is taken as the schedule start time, measured relative to midnight (00:00:00). See above for a full description of how the schedule start time is determined.
Curve (optional)	The name of an entry in the Timetable Curve File curve file. The specified population of agents will be created according to the curve distribution. If no curve is specified, all agents are created over 1 second.
Avatar or Colour (optional)	The name of an existing avatar in the project or a valid colour name. If the text matches the name of an avatar, then agents created by the schedule will be given that avatar. If the text does not match the name of an avatar but corresponds to a recognized colour, then agents will be created with the default avatar and given the specified colour. If the entry is blank the default avatar is used and the agent is coloured grey. Colors: aqua, blue, green, orange, red, yellow, black, white, grey, lightgrey, darkgrey. See Timetable Colours for a full list of supported colours.
Profile (optional)	The name of an existing profile or collection of profiles in the project. If a collection is specified each agent is given one of the profiles chosen randomly according to the collection weighting. If no profile is specified, agents will be given the default profile.
Init Action (optional)	The name of an existing action in the project. The action will be applied to any agent created by the schedule. The action is applied after the agent is given any optional tokens from subsequent columns.
Give Tokens... (optional, variable)	Each subsequent column can specify a single token or collection of tokens by name. The token or token collection must exist in the project. Agents created by a schedule that refers to this event will be given the specified tokens. The tokens are given before the Init Action is applied.

Example

See [Timetable Schedule Example](#) and [Timetable Reference Event Example](#).

The following colour names can be used in the [Timetable Schedule File](#).

Agent Colours

amber	FFBF00	
aqua	00FFFF	
azure	007FFF	
beige	F5F5DC	
black	000000	
blue	0000FF	
brown	8B4513	
chartreuse	7FFF00	
darkblue	00007F	
darkgray	404040	
darkgreen	007F00	
darkred	7F0000	
gray	7F7F7F	
green	00FF00	
ivory	FFFFFF0	
lightgray	BFBFBF	
magenta	FF00FF	
mint	BDFCC9	
navy	00007F	
olive	6B8E23	
orange	FF7F00	

pink	FFB5C5	
purple	9B30FF	
red	FF0000	
rose	FF007F	
salmon	FA8072	
teal	808000	
turquoise	E34234	
vermilion	40E0D0	
violet	7F00FF	
wheat	F5DEB3	
white	FFFFFF	
yellow	FFFF00	

4.3.2.12.1.3 Timetable Curve File

The timetable curve file is a comma separated (csv) text file defining different arrival profiles for use by the timetable schedule. Each row corresponds to a single curve distribution and can be referenced from [Timetable Schedule File](#) by name.

Column Headers	
Curve Name	The name of the curve.
Interval Duration	The length of each step in the curve. The value must be a single number indicating seconds, a single number with a 'h', 'm', or 's' designator, or a string of the form hh:mm:ss. Agents created inside each interval are distributed randomly within the interval.
Values... (variable)	Each subsequent column specifies a single value indicating the percentage of the total population that is to be created within that interval. Use a single value of 1 to indicate that all agents should be created within a single interval. Values of 0.25, 0.5, 0.25 would indicate that a quarter of the

	agents should be created over the first interval, half over the second, and the remaining quarter over the third interval. Values in a curve must sum to 1.
--	---

Example

```

#
# Sample MyTimetableCurve.csv
#
Curve Name,           Interval DurationValues..

# all agents within a single second
CBurst1,             1,                 1

# uniformly random over 10 seconds
CConstant10,         10,                1

# uniformly random over 120 seconds
CConstant120,        00:02:00,          1

# tapered over 60 seconds
CTapered60,          10,                0.5,   0.3,   0.1,   0.05,  0.025,  0.025

# tapered over 120 seconds
CTapered120,         20,                0.5,   0.3,   0.1,   0.05,  0.025,  0.025

# custom rates over 1 hour
CCustom1H,           0.2h,              0.2,    0.01,   0.45,   0.15,   0.29

```

Also, see [Timetable Schedule Example](#).

4.3.2.12.1.4 Timetable Location File

The timetable location file is a comma separated (csv) text file defining a group of portals. The header lists all portals available in the project. Each row corresponds to a different group, with non-zero values indicating that the given portal is to be included in the group. Fractional values are used to indicate percentage allocations within the group. The location group names must be unique both within the file and within the MassMotion project.

Location groups can be referenced by the [Timetable Reference Event File](#), [Timetable Schedule File](#), or [Timetable Evacuation Event File](#).

Column Headers	
Group Name	The name of the location group. The name must be unique both within the file and across the entire MassMotion project.

Use Closest Goal (optional)	This determines whether agents using this location as their goal will be assigned a specific member portal based on the distribution (if false or blank), or given all portals and told to seek the closest (if true). Use Y or 1 to indicate true.
Portal or Collection Names... (variable)	<p>Each location can indicate which portals are to be included in the group by specifying a non-zero value in the corresponding column. Values should be between 0 and 1. All values for a group should sum to 1. When a location group is specified but only a single portal is required (for example when determining where to create an agent) a portal is chosen from the group using the probability distribution defined by the non-zero fractional values.</p> <p>When collection names are used the location will include all portal members of the collection. Non portal members are ignored. Weights for individual portals are calculated by multiplying the collection member weight by the weight specified for the collection in the location file. When a collection does not specify weights, portal members are considered equally weighted within the collection. If the same portal appears multiple times, its weights are summed.</p>

Example

```

Assume the following collections defined in the project:
1. CollNoWeight: Portal_A, Portal_B
1. CollManualWeight: Portal_A (0.25), Portal_B (0.75)

#
# Sample MyTimetableLocation.csv
#
Group 1Use ClPortal_Portal_Portal_CollNoWeight          CollManualWeight

# create a group with A and B and equal entrance and exit distribution
GroupA!,      Y,      Y

# create a group with A and B where agents are 3 times more likely to use A than B
GroupA!,      0.75,   0.25

# create a group with equal entrance distribution over A, B, D, where when exiting
GroupPAY,     Y,      Y,      0,      Y

# create a group with C and D where as entrances agents are twice as likely to pick
GroupCDY,     ,      ,      0.6666,0.3333

# create a group with members and weightings Portal_A (0.6*0.5=0.3), Portal_B (0.6*
ColEx1           0.4           0.6

# create a group with members and weightings Portal_A (0.8*0.25=0.2), Portal_B (0.8
ColEx2           0.2           0.8

```

Also, see [Timetable Schedule Example](#).

4.3.2.12.1.5 Timetable Gate File

The timetable gate file is a comma separated (csv) text file defining a group of gates. The header lists all gates available in the project or collections which contain gates. Each row corresponds to a different group, with non-zero values indicating that the given gate is to be included in the group. The gate group names must be unique both within the file and within the MassMotion project.

Gate groups can be referenced by the [Timetable Gate Event File](#).

Column Headers	
Group Name	The name of the location group. The name must be unique both within the file and across the entire MassMotion project.
Gate or Collection Names... (variable)	Each gate group can indicate which gates are to be included in the group by specifying a non-zero value in the corresponding column. If a collection name is specified, the group will contain all gates found in the collection.

Example

See [Timetable Gates Example](#)

4.3.2.12.1.6 Timetable Gate Event File

The timetable gate event file is a comma separated (csv) text file defining a number of gate events. Each row corresponds to a single event and will open one or more gates for a specified period of time. The names of the events must be unique both within the file and across the MassMotion project. The events defined within the timetable have no connection to events defined elsewhere in the project.

The start time for an event depends on whether or not a reference event was specified. When using a reference event, the start time is taken from the reference event. If no reference event is specified, the start time is assumed to be midnight on the day at which the simulation begins (so the time offset effectively becomes the start time).

Column Headers	
Reference Event Name (optional)	The name of a reference event as defined in the Timetable Reference Event File . The field can be left blank to indicate that the event is not associated with any reference event.
Time Offset (optional)	Combines with the event start time to define the time at which the event fires. If a reference event has been specified, this time is added to the reference event start time. If no reference event has been specified, this time is taken as the gate event start time, measured relative to midnight (00:00:00). The value must be either a single number indicating seconds, or a string of the form hh:mm:ss. If no value is specified a value of 0 is assumed.

Duration (optional)	The length of time the gate will remain open. If a reference event has been specified, this field can be left blank to indicate that the reference event duration should be used. The value must be either a single number indicating seconds, or a string of the form hh:mm:ss.
Apply only to Reference Event	If a reference event has been specified and a true value (Y or 1) is used, the gate will only open for those agents created by a schedule that uses the specified reference event. The gate will remain closed to all agents not arriving from or heading to the reference event.
Key Token (optional)	The name of an existing token in the project. If specified, the gate will only open for those agents holding the specified token.
Gates... (variable)	Each subsequent column can specify a gate or gate group to be opened by the event. Each entry must refer either to an existing gate object in the project, a project collection which contains gates, or to a gate group defined in the Timetable Gate File .

Example

See [Timetable Gates Example](#).

4.3.2.12.1.7 Timetable Action Event File

The timetable action event file is a comma separated (csv) text file defining a number of action events. Each row corresponds to a single event and will fire the specified action for a specified period of time. The names of the events must be unique both within the file and across the MassMotion project. The events defined within the timetable have no connection to events defined elsewhere in the project.

The start time for an event depends on whether or not a reference event was specified. When using a reference event the start time is taken from the reference event. If no reference event is specified the start time is assumed to be midnight on the day at which the simulation begins (so the time offset effectively becomes the start time).

When the event fires, the action is applied to all agents in the scene that meet the criteria defined by the event definition. The event then remains active for the specified duration. If a zone is specified, the active event will be applied to all agents that enter the zone. If no zone is specified, the active event will apply to all agents entering the simulation. The event will not be applied to the same agent twice unless a zone is specified and the agent enters then leaves then re-enters the zone.

Column Headers	
Reference Event Name (optional)	The name of a reference event as defined in the Timetable Reference Event File . The field can be left blank to indicate that the event is not associated with any reference event.
Time Offset (optional)	Combines with the event start time to define the time at which the event fires. If a reference event has been specified, this time is added to the reference event start time. If no reference event has been specified, this

	time is taken as the event start time measured from midnight (00:00:00). The value must be either a single number indicating seconds, or a string of the form hh:mm:ss. If no value is specified a value of 0 is assumed.
Duration	The length of time the event remains active. See above for a description of how the event is applied while active.
Apply only to Reference Event	If a reference event has been specified and a true value (Y or 1) is used, the action will only be applied to those agents created by a schedule that uses the specified reference event.
Key Token (optional)	The name of an existing token in the project. If specified, the action will only be applied to agents holding the specified token.
Target Zone (optional)	The name of an existing zone in the project. If specified, the action will only be applied to agents in the target zone. If new agents enter the zone while the event is active, the action is applied to those agents as they enter the zone. If no zone is specified, the event is applied to all agents in the scene regardless of location.
Action	The name of an existing action in the project. This action will be applied once to all agents currently in the scene that meet the event criteria, then subsequently to all agents that either enter the zone or scene while the event is active.
Give Tokens... (optional, variable)	Each subsequent column can specify a single token or collection of tokens by name. The token or token collection must exist in the project. Each agent that is affected by the action event will also be given the specified tokens. Agents receive the tokens before the event action is applied.

4.3.2.12.1.8 Timetable Evacuation Event File

The timetable evacuation event file is a comma separated (csv) text file defining a number of evacuation events. Each row corresponds to a single event and will fire for a specified period of time. The names of the events must be unique both within the file and across the MassMotion project. The events defined within the timetable have no connection to events defined elsewhere in the project.

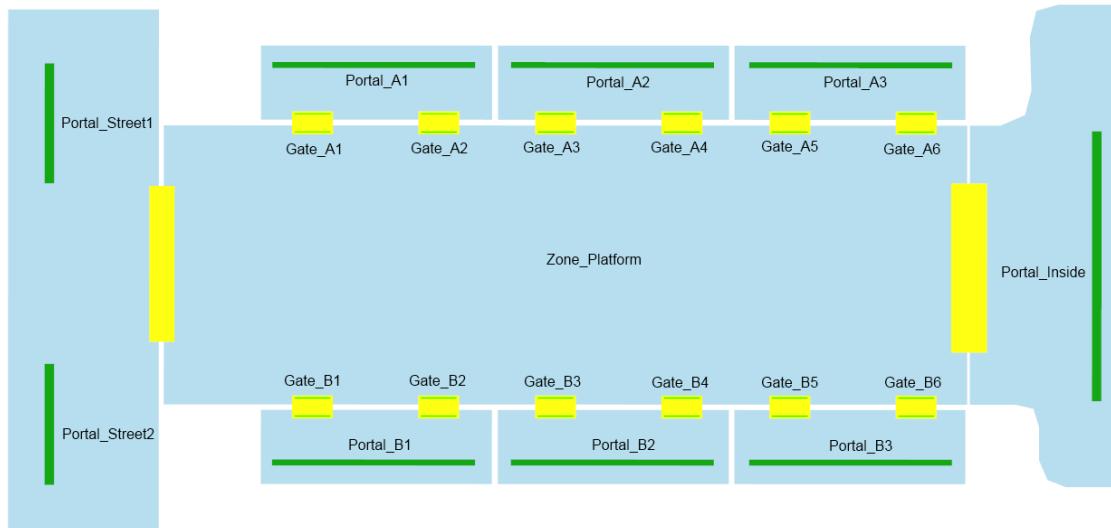
The start time for an event depends on whether or not a reference event was specified. When using a reference event the start time is taken from the reference event. If no reference event is specified, the start time is assumed to be midnight on the day at which the simulation begins (so the time offset effectively becomes the start time).

When the event fires, the evacuation command is given to all agents in the scene that meet the criteria defined by the event definition. The event then remains active for the specified duration. If a zone is specified, the active event will be applied to all agents as they enter the zone. If no zone is specified, the active event will apply to all agents entering the simulation. The event will not be applied to the same agent twice unless a zone is specified and the agent enters then leaves then re-enters the zone.

Column Headers	
Reference Event Name (optional)	The name of a reference event as defined in the Timetable Reference Event File . The field can be left blank to indicate that the event is not associated with any reference event. The reference event can be used to define either the event start time or evacuation location.
Time Offset (optional)	Combines with the event start time to define the time at which the event fires. If a reference event has been specified, this time is added to the reference event start time. If no reference event has been specified, this time is taken as the event start time measured from midnight (00:00:00). The value must be either a single number indicating seconds, or a string of the form hh:mm:ss. If no value is specified, a value of 0 is assumed.
Duration	The length of time the event remains active. See above for a description of how the event is applied while active.
Apply only to Reference Event	If a reference event has been specified and a true value (Y or 1) is used, the evacuation will only be applied to those agents created by a schedule that uses the specified reference event.
Key Token (optional)	The name of an existing token in the project. If specified, the evacuation will only be applied to agents holding the specified token.
Target Zone (optional)	The name of an existing zone in the project. If specified, the evacuation will only be applied to agents in the target zone. If new agents enter the zone while the event is active, the evacuation is applied to those agents as they enter the zone. If no zone is specified the event is applied to all agents in the scene regardless of location.
Pre Movement Distribution (not used)	Not yet supported.
Location... (optional)	The name of an existing portal in the project, the name of a collection of portals in the project, or the name of a location group from the Timetable Location File . If left blank and a reference event has been specified, the location associated with the reference event is used. Agents will be told to seek the location. Once the agent reaches the location it will successfully exit the scene.
Give Tokens... (optional, variable)	Each subsequent column can specify a single token or collection of tokens by name. The token or token collection must exist in the project. Each agent that is affected by the evacuation event will also be given the specified tokens.

4.3.2.12.2 Timetable Examples

All timetable examples assume the same general scene which can either be created from scratch using the steps below, or opened pre built from the TimetableExample.mm project in the Examples folder of the MassMotion installation directory.



1. Create a scene with the objects positioned and named as shown above.
2. Create an empty timetable object from the 'Activities' ribbon in the MainWindow and name it 'MyTimetable'.
3. Open the MyTimetable properties and use the File button to 'Export Empty Timetable' files to a folder.
4. Edit the generated timetable files as appropriate (see the examples listed below).
5. Reload all file changes back into the timetable object using the 'Reload' button in the timetable's properties window.
6. The project is ready for simulation.

Examples:

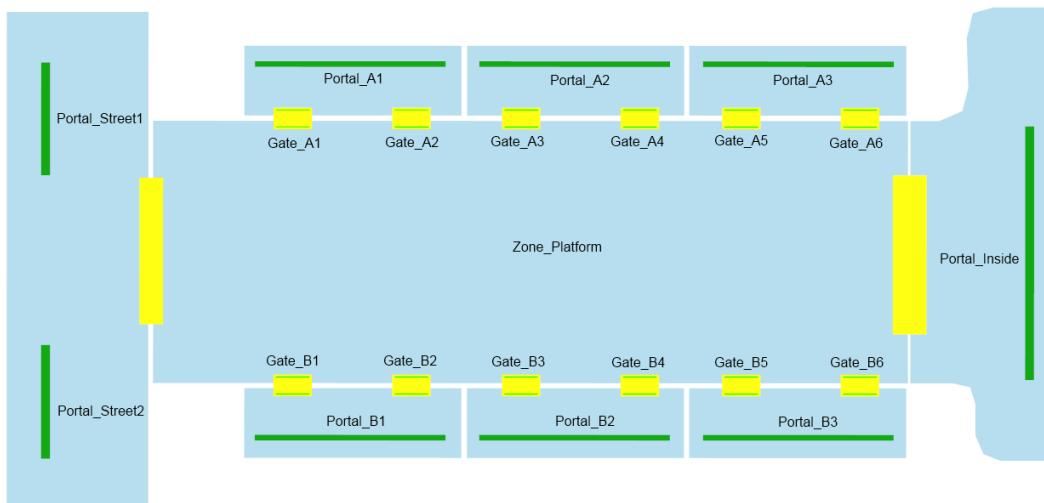
- [Timetable Schedule Example](#)
- [Timetable Gates Example](#)
- [Timetable Reference Event Example](#)

4.3.2.12.2.1 Timetable Schedule Example

This example includes timetable files for generating a few simple streams of agents moving between the portals as shown below.

Scene Setup

Create a scene as described in [Timetable Examples](#) before attempting to edit the timetable files.



Timetable Setup

A simple curve file defines a few arrival distributions for use in the schedule file:

#								
#								
# Sample MyTimetableCurve.csv								
#								
Curve Name,	Interval	Durat	Values..					
# uniformly random over 30 second								
CConstant30,	30,		1					
# uniformly random over 120 secon								
CConstant120,	00:02:00,		1					
# tapered over 60 seconds								
CTapered60,	10,	0.5,	0.3,	0.1,	0.05,	0.025,	0.025	
# custom rates over 1 hour								
CCustom1H,	0.2h,	0.2,	0.01,	0.45,	0.15,	0.29		

A simple location file defines groupings of portals for easy reference in the schedule file:

#								
#								
# Sample MyTimetableLocation.csv								
#								
Group Name	Use Closest	Portal_A1, Portal_B1	Portal_A2, Portal_B2	Portal_A3, Portal_B3	Portal_A4, Portal_B4	Portal_A5, Portal_B5	Portal_A6, Portal_B6	Portal_Inside
# Track A has uneven arrival distribution of agents across the cars, but departing								

GTrackA,	Y,		0.20,		0.40,	0.40					
# Track B has even arrival distribution and departing agents are even											
GTrackB,	,	,	,	,	,	Y,	Y,	Y			
# A simple group to include both streets											
GStreet,	,	,	,	,	,	,	,	,	Y,	Y	

And finally the schedule file for generating agents

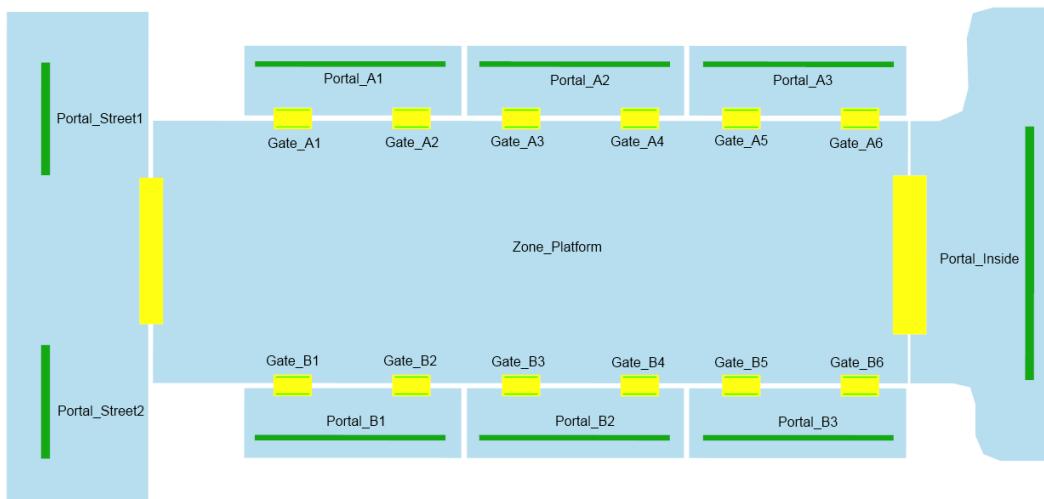
#											
# Sample MyTimetableSchedule.csv											
#											
From,	To,	Population	Time OffCurve,	Avatar or CProfile	Init Action	Give Tokens...					
# 100 agents at 00:15:00 over 1 hour, from either street portal to Portal_Inside											
GStreet,	Portal_Inside	100,	00:15:00	CCustom1	Red						
# 45 and 23 agents at 00:15:00 over 1 hour, from Portal_Inside to the street											
Portal_Inside	Portal_Street45,	15m,	CCustom1	Blue							
Portal_Inside	Portal_Street23,	15m,	CCustom1	Blue							
# 60 agents at 00:20:00 over 1 second from portals on Track A to the street, initiating green light											
GTrackA,	GStreet,	60,	00:20:00	Green,		InitArrive					
# 100 agents at 27:30:00 over 120 seconds, from TrackA portals to TrackB portals, changing light to red											
GTrackA,	GTrackB,	100,	27:30:00	CConstant	Red,	,	,		TNextDay	Ttransfe	

4.3.2.12.2.2 Timetable Gates Example

This example includes timetable files for opening and closing a series of gates. This example could be used in combination with other timetable files, regular agent schedules, or regular gate events to achieve the desired result.

Scene Setup

Create a scene as described in [Timetable Examples](#) before attempting to edit the timetable files.



Timetable Setup

A simple gate file defines groupings of links for easy reference in the gate event file:

```
# 
# Sample MyTimetableGate.c
#
# Group Name: Gate_A1, Gate_A2, Gate_A3, Gate_A4, Gate_A5, Gate_A6, Gate_B1, Gate_B2, Gate_B3, Gate_B4, Gate_B5, Gate_B6
#
# Combine all gates for track A into a single group for easy reference
Gates_A,Y, Y, Y, Y, Y, Y
#
# Track B has even arrival distribution and departing
Gates_B,, , , , , , Y, Y, Y, Y, Y, Y,
```

And finally the gate event file for opening and closing gates.

```
# 
# Sample MyTimetableGateEvent.csv
#
# Reference: Time Offset, Duration, Apply Only, Key Token, Gate
#
# Open all gates in the group Gates_A at 00:30:00 for 1 minute, for all agents
, 00:30:00, 1m, , , , Gates_A
#
# Open all gates in the group Gates_B at 00:35:00 for 30 seconds, only for agents having TArriving
, 00:35:00, 30, , , TArriving, Gates_B
#
# Open Gate_B4 at 32:30:00 for 1 hour, for all agents
#
```

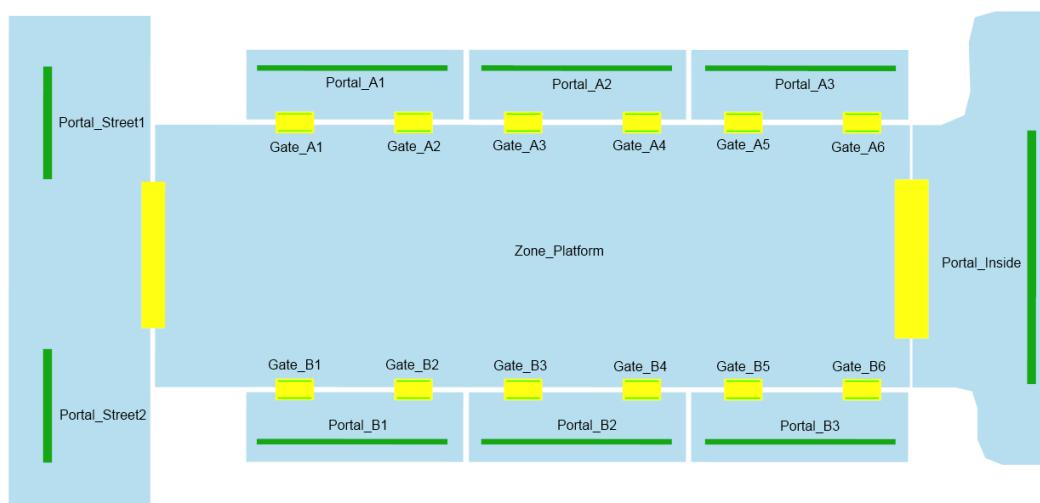
,	32:30:00,	01:00:00,,	,	Gate_B4		
---	-----------	------------	---	---------	--	--

4.3.2.12.2.3 Timetable Reference Event Example

This example includes timetable files for simulating a simple train platform using reference events. A continuous stream of departing agents will move from the street and inside portals to both of the platforms. Train arrivals will be represented by reference events. When a train arrives on track A or B, a group of arriving agents will be generated and the corresponding gates opened to allow passage for boarding and alighting passengers. In addition to the train arrivals, a reference event will be used to represent a street festival to which some agents will be

Scene Setup

Create a scene as described in [Timetable Examples](#) before attempting to edit the timetable files. In addition to the general steps outlined above, create tokens TTrainA, TTrainB



Timetable Setup

A simple curve file defines a few arrival distributions for use in the schedule file:

```
#  
# Sample MyTimetableCurve.csv  
  
#  
Curve Name, Interval DurationValues..  
  
# uniformly random over 1 hour  
CConstant1H, 01:00:00, 1
```

A simple location file defines groupings of portals for easy reference in the schedule file:

#									
# Sample MyTimetableLocation.csv									
#									

Group Name	Use Closest	Portal_A1	Portal_B1	Portal_C1	Portal_D1	Portal_E1	Portal_F1	Portal_G1	Portal_H1
# Track A has uneven arrival distribution of agents across the cars, but departing									
GTrackA,	Y,	0.20,	0.40,	0.40					
# Track B has even arrival distribution and departing agents are even									
GTrackB,	,	,	,	,	Y,	Y,	Y		
# A simple group to include both streets									
GStreet,	,	,	,	,	,	,	,	Y,	Y

The reference event file defines each reference event with corresponding time and location. The reference event can then be referenced from other event files or the schedule file.

#									
# Sample MyTimetableReferenceEvent.csv									
#									
Reference	Start Time,	Duration,	Location,	Init Action	Give Tokens...				
# Train A arrivals at portals in the GTrackA group (could be repeated any number of times)									
Arrive_A1,	14:40:00,	,	GTrackA,	,					
Arrive_A2,	14:55:00	,	GTrackA	,					
# Train B arrivals at portals in GTrackB group (could be repeated any number of times)									
Arrive_B1,	14:45:00,	,	GTrackB,	,					
Arrive_B2,	14:54:00,	,	GTrackB,	,					
# Festival event happening at Portal_Street1									
Festival,	15:00:00,	01:00:00,	Portal_Street1	InitFestiva					

The schedule generates agents. Some agents are based on the locations and times of reference events, and others are simply bound from one portal or location to another.

#									
# Sample MyTimetableSchedule.csv									
#									
From,	To,	Population	Time Off	Curve,	Avatar,	Profile,	Init Action	Give Tokens...	
# agents departing on tracks A and B (independent of any reference events)									
GStreet,	GTrackA,	200,	14:15:00	CCConstan	Red				
Portal_1	GTrackA,	100	14:15:00	CCConstan	Red				
GStreet,	GTrackB,	200,	14:15:00	CCConstan	Blue				
Portal_1	GTrackB,	100,	14:15:00	CCConstan	Blue				

```

# agents arriving on trains A1 and A2 (over 1s), with a -5s offset to make
Arrive_1GStreet, 20, -5, , Green
Arrive_1Portal_Inside6, -5, , Green

# agents arriving on trains B1 and B2 (over 1s), with a -5s offset to make sure the
Arrive_1GStreet, 25, -5, , White
Arrive_1Portal_Inside10, -5, , White

# agents going to the festival, starting to appear 45 minutes before it starts
Portal_1Festival, 100, -00:45:(CConstarYellow
GStreet,Festival, 57, -00:45:(CConstarYellow

# agents arriving on trains and going to the location defined by the Festiv
Arrive_1Festival, 3, -5s, , Orange
Arrive_1Festival, 6, -5s, , Orange
Arrive_1Festival, 1, -5s, , Orange

```

The gate file defines groupings of links for easy reference in the gate event file:

The gate event file opens and closes the gates based on train arrival reference events

```

# Sample MyTimetableGateEvent.csv

# Reference Time Offset, Duration, Apply Only Key Token, Gate

# Open gates briefly for arriving agents only (those generated from the schedule base)
Arrive_A1 00:00:00, 10, Y, , Gates_A

# Open gates for all other agents departing on track A
Arrive_A1 00:00:10, 50, , , , Gates_A

# Similar events for all other arrivals
Arrive_A2 00:00:00, 10, Y, , Gates_A

```

Arrive_A2	00:00:10,	50,	,	,	Gates_A		
Arrive_B1	00:00:00,	10,	Y,	,	Gates_B		
Arrive_B1	00:00:10,	50,	,	,	Gates_B		
Arrive_B2	00:00:00,	10,	Y,	,	Gates_B		
Arrive_B2	00:00:10,	50,	,	,	Gates_B		

4.3.2.13 Token

Tokens are objects held by agents. They can be used to identify certain agents or to limit access at [connection objects](#). Tokens are given or removed using [Agent Actions](#).

4.3.2.14 Triggers

A trigger can fire in response to conditions in the simulation. When a trigger fires, connected events become active. Some triggers fire in a discrete manner, becoming active for a single frame at a time. Other triggers fire continuously over an interval. The type of triggers available will depend on whether the context calls for a discrete or interval based trigger. Some triggers, like the 'Whenever' or 'Beginning of' triggers, can convert the output of an interval trigger into a discrete single frame response.

For information on using triggers to drive events, see [Triggering Events](#).

Time triggers are discrete and pulse once at the indicated time.

Time Based Triggers	
Absolute time	Fire once at the specified simulation time.
Event start time	Fire once at the specified offset from the start time of the indicated event. The offset can be negative. The event must have a resolvable fixed start time that is not scene dependent.
Simulation start	Fire once at the specified offset from the simulation start.
Simulation end	Fire once at the specified offset from the simulation end.

Special triggers are discrete and fire at some time in relation to a reference trigger.

Special Triggers	
Blocking	Fire when the reference trigger fires, then do not fire again until after the specified interval. During the interval the reference trigger continues to be active, but is ignored.

Delayed	When the reference trigger fires, wait the specified interval and then fire. During the interval the reference trigger continues to be active but is ignored.
Named trigger	Fire whenever the reference trigger object fires.
Periodic	Fire when the reference trigger fires, and then repeatedly for the specified count with each iteration separated by the specified period. When repeating, the reference trigger continues to be active but is ignored until the final count has completed.

Compound triggers combine the results from multiple triggers.

Compound Triggers	
All of	Fire only when all of the reference triggers are firing.
Any of	Fire when any of the reference triggers are firing.
None of	Fire whenever none of the reference triggers are firing.
Not	Fire whenever the reference trigger is not firing.

Impulse triggers convert interval triggers into a discrete trigger.

Impulse Triggers	
Beginning of	Fire once when the reference trigger begins firing. Ignore the reference trigger until it has stopped firing.
End of	Fire once when the reference trigger stops firing. Ignore the reference trigger until it has started firing again.
Whenever	Fire once whenever the reference trigger fires. This can be used to convert an interval based trigger into a continuously firing discrete trigger.

Scene triggers fire based on conditions in the simulation.

Scene Triggers	
Area population	Fire when the combined population in the specified areas is within the specified range. Possible areas include floors, links, ramps, stairs,

	escalators, paths, volumes, and collections. The counts for each specified area are combined into a single total. If the same agent appears in multiple areas it will be counted multiple times.
Clock in time range	Fire when the simulation clock is within the specified range.
Event	Fire when any of the specified event is actively engaged in the specified activity.
Gate state	Fire when any of the specified gates are in the specified state.
Over duration	Fire continuously over the specified time interval.
Server capacity	Fire when the combined available capacity of the specified servers is within the specified range. Servers that do not have a limited capacity are assumed to have infinite capacity.
Server population	Fire when the combined server population is within the specified range. Approach/Queuing: Count all agents at or heading towards the server. Queuing: Count agents currently queuing or being processed at the server.
Server state	Fire when any of the specified servers are in an open/close state which matches the specified state.
Transition count	Fire once the specified number of agents have crossed the specified transition . Counting begins at 0 once the reference trigger fires. Counting continues until the target number is reached or exceeded. If the trigger is set to loop, the count is reset to 0 immediately after the trigger fires.

4.3.2.15 Trip Matrix

A trip matrix will create agents using a simple origin destination matrix. Origins are represented as rows and destinations as columns. Each cell describes the total number of agents that are to be created at the origin and sent to the destination.

[Collections](#) can be used as either origins or destinations. When a collection contains multiple portals, the population is distributed randomly across members of the collection according to the collection weighting.

Active

A journey is active over the interval for which it can create agents. This will depend on the population demand type. When using 'Instant' the event is active only for an instant. When using 'Random' or 'Evenly spaced', the event is active for the duration of the specified interval, including those frames when no agent is created. When using a 'Table', the event is active from when the start condition is met until the final interval in the table is complete.

Properties

Agents	
Timing: Start Time	The condition for starting the event. See Triggering Events for more information.
Population: Profile	The profile used to create agents. If a collection is specified, each agent will be assigned one of the profiles from the collection. A weighted collection can be used to alter the distribution of profiles amongst the population.
Population: Demand	<p>The manner in which the population will be distributed over time.</p> <p>Evenly spaced: The total number of agents will be distributed evenly across the duration.</p> <p>Instant: The total number of agents will arrive all at once at the event start time.</p> <p>Random: The total number of agents will arrive according to the specified distribution over the duration. See Duration Distributions for information on arrival distributions.</p> <p>Table: Complex agent arrival is described by a series of rows. Each row contains the duration of an interval and the weight of the total population that will arrive during that interval. Weights are automatically normalized during simulation initialization. The first interval starts at the event start. Subsequent intervals begin when the previous interval ends. Agents are created according to a uniform distribution within each interval.</p>
Origins and Destinations	The portals or collections of portals to be used as both origins and destinations in the trip matrix. Use the 'Edit' button to modify matrix values. Values can be copied and pasted from Excel or other spreadsheet applications.

Colours Tab	
Colours	<p>Event colour: Agents are assigned the same colour as the event object.</p> <p>Lighten event colour: Agents are assigned a lighter version of the event object colour.</p> <p>Darken event colour: Agents are assigned a darker version of the event object colour.</p> <p>Rule based: Agents are assigned a colour according to the colouring rules. Working from top to bottom, agents will use the first colour for which the condition evaluates to true.</p> <p>Specified colour: Agents are assigned the specified colour.</p>

Actions Tab	
On birth	The action will be applied to all agents created by the event as they enter the simulation. For a description of the order in which actions are applied see Action Order of Execution .

4.3.2.16 Vehicle

Vehicle events are used to simulate the controlled arrival and departure of agents at periodic intervals. The event is designed around the idea of a train or bus. It provides options for specifying arrival times, creating boarding agents before each arrival, creating alighting/through passengers at each arrival, opening gated links while the vehicle is in station, and controlling access to the vehicle based on a fixed capacity.

Arrival Times

Each vehicle event can have multiple arrival times. These times can be episodic through the calculation of random headway intervals or specified explicitly through the use of a schedule.

Alighting / Boarding

Alighting agents are created at or just before each vehicle arrival, while boarding agents are typically created over a longer period but are still specified per arrival. Both are optional. Generally the origins for the alighting agents will be the destinations for the boarding agents, but this does not have to be the case.

Through Passengers

Through passengers are agents that arrive and depart with each vehicle arrival. They arrive and depart at the same vehicle origin. They can be created virtually for the purposes of capacity calculations, or 'In Scene' as standard agents that appear with the alighting agents and exit when the vehicle departs. Virtual agents have no impact on simulation performance. Through passengers can be specified as a single count which is then distributed across the entire vehicle, or as a function of alighters and capacity so as to achieve a target occupancy level per car.

Access

If capacity is enabled, boarding agents will be prevented from accessing the car floors when the population of the car floors reaches capacity. This will only work when access to the car floors is via the links chosen as car doors. Capacity calculations are on a per floor basis.

Use of open gates can be restricted to those agents created by the vehicle event or those agents that pass a test. In this case car floors must be specified and connected to the gated car links in order to determine the boarding and alighting directions.

Alternative Uses

Not all features of the vehicle event need to be used at once, nor does the event need to be used specifically for vehicles. It can be used simply to open gates at irregular intervals, or to create bursts of agents at controllable intervals.

Properties

General Tab	
Timing: Start	The time at which the event will start. If using a periodic arrival type, this will coincide with the first vehicle arrival. If using a scheduled arrival time, this time represents the 00:00:00 time within the schedule.
Timing: Dwell Time	How long vehicles dwell with the vehicle doors open. This is can be specified as a distribution . If dwell time exceeds headway time, the vehicle doors will remain open until the last vehicle leaves.
Repeat: Type	Periodic: The first arrival will be at the event start. The next arrival will be

	<p>after first the dwell interval and then the headway interval have elapsed.</p> <p>Periodic with lookup: Arrival times are periodic, but population counts are determined by looking each arrival time up in a table of time intervals, and using the population values specified for that interval. Time intervals are relative to the event start time.</p> <p>Scheduled: Arrival times are set explicitly through a table. Scheduled times are relative to the event start time.</p>
Repeat: Count	The number of vehicle arrivals (available only with periodic types)
Repeat: Headway	The time between vehicle arrivals. This can be specified as a distribution (available only with periodic types).
Repeat: Alighter counts	Specify alighting agent counts in the arrival schedule (available only with table based types).
Repeat: Through passenger counts	Specify through passenger counts in the arrival schedule (available only with table based types).

Access Tab	
Car Doors	Gated links and collections of gated links representing the vehicle doors. These doors are opened when the vehicle arrives and are kept open for as long as the vehicle dwells. This property is optional.
Boarding Access	<p>Determine the agents that will be able to use the gate in the boarding direction. Only these agents will perceive the gate as open while the remaining agents will continue to see it as closed. The boarding direction is the direction leading onto a 'Car Floor'.</p> <p>Open to all: Any agent can use the gate.</p> <p>Open to boarders: Only agents created by this event can use the gate.</p> <p>Open if test true: Only agents for which the test is true can use the gate.</p>
Alighting Access	<p>Determine the agents that will be able to use the gate in the alighting direction. Only these agents will perceive the gate as open while the remaining agents will continue to see it as closed. The alighting direction is the direction leading off of a 'Car Floor'.</p> <p>Open to all: Any agent can use the gate.</p> <p>Open to alighters: Only agents created by this event can use the gate.</p> <p>Open if test true: Only agents for which the test is true can use the gate.</p>
Enforce capacity limits on car floors	Control access through the car doors onto the car floors based on the set capacity. The capacity control applies to agents in boarding direction.
Max Occupancy	The maximum number of passengers allowed on a single car floor.

per Car	
Car Floors	Each floor included directly or through a collection will be assumed to have the specified capacity. Car doors leading onto a car floor will be closed when the capacity is reached.

Boarding Tab	
Create boarding agents	Enable the creation of boarding agents.
Timing: Before arrival	The time before vehicle arrival that boarding agents start being created.
Population: Profile	The profile used to create boarding agents. If a collection is specified, each agent will be assigned one of the profiles from the collection. A weighted collection can be used to alter the distribution of profiles amongst the population.
Population: Demand	<p>The number of agents the event will create and when they will be created (relative to the start of boarding arrivals as specified by the 'Before arrival' and vehicle arrival times). If demand duration exceeds headway time, separate distributions of boarding agents will overlap.</p> <p>Evenly spaced: The specified number of agents will arrive at a constant rate over the duration.</p> <p>Instant: The specified number of agents will arrive all at once at the event start time.</p> <p>Random: The specified number of agents will arrive according to the specified distribution over the duration. See Agent Start Distributions for information on arrival distributions.</p> <p>Table: Complex agent arrival is described by a series of rows. Each row contains the duration of an interval and the number of agents to create over that interval. The first interval starts at the event start. Subsequent intervals begin when the previous interval ends. Agents are created according to a uniform distribution within each interval.</p>
Vehicle Origins	The portals at which boarding agents will be created. Portals can be weighted to alter the distribution of agents across the set. See Choosing Objects for more details.
Vehicle Destinations	<p>The portals from which the boarding agent will be given its initial goal.</p> <p>Grouped: lowest cost: Agents are given all portals and instructed to seek the portal with the lowest cost route. Agents will continuously re-evaluate route costs as they navigate the scene and alter their choice as conditions change.</p> <p>Single: by chance: The agent will be assigned a single portal by chance. Weights can be specified to alter the likelihood of each portal being assigned. See Choosing Objects for information on how weights are used in portal assignment.</p>

Alighting Tab	
Create alighting agents	Enable the creation of alighting agents.
Timing: Before arrival	The time before vehicle arrival that alighting agents are created.
Alighters: Profile	The profile used to create alighting agents. If a collection is specified, each agent will be assigned one of the profiles from the collection. A weighted collection can be used to alter the distribution of profiles amongst the population.
Alighters: Demand	<p>The number of alighting agents created each time a vehicle arrives. Agents will be created a few seconds before the vehicle arrives and doors open to give them time to marshal in front of the vehicle doors.</p> <p>Random: The number of alighting agents to create for each arrival is determined based on the distribution.</p> <p>Lookup Table: The number of alighting agents is determined by comparing each arrival time to a table of time intervals and using the population value for that interval.</p> <p>Scheduled: The number of alighting agents is taken from the arrival schedule.</p>
Vehicle Origins	The portals at which alighting agents will be created. Portals can be weighted to alter the distribution of agents across the set. See Choosing Objects for more details.
Vehicle Destinations	<p>The portals from which the alighting agent will be given its initial goal.</p> <p>Grouped: lowest cost: Agents are given all portals and instructed to seek the portal with the lowest cost route. Agents will continuously re-evaluate route costs as they navigate the scene and alter their choice as conditions change.</p> <p>Single: by chance: The agent will be assigned a single portal by chance. Weights can be specified to alter the likelihood of each portal being assigned. See Choosing Objects for information on how weights are used in portal assignment.</p>

Through Tab	
Create through passengers	Enable the creation of through passenger agents. These agents arrive with the alighting agents but remain on the vehicle and depart when the vehicle departs.
Type	<p>Virtual: Through passenger numbers are calculated and used to determine car capacity, but no agents are created in the scene.</p> <p>In Scene: Through passengers are created as standard agents. They arrive with the alighting agents, wait in place while the vehicle is in the</p>

	station, then exit the simulation when the vehicle departs.
Before Arrival	The time before vehicle arrival that through agents are created.
Arrival Population: Profile	The profile used to create through passenger agents. If a collection is specified, each agent will be assigned one of the profiles from the collection. A weighted collection can be used to alter the distribution of profiles amongst the population.
Arrival Population: Type	<p>Calculated to achieve car occupancy: Specify a target occupancy level. The number of through passengers created per car will be calculated as the car's target occupancy minus the number of alighters in that car. This is only available when access capacity is enabled.</p> <p>Specified across vehicle: Create a single count of agents per arrival and distribute the agents across the vehicle origin portals.</p>
Cars Occupancy	<p>At full capacity: Each car arrives at full capacity. The number of through passengers in a car will be equal to the capacity minus the number of alighters leaving that car.</p> <p>At percent capacity: Each car arrives at some percentage of capacity. The number of through passengers in a car will be equal to the total occupancy minus the number of alighters leaving that car.</p>
Vehicle Demand	<p>Random: Generate a random count using the specified distribution.</p> <p>Lookup Table: The population is determined by comparing each arrival time to a table of time intervals and using the population value for that interval.</p> <p>Scheduled: The population is taken from the arrival schedule.</p>
Vehicle Origins	The portals through which passenger agents will be created. When the population type is set to distribute a single count across the vehicle, portals can be weighted to alter the distribution of agents across the set. When using a capacity based demand, the portals are not used for capacity calculations but only to place agents in the scene.

Colours Tab	
Colours	<p>Defines the colour scheme for boarding/alighting/through agents.</p> <p>Event colour: Agents are assigned the same colour as the event object.</p> <p>Lighten event colour: Agents are assigned a lighter version of the event object colour.</p> <p>Darken event colour: Agents are assigned a darker version of the event object colour.</p> <p>Rule based: Agents are assigned a colour according to the colouring rules. Working from top to bottom, agents will use the first colour for which the condition evaluates to true.</p> <p>Specified colour: Agents are assigned the specified colour.</p>

Actions Tab	
On birth	The action will be applied to all boarding/alighting/through agents created by the event as they enter the simulation. For a description of the order in which actions are applied see Action Order of Execution .

Collections in vehicle events

[Collections](#) can be used in the "Vehicle Doors" property. All member links with gates enabled will be opened as if they were directly used.

They can also be used in "Origins" and "Destination" properties for boarding, alighting, and through agents. The collections can be weighted, changing the distribution of agents going from/to various portals.

4.3.3 Analysis

Analysis Object Type	Description
Simulation Run	Represents the results of a simulation by defining links to results database files (.mmdb). These form the basis the analysis system and are used as a parameter to most types of queries.
Agent Filter	A reusable analysis object. These allow queries to target agents meeting specific criteria, including location, density, etc.
Trip	A reusable analysis object. These objects represent an ordered series of locations an agent may traverse over its lifetime.
Graphs	<p>A query analysis object that produces graphs.</p> <p>Agent Density: Counts the number of agents at various levels of crowd density.</p> <p>Agent Speed Ratio: Counts the number of agents with different ratios of actual to desired speed..</p> <p>Composite: Fully customizable graph which can combine any number of simulation runs and values.</p> <p>Flow Count: Counts the number of agents crossing various transitions.</p> <p>Cumulative Flow Count: Counts the number of agents that have crossed various transitions.</p> <p>Performance Graph: Compares performance of simulation runs.</p> <p>Population Count: Counts the number of agents in different areas.</p> <p>Volume Density: Measures the average density over one or more volumes.</p> <p>Server Population Count: Counts the number of agents at various servers.</p>
Maps	<p>A query analysis object. These queries paint objects in the scene based on the behaviour of agents. With the exception of the Vision Time Map, all maps may only be applied to walkable objects.</p> <p>Agent Count: Counts the number of unique agents that cross each point.</p> <p>Agent Path: Traces the route taken by each agent.</p> <p>Agent Time to Exit: The time required for an agent to exit from each point.</p>

	<p>Average Density: The average density at each point.</p> <p>Average Non-Zero Density: The average non-zero density at each point.</p> <p>Dynamic Path: The average non-zero density at each point.</p> <p>Experienced Density: The experienced density at each point.</p> <p>Instantaneous Density: The current density at each point. This map is "live" and updates with simulation playback.</p> <p>Maximum Density: The maximum density at each point.</p> <p>Static Cost: The cost perceived by agents to reach various destination portals. This map does not require a simulation run.</p> <p>Static Distance: The measured distance to various destination portals. This map does not require a simulation run.</p> <p>Time Above Density: The time agents spend above a specified density at each point.</p> <p>Time Occupied: The time for which each point is occupied by an agent.</p> <p>Time Until Clear: The time before the last agent leaves each point.</p> <p>Vision Time: The time agents spend looking at a surface. This map can be applied to barriers.</p>
Tables	<p>A query analysis object that produces tables.</p> <p>Agent Area Time: Lists the amount of time agents spend in given areas.</p> <p>Agent LOS Time: Lists the amount of time agents spend at each level of service.</p> <p>Agent Process Chain Time: Lists the amount of time agents spend in a process chain.</p> <p>Agent Summary: Provides general information about each agent.</p> <p>Agent Timetable Summary: Provides a summary of agents produced by a given timetable</p> <p>Agent Token Time: Lists the amount of time agents carry given tokens.</p> <p>Agent Trip Time: Lists the time required for agents to complete a given trip.</p> <p>Origin/Destination: Counts the number of agents entering and exiting at each portal</p> <p>Performance Table: Provides diagnostics for simulation runs</p> <p>Server Summary: Lists queue times and other information for servers.</p>

4.3.3.1 Simulation Run

A simulation run represents a single iteration of a MassMotion simulation. It maintains a connection to a generated database and is used by both playback and analysis queries to extract results from disk.

A simulation run can be created automatically when a [simulation is executed](#), with results written to the specified database file (see [Simulation Data](#)). An empty simulation run can also be created from the main window's analysis ribbon. An empty simulation run can be used to connect to an existing database file by editing the simulation run properties. This is useful when comparing results from different projects; a simulation run object can be created in one project that is then set to point at the results generated from a different project so that they can be compared.

For the purposes of playback and queries, it is possible to have multiple simulation runs reading from the same database file at the same time (perhaps highlighting different areas by using the run's agent filter). However, only one simulation may be executed at once. During simulation any other simulation runs which point to the same database will be prevented from reading the database until the simulation is complete. Similarly, when using the [movie and image export tools](#), a lock is placed on the simulation runs used and they may not be used for simulation until the export window is closed.

Object Properties

The properties of a simulation run object allow users to change which database file is connected as well as the appearance of agents displayed by the object.

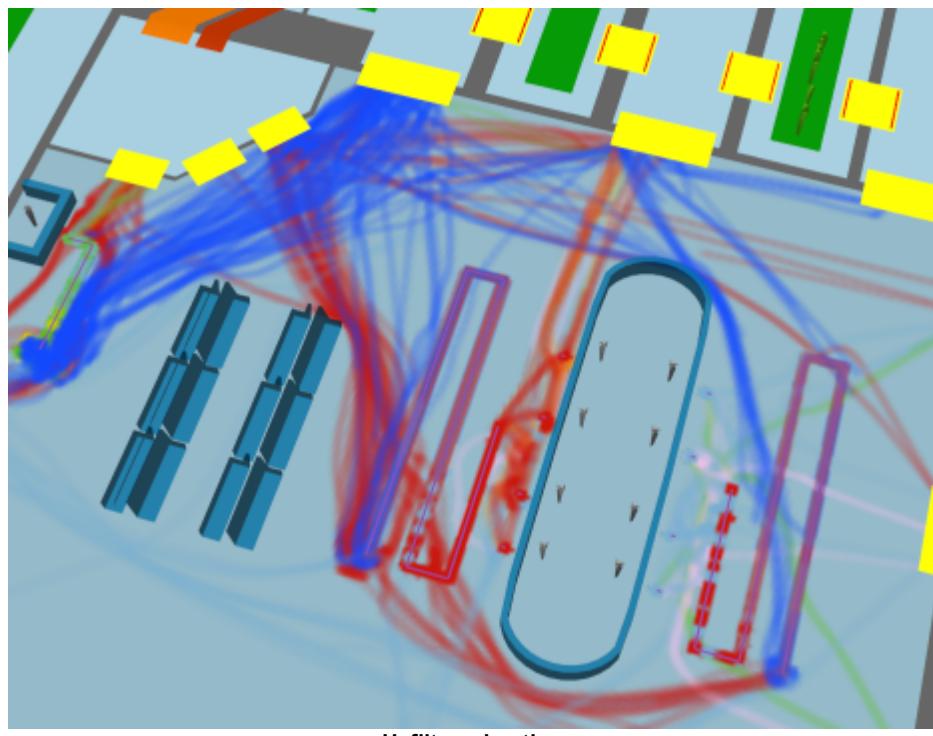
Properties	
Database File	The file to which the object is connected. Simulation execution writes to this file while playback and analysis read from this file.
Status	The status of the simulation run's connection to the database. Users can refresh the connection by pressing the refresh button.
Agent Colour	<p>The colour of agents from the simulation run.</p> <p>The following options are available:</p> <ul style="list-style-type: none"> • Custom: User specified colour. • Simulation Run Colour: The colour of the simulation run object. • Database: The agent colours stored in the database. This is the default setting. • Database Darkened: The agent colours stored in the database but darkened. • Database Lightened: The agent colours stored in the database but lightened. • Fruin LOS (auto): Use object type specific Fruin Level of Service colouring. The exact colour cutoff values will vary by the type of object agents are on (eg. stairs vs floors). • Fruin Queuing (Platform) LOS: Use standard Fruin colouring for queuing. • Fruin Stairway LOS: Use standard Fruin colouring for stairs. • Fruin Walkway LOS: Use standard Fruin colouring for walkways. • IATA Wait/Circulate LOS: Use standard IATA (International Air Transport Association) Wait/Circulate colouring.
Agent Filter	<p>Simulation runs can use an agent filter to modify how agents are displayed. For instance, an agent filter could be used to only show agents that were created by a particular schedule, or give a different colour to agents currently undergoing a particular trip.</p> <p>The following properties control how the filter is used:</p> <ul style="list-style-type: none"> • Enable agent filter: This must be checked to enable the agent filter. • Mode: Set whether agents matching the filter are coloured differently or are hidden. Alternatively, agents not matching the filter can be hidden. • Colour: What colour to use for filtered agents (only available if 'Colour filtered agents' is specified). • Filter: The agent filter to use. • Status: Indicates whether the agent filter is currently applied. Users may need to refresh this when the agent filter or properties are changed.

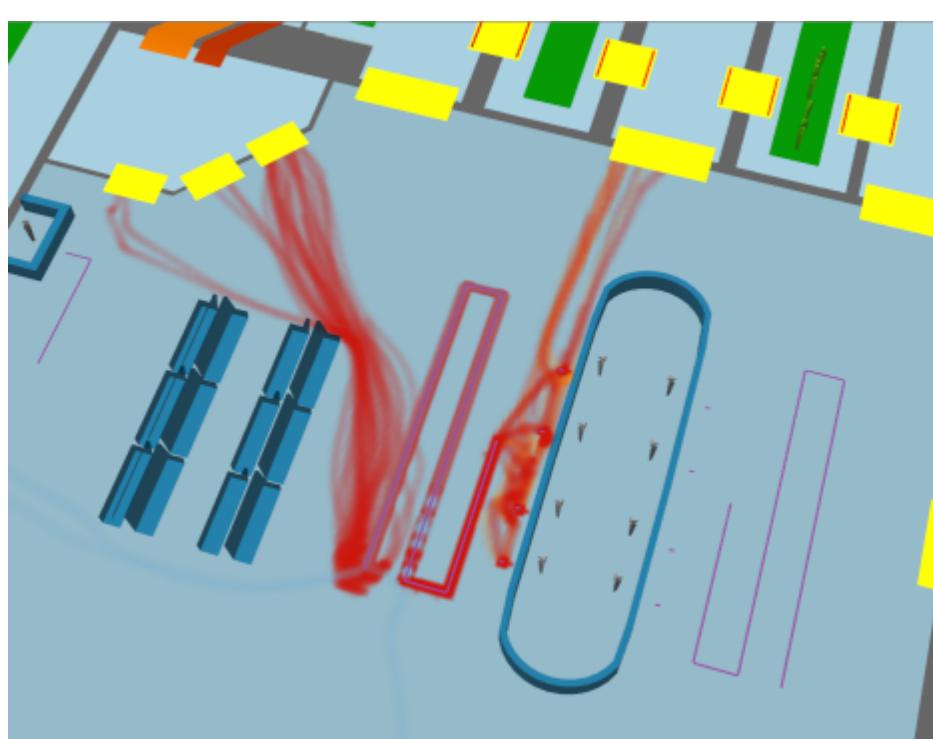
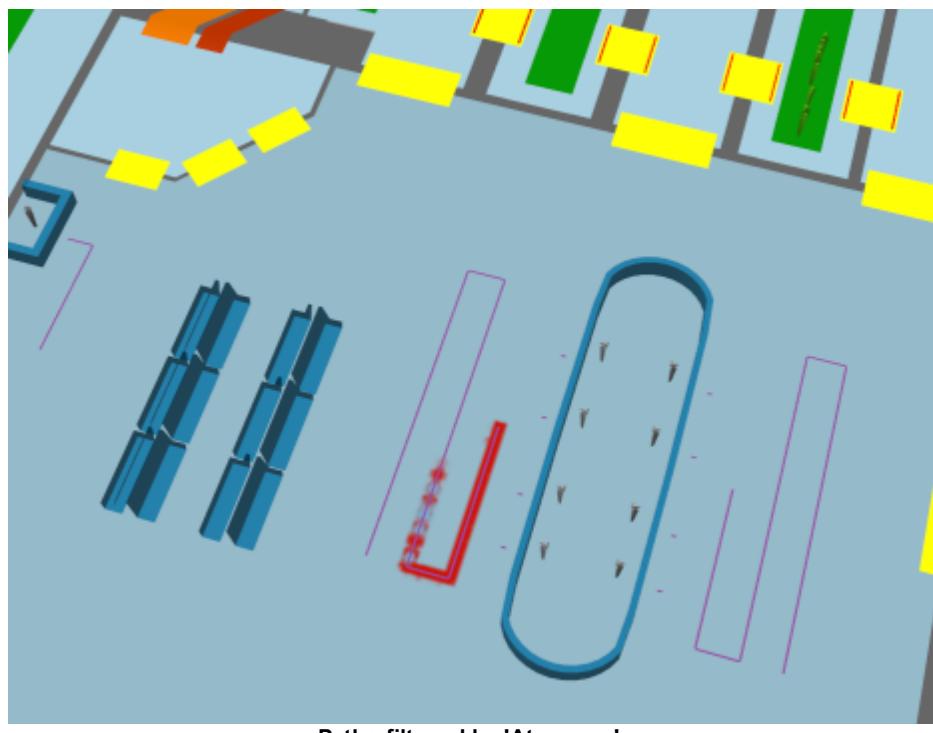
4.3.3.2 Agent Filter

Agent filters provide a powerful way to set up queries (graphs, tables, maps) that operate on a specific (possibly time-varying) set of agents. Refer to the various [Graph](#), [Table](#) and [Map](#) types for descriptions of how filters can be used in different types of queries.

Fundamentally, a filter is an object that, for any instant in time, generates a list of agents satisfying the filter. For instance, a 'holding token' filter would generate, at every instant, a list of all agents holding a particular token at that instant. Some filters combine or transform other filters in different ways. For instance, an 'all of' filter could combine a 'holding token' and an 'at server' filter to create a combined filter that would generate, at any instant, a list of agents at a particular server holding a particular token.

One important type of transforming filter is an 'are ever' filter. This filter can be thought of as a qualifier on another filter; instead of agents only being included in the generated list **while** they satisfy some criterion (and therefore potentially dropping in and out of the generated list over time), they are always included in the list if they **ever** satisfy the criterion during a particular time period. For instance, as shown below, an [Agent Path Map](#) using the filter 'at server' would result in agent paths being shown only for agents currently at the server. By using 'are ever' in combination with 'at server' during a particular time period, the map would instead show paths of agents as they approached and after they left the server (but no paths at all for agents who were never at the server).





Filter Debugging

An excellent way to determine if a filter is working as expected is to set a particular simulation to colour agents differently based on whether or not they satisfy the filter (see [Simulation Run](#) for details). For instance, a simulation run can be set to colour all agents blue unless they currently satisfy a given filter, in which case they should be coloured green. By then using the various playback controls in the [time panel](#) (such as dragging the timeline slider), it is easy to see which agents satisfy the filter at which times.

Named Filters

Agent filters can be created inline within a query, for use within that query. Filters can also be created as independent, named objects by clicking on the 'Agent Filter' button in the Analysis toolbar; these can then be referred to within other filters and queries, as discussed below.

Building Filters

Filters are built using a cascading set of drop-down menus. Wherever a filter is required, a drop-down menu will be available to select the filter type. Each filter type may reference one or more other objects. Depending on the type of filter chosen, more drop-down menus or entry fields may appear to select those objects. The table below shows the various filter types available, along with their required references and what agents are included in the generated list at every instant.

Note that not all filter types are immediately available in all situations, as some types of queries require a filter that produces a fixed set of agents instead of a dynamically-changing one. In these cases, an 'are ever' filter can usually be used in combination with the desired filter to obtain the desired effect. For instance, it is not possible to create an [Origin/Destination](#) table for agents at a particular cordon (as it is not clear what that would mean), but it is possible to create such a table for agents that are ever at a particular cordon.

Collections in agent filters

[Collections](#) can be used to define agent filters and allow for the creation of more complex filters. It is also more convenient to use a single "in area" filter with a collection, as opposed to an "any of filter" followed by several individual "in area" filters.

Filter Type	References	Agents Included
All agents	None	All agents.
Selected agents	None	Agents that are currently selected. Note that this filter is 'live', and refers to whatever agents are selected when the filter is actually used, not when it is created. For instance, if an Agent Path map was created using this filter, whatever agents were selected when the 'Evaluate' button was pressed would have their paths shown. If later on a different set of agents was selected and the map was re-evaluated, the map would change to show the paths of the newly-selected agents.
Named filter:	Named filter	Those included by the referenced named filter.
Are ever:	Filter	Agents that are ever included by the referenced filter at any instant during a particular time period.
Not:	Filter	Agents not included by the specified filter.
Compound filter:	Two filters	Agents included by the two filters combined with the specified logic.
All of:	One or more filters	Agents included by all of the referenced filters at a given instant.
Any of:	One or more filters	Agents included by any of the referenced filters at a given instant.

Filter Type	References	Agents Included
None of:	One or more filters	Agents included by none of the referenced filters at a given instant.
Created by:	Timetable or schedule	Agents that were initially created by the referenced timetable or schedule.
Entered simulation at:	Portal	Agents that entered the simulation at the given portal. With collections: Agents that entered the simulation at any of the portals in the collection are included.
Exited simulation at:	Portal	Agents that exited the simulation at the given portal. With collections: Agents that exited the simulation at any of the portals in the collection are included.
From profile:	Profile	Agents that were created with the referenced profile. With collections: Agents that were created with any of the profiles in the collection are included.
Has end state:	None	Agents that finished the simulation with the specified state: in simulation: still in scene at simulation end exited with success: exited simulation as expected exited with error: was deleted from simulation with an error.
At server:	Server	Agents that are at the referenced server. Agents are considered to be 'at' a server from the first time when they are either being processed by the server or are queueing for the server (blocked by another agent that is at the server), until they are finished being processed by the server. With collections: Agents that are at any of the servers in the collection are included.
At transition:	Transition	Agents that are currently performing the specified transition (this will only be true for an instant for any agent and so is often used in combination with 'Are ever').
Local density:	Upper and lower density bounds	Agents that currently have a local density around them that is in the given range.
Current speed:	Upper and lower speed bounds	Agents whose speed is currently in the given range.
Holding token:	Token	Agents currently holding the referenced token. With collections: Agents currently holding any of the tokens in the collection are included.
In area:	Area	Agents currently in the given area. With collections: Agents currently in any of the areas in the collection are included.
In trip:	Trip	Agents currently in the referenced trip (have started and have not yet finished). See Trips for a description of when an agent is considered to be 'in' a trip.

4.3.3.3 Trip

A trip in MassMotion is a way of describing a particular route or path through the model. It is defined by a list of one or more [areas](#), [cordons](#), [portals](#) or servers.

Agents are considered to complete a trip if they crossed each of the objects in the trip in sequence. There may be gaps in between objects. For instance, a trip could be specified as two links. Agents that crossed the first link, then traversed an intermediate floor, then crossed the second link would be considered to have completed the trip even though while crossing the floor they were not at either of the two links.

Trips are created by using the 'Trip' button in the Analysis toolbar, or can be created inline when constructing some types of queries (such as the [Agent Trip Time](#) table) or [filters](#) ('In trip'). Trips created using the toolbar button can later be referenced by queries or filters.

In addition to specifying an ordered list of objects that define the trip, options exist to define when exactly the trip is considered to begin and end (and therefore when an agent is considered to be 'in' the trip):

Begin when	
Entering first item	The trip begins at the moment the agent enters or crosses the first object. Agents may enter an object by transitioning from another area/object, or entering the simulation within that item.
Entering or at first item	The trip begins at the moment the agent enters or crosses the first object, or at the beginning of the query period if the agent is already on/in the object/area.
Exiting first item	The trip begins at the moment the agent exits or crosses the first object.

End when	
Exiting last item	The trip ends at the moment the agent exits or crosses the last object. Agents may exit an object by transitioning to another area/object, or by exiting the simulation within that item.
Exiting or at last item	The trip ends at the moment the agent exits or crosses the last object, or at the end of the query period if the agent is still on/in the object/area.
Entering last item	The trip ends at the moment the agent enters or crosses the last object.

Note that for the special case of cordons, all of the above options are equivalent and simply refer to the time at which the agent crossed the cordon. If, therefore, the trip is defined as starting and ending at cordons, the options chosen are irrelevant.

Collections in trips

If a [collection](#) is part of a trip, agents are considered to complete that part of the trip if they reach any of the members in the collection. This can be used to construct more complex trips with branching routes.

A current limitation on trips is that each object may only appear once per trip, however collections can be used as a workaround. For example, to create a round trip from FloorA to FloorB and back, a trip can be created consisting of FloorA, FloorB and a collection containing only FloorA.

4.3.3.4 Graphs

Graph queries plot the number of agents under various conditions over time, including at certain locations or in crowds above a certain density.

Once evaluated, graphs can be exported as an image or a CSV file of the plotted values. The following image formats are supported: *.png, *.svg, *.pdf

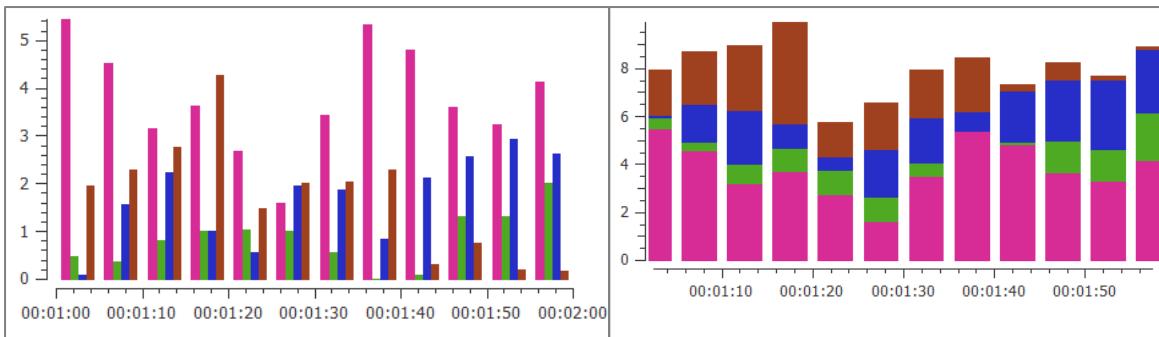
Graph Styles

The title and axis labels of graphs can be set for each graph, as well as the inclusion of a legend. The colour of datasets is set by the groups in the graph structure (see below).

Several styles of graph are available, though not all types of graphs may support each one. Stepped graphs and bar graphs require a "bucket size" which is the duration which each section of the graph lasts.

Stacked area and bar graphs additionally support a 'normalized' option. If this is selected, the values at every instant will be normalized to sum to 100. This allows, for instance, indicating the percentage of agents at different density levels in an [Agent Density](#) graphs instead of the absolute counts.





Navigating Graphs

Once a graph is generated, subsections of the graph can be examined in further detail by clicking and dragging to define an area to zoom to in the graph. The view can be reset by middle clicking the graph.

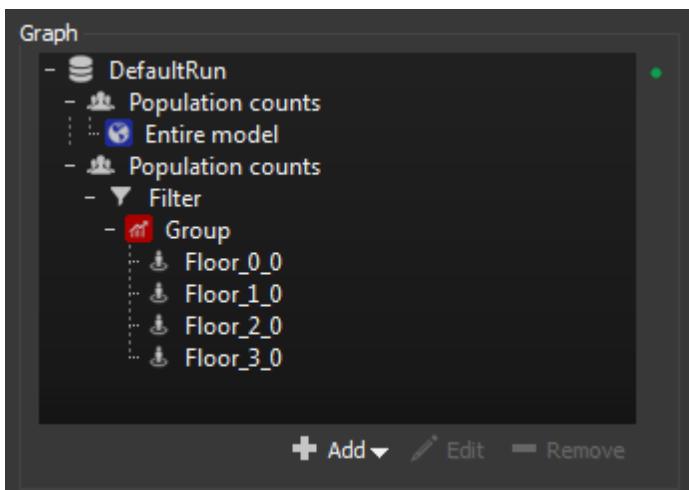
Graph Structure

Graphs use a tree structure to organize their source data into datasets. Multiple items can be added at each level; for instance, multiple groups can be placed under a filter.

Items are nested in the following order:

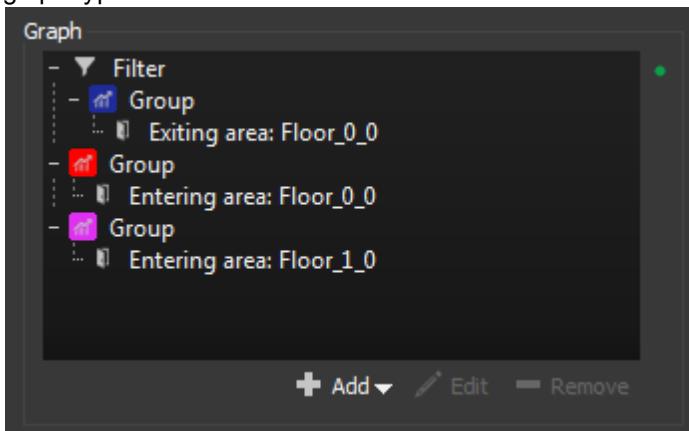
Graph Item	Description
1. <u>Simulation Run</u>	The simulation run to analyse. Most graphs only operate on a single simulation run and have it as a separate "General" parameter.
2. Graph Type	The type of data to graph. Composite graphs can combine different Cumulative Flow Counts , Flow Counts , Population Counts or Server Population Counts .
3. Filter (optional)	An agent filter that limits which agents are counted.
4. Group	A dataset. The colour shown in the graph is set by this item.
5. Group Members	Sources of data which are grouped into a dataset. Counts from individual group members can either be summed, or displayed as separate series on the graph.

[Composite graphs](#) allow full use of this tree structure:



Composite graph tree structure

Most graphs, however, use a more simplified tree structure and implicitly add simulation run and graph types.



Flow graph tree structure

[Agent density graphs](#) generate the entire tree structure implicitly.

Graph Types	
Agent Density	Counts the number of agents at various levels of crowd density.
Agent Speed Ratio	Counts the number of agents with different ratios of actual to desired speed.
Composite	Fully customizable graph which can combine any number of simulation runs and values.
Cumulative Flow Count	Counts the number of agents that have crossed various transitions .
Flow Count	Counts the number of agents crossing various transitions .
Performance Graph	Compares performance of simulation runs .
Population	Counts the number of agents in different areas .

Count	
Volume Density	Computes the average density over time for one or more volumes .
Server Population Count	Counts the number of agents at various servers.

4.3.3.4.1 Agent Density

An agent density graph is a special graph type that shows the breakdown of agents within different density ranges (see [LOS Colour Mapping](#)). The graph will be shown as stacked areas, with each band corresponding to one density range.

Agent Density Parameters	
Name	The name of the graph.
Simulation run	The simulation run for which counts should be calculated.
Reporting period	The time period over which counts should be calculated.
Sampling period	How frequently to count the numbers of agents at different densities. Specifying a larger value will reduce the amount of time needed to generate the graph, but using very large values runs the risk of missing peaks in density that may occur between samples.
Title	Graph title (will be included in exported images and CSV files).
X axis	X axis label (will be included in exported images and CSV files).
Y axis	Y axis label (will be included in exported images but not CSV files).
Normalized	If checked, agent counts will be normalized to sum to 100 (i.e., displayed as percentages instead of absolute values).
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Agent Filter	Used to specify which agents should be included in the graph. This can be used to display density ranges only for agents in a given area, only for those undergoing a particular trip, only those holding a specific token, etc.
Density Ranges	Specifies the density ranges and corresponding colours that should be used to build the graph. In addition to the standard Fruin walkway, stairway and platform (queueing) metrics, custom density levels and colours can be defined.
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

4.3.3.4.2 Agent Speed Ratio

An agent speed ratio graph is a special graph type that shows the breakdown of agents within different ranges of speed ratios (ratio of actual to desired speed). The graph will be shown as stacked areas, with each band corresponding to one speed ratio range.

LOS	ft/min	m/s	Ratio of max 1.35ms/
A	265	1.35	1
B	260	1.321	0.963
C	250	1.270	0.941
D	240	1.219	0.904
E	225	1.143	0.844
F	150	0.762	0.563

Table 1: Default speed ratio ranges.

Agent Density Parameters	
Name	The name of the graph.
Simulation run	The simulation run for which counts should be calculated.
Reporting period	The time period over which counts should be calculated.
Sampling period	How frequently to count the numbers of agents at different speed ratios. Specifying a larger value will reduce the amount of time needed to generate the graph, but using very large values runs the risk of missing peaks that may occur between samples.
Title	Graph title (will be included in exported images and CSV files).
X axis	X axis label (will be included in exported images and CSV files).
Y axis	Y axis label (will be included in exported images but not CSV files).
Normalized	If checked, agent counts will be normalized to sum to 100 (i.e., displayed as percentages instead of absolute values).
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Agent Filter	Used to specify which agents should be included in the graph. This can be used

	to display speed ratio ranges only for agents in a given area, only for those undergoing a particular trip, only those holding a specific token, etc.
Speed Ratio Ranges	<p>Specifies the speed ratio ranges and corresponding colours that should be used to build the graph.</p> <p>The default ranges represent the expected reductions in speed at the various Fruin LOS density bands A - F [1]. The speed ratios are calculated using the average speed with a level of service grade divided by the average desired speed of an agent (see Table 1 above).</p>
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

[1] Fruin, John J. Pedestrian Planning & Design, Revised Edition Chapt. 4, Elevator World, 1987 - Chapter 3

4.3.3.4.3 Composite

Composite graphs are an advanced feature that allow data of different types and/or from different simulation runs to be compared. For instance, flow counts could be compared between two different simulation runs with slightly different configurations, or flow counts and population counts could be compared on the same graph.

The [tree structure](#) used to define composite graphs has a more complex structure than other graph types. In addition to filters, groups, and group member items, composite graph trees have separate items corresponding to different simulation runs and different graph types. As with other graph types, composite graphs are built top-down. Items are added in the following order:

1. Simulation run
2. Graph type ([cumulative flow count](#), [flow count](#), [population count](#), or [server population count](#))
3. Filter (optional)
4. Group
5. Group members

Multiple items can be added at each level; for instance, multiple graph types can be added under a single simulation run, and a graph type can have multiple groups or filtered groups beneath it.

Composite Graph Parameters	
Name	The name of the graph.
Reporting period	The time period over which results should be calculated.
Title	Graph title (will be included in exported images and CSV files).
X axis	X axis label (will be included in exported images and CSV files).
Y axis	Y axis label (will be included in exported images but not CSV files).
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show	Display information about the MassMotion version and database file used to

Metadata	generate the graph (will be included in exported images and CSV files).
Style	Composite graphs can be displayed as curves, stepped curves and bars. For stepped curves and bars, a bin size must be specified and values for each series on the graph will be aggregated within time intervals of the given size. Note that this will occur in whichever way is most appropriate for each series type; eg. series representing population or queue counts will be averaged within time intervals while flow counts will be summed. If sampling period exceeds bin size, zero values will be present.
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

4.3.3.4.4 Cumulative Flow Count Graph

Flow count graphs can be created to measure the number of agents which have crossed specified [transitions](#) from the start of the reporting period to a given time. When using time intervals (bins), agents crossing the transition up to the end of the interval are counted.

Groups in a cumulative flow count graph are composed of one or more [transitions](#). Each graph can be configured to produce multiple series showing the counts for each of the selected transitions independently, or one series showing the flow count treating all selected transitions as a single combined transition.

If a group of transitions is created under a filter, only agents satisfied by that filter will be included in the associated counts. Note the distinction between using a filter such as 'holding token' versus 'are ever holding token'. In the first case, agents will be included in the flow count only if they are holding the specified token while crossing the specified transition. In the second case, agents will be included in the flow count as long as they ever held the specified token at some point during the reporting period.

This graph can be thought of as the integral of a [flow count graph](#).

Cumulative Flow Count Parameters	
Name	The name of the graph.
Simulation run	The simulation run for which counts should be calculated. To compare cumulative flow counts between different runs, a composite graph can be used.
Reporting period	The time period over which counts should be calculated.
Title	Graph title (will be included in exported images and CSV files).
X axis	X axis label (will be included in exported images and CSV files).
Y axis	Y axis label (will be included in exported images but not CSV files).
Style	Cumulative flow counts can be displayed as either curves, stepped curves, stacked areas, stepped stacked areas, bars, or stacked bars. If stepped curves, stepped areas, bars or stacked bars are chosen, a bin size

	<p>must be specified. Each stepped portion or bar will then correspond to an interval of time with the size specified, and the associated value will be the total flow during that time interval. If sampling period exceeds bin size, zero values will be present.</p> <p>If stacked areas, stepped areas or stacked bars are chosen, a 'Normalized' option is available. If selected, flow counts will be displayed as percentages instead of absolute values and will always sum to 100.</p>
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

4.3.3.4.5 Flow Count

Flow count graphs can be created to measure the number of agents performing specified [transitions](#) during particular time intervals (bins).

Groups in a flow count graph are composed of one or more [transitions](#). Each graph can be configured to produce multiple series showing the flow counts for each of the selected transitions independently, or one series showing the flow count treating all selected transitions as a single combined transition.

If a group of transitions is created under a filter, only agents satisfied by that filter will be included in the associated counts. Note the distinction between using a filter such as 'holding token' versus 'are ever holding token'. In the first case, agents will be included in the flow count only if they are holding the specified token while crossing the specified transition. In the second case, agents will be included in the flow count as long as they ever held the specified token at some point during the reporting period.

Flow Count Parameters	
Name	The name of the graph.
Simulation run	The simulation run for which counts should be calculated. To compare flow counts between different runs, a composite graph can be used.
Reporting period	The time period over which counts should be calculated.
Title	Graph title (will be included in exported images and CSV files).
X axis	X axis label (will be included in exported images and CSV files).
Y axis	Y axis label (will be included in exported images but not CSV files).
Style	Flow counts can be displayed as either curves, stepped curves, stacked areas, stepped stacked areas, bars, or stacked bars. If stepped curves, stepped areas, bars or stacked bars are chosen, a bin size

	<p>must be specified. Each stepped portion or bar will then correspond to an interval of time with the size specified, and the associated value will be the total flow during that time interval. If sampling period exceeds bin size, zero values will be present.</p> <p>If stacked areas, stepped areas or stacked bars are chosen, a 'Normalized' option is available. If selected, flow counts will be displayed as percentages instead of absolute values and will always sum to 100.</p> <p>Curves and stacked areas use a single frame as the interval and are therefore difficult to read, but may be useful when exported to CSV for further analysis. A cumulative flow count graph may be easier to read.</p>
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

4.3.3.4.6 Performance

Performance graphs can be used to compare time and operations required to process simulation steps for each simulation frame.

Performance Table Parameters	
Name	The name of the table.
Simulation runs	The simulation runs to be analysed
Reporting period	The time period over which counts should be calculated.
Series: Metric	<p>How performance statistics should be listed.</p> <p>Duration (ms): Time required. Operations: Operations required. 1000 * Duration (ms) / Operations: Time per operation. 1000 * Duration (ms) / Population: Time per population.</p>
Series	<p>Performance statistics to display.</p> <ul style="list-style-type: none"> • Entire Frame: Processing an entire frame. • Serial Components: Processing the serial components of a frame. • Threaded Components: Processing the threaded components of a frame. <p>Information from individual components can be displayed as well.</p>
Title	Graph title (will be included in exported images and CSV files).
X Axis	X axis label (will be included in exported images and CSV files).

Y Axis	Y axis label (will be included in exported images but not CSV files).
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

4.3.3.4.7 Population Count

Population count graphs can be created to measure the total number of agents over time in specified areas.

Groups in a population count graph are composed of one or more [areas](#). Each group can be configured to produce multiple series showing the population counts in each of the selected areas independently, or one series showing the population count treating all selected areas as a single combined area.

If a group of areas is created under a filter, only agents satisfied by that filter will be included in the associated counts. Note the distinction between using a filter such as 'holding token' versus 'are ever holding token'. In the first case, agents will be included in the population count only while they are holding the specified token. In the second case, agents will be included in the population count for the entire reporting period as long as they ever held the specified token at some point during that period.

Population Count Parameters	
Name	The name of the graph.
Simulation run	The simulation run for which counts should be calculated. To compare population counts between different runs, a composite graph can be used.
Reporting period	The time period over which counts should be calculated.
Sampling period	How frequently to measure the population. Specifying a larger value will reduce the amount of time needed to generate the graph, but using very large values runs the risk of missing peaks in population that may occur between samples.
Title	Graph title (will be included in exported images and CSV files).
X Axis	X axis label (will be included in exported images and CSV files).
Y Axis	Y axis label (will be included in exported images but not CSV files).
Style	Population counts can be displayed as either curves, stepped curves, stacked areas, stepped stacked areas, bars, or stacked bars. If stepped curves, stepped areas, bars or stacked bars are chosen, a bin size must be specified. Each bar will then correspond to an interval of time with the size specified, and the associated value will be the average population within

	that time interval. If sampling period exceeds bin size, zero values will be present. If stacked areas, stepped areas or stacked bars are chosen, a 'Normalized' option is available. If selected, population counts will be displayed as percentages instead of absolute values and will always sum to 100.
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

4.3.3.4.8 Server Population Count

Server population count graphs can be created to measure the total number of agents at specified servers over time. See [Server](#) for a description of when an agent is considered to be at a server. To obtain detailed information about entire process chains instead of single servers, an [Agent Process Chain Time](#) table can be used instead.

Groups in a server population count graph are composed of one or more servers. Each group can be configured to produce multiple series showing the population counts for each of the selected servers independently, or one series showing the total population count for all selected servers.

If a group of servers is created under a filter, only agents satisfied by that filter will be included in the associated counts. Note the distinction between using a filter such as 'holding token' versus 'are ever holding token'. In the first case, agents will be included in the server population count only while they are holding the specified token. In the second case, agents will be included in the count for the entire reporting period as long as they ever held the specified token at some point during that period.

Server Population Count Parameters	
Name	The name of the graph.
Simulation run	The simulation run for which counts should be calculated. To compare server population counts between different runs, a Composite Graph can be used. Alternatively, a Server Summary table can be used to compare aggregate information about different servers in different simulation runs directly.
Reporting period	The time period over which counts should be calculated.
Sampling period	How frequently to measure the server population. Specifying a larger value will reduce the amount of time needed to generate the graph, but using very large values runs the risk of missing peaks in population that may occur between samples.
Title	Graph title (will be included in exported images and CSV files).
X Axis	X axis label (will be included in exported images and CSV files).
Y Axis	Y axis label (will be included in exported images but not CSV files).

Style	<p>Server population counts can be displayed as either individual curves, stacked areas, bars, or stacked bars.</p> <p>If either bars or stacked bars are chosen, a bin size must be specified. Each bar will then correspond to an interval of time with the size specified, and the associated value will be the average count within that time interval. If sampling period exceeds bin size, zero values will be present. If sampling period exceeds bin size, zero values will be present.</p> <p>If stacked areas, stepped areas or stacked bars are chosen, a 'Normalized' option is available. If selected, population counts will be displayed as percentages instead of absolute values and will always sum to 100.</p>
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

4.3.3.4.9 Volume Density

Volume density graphs can be used to show how the average density (total population divided by total area) varies over time within one or more [volume](#) objects. Each volume will have a corresponding series on the graph showing its average density over time, and the graph will have coloured horizontal background stripes indicating different density ranges. Optionally, multiple simulation runs can be specified with an aggregate result shown.

Volume Density Parameters	
Name	The name of the graph.
Simulation runs	The simulation runs for which densities should be calculated.
Aggregation type	How density data should be aggregated over multiple runs for display in the graph. Depending on the value chosen here, the value shown at each point in time on the resulting graph will either be the minimum, maximum or average of the average volume densities recorded at that point in time during each chosen simulation run. Note that these options are all equivalent if only a single run is chosen.
Reporting period	The time period over which densities should be calculated.
Sampling period	How frequently to measure each volume's population and calculate its density. Specifying a larger value will reduce the amount of time needed to generate the graph, but using very large values runs the risk of missing peaks in density that may occur between samples.
Title	Graph title (will be included in exported images and CSV files).
X Axis	X axis label (will be included in exported images and CSV files).

Y Axis	Y axis label (will be included in exported images but not CSV files).
Style	Densities can be displayed as either curves, stepped curves, or bars. If stepped curves or bars are chosen, a bin size must be specified. Each bar will then correspond to an interval of time with the size specified, and the associated value will be the average density within that time interval. If sampling period exceeds bin size, zero values will be present.
Show Legend	Display graph legend (will be included in exported images but not CSV files). Graph must be regenerated to update dataset labels.
Show Metadata	Display information about the MassMotion version and database file used to generate the graph (will be included in exported images and CSV files).
Volumes	Which volumes to include in the graph. Each volume will correspond to one graph series.
Density Ranges	Which colours and density ranges to use for the coloured background stripes of the graph. Any of the standard LOS Colour Mapping types can be used, or custom ranges and colours can be specified.
Notes	A simple field that can be used to save comments or explanation about the graph. This will be saved, but will not be exported to CSV.

4.3.3.5 Maps

Map queries paint objects in the scene based on the behaviour of agents.

All maps have a "Surface Objects" parameter which determines which objects will be painted. Most maps can only paint walkable surfaces, with the exception of [vision time maps](#), which can paint barriers as well.

Several maps can customize how they display values on their surfaces. Using transparent values will allow an object's colour to be displayed instead of other colours. See [Working with Colours](#) for more information.

Only one map can be displayed at any time, evaluating or showing a map will hide any other map that is shown. Maps can be hidden from the view menu or by right clicking map objects in the list view.

Maps cannot be directly exported, but the [movie and image exporter](#) can be used instead.

List of Maps

Map Type	Description
Agent Count	Counts the number of unique agents that cross each point.
Agent Path	Traces the route taken by each agent.
Agent Time to Exit	The time required for an agent to exit from each point.
Average	The average density at each point.

Density	
<u>Average Non-Zero Density</u>	The average non-zero density at each point.
<u>Dynamic Path</u>	Shows dynamic 'trails' behind each agent as they move around the model.
<u>Experienced Density</u>	The experienced density at each point.
<u>Instantaneous Density</u>	The current density at each point. This map is "live" and updates with simulation playback.
<u>Maximum Density</u>	The maximum density at each point.
<u>Static Cost</u>	The cost perceived by agents to reach various destination portals. This map does not require a simulation run.
<u>Static Distance</u>	The measured distance to various destination portals. This map does not require a simulation run.
<u>Time Above Density</u>	The time agents spend above a specified density at each point.
<u>Time Occupied</u>	The time for which each point is occupied by an agent.
<u>Time Until Clear</u>	The time before the last agent leaves each point.
<u>Vision Time</u>	The time agents spend looking at a surface. This map can paint barriers.

4.3.3.5.1 Agent Count

Agent count maps can be used to display how many different agents use different parts of a walkable object. The colour at each point will indicate the number of unique agents that ever stood at that point during the given time range.

Agent Count Map Parameters	
Name	The name of the map.
<u>Simulation run</u>	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
<u>Agent Filter</u>	Used to select a subset of agents to consider when generating the map.
Colouring	The colours that will be used in the map. Ranges are given as agent counts. See <u>Working with Colours</u> for more information.

Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.2 Agent Path

Agent path maps can be used to show where agents tend to walk. As agents move around the model, they will lay down a semi-transparent trail with the same colour as the agent itself. These paths will be laid down on top of each other, so later agents will tend to obscure earlier ones.

Agent path maps are very useful when constructing [filters](#), as they can provide immediate visual feedback on whether the filter is performing as expected.

Agent Path Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated. This also controls the colour of the paths; the agent colouring options set on the simulation run are used when generating the paths.
Time range	The time period over which paths should be generated.
Agent Filter	Used to select a subset of agents to consider when generating the map.
Opacity	The opacity of the path laid down by each agent, in percent.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.3 Agent Time To Exit

Agent time to exit maps can be used to measure how long it takes agents to exit the simulation from any point in their journey through the simulation. The colour at each point will indicate the longest time it took any agent to exit the simulation after standing at that point. For instance, in an evacuation scenario, points far away from the exits would have a large value since agents standing at those points would take a long time to be able to exit the simulation. Points near the exits would have small values since agents at those points would exit the simulation shortly after the evacuation begins.

Agent Time To Exit Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
Agent Filter	Used to select a subset of agents to consider when generating the map.

Colouring	The colours that will be used in the map. Ranges are given as times in seconds. See Working with Colours for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.4 Average Density

Average density maps can be used to display what parts of an object were, on average, most crowded. The colour at each point will indicate the average density (agents per square metre) over the given time range in a circle about that point. The circles used to calculate density have a standard Fruin area of 3.25 square metres.

The average density is defined as:

$$LOS(t) = \frac{\sum_{n=1}^t density(n)}{t}$$

Average Density Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
Sampling period	How frequently to sample agent positions when generating the map. Specifying a larger value will reduce the amount of time needed to generate the map, but decrease accuracy.
Colouring	The colours that will be used in the map. Any of the standard Fruin metrics plus the IATA (International Air Transport Association) Wait/Circulate standard can be used. If 'Fruin (auto)' is used, Fruin walkway values will be used for floor and links, and Fruin stairway values will be used for stairs and escalators. Finally, custom density ranges and corresponding colours can also be defined. See Working with Colours and LOS Colour Mapping for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.5 Average Non-Zero Density

Average non-zero density maps are the same as [Average Density](#) maps except that zero density values are not included in the average. Therefore, long stretches of time with no agents will not affect the computed values.

Average Non-Zero Density Map Parameters

Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
Sampling period	How frequently to sample agent positions when generating the map. Specifying a larger value will reduce the amount of time needed to generate the map, but decrease accuracy.
Colouring	The colours that will be used in the map. Any of the standard Fruin metrics plus the IATA (International Air Transport Association) Wait/Circulate standard can be used. If 'Fruin (auto)' is used, Fruin walkway values will be used for floor and links, and Fruin stairway values will be used for stairs and escalators. Finally, custom density ranges and corresponding colours can also be defined. See Working with Colours and LOS Colour Mapping for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.6 Dynamic Path

Dynamic path maps are similar to [agent path maps](#), but the trails left behind agents fade out over a set period of time. The net effect is that each agent can have (for instance) a trail showing where it has been in the last 10 seconds, which can be useful for visualization purposes.

A couple of techniques that can be used with dynamic path maps include:

- Setting the decay time to zero and opacity to a small value (10-20%): this will have the effect of adding a small circular 'shadow' under each agent.
- Setting up a dynamic path map and then hiding the corresponding simulation run: in this way only the paths themselves will be shown, which can be useful in visualizing overall flow patterns.

Dynamic path maps can be used when [exporting movies](#), but can only be effectively previewed by using the 'play' option of the [Time Panel](#). Manually dragging the playback slider will erase and reset all paths.

Dynamic Path Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated. This also controls the colour of the paths; the agent colouring options set on the simulation run are used when generating the paths.
Agent Filter	Used to select a subset of agents to consider when generating the map.
Initial Opacity	The opacity of the path as initially laid down by an agent, in percent (i.e., the opacity of the path directly under the agent's feet).
Decay Time	Approximately how long each path will be, in seconds. For instance, setting this to 10 seconds will mean that the trail behind each agent will show approximately the last 10 seconds of movement before fading into invisibility. Experimentation

	may be needed to find a combination of initial opacity and decay time that produces the desired visual effect.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.7 Experienced Density

Experienced density maps are a measure of the average density experienced by the agents (the average of all experiences), computed as a weighted average. The measure is calculated as:

$$LOS(t) = \frac{\sum_{n=1}^t density(n)^2}{\sum_{n=1}^t density(n)}$$

While the regular time based [Average Density](#) tends to smooth out dense but intermittent bursts in traffic, the experienced average highlights those bursts regardless of their frequency.

Experienced Density Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
Sampling period	How frequently to sample agent positions when generating the map. Specifying a larger value will reduce the amount of time needed to generate the map, but decrease accuracy.
Colouring	The colours that will be used in the map. Any of the standard Fruin metrics plus the IATA (International Air Transport Association) Wait/Circulate standard can be used. If 'Fruin (auto)' is used, Fruin walkway values will be used for floor and links, and Fruin stairway values will be used for stairs and escalators. Finally, custom density ranges and corresponding colours can also be defined. See Working with Colours and LOS Colour Mapping for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.8 Instantaneous Density

Instantaneous density maps can be used to produce a live, animated display of what parts of one or more objects are most crowded. The colour at each point indicates the current density (agents per square metre) in a circle about that point. The circles used to calculate density have a standard Fruin area of 3.25 square metres.

Average Density Map Parameters

Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Colouring	The colours that will be used in the map. Any of the standard Fruin metrics plus the IATA (International Air Transport Association) Wait/Circulate standard can be used. If 'Fruin (auto)' is used, Fruin walkway values will be used for floor and links, and Fruin stairway values will be used for stairs and escalators. Finally, custom density ranges and corresponding colours can also be defined. See Working with Colours and LOS Colour Mapping for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.9 Maximum Density

Maximum density maps are similar to [average density maps](#), but show the maximum density ever reached at each point during the given time range.

Maximum Density Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
Sampling period	How frequently to sample agent positions when generating the map. Specifying a larger value will reduce the amount of time needed to generate the map, but decrease accuracy (specifically, density peaks will be missed if they fall in between sample times).
Colouring	The colours that will be used in the map. Any of the standard Fruin metrics plus the IATA (International Air Transport Association) Wait/Circulate standard can be used. If 'Fruin (auto)' is used, Fruin walkway values will be used for floor and links, and Fruin stairway values will be used for stairs and escalators. Finally, custom density ranges and corresponding colours can also be defined. See Working with Colours and LOS Colour Mapping for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.10 Static Cost

Static Cost Maps show how agents perceive the network and the cost in seconds to arrive at given portals from each point. This map does not take crowds into account and can be evaluated before a simulation is run. **Evaluating this map rebuilds the scene network which can be time consuming and the evaluate command cannot be canceled.**

The value shown on the map at any point is the estimated time taken for an agent to get **from** that point **to** the nearest of the given portals. This will be affected by distance penalties and directionality on links, stairs, paths etc. In particular, although the map will appear as a wave propagating **outwards** from the given portals, the wave will only propagate through unidirectional links that are oriented **inwards** towards the portals (since those are the only unidirectional links that agents will be able to use to get to the portals) and will be blocked by any unidirectional links oriented outwards.

Vertical costs of vertical elements such as [stairs](#) or [escalators](#) and other cost penalties are applied as a single step before the next object which may lead to visual discontinuities. Within an object, only horizontal costs are considered. Costs are calculated using a nominal agent speed of 1 m/s.

Static Cost Map Parameters	
Name	The name of the map.
Colouring	The colours that will be used in the map. Ranges are given as times in seconds. See Working with Colours for more information.
Surface Objects	Which objects to apply the map to.
Portals	The map will show the cost used by agents to arrive at any of the given portals. With multiple portals, the lowest cost will be displayed for each point.
Network Objects	The objects included in the network calculations. The map includes the entire model by default, reflecting what occurs in simulation. A subset of the model can be used to speed up processing time or to focus the analysis.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.11 Static Distance

Static Distance Maps show the distance from each point to the given portals. This map does not take crowds into account and can be evaluated before a simulation is run. **Evaluating this map rebuilds the scene network which can be time consuming and the evaluate command cannot be canceled.**

The value shown on the map at any point is the walking distance **from** that point **to** the nearest of the given portals. This will be affected by directionality on links, stairs, paths etc. In particular, although the map will appear as a wave propagating **outwards** from the given portals, the wave will only propagate through unidirectional links that are oriented **inwards** towards the portals (since those are the only unidirectional links that agents will be able to use to get to the portals) and will be blocked by any unidirectional links oriented outwards. Any applied distance penalties, however, will not be considered (in these cases the [Static Cost](#) map may be more appropriate).

Distances along vertical elements such as [stairs](#) or [escalators](#) are taken as the Cartesian distance along their lengths. For other objects, only horizontal distance are considered. For example, any height variation on a floor is ignored.

Static Distance Map Parameters	
Name	The name of the map.

Colouring	The colours that will be used in the map. Ranges are given as distances in metres. See Working with Colours for more information.
Surface Objects	Which objects to apply the map to.
Portals	The map will show the distance from any of the given portals. With multiple portals, the shortest will be displayed for each point.
Network Objects	The objects included in the network calculations. The map includes the entire model by default, reflecting what occurs in simulation. A subset of the model can be used to speed up processing time or to focus the analysis.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.12 Time Above Density

Time above density maps can be used to find parts of walkable objects where the agent density exceeded a given threshold, and determine for how long this occurred. Map colours will indicate the amount of time each point on each selected object had a local density greater than a given threshold.

Time Above Density Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
Minimum Density	The density value cutoff to use. Standard Fruin walkway values can be selected, or a custom density value can be specified.
Colouring	The colours that will be used in the map. Ranges are given as times in seconds. See Working with Colours for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.13 Time Occupied

Time occupied maps can be used to measure how long a given location was occupied by agents during the simulation. The colour at each point will indicate the cumulative count (in seconds) that any agent stood at that point. For instance, in train station scenario, a time occupied map might be used to determine how much time people spent waiting near the departures board in the main concourse.

Time Until Clear Map Parameters	
Name	The name of the map.

Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed. Time values will be computed from the start of the time range.
Agent Filter	Used to select a subset of agents to consider when generating the map.
Colouring	The colours that will be used in the map. Ranges are given as times in seconds. See Working with Colours for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.5.14 Time Until Clear

Time until clear maps can be used to measure how long it took until no agents were left at various points. The colour at each point will indicate the last time, relative to the beginning of the given time range, that any agent stood at that point. For instance, in an evacuation scenario, points far away from the exits would have small values since those areas would be left quickly. Points near the exits would have large values since those points would continue to be visited by agents as they exited.

Time Until Clear Map Parameters	
Name	The name of the map.
Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed. Time values will be computed from the start of the time range.
Agent Filter	Used to select a subset of agents to consider when generating the map.
Colouring	The colours that will be used in the map. Ranges are given as times in seconds. See Working with Colours for more information.
Surface Objects	Which objects to apply the map to.
Notes	A simple field that can be used to save comments or explanation about the map.

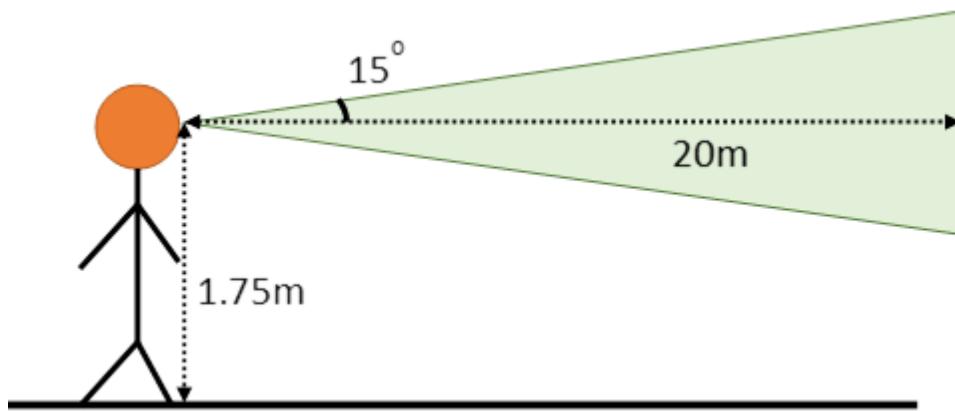
4.3.3.5.15 Vision Time

Vision time maps are an **experimental** feature which calculates where agents are looking as they move through a simulation. Unlike other maps, vision time maps can also be applied to barriers.

Vision time maps display the amount of time a given point on an object is viewed. The time is multiplied by the number of agents, thus two agents looking at a wall for 1 second and one agent looking at a wall for 2 seconds will both yield a time value of 2 seconds.

The scene is divided into volumetric elements or "voxels". All agents will project a viewing cone ahead of them marking voxels they see. This cone is currently fixed at a 15 degree half angle, 20

metre length and 1.75m above the floor.



Agents will mark any voxels containing scene objects, including hidden objects and reference geometry and are unable to see through them. They will, however, see through any other agents in front of them and analysis [cordons](#) and [volumes](#).

The voxel based approach can cause certain visual artefacts may occur as voxels obscure each other.

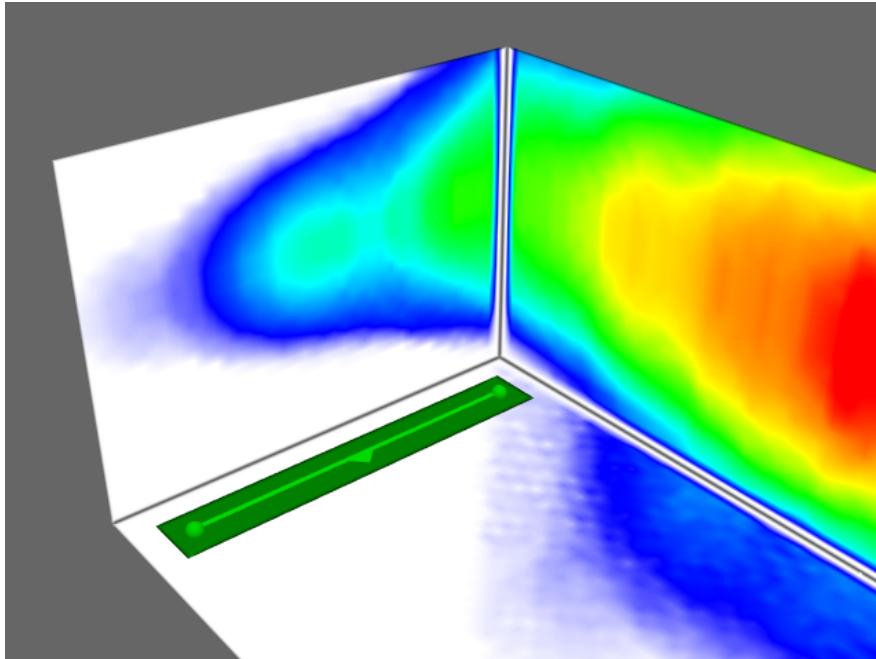


Figure 1: Voxels in corners have no set values because they are blocked by adjacent voxels.

This map is very resource intensive, consuming both CPU time and memory. Changing the sampling period is an effective way of speeding up the map computation; the amount of memory consumed can only be reduced by choosing a smaller set of objects.

Average Density Map Parameters	
Name	The name of the map.

Simulation run	The simulation run for which the map should be generated.
Time range	The time period over which map values should be computed.
Sampling period	How frequently to sample agent positions when generating the map. Specifying a larger value will reduce the amount of time needed to generate the map, but decrease accuracy.
Colouring	The colours that will be used in the map. The default values may need to be changed as value ranges change dramatically based on the population counts and characteristics. See Working with Colours for more information.
Surface Objects	Which objects to apply the map to. Unlike most maps, vision maps can also include barriers as surface objects. The amount of memory used during vision map computation depends on the size of a rectangular box that fits around all selected objects. Therefore, selecting a very large object or even two small objects that are far apart will require a large amount of memory.
Notes	A simple field that can be used to save comments or explanation about the map.

4.3.3.6 Tables

Table queries all produce tabular data in different forms. Once evaluated, tables can be exported to a CSV file. Additionally, right-clicking on any table column allows the generation of a histogram of the values in that column, which can itself be exported to CSV.

List of Tables

Table Type	Description
Agent Area Time	Lists the amount of time agents spend in given areas.
Agent LOS Time	Lists the amount of time agents spend at each level of service.
Agent Process Chain Time	Lists the amount of time agents spend in a process chain.
Agent Social Cost	Lists agent journey times expressed as a generalized time or cost.
Agent Summary	Provides general information about each agent.
Agent Timetable Summary	Provides general information about agents produced by a given timetable.
Agent	Lists the amount of time agents carry given tokens.

<u>Token Time</u>	
<u>Agent Trip Time</u>	Lists the time required for agents to complete a given trip.
<u>Area OD Count Matrix</u>	Counts the number of agents entering and exiting a zone or floor organized by entrance and exit object.
<u>Simulation OD Count Matrix</u>	Counts the number of agents entering and exiting the simulation organized by entrance and exit portal.
<u>Simulation OD Time Matrix</u>	Counts the time spent in the simulation organized by entrance and exit portal.
<u>Simulation OD Social Cost Matrix</u>	Counts the generalized time or cost for agents organized by entrance and exit portal.
<u>Performance Table</u>	Provides diagnostics for simulation runs.
<u>Server Summary</u>	Lists queue times and other information for servers.

4.3.3.6.1 Agent Area Time

Agent area time tables can be used to determine how long different agents spend in different [areas](#).

Agent Area Time Parameters	
Name	The name of the table.
<u>Simulation run</u>	The simulation run for which region times should be calculated.
Time range	The time period over which times should be calculated.
<u>Agent Filter</u>	Determines which agents in a given frame can be included in the time count.
Areas	Which areas should be included in the table.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent. Agents will only be included in the table if they satisfy the given filter during the given time range, and are ever in any of the given areas during that time range.

Agent Area Time Columns

Agent ID	Internal agent ID.
Names (variable)	One column per selected areas , showing how long the agent spent in that area while simultaneously satisfying the given filter. For instance, using an 'in trip' filter will result in each row showing the amount of time one agent spent in various areas while undergoing a particular trip . Times are rounded to the nearest second.

4.3.3.6.2 Agent LOS Time

Agent LOS time tables can be used to determine how long different agents spend at different levels of service.

Agent LOS Time Parameters	
Name	The name of the table.
Simulation run	The simulation run for which LOS times should be calculated.
Time range	The time period over which times should be calculated.
Agent Filter	Determines which agents in a given frame can be included in the time count.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent. Agents will only be included in the table if they ever satisfy the given filter during the given time range. All times are rounded to the nearest second.

Agent LOS Time Columns	
Agent ID	Internal agent ID.
Total Duration	Total amount of time that the agent satisfied the given filter. Note that this number may be less than expected if the agent entered or exited the simulation during the specified time range.
LOS [A,B,C,D,E,F] Duration	Total amount of time that the agent spent at each level of service while simultaneously satisfying the given filter. For instance, using an 'in area' filter with a particular floor, each row will show how long one agent spent at each level of service while on that floor. The level of service is calculated based on standard Fruin values, with the LOS type determined by what sort of walkable object the agent is standing on. Floors and links use Fruin walkway LOS values, and stairs and escalators use Fruin stairway LOS values.

4.3.3.6.3 Agent Process Chain Time

Agent process chain time tables can be used to produce agent summary information about a given process.

Agent Process Chain Time Parameters

Name	The name of the table.
Simulation run	The simulation run for which process chain times should be calculated.
Finished end server at	A special type of time range: only agents that left the final server in the process during the given time range will be included in the table. Agents that started the process before the start of the interval but finished during the interval will be included. Conversely, agents that started the process during the given time range but did not finish until afterwards will not be included.
Include Agents	An agent filter that determines which agents will be included in the table.
Servers	Specifies lists of start and end servers defining the process. An agent is defined as starting the process chain when it starts the pre-contact wait stage at any of the first servers (see Server for details on different server stages), and is defined as finishing the process chain when it exits any of the end servers. It is possible to specify the same server(s) as both start and end.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent's processing time. Agents will only be included in the table if they satisfy the given filter during the given time range. All times are rounded to the nearest second.

Agent Process Chain Time Columns	
Agent ID	Internal agent ID.
Start Server	Which of the specified start servers the agent started the process chain at.
End Server	Which of the specified end servers the agent ended the process chain at.
Start Time	What time the agent started the process chain. This is the first time when they are either being processed by one of the start servers or are queueing for the server (blocked by another agent that is at the server).
End Time	What time the agent ended the process chain. This corresponds to the time at which the agent was finished being processed by one of the end servers.
Total Duration	How long the agent took to finish the process chain (end time minus start time).
In Transit	Total amount of time the agent spent moving between servers. This includes both the time spent moving to a server line and any time spent unobstructed along the line.
Pre-Contact Wait	Total amount of time the agent spent waiting in any server input buffers before being processed..
Contact Wait	Total amount of time the agent spent in contact with and being processed by servers.

Post-Contact Wait	Total amount of time the agent spent waiting in server output buffers for a space to become available at a downstream server.
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4.3.3.6.4 Agent Social Cost

The agent social cost table displays information about the journey of each agent, expressed as a weighted time or cost value. The default weights, cost factors, and algorithms are taken from the Transport For London Business Case Development Manual [1].

In general an agent journey is broken down into the time spent on various activities such as walking, waiting, or climbing stairs. A weight factor is applied to each of these component activities. The sum of the weighted components is termed the 'Generalized Journey Time' and is expressed in seconds.

An additional congestion penalty is calculated while the agent is walking or waiting. The sum of the congestion penalty and generalized journey time is used to calculate a total cost. If the total cost is assumed to be the cost for one day, an annualized cost can be calculated using the number of days in the year.

Congestion Factor

Density P (ppl/m ²)	Congestion Factor Walking	Congestion Factor Waiting
P <= 0.5	0.0	0.0
P >= 2.0	0.5 * 1.5 = 0.75	1.5
0.5 < P < 2.0	0.5 * 0.667 * (P - 0.5) ²	0.667 * (P - 0.5) ²

Agent Social Cost Parameters	
<u>Simulation run</u>	The simulation run for which social cost values should be calculated.
<u>Time range</u>	The time period over which times should be calculated.
<u>View</u>	<p>Activity Summary: Display the time, generalized time, and cost values summed over all agents, broken down into the component activity types.</p> <p>All agent data: Display the time, generalized time, and cost values for each agent.</p> <p>Agent costs: Display cost values for each agent.</p> <p>Agent generalized journey times: Display generalized journey times and congestion factors for each agent.</p> <p>Agent journey times: Display journey times for each agent.</p>
<u>Agent Filter</u>	Determines which agents in a given frame can be included in the time count.
<u>Cost per</u>	The price used to convert the generalized journey time to a cost value. The cost

Hour	is first converted into a 'cost per second' value, then multiplied by the generalized journey times.
Days per Year	The number of days in a year. It is assumed that calculated costs are for one day. These day cost values are multiplied by the number of days in a year to produce the annualized cost.
Walking Weight	A factor applied to time spent walking on floors or ramps.
Waiting Weight	A factor applied to time spent waiting. This time includes waiting for a closed gate to open or waiting in response to a wait task. A wait task can be given by the creation event (evacuation event, circulation event) or given by an action.
Queuing Weight	A factor applied to time spent queuing at a server. This does not apply to agents queuing at a link, stair, ramp, or escalator.
Processing Weight	A factor applied to time spent being processed by a server.
Stairs Up Weight	A factor applied to time spent walking up stairs.
Stairs Down Weight	A factor applied to time spent walking down stairs.
Escalator Weight	A factor applied to time spent riding on escalators (up or down).
Custom Weight	A custom weight that can be applied to agents based on an agent filter. When enabled, agents that pass the filter in a given frame will use the custom weight for that frame. Only agents that do not pass the filter will use the other activity weights such as walking or waiting. This can be useful for applying a custom weight to a specific activity in a specific area of the model. Or by setting the weight to 0, it can also be used to exclude agents from being counted under certain conditions.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent. Agents will only be included in the table if they ever satisfy the given filter during the given time range. All times are rounded to the nearest second.

[1] Business Case Development Manual, Transport For London, May 2013, Appendix E 3.1

4.3.3.6.5 Agent Summary

Agent summary tables can be used to display a variety of overall summary information for a set of agents. When combined with the agent filters the table becomes a powerful way to validate components of a simulation.

For example:

- Right-click on the Entrance column header to display a histogram of the number of agents entering through each portal.

- Right-click on the Desired Speed column header to display the number of agents in various speed ranges.
- Right-click on an agent Start Time value to focus the 3D view and timeline on the agent at the time it entered the simulation.

Agent Summary Parameters	
Name	The name of the table.
Simulation run	The simulation run for which agent summaries should be calculated.
Agents alive at	A special type of time range: only agents that were alive at any point during the given interval will be included in the table. Values in the table (duration, distance traveled etc.) will still refer to the entire lifetime of each agent.
Include Agents	An agent filter that determines which agents will be included in the table.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent. Agents will only be included in the table if they satisfy the given filter during the given time range. All times are rounded to the nearest second.

Agent Summary Columns	
Agent ID	Internal agent ID.
Profile	The profile assigned to the agent when it was created.
Creator	The event which created the agent.
Entrance	What portal the agent entered the simulation at.
Exit	What portal the agent exited the simulation at. If the field is blank, the agent was still in the scene when the simulation ended.
Start Time	What time the agent entered the simulation.
End Time	What time the agent exited the simulation. Agents still in the scene when the simulation ended will list the simulation end time.
Duration	Total amount of time the agent spent in the simulation (end time minus start time).
Distance Traveled (m)	Total distance traveled by the agent. This includes any stuttering back and forth when congested.
Desired Speed (m/s)	Innate desired speed of the agent as designated by the agent's profile .
End State	The end state of the agent after leaving the simulation or the simulation ends.

	in simulation: still in scene at simulation end exited with success: exited simulation as expected exited with error: was deleted from simulation with an error.
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4.3.3.6.6 Agent Timetable Summary

Agent timetable summary tables can be used to display information for a set of agents associated with a set of reference events from a particular [Timetable](#) object. Reference events are not visible to any object outside of the Timetable object in which they are defined. The timetable summary table allows for queries that target agents generated by a Timetable schedule that were based on one or more reference events. For example, if the timetable is describing the operations of an airport and reference events correspond to flights, the table can be made to display information about all those agents who were either arriving or departing on a particular flight.

Agent Timetable Summary Parameters	
Name	The name of the table.
Simulation run	The simulation run for which agent summaries should be calculated.
Agents alive at	A special type of time range: only agents that were alive at any point during the given interval will be included in the table. Values in the table (duration, distance traveled etc.) will still refer to the entire lifetime of each agent.
Include Agents	An agent filter that determines which agents will be included in the table.
Timetable	The timetable object the table should refer to. Only agents created by this timetable will be included in the table.
Reference events	Optionally provide a list of timetable reference events. If used, only agents that were produced by or sent to any of the given reference events will be included in the table.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent. Agents will only be included in the table if they satisfy the given filter during the given time range. All times are rounded to the nearest second.

Agent Timetable Summary Columns	
Agent ID	Internal agent ID.
From Reference Event	Reference event from which the agent was created (blank if the schedule did not specify a 'From' reference event).
To Reference Event	Reference event the agent was sent to (blank if the schedule did not specify a 'To' reference event).

Entrance	What portal the agent entered the simulation at.
Exit	What portal the agent exited the simulation at. If the field is blank, the agent was still in the scene when the simulation ended.
Start Time	What time the agent entered the simulation.
End Time	What time the agent exited the simulation. Agents still in the scene when the simulation ended will list the simulation end time.
Duration	Total amount of time the agent spent in the simulation (end time minus start time).
Distance Traveled (m)	Total distance traveled by the agent.
Desired Speed (m/s)	Innate desired speed of the agent as designated by the agent's profile .

4.3.3.6.7 Agent Token Time

Agent token time tables can be used to determine how long different agents spend holding different [tokens](#).

Agent Token Time Parameters	
Name	The name of the table.
Simulation run	The simulation run for which token times should be calculated.
Time range	The time period over which token times should be calculated.
Agent Filter	Determines which agents in a given frame can be included in the time count.
Tokens	Which tokens should be included in the table.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent. Agents will only be included in the table if they satisfy the given filter during the given time range, and ever possess any of the given tokens during that time range. All times are rounded to the nearest second.

Agent Token Time Columns	
Agent ID	Internal agent ID.
Names (variable)	One column per selected token, showing how long the agent spent holding that token while simultaneously satisfying the given filter. For instance, using an 'in trip' filter will result in each row showing the amount of time one agent spent holding various tokens while undergoing a particular trip .

4.3.3.6.8 Agent Trip Time

Agent trip time tables can be used to determine how long agents spent to complete a certain [trip](#).

Agent Trip Time Parameters	
Name	The name of the table.
Simulation run	The simulation run for which trip times should be calculated.
Time range	The time period over which times should be calculated.
Agent Filter	Determines which agents in a given frame can be included in the time count.
Trip	The trip the table will refer to.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one agent's trip. Agents will only be included in the table if they satisfy the given filter during the given time range, and fully complete the trip within the specified time range. See [Trips](#) for the different ways in which a trip can be defined in terms of start and end criteria. All times are rounded to the nearest second.

Agent Trip Time Columns	
Agent ID	Internal agent ID.
Start Time	When the agent started the trip.
End Time	When the agent finished the trip.
Duration	Total time the agent spent in the trip (end time minus start time).

4.3.3.6.9 Area OD Count Matrix

The origin/destination matrix displays a count of agents by the objects through which they enter and exit a zone or floor. Possible entry and exit objects include portals, links, stairs, ramps, escalators, or paths. A time range can be used to target a particular interval within the simulation. Results can be displayed in matrix or list form.

Zone/floor entrances are listed as row headers. Zone/floor exits are listed as column headers.

Origin/Destination Parameters	
Simulation run	The simulation run for which counts should be calculated.
Count if:	Agent starts in range: Count/list agents who enter the simulation during the specified time range.

	<p>Agent ends in range: Count/list agents who exit the simulation during the specified time range.</p> <p>Agent starts and ends in range: Count/list agents who both enter and exit the simulation completely within the specified time range.</p> <p>Agent exists during range: Count/list agents who are present in the simulation during the specified time range.</p>
Time range	The time period used to determine which agents to count/list.
View as	<p>Whether to show results as a matrix or list.</p> <p>Matrix: Each cell represents the total number of agents that entered and exited the zone/floor using the given object pair.</p> <p>List: Each row is a single agent, with columns displaying the entrance portal and time and the exit portal and time.</p>
Hide empty rows and columns	When checked, rows and columns that contain only zeros are hidden.
<u>Include Agents</u>	An agent filter that determines which agents will be included in the table.
Target	<p>Zone boundary objects: All portals, links, stairs, ramps, escalators, and paths leading into and out of the specified zone are used. Agents are counted based on the object through which they enter the zone and the object through which they exit the zone.</p> <p>Floor boundary objects: All portals, links, stairs, ramps, escalators, and paths leading onto and off of the specified floor are used. Agents are counted based on the object through which they enter the floor and the object through which they exit the floor.</p>
Notes	A simple field that can be used to save comments about the table. This will be saved, but will not be exported to CSV.

4.3.3.6.10 Simulation OD Count Matrix

The origin/destination matrix displays a count of agents by their entrance and exit portals. A time range can be used to target a particular interval within the simulation. Results can be displayed in matrix or list form.

Entrance portals are listed as row headers. Exit portals are listed as column headers.

Origin/Destination Parameters	
<u>Simulation run</u>	The simulation run for which counts should be calculated.
Count if:	Agent starts in range: Count/list agents who enter the simulation during the specified time range.

	<p>Agent ends in range: Count/list agents who exit the simulation during the specified time range.</p> <p>Agent starts and ends in range: Count/list agents who both enter and exit the simulation completely within the specified time range.</p> <p>Agent exists during range: Count/list agents who are present in the simulation during the specified time range.</p>
Time range	The time period used to determine which agents to count/list.
View as	<p>Whether to show results as a matrix or list.</p> <p>Matrix: Each cell represents the total number of agents that completed the trip starting at the origin portal and exiting the simulation at the exit portal.</p> <p>List: Each row is a single agent, with columns displaying the entrance portal and time and the exit portal and time.</p>
Hide empty rows and columns	When checked, rows and columns that contain only zeros are hidden.
Include Agents	An agent filter that determines which agents will be included in the table.
Target	<p>All portals in model: Agents entering or exiting from any portal in the scene are included. Portals are listed in alphabetical order.</p> <p>Specified portals: Agents entering or exiting from the specified portals. If collections are used, counts for all portals in the collection are reported for the collection. If the same portal occurs in multiple collections then counts for that portal will be presented multiple times. Entries are listed in alphabetical order.</p> <p>Specified portals in order: Agents entering or exiting from the specified portals. If collections are used, counts for all portals in the collection are reported for the collection. If the same portal occurs in multiple collections then counts for that portal will be presented multiple times. Entries are listed in the order specified.</p>
Notes	A simple field that can be used to save comments about the table. This will be saved, but will not be exported to CSV.

4.3.3.6.11 Simulation OD Time Matrix

The origin/destination matrix displays the number of seconds agents were in the simulation, organized by entrance/exit. Results can be displayed as the total time for all agents with the given entrance/exit pair, the average trip time, the maximum, or the minimum. When using an agent filter, each agent's time count includes only those frames when the agent satisfied the filter.

Entrance portals are listed as row headers. Exit portals are listed as column headers.

Origin/Destination Parameters

<u>Simulation run</u>	The simulation run for which time values should be calculated.
Count if:	<p>This can be used to specify which agents to include based on whether or not they enter or exit the simulation within a specified time range. If an agent is included in the count, the count is of the entire agent's journey time, even if a portion of the journey takes place outside of the specified time range.</p> <p>Agent starts in range: Count/list agents who enter the simulation during the specified time range.</p> <p>Agent ends in range: Count/list agents who exit the simulation during the specified time range.</p> <p>Agent starts and ends in range: Count/list agents who both enter and exit the simulation completely within the specified time range.</p> <p>Agent exists during range: Count/list agents who are present in the simulation during the specified time range.</p>
Time range	The time period used to determine which agents to count/list.
View as	<p>Whether to show results as a matrix or list.</p> <p>Matrix: Each cell represents the total number of agents that completed the trip starting at the origin portal and exiting the simulation at the exit portal.</p> <p>List: Each row is a single agent, with columns displaying the entrance portal and time and the exit portal and time.</p>
Aggregation Type	<p>Total: Add times for all agents with the same entrance/exit pair.</p> <p>Average: Calculate the average trip time between each entrance/exit pair.</p> <p>Minimum: Calculate the minimum trip time between each entrance/exit pair.</p> <p>Maximum: Calculate the maximum trip time between each entrance/exit pair.</p>
Hide empty rows and columns	When checked, rows and columns that contain only zeros are hidden.
<u>Include Agents</u>	An agent filter that determines which agents will be included in the table. When set, time will only be recorded for an agent when it satisfies the filter. This means that some agents may have only a portion of their journey included.
Target	<p>All portals in model: Agents entering or exiting from any portal in the scene are included. Portals are listed in alphabetical order.</p> <p>Specified portals: Agents entering or exiting from the specified portals. If collections are used, counts for all portals in the collection are reported for the collection. If the same portal occurs in multiple collections then counts for that portal will be presented multiple times. Entries are listed in alphabetical order.</p> <p>Specified portals in order: Agents entering or exiting from the specified portals.</p>

	If collections are used, counts for all portals in the collection are reported for the collection. If the same portal occurs in multiple collections then counts for that portal will be presented multiple times. Entries are listed in the order specified.
Notes	A simple field that can be used to save comments about the table. This will be saved, but will not be exported to CSV.

4.3.3.6.12 Simulation OD Social Cost Matrix

The origin/destination matrix displays the social cost or generalized journey times for agents, organized by entrance/exit. Results can be displayed as the total value for all agents with the given entrance/exit pair, the average value, the maximum, or the minimum. When using an agent filter, each agent's time/cost count includes only those frames when the agent satisfied the filter.

Entrance portals are listed as row headers. Exit portals are listed as column headers.

For details on the agent social cost calculations see [Agent Social Cost](#).

General	
Simulation run	The simulation run for which time values should be calculated.
Count if:	<p>This can be used to specify which agents to include based on whether or not they enter or exit the simulation within a specified time range. If an agent is included in the count, the count is of the entire agent's journey time, even if a portion of the journey takes place outside of the specified time range.</p> <p>Agent starts in range: Count/list agents who enter the simulation during the specified time range.</p> <p>Agent ends in range: Count/list agents who exit the simulation during the specified time range.</p> <p>Agent starts and ends in range: Count/list agents who both enter and exit the simulation completely within the specified time range.</p> <p>Agent exists during range: Count/list agents who are present in the simulation during the specified time range.</p>
Time range	The time period used to determine which agents to count/list.
View as	<p>Whether to show results as a matrix or list.</p> <p>Matrix: Each cell represents the total number of agents that completed the trip starting at the origin portal and exiting the simulation at the exit portal.</p> <p>List: Each row is a single agent, with columns displaying the entrance portal and time and the exit portal and time.</p>
Aggregation Type	<p>Total: Add times for all agents with the same entrance/exit pair.</p> <p>Average: Calculate the average trip time between each entrance/exit pair.</p>

	<p>Minimum: Calculate the minimum trip time between each entrance/exit pair.</p> <p>Maximum: Calculate the maximum trip time between each entrance/exit pair.</p>
Hide empty rows and columns	When checked, rows and columns that contain only zeros are hidden.
<u>Include Agents</u>	An agent filter that determines which agents will be included in the table. When set, time will only be recorded for an agent when it satisfies the filter. This means that some agents may have only a portion of their journey included.
Target	<p>All portals in model: Agents entering or exiting from any portal in the scene are included. Portals are listed in alphabetical order.</p> <p>Specified portals: Agents entering or exiting from the specified portals. If collections are used, counts for all portals in the collection are reported for the collection. If the same portal occurs in multiple collections then counts for that portal will be presented multiple times. Entries are listed in alphabetical order.</p> <p>Specified portals in order: Agents entering or exiting from the specified portals. If collections are used, counts for all portals in the collection are reported for the collection. If the same portal occurs in multiple collections then counts for that portal will be presented multiple times. Entries are listed in the order specified.</p>
Notes	A simple field that can be used to save comments about the table. This will be saved, but will not be exported to CSV.

Social Cost	
Display Type	Specifies the type of value to calculate and display in the matrix or list.
Cost per Hour	The price used to convert the generalized journey time to a cost value. The cost is first converted into a 'cost per second' value, then multiplied by the generalized journey times.
Days per Year	The number of days in a year. It is assumed that calculated costs are for one day. These day cost values are multiplied by the number of days in a year to produce the annualized cost.
Walking Weight	A factor applied to time spent walking on floors or ramps.
Waiting Weight	A factor applied to time spent waiting. This time includes waiting for a closed gate to open or waiting in response to a wait task. A wait task can be given by the creation event (evacuation event, circulation event) or given by an action.
Queuing Weight	A factor applied to time spent queuing at a server. This does not apply to agents queuing at a link, stair, ramp, or escalator.
Processing Weight	A factor applied to time spent being processed by a server.

Stairs Up Weight	A factor applied to time spent walking up stairs.
Stairs Down Weight	A factor applied to time spent walking down stairs.
Escalator Weight	A factor applied to time spent riding on escalators (up or down).
Custom Weight	<p>A custom weight that can be applied to agents based on an agent filter. When enabled, agents that pass the filter in a given frame will use the custom weight for that frame. Only agents that do not pass the filter will use the other activity weights such as walking or waiting.</p> <p>This can be useful for applying a custom weight to a specific activity in a specific area of the model. Or by setting the weight to 0, it can also be used to exclude agents from being counted under certain conditions.</p>

4.3.3.6.13 Server Summary

Server summary tables can be used to measure the average, maximum or minimum values of various [server](#) performance metrics over several simulation runs (e.g., several runs with different random seeds used to check for random variation).

Server Summary Parameters	
Name	The name of the table.
Simulation run	The simulation runs over which server summaries will be calculated.
Aggregation	How values should be aggregated across multiple simulation runs (average, maximum or minimum).
Time range	The time period over which values should be calculated.
Include Agents	An agent filter that determines which agents will be included in the table.
Servers	Which servers the table will refer to.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one server, aggregated across the given runs using the given aggregation type. Only agents that satisfy the given filter will contribute to the computed values. All times are rounded to the nearest second.

Server Summary Columns	
Server Name	Server name.

Total Agents Processed	Total number of agents successfully processed by the server.
Mean Population	Average number of agents at the server.
Mean Pre-Contact Wait	Average amount of time agents waited in the input buffer before being processed by the server.
Mean Contact Wait	Average amount of time agents spent in contact being processed by the server.
Mean Post-Contact Wait	Average amount of time agents waited in the output buffer after being processed (until a space became available at a downstream server).
Mean Total Duration	Average total amount of time agents spent waiting at the server (pre-contact + contact + post-contact).
Max Population	Maximum number of agents ever at the server at one time.
Max Pre-Contact Wait	Maximum amount of time any agent waited in the input buffer before being processed by the server.
Max Contact Wait	Maximum amount of time any agent spent in contact being processed by the server.
Max Post-Contact Wait	Maximum amount of time any agent waited in the output buffer after being processed (until a space became available at a downstream server).
Max Total Duration	Maximum total amount of time any agent spent waiting at the server (pre-contact + contact + post-contact).

Note that 'Mean' or 'Max' in each column name refers to a mean or max that is performed **within** each run; these values are then aggregated **across** runs using the given aggregation type. For example:

- If aggregation type is set to 'Average over simulations', then the 'Max Queue Size' column has the following interpretation: For a particular server, calculate the maximum queue size at the server within each run, then take the average of those values to report in the table.
- If the aggregation type is set to 'Maximum over simulations', then the 'Mean Queue Size' column has the following interpretation: For a particular server, calculate the mean queue size at the server within each run, then take the maximum of those values to report in the table.

4.3.3.6.14 Performance Table

Performance tables can be used to compare performance statistics about different simulation runs. This includes both population data and timing information from when the simulation was run.

Performance Table Parameters	
Name	The name of the table.
Simulation run	The simulation runs to be analysed
Aggregation	<p>How timing information for each frame should be combined.</p> <p>Total Duration (s): Display the total time the simulation spent on each simulation component over the entire time range.</p> <p>Average Frame Duration (s): Display the average time the simulation spent on each simulation component for each frame.</p> <p>Maximum Frame Durations (s): Display the maximum time the simulation spent on each simulation component for each frame.</p>
Time range	The time period over which simulation statistics should be calculated.
Notes	A simple field that can be used to save comments or explanation about the table. This will be saved, but will not be exported to CSV.

Each row of the table has information on one simulation run.

Agent Token Time Columns	
Simulation Run	Name of the simulation run.
Population Data	<p>Information about each simulation run's population over the specified time range.</p> <p>Avg Population: The average population over the time range.</p> <p>Avg Density: The average population density over the time range.</p> <p>Max Population: The maximum population over the time range.</p> <p>Max Density: The maximum density over the time range.</p>
Timing Information	<p>Timing information from when the simulation was run. Aggregates of each simulation component's run time are displayed here.</p> <p>Entire Frame: The total time taken to process a frame. If the aggregation type is "Total Duration", this column will list the total time the simulation took to run. If the aggregation type is "Average Frame Duration", this column will list the average time to simulate one frame. If the aggregation type is "Maximum Frame Duration", this will list the longest time to simulate one frame.</p> <p>Additional Debug Information:</p> <ul style="list-style-type: none"> • Serial Components: The total time taken to process the serial components. • Threaded Components: The total time taken to process the threaded components. • Update Factories

	<ul style="list-style-type: none"> • Create/Delete Agents • Agent Spatial Hash • Cache Agent State • Find Agent Neighbours • Update Events • Frame Begin • Execute Tasks • Update Queues • Update Controllers • Update Process Chains • Move Agents • Correct Agent Overlap • Correct Agent Height • Write Database • Process Agents • Assess Task Progress • Frame End
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4.4 Simulation

4.4.1 Running a Simulation

A new simulation can be started from the 'Run Simulation' button in the simulation & analysis ribbon of the main window. The launch dialog provides the ability to specify the type of run and the simulation run object in which to store the results.

Type	
Standard console	This will run a Console Simulation , which is the fastest option but does not include a graphical window for viewing the simulation as it runs.
Debug viewer	This will run a Debug Simulation , which will run more slowly than a console simulation but has a scene view that allows interactive viewing and debugging of the simulation as it runs. Additionally, a breakpoint can be set to pause the simulation at the specified time. The breakpoint is useful when debugging problems that occur late in the simulation at known times.
Multiple runs	This will run several iterations of the same simulation with different random seeds (see below for details). The results for each iteration will be placed in a different simulation run object.

Simulation Run	
Create new	<p>Console/Debug: Create a new simulation run object with the given name. The results from the simulation will be placed in the specified database file and referenced by the new simulation run.</p> <p>Multiple Runs: Create the specified number of simulation run objects. The objects will be given unique names by appending numbers to the specified name stem. Numbers are chosen so as not to collide with existing names in the project. Database files will be named after the corresponding run and placed in the specified</p>

Simulation Run	
	path.
Overwrite existing	<p>Console/Debug: Use an existing simulation run object; the database file referenced by the run will be overwritten.</p> <p>Multiple Runs: Create or overwrite the specified number of simulation run objects. If new simulation run objects are created, database files are named after the run and placed in the specified path. If simulation run objects with the requested names already exist they are used and their existing database files overwritten.</p>

Random Seeds

In all cases, it is possible to either set the [random seed](#) used to run the simulation, or leave it at the default value (which is taken from the [project settings](#)). Running a simulation twice with the same random seed will produce identical results. Running a simulation with a different random seed will introduce random variation in agent behaviour but should produce statistically similar overall behaviour; varying the random seed is one way to determine the sensitivity of the model to small changes.

In the case of a multi-run simulation, the specified random seed will be used for the first run, and will then be used to generate a new random seed for the second run and so on. This is done in a consistent way so if a second multi-run simulation is performed with the same initial seed, all subsequent seeds will be the same as in the first multi-run simulation.

Threading

By default, MassMotion will run a fully multi-threaded simulation using all available CPU cores. This will typically result in the shortest simulation time but other applications on the same computer may become sluggish. To avoid this, it is possible to disable threading entirely (so that MassMotion will only use one CPU core) or specify the number of threads that should be used. When setting the number of threads to be used, there are two main considerations to keep in mind:

- Specifying a number of threads greater than the number of CPU cores available can result in slower performance.
- Larger simulation populations are required to take full advantage of a larger number of threads. In some cases when dealing with a small population over a long period of time, it is better to specify a lower number of threads.

Stopping a Simulation

All simulation types provide a 'stop' button; closing a simulation window will also stop the simulation. Stopping a simulation causes all current results to be written to the results database. As a result, a simulation that is stopped early can still be used for playback and analysis, although care must be taken when interpreting results.

4.4.2 Console Simulation Window

The Console Simulation runs with minimal overhead, thereby maximizing use of available computing resources to minimize run time. A console simulation runs faster than a [debug simulation](#), however, details of the simulation cannot be accessed while the simulation is running. The results of the run become available for playback and analysis once the run is complete, or is stopped by the user midway.

Console Simulation Window Components	
Log Window	On the left side of the console simulation window is a live console that

Console Simulation Window Components	
	displays diagnostic information, warnings, and errors about the initialization and execution of the current project. The level of detail reported in the console can be specified by right-clicking on the console or by selecting an option from the drop-down menu above the console. The output can also be saved to a text file with the 'save' icon above the console.
Issues Window	On the right side of the console simulation window is an embedded version of the issues window that shows warnings and errors that were encountered while running the simulation. The buttons along the top of the issue window allow expanding or collapsing all items, saving the issues to a file or clearing all current issues.
Simulation Controls	At the bottom of the console simulation window is a progress bar showing the current progress of the simulation and buttons for pausing the simulation or stopping it entirely. The 'reload' button will reload any changes made to the current project, and then restart the simulation with those changes.

4.4.3 Debug Simulation Window

Running a debug simulation creates a new window that allows visual debugging of the simulation. The debug simulation window includes all the functionality of the console simulation window, including a console window for displaying information about simulation execution, an issues window for displaying warnings/errors, and controls for reloading, pausing/resuming and stopping the simulation; see [Console Simulation Window](#) for details.

In addition, the debug simulation window has a list view that works exactly the same way as the main window [list view](#) to allow selection of objects in the simulation, and its own scene view similar to the one in the main window but with additional functionality available only while simulating; see [Simulation Scene View](#) for details. A properties pane is also available on the right-hand side to [view details](#) about the state of the currently selected agent or scene object.

The debug simulation window toolbar contains buttons on the right-hand side for hiding and showing the list view, scene view, console/issue windows and object details pane.

4.4.3.1 Simulation Scene View

The Debug simulation window has 3D view controls similar to those of the main window as described in [3D Scene View](#). In addition, there are controls for pausing/stepping/resuming the simulation, and options for displaying debug information about individual agents and scene objects.

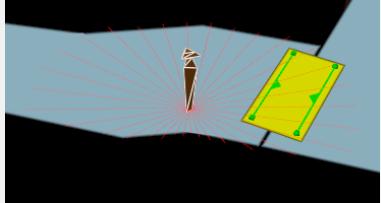
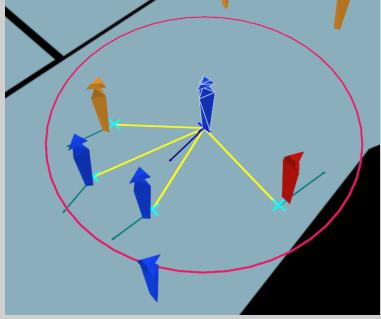
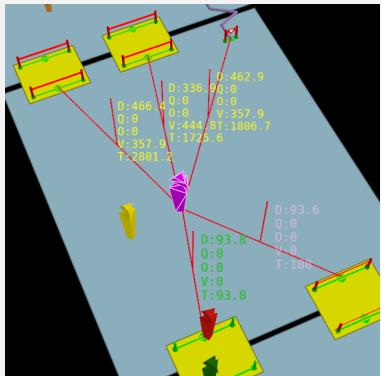
Simulation Control

Simulation execution can be paused and controlled using the keyboard.

Simulation Control	
Space Bar/ Up Arrow Key	Toggles the simulation paused state.
Left Arrow Key	Advances the simulation by one frame at a time. This feature is only available when the simulation is paused.

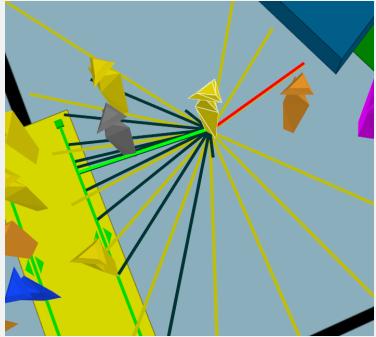
Agent Display Options

Right-clicking on one or more agents in a debug simulation window will bring up a context menu with various options under the 'Display' sub-menu that are not available during playback. These include:

Agent Display Options											
Avail able Spac e	 <p>Displays the available space around an agent. Each line indicates how far the agent can move in a certain direction.</p> <p>The lines turn red when the agent is approaching a connection object.</p>										
Neig hbourhood	 <p>Displays the local area vision bounds and indicates neighbouring agents within the selected agent's awareness. Note: The information displayed is for the previous simulation frame.</p> <table border="1"> <tr> <td>Yellow Line</td><td>Lines from central agent to surrounding neighbours.</td></tr> <tr> <td>Pink Ring</td><td>Displays geometric bounds of agent's awareness.</td></tr> <tr> <td>Turquoise Arrows</td><td>Velocity of neighbouring agent.</td></tr> <tr> <td>Dark Blue Arrows</td><td>Velocity of central agent.</td></tr> </table>	Yellow Line	Lines from central agent to surrounding neighbours.	Pink Ring	Displays geometric bounds of agent's awareness.	Turquoise Arrows	Velocity of neighbouring agent.	Dark Blue Arrows	Velocity of central agent.		
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Rout e Costi ng	 <p>Displays instantaneous costs (distance, queue, vertical, total) that the agent is subjected to. Red lines connect selected agents to other waypoints on the floor.</p> <table border="1"> <tr> <td>D Distance cost</td><td>Total distance cost</td></tr> <tr> <td>Q Queue cost</td><td>Total queue cost (proportional to size of queue)</td></tr> <tr> <td>O Opposing cost</td><td>Cost proportional to the magnitude of the flow in the opposing direction</td></tr> <tr> <td>V Vertical cost</td><td>Total vertical cost (proportional to vertical stair/ramp/escalator height)</td></tr> <tr> <td>T Total cost</td><td>Cumulative cost *</td></tr> </table>	D Distance cost	Total distance cost	Q Queue cost	Total queue cost (proportional to size of queue)	O Opposing cost	Cost proportional to the magnitude of the flow in the opposing direction	V Vertical cost	Total vertical cost (proportional to vertical stair/ramp/escalator height)	T Total cost	Cumulative cost *
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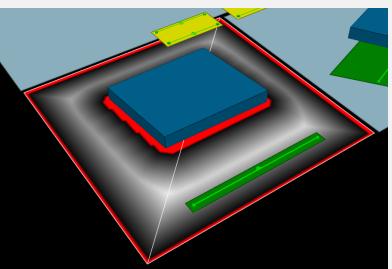
Agent Display Options

		<p>*Note: Total cost may not always equal the sum of individual costs, as only significant individual costs are shown.</p> <p>Agents can be presented with multiple choices (e.g. 3 doors), meaning more than one exit on a floor can have an associated route cost. Different colours of text indicate different messages.</p> <table border="1"> <tbody> <tr> <td>Green</td><td>This route has been chosen as the target.</td></tr> <tr> <td>Red</td><td>This route is not available.</td></tr> <tr> <td>Yellow</td><td>This object has already been crossed.</td></tr> <tr> <td>Blue</td><td>Backtracking costs may be applied.</td></tr> <tr> <td>White</td><td>This route has not been chosen to travel. Slightly different pale colours are used for each route to allow them to be distinguished from each other.</td></tr> <tr> <td>Grey</td><td></td></tr> <tr> <td>Cyan</td><td></td></tr> <tr> <td>Orange</td><td></td></tr> <tr> <td>Purple</td><td></td></tr> </tbody> </table>	Green	This route has been chosen as the target.	Red	This route is not available.	Yellow	This object has already been crossed.	Blue	Backtracking costs may be applied.	White	This route has not been chosen to travel. Slightly different pale colours are used for each route to allow them to be distinguished from each other.	Grey		Cyan		Orange		Purple										
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Agent Display Options											
Surface Probe											
	<p>Displays agent awareness of surrounding space as it relates to obstacle avoidance and the direction of goal.</p> <table border="1"> <tr> <td>Black</td><td>Displays directions of potential forward routes</td></tr> <tr> <td>Green</td><td>Displays direction of best forward route</td></tr> <tr> <td>Gold</td><td>Points to nearby obstacles/boundaries</td></tr> <tr> <td>Red</td><td>Points to closest obstacle/boundary</td></tr> </table>			Black	Displays directions of potential forward routes	Green	Displays direction of best forward route	Gold	Points to nearby obstacles/boundaries	Red	Points to closest obstacle/boundary
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Scene Object Display Options

The right-click context menu for scene objects during a debug simulation has the same display options as in authoring/playback, plus the following:

Scene Object Display Options	
Obstacle Map (surfaces)	 <p>Displays the obstacle surface map for the selected scene object. Areas that are unavailable to agents (obstacles, floor edges) are coloured red. Note: The map may require several seconds to calculate and display after pressing the button. Be cautious when using this attribute on very large objects.</p>

4.4.3.2 Object Properties

The properties tab is available in the Information Pane at the right-hand side of the Simulation window. It can be used to monitor property values for selected agents and scene objects in the simulation. Information is unique to the type of object currently selected.

Agents	
Properties Tab	

ID	The unique agent ID.
Age	How long this agent has been in the simulation.
Avatar	The avatar currently used by this agent. This is initially assigned by the schedule which created the agent, but may be modified mid-simulation by an action.
Profile	The name of the profile used by this agent.
Radius (m)	The current body radius of the agent.
Tokens	A list of tokens currently held by the agent - this can change over the course of the simulation.
Active Task	The current task being performed by the agent. In the case of the Seek task, the ultimate goal of the agent is also listed.
Active Dispatch	The name of the dispatch currently controlling the agent.
Next Waypoint	B -> C: The agent's next floor transition (moving from B to C where C is considered the local goal).
Current Floor	The floor, link, stair, escalator, or ramp that the agent believes it is standing on.
Last Waypoint	A -> B: The agent's previous floor transition (moving from A to B).
Speed Current (m/s)	The current speed of the agent.
Speed Current Max (m/s)	The current maximum speed the agent could achieve (affected by local limits imposed by the current floor, link, escalator, ramp, or stair, or by density related constraints).
Speed Default/Natural Walkway (m/s)	The natural walking speed of the agent if on flat ground and unconstrained by neighbours.
Activity	What kind of activity the agent is currently involved in. Possible values are: <ul style="list-style-type: none"> • In Input Buffer (wait): The agent is waiting for a gate to open. • In Input Buffer (queue): The agent is queueing to reach the next waypoint. • In Input Buffer (free): The agent is freely moving towards the next waypoint. • Being Processed: The agent has reached and is currently being processed by the next waypoint. • In Output Buffer: The agent has finished processing and is waiting for downstream capacity. • Waiting: The agent has been put in a wait state by an action. • Not Registered: Agent is in an error state and may be deleted.
Waiting?	True if the agent has chosen a gated link as its next waypoint, and is currently waiting for the gate to open.
Queuing?	True if the agent is queueing to reach the next waypoint.

Time in Queue (s)	If queuing, this is the time the agent has so far spent queuing for the next waypoint.
LOS Letter Value	The Fruin LOS letter grade given the stated density (always uses walkway mapping - never queue or stair mappings).
Density (ppl/m²)	The current density immediately around the agent.
Space (m²/ppl)	The personal space immediately around the agent (inverse of density).
Created By	The agent schedule or timetable that generated the agent.
Notes	Any notes from the agent creation. If generated by a timetable, this will include the corresponding timetable schedule file name and line number.
Start Floor	The floor or portal where the agent entered the simulation.
Start Time	The time at which the agent entered the simulation.
Tasks Tab	
ID	The unique agent ID.
Task Stack	The queue of tasks that are currently part of the agent's itinerary. Tasks are executed in order from top to bottom with new tasks added to the top of the list. The current task is indicated in bold.
Tokens Tab	
ID	The unique agent ID.
Token List	Enumeration of all the tokens that the agent is currently holding.
Actions Tab	
ID	The unique agent ID.
Action List	A list of the actions that have been applied to the selected agent. Each action is represented as an expandable group, with the title of the group containing the time at which the action was applied, the name of the action, and the manner in which the action was triggered (e.g. entering a zone, from an event). The expandable group contains a record of the operations carried out by the action, including TEST, DO, MODIFY, and TASK.
Floors	
ID	The unique object ID.

Name	The unique object name.
Type	The type of object.
Zones	Zones of which this floor is a member
Travel Type	Indicates if agents will traverse floor instantly (virtual), ignoring barriers, or normally.
Surface Resolution	Sampling frequency for goal and obstacle distances on this floor.
Population	Current number of agents on floor.
Route Information	See the description of Waypoint Route Information in the table below.

Portals	
ID	The unique object ID.
Name	The unique object name.
Type	The type of object.
Zones	Zones of which this portal is a member.
On Floor	The name of the floor under the portal.
Is Entrance?	True if the portal is configured as an entrance.
Is Exit?	True if the portal is configured as an exit.
Exit Information	See the description of Waypoint Route Information in the table below.

Links, Stairs, Escalators, Ramps	
ID	The unique object ID.
Name	The unique object name.
Type	The type of object.
Zones	Zones of which this connector is a member.
Travel Type	Indicates if agents will traverse floor instantly (virtual), ignoring barriers, or normally.
Surface Resolution	Sampling frequency for goal and obstacle distances on this object.
Population	Current number of agents on object.
Rise Angle (deg)	The angle of inclination for the stair, ramp, or escalator (not available for links).
Distance Penalty (m)	The distance penalty added to all distance based route costs for this

	object.
Queue Penalty Factor	The cost factor applied to all queuing at this object.
Perimeter	Indicates perimeter membership.
Bank	Indicates bank membership.
Is Gated?	True if the object is configured as a gate and can be opened or closed.
Wait Style	The agent behavior when waiting for a gate.
Route Information	See the description of Waypoint Route Information in the table below.

Waypoint Route Information	
Available Width (m)	The width of the goal line between the connected floors.
Flow Limit (ppl/min)	Cap (if any) on the allowed flow rate through the waypoint.
Flow Average (ppl/min)	The average flow rate through the waypoint over the previous 5 seconds.
Total Processed	The number of agents who have successfully been processed by this waypoint.
Approaching	The number of agents currently approaching (but not queuing or waiting for) the waypoint.
Queuing	The number of agents currently queuing for the waypoint (an agent is only considered queuing if it has the waypoint as its 'Next Waypoint' and has a speed below a certain threshold).

4.4.4 Running from the Command Line

A simulation can be executed using MassMotionConsole from a DOS command prompt. This is useful when running multiple projects in sequence, or when running the same project multiple times with different random seeds.

How to Run

- From a DOS command console, navigate to the MassMotion installation folder (by default C:\Program Files\Oasys\MassMotion 9.0).
- Run MassMotionConsole.exe with the desired parameters (see table below).
- Note all diagnostic information will be written to the simulation log text file which will be placed alongside the generated database file.

Arguments / Parameters

Parameters are prefixed with a hyphen "-". Some parameters require values separated from the parameter name by a space (e.g., -seed 5).

Option	Description	Example
--------	-------------	---------

-csvseparator #	If used in combination with -query, specifies the separating character used in exported csv files.	-csvseparator ;
-dump	Write diagnostic information to a 'debug' folder in the project's working folder (see Project Settings).	-dump
-fullscreen	If used in combination with -vis, the 3D viewer is drawn in full-screen mode.	-fullscreen
-help	Displays the list of available parameters and exits.	-help
-nothreads	Disable the use of threads during the simulation.	-nothreads
-popscale	A number greater than 0, used to scale the number of agents generated by all events.	-popscale 2.0
-project #	Specify the MassMotion project file (.mm file) to open and run.	-project C:\mm\testproject\testproject.mm
-query #	Execute the named query and export the table results to a csv. Any simulation run saved in the query is replaced by the database just generated. The file name is constructed from the database file name and query name. This option can be used once for each query object in the project.	-query AgentSummaryTable1 -query AgentSummaryTable2
-queryall	Execute -query on all query objects in the project.	-queryall
-results #	Specify the output database file for results. If the path is relative it is assumed to be relative to the folder containing the project file.	-results C:\mm\Testproject\firstrun.mmdb
-seed #	Override the seed value from the project settings with the given seed value. The same project run multiple times with the same seed value will always produce the same results. If no seed value is specified, the seed value from the project settings is used.	-seed 44321

-threads #	Use the specified number of threads in executing a simulation. By using multiple threads, multiple operations can be performed at the same time, greatly improving performance. The default number is equal to the number of system processors (e.g., 4 for a quad-core computer). A value of 1 will disable multithreading. Note that more threads does not necessarily mean faster execution given the overhead required to start, stop, and manage each thread. The default value is recommended.	-threads 1 (all operations are performed in the main thread) -threads 8 (8 threads are used)
-verbosity #	Control the number and verbosity of messages written to the project log.txt file. Possible values include ERROR (only log error messages), WARNING (log error and warning messages), APPLICATION (log errors, warnings, and standard messages), VERBOSE, DEBUG. The default is APPLICATION.	-verbosity DEBUG -verbosity APPLICATION
-vis	Display a 3D view of the scene. The view can be navigated and controlled using the same controls as the regular MassMotion 3D scene view , but there are no menus and it is not possible to run more than one project. Running with the 3D view shown will have a negative impact on performance.	-vis

4.4.5 Generated Simulation Files

The following files can be produced when execution a simulation:

Output Type	
DefaultRun.mmdb	An sqlite database file containing all of the information required to analyse and playback a single simulation run. For information on the database see Simulation Data . For information on using map, table, and graph queries to interrogate the database, see Analysis .

DefaultRun.txt	A text log file is created each time a simulation is run. The file contains diagnostic information on project initialization, execution, and general performance. All output displayed in the MassMotion console is also written to the log file. The file is created in the same folder as the database file and given the same name.
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A simulation can be configured to generate debug information about the project. The files are placed in a 'debug' folder created inside the project's working path.

Debug File	
Obstacle Map (*.jpg)	<p>File (.jpg) containing a visual map of the available space on the given surface and the distance from every point to the nearest obstacle or surface edge.</p> <p>White - Point farthest from obstacle or surface edge, or indicates the presence of a corner Black - Point closest to an obstacle or surface edge Red - Covered by obstacle or not on the surface</p> <p>Note: this file is only generated if the dumping of surface maps is enabled in the debug tab of the project settings.</p>
Approach Map (*.jpg)	<p>File (.jpg) containing a visual map of the distance from every point on a surface to the connected destination object.</p> <p>Green - Goal line White - Point farthest from the destination goal line Black - Point closest to the destination goal line Red - Covered by an obstacle or not on the surface Blue - Indicates an unreachable area not connected to the goal line</p> <p>Note: this file is only generated if the dumping of surface maps is enabled in the debug tab of the project settings.</p>
CostTree (*.csv)	<p>A file which describes the distance from every decision point in the scene to the specified goal.</p> <p>Note: this file is only generated if the dumping of route costs is enabled in the debug tab of the project settings.</p>

4.4.6 Randomness

Random Seed

MassMotion uses random numbers throughout the simulation. All random numbers are generated from an initial integer seed value (see [Project Settings](#)). A project simulated multiple times with the same random seed should produce exactly the same results. Changing the seed or any element in the project will result in different random numbers during the simulation and so different simulation results.

Distributions	
Agent Start	Duration based distribution used by journey and circulate events to determine when agents enter the simulation.
Single Value	Distributions used nearly everywhere, influencing how agents may interact with the scene.

4.4.6.1 Duration Distributions

A duration distribution is used to determine agent arrival times within an interval. There are fewer options than with a [standard distribution](#) as the min and max are taken automatically from the event start time and duration. The specified distribution automatically uses 0 as the min and the event duration as the max. Values generated by the distribution are added to the event start time to produce an agent's ultimate arrival time.

Possible distributions are as follows:

Distribution Types	
Uniform	Agents are assigned random start times according to a uniform distribution. With a large enough number of agents, this should converge on results similar to the constant distribution.
Normal	Agent start times will follow a normal distribution. Mean: The mean of the normal distribution relative to the start of the event. Std: The standard deviation.
Triangular	Agent start times will follow a triangular distribution. Mode: The mode of the triangular distribution is relative to the start of the event.
Log Normal	Agents will have start times as if they were assigned by a log normal single value distribution with "Shift" as the event start time and "Max" as the event duration in seconds. Mu: The mean of the log of the distribution. Sigma: The standard deviation of the log of the distribution.
Exponential	Agents will have start times as if they were assigned by an exponential single value distribution with "Shift" as the event start time and "Max" as the event duration in seconds. 1 / Lambda: The mean start time relative to the start of the event.

4.4.6.2 Standard Distributions

Many object numeric properties are described using a distribution. These properties resolve to single values based on the probability function of the distribution. For example, a [profile](#) defines agent speed according to a distribution, with each agent given a single speed value according to the distribution.

For information on duration based distributions used by some events in describing agent arrival times, see [Duration Distributions](#).

The following single value distribution types are supported:

Distribution Types	
Constant	<p>The distribution will always produce the same constant value.</p> <p>Value: A single number.</p> <p>Resultant Mean: value</p>
Uniform	<p>The distribution will produce a random number between the minimum and maximum value. All values within the range are equally likely.</p> <p>Min: The minimum possible value. Max: The maximum possible value.</p> <p>Resultant Mean: $(\text{max} - \text{min}) / 2.0$</p>
Normal	<p>A value is produced by iteratively generating numbers using a boundless normal distribution and rejecting any values that lie outside of the allowed range.</p> <p>Min: The minimum possible value. Max: The maximum possible value. Mean: The mean of the normal distribution. Std: The standard deviation.</p> <p>Resultant Mean: Mean</p>
Triangular	<p>The distribution will produce a random number between the minimum and maximum value according to a regular triangular distribution, with values being more likely around the mode.</p> <p>Min: The minimum possible value. Max: The maximum possible value. Mode: The mode of the triangular distribution.</p> <p>Resultant Mean: $(\text{Min} + \text{Max} + \text{Mode}) / 3.0$</p>
Log Normal	<p>A value is produced by iteratively generating numbers using the given boundless log normal distribution, shifting the resulting values by the minimum, and rejecting any values that are greater than the maximum.</p> <p>Shift: The minimum possible value. This value is added to the number produced by a regular log normal distribution. Max: The maximum possible value. Mu: The mean of the log of the distribution. Sigma: The standard deviation of the log of the distribution.</p> <p>Resultant Mean: $\text{Min} + e^{(\text{Mu} + (\text{Sigma}^2 / 2))}$</p>

Exponential	<p>A value is produced by iteratively generating numbers using the given boundless exponential distribution, shifting the resulting values by the minimum, and rejecting any values that are greater than the maximum.</p> <p>Shift: The minimum possible value. This value is added to the number produced by a regular exponential distribution.</p> <p>Max: The maximum possible value.</p> <p>1 / Lambda: The average (inverse of the lambda rate).</p> <p>Resultant Mean: $\text{Min} + (1.0 / \text{Lambda})$</p>
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4.5 Analysis & Reporting

Analysis is accomplished through the creation and evaluation of [graph](#), [map](#), and [table](#) objects. These objects rely on simulation results made available through one or more [simulation run](#) objects. This section expands on a number of concepts that are important to many of the analysis functions in MassMotion. This section also details how to [export agent position data, images, and videos](#). For a comprehensive description of all the available analysis functions please refer to the [Analysis Objects](#) section.

4.5.1 Agent Observer

The Agent Observer window is used to view properties about a particular agent from a recorded simulation run. The window can be shown by right-clicking on an agent and choosing 'Observe', or by selecting an agent and using the main window's View -> Observer Agent menu.

The focus button at the top of the window will focus the window on the currently selected agent. The agent ID and simulation run are displayed immediately below the focus button. The target button to the right of the simulation run can be used to find the agent in the scene. It is possible to change the simulation run or manually enter a new agent ID. Manually entering an ID is useful when trying to find agents mentioned by errors during the simulation.

Right-click on an object in the agent's route to find the object in the scene or jump to the time when the agent enters or leaves the object.

Agent Observer	
Created by	The event which created the agent.
Profile	The profile used by the agent.
Start time	The time at which the agent entered the simulation.
End time	The time at which the agent exited the simulation.
Age	The amount of time the agent has been in the simulation.
Avatar	The avatar used by the agent.
Density	The density currently experienced by the agent (ppl / m ²)
Speed	The current speed of the agent (m/s)
State	The state of the agent:

	Waiting: The agent is executing a wait task. In Transit: The agent is moving freely towards its target. Queuing: The agent is queuing for its target. Waiting for Access: The agent is waiting for access to its target (waiting for a gate to open). Pre-Contact Wait: The agent is queuing for a server. In-Contact: The agent is being processed by a server. Post-Contact Wait: The agent is being held by a server until there is capacity downstream in the process chain.
Target	The object to which the agent is moving.
Tokens	A list of tokens held by the agent over the course of its life. Tokens currently held by the agent are indicated with an arrow.
Route	An ordered list of objects on which the agent walked over the course of its life. The object that the agent is currently on is marked with an arrow.
Servers	An ordered list of the servers used by the agent over the course of its life. The server that the agent is currently on or moving towards is marked with an arrow.
Actions	<p>A list of all actions applied to the agent, identified by the source of the action. Actions that have already been applied are marked with a check. Actions that are being applied in the current frame are marked with an arrow.</p> <p>The first column is the object which applied the action. The second column further clarifies the source (see Where to Use Actions). Most values in the second column are self explanatory, with the exception of 'Zone Event'. When an agent receives an action from an action event as it fires, it is recorded as 'Action Event'. However, if the action event targets a zone, and the agent receives the action as it enters the zone while the event is active, the action is recorded as 'Zone Event' and references the zone instead of the action event.</p>

4.5.2 Event Observer

The Event Observer window is used to view the activity of a particular event from a recorded simulation run. The window can be shown by right-clicking on an event and choosing 'Observe'.

The refresh button at the top of the window will reload data about the event from the chosen simulation run. The chosen event and simulation run are displayed immediately below the refresh button.

Right-click on a time in the event details to focus the playback on that time.

Event Observer	
Type	The event which created the agent.
State	The profile used by the agent.

Time	A list of times represented by the event (used by Time events only).
Create Agents	The intervals over which the event was creating agents. Note that this does not mean that agents were actually being created, but that the event was in agent creation mode.
Open Gate	The intervals over which the event was opening one or more gates.
Close Gate	The intervals over which the event was closing one or more gates.
Open Server	The intervals over which the event was opening one or more servers.
Close Server	The intervals over which the event was closing one or more servers.
Action	The intervals over which the event was applying an action (other than any agent initialization actions). This is currently only used by the Broadcast and Timetable events.

4.5.3 Areas

Various types of analysis objects such as [agent filters](#), [transitions](#), [trips](#) and [population count graphs](#) use the concept of 'areas'. For the purposes of analysis, several types of objects can be used as areas:

Area Type	Agents Considered 'In'
Walkable object	Agents currently on the walkable object (floor, link, escalator, ramp or stair).
Volume	Agents with the point at the centre of their feet contained within the volume.
Zone	Agents on any of the walkable objects that are part of the zone.
Collection	Collections which contain area objects can be used as areas themselves; they will be displayed using the '.Areas' suffix. Agents are 'in' the collection area if they are in any of the member's areas. Any members which are not areas will be ignored.

Areas can also be used in the Area Population [trigger](#).

4.5.4 Transition

The concept of a transition is used within MassMotion to mean a point in time when an agent moves from one location or state to another. Transitions can be used to define a [flow count graph](#) or an 'At transition' [agent filter](#). Transitions can also be used in the Transition Count [trigger](#).

Transitions are defined by selecting a transition type in a drop-down menu. Depending on the type of transition selected, other entry fields will be made available to define the transition.

Collections in transitions

[Collections](#) can be used to define complex transitions.

Transition Types	
At portal	<p>Transition occurs when an agent enters at a portal, exits at a portal, or reaches a portal that they have been given as a target (such as by a 'Seek Portal' task).</p> <p>With a collection: Agents at any portal within the collection are at the transition.</p>
Between objects	<p>Transition occurs when an agent steps from one given object to a second given object.</p> <p>With a collection as the from object: Agents stepping off any walkable in the collection to the to object are at the transition.</p> <p>With a collection as the to object: Agents stepping off the from object to any walkable in the collection are at the transition.</p> <p>With collections as both from and to objects: Agents stepping off any object in the from collection onto any walkable in the to collection are at the transition. The same collection can be used for both from and to to track internal transitions.</p>
Crossing cordon	<p>Transition occurs when an agent passes through a given cordon.</p> <p>With a collection: Agents crossing any cordon in the collection are at the transition.</p>
Entering area	<p>Transition occurs when an agent enters a given area, or enters the simulation in the given area.</p> <p>With a collection: Agents entering the areas in the collection are at the transition. Internal transitions between areas in the collection are not counted.</p>
Entering simulation at	<p>Transition occurs as soon as agent enters simulation from a given portal.</p> <p>With a collection: Agents entering the simulation at any of the portals in the collection are at the transition.</p>
Exiting area	<p>Transition occurs when an agent exits a given area (possibly by exiting the simulation).</p> <p>With a collection: Agents exiting the areas in the collection are at the transition. Internal transitions between areas in the collection are not counted.</p>
Exiting simulation at	<p>Transition occurs when an agent exits the simulation at the same time as reaching a portal. This usually occurs when simply exiting at a destination, but may also happen when removed by an action as an agent reaches a portal they have been given as a target.</p> <p>With a collection: Agents exiting the simulation at any of the portals in the collection are at the transition.</p>

Transition Types	
Server begin	Transition occurs when an agent enters the pre-contact stage of a given server . With a collection: Agents entering the pre-contact stage of any server in the collection are at the transition.
Server end	Transition occurs when an agent leaves a given server. With a collection: Agents leaving any server in the collection are at the transition.

4.5.5 LOS Colour Mapping

Colour mapping describes how density values are converted into colours in [maps](#) and [graphs](#). Density colour mapping can also be used to colour agents during playback through the [simulation run](#). Values are taken from standard Fruin and IATA (International Air Transport Association) LOS mappings. When used in maps, black is used to indicate 'no data' (no agent walked in that area).

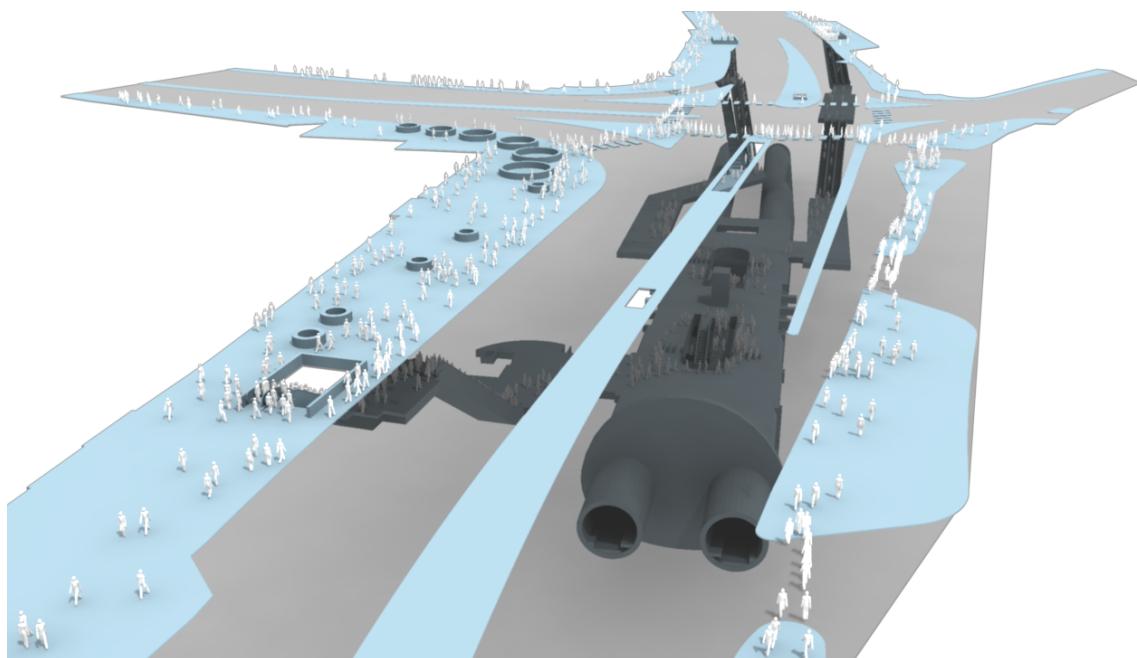
LOS Colour Mapping Values				
Fruin Walkways	Area of circle used to calculate density: 3.24m ² .			
	LOS	Density (person/m ²)	Space (m ² /person)	Colour
	A	x <= 0.309	x >= 3.24	
	B	0.309 < x <= 0.431	3.24 > x >= 2.32	
	C	0.431 < x <= 0.719	2.32 > x >= 1.39	
	D	0.719 < x <= 1.075	1.39 > x >= 0.93	
	E	1.075 < x <= 2.174	0.93 > x >= 0.46	
	F	2.174 < x	0.46 > x	
Fruin Stairways	Area of circle used to calculate density: 1.81m ² .			
	LOS	Density (person/m ²)	Space (m ² /person)	Colour
	A	x <= 0.541	x >= 1.85	
	B	0.541 < x <= 0.719	1.85 > x >= 1.39	
	C	0.719 < x <= 1.076	1.39 > x >= 0.93	
	D	1.076 < x <= 1.539	0.93 > x >= 0.65	
	E	1.539 < x <= 2.702	0.65 > x >= 0.37	
	F	2.702 < x	0.37 > x	
Fruin Platforms (Queuing)	Area of circle used to calculate density: 1.21m ² .			
	LOS	Density (person/m ²)	Space (m ² /person)	Colour
	A	x <= 0.826	x >= 1.21	
	B	0.826 < x <= 1.075	1.21 > x >= 0.93	

	C	$1.075 < x \leq 1.538$	$0.93 > x \geq 0.65$	Green
	D	$1.538 < x \leq 3.571$	$0.65 > x \geq 0.28$	Yellow
	E	$3.571 < x \leq 5.263$	$0.28 > x \geq 0.19$	Orange
	F	$5.263 < x$	$0.19 > x$	Red
IATA Wait/Circulate				
LOS	Density (person/m ²)	Space (m ² /person)	Colour	
A	$x \leq 0.370$	$x \geq 2.70$	Blue	
B	$0.826 < x \leq 0.435$	$2.70 > x \geq 2.30$	Cyan	
C	$0.435 < x \leq 0.526$	$2.30 > x \geq 1.90$	Green	
D	$0.526 < x \leq 0.667$	$1.90 > x \geq 1.50$	Yellow	
E	$0.667 < x \leq 1.00$	$1.50 > x \geq 1.00$	Orange	
F	$1.00 < x$	$1.00 > x$	Red	

4.5.6 Alembic Export

Alembic is an open computer graphics interchange framework. Alembic distils complex, animated scenes into a non-procedural, application-independent set of baked geometric results. For more information please visit www.alembic.io.

MassMotion provides the ability to export Alembic files (*.abc) containing animated agent meshes that can be imported into visualization software such 3DS Max or Maya for inclusion in rendered scenes. The Alembic export option can be found on the Simulation & Analysis tab of the main window. Note that the exported data does not currently include the scene geometry (floors, walls etc.); if desired, scene geometry can be exported separately from the [main menu](#).



Alembic Export Options	
Output file	What Alembic (.abc) file to export to.
Simulation run	Which simulation run to use as the source for agent data.
Time range	The time range over which to export agent data.
Agent filter	Which agents to include in the output.

4.5.7 Agent Position Export

The agent position and other physical attribute data generated by a MassMotion simulation can be exported to a CSV file using the "Agent Position Table Export" dialog. This dialog can be accessed through a button in the project tab of the main window's ribbon.

The exported table will include the frame number, agent ID and XYZ position of each agent. Additional data can be included by checking the "Optional columns" options.

Columns are in the following order:

Frame Number, Agent ID, X Position, Y Position, Z Position, Clock Time (optional), Speed (optional)

Options

Option Name	Description
File	The CSV file to which the table will be written.
Simulation run	The simulation run for which data will be written to the table
Time range	The time period over which agent positions will be included.
Sampling period	Modifies the number of samples included in the table. By default, every frame will be sampled, producing data for every agent for every frame. However, the number of samples can be reduced to once per second or more.
Agent Filter	Used to select which agents will be included in the table.
Optional columns	Additional information can be included in the agent position table, toggled by the following options: Clock time: The simulation clock time corresponding to the frame number. Speed: The agent's speed in m/s. Heading: The agent's heading in degrees. An agent facing the same direction as the Z axis will have a heading of 0, and the angle increases as the agent turns counterclockwise. Move State: The agent's move-state as a number. The meaning of move state values is listed below. Animation time: The time an agent has spent in a given move state, useful for controlling the speed of animations. When walking on flat ground, the value is the number of strides taken by the agent.

Move State

Integer Value	Description
0	Walking on a flat surface
1	Shuffling (occurs in crowded places)
2	Standing still
3	Walking Up
4	Walking Down

4.5.8 Movie and Image Export

Movies and images of the scene can be produced from within MassMotion using the movie/image export window. The export window can be accessed from the project tab of the main window's ribbon.

Default settings for movie/image export can be set in the application preferences available through the main window [menu bar](#).

Project and scene changes

When the export window is first opened, the scene's appearance is copied from the scene in the main window. This includes agent appearance, background colour and camera position. These can be further changed within the export window without affecting the main window.

The export window operates on a copy of the current project and so any modifications within the main window will not affect the export window. However, simulation databases are locked and existing [simulation runs](#) cannot be re-run while the export window is open.

Both the appearance of the scene and the project in general can be reloaded from the main window by pressing the "Reload" button.

Toolbar	
Reload	Reload changes to the project and scene's appearance from the main window.
Render	Start rendering a movie or frames. This process may take some time.
Pause	Pause current render.
Abort	Stop current render and possibly discard any progress.
Single Image	Take a single image. The user will be prompted for a file name. The following file formats are supported: *.png, *.jpg, *.tiff

File Options	
Save Movie	A movie file will be produced with the desired quality setting. Increased quality will increase file size. The following file formats are supported: *.mov, *.mp4,

	*.m4v, *.wmv
Save Individual Frames	Individual frames will be produced and placed in the specified directory. All images will have the *.png format.
Save Movie and Frames	Both a movie file and individual frames will be produced.

Timing	
Time Range	The period of time to export.
Frame Rate	The frame rate of the movie to be exported. A higher frame rate will increase the movie file size and the number of frames produced.
Play Speed	How fast the movie will appear to play.
Time Lapse	Create an image (or movie frame) once per specified interval.

Appearance	
Resolution	The resolution of movies, frames and images produced. Can dramatically affect the size of file outputs. Changing the resolution will darken regions at the edges of the scene. These regions are cropped in the outputs to fit the desired resolution.
Background	The background colour to use.

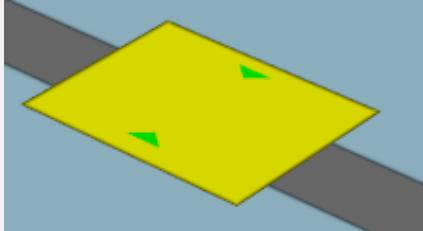
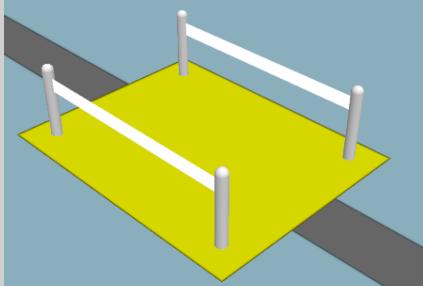
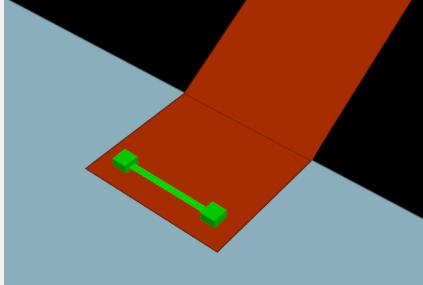
Overlay	
Text	The colour to use to display overlay text (if any).
Population count	Whether to include text which shows the current population.
Simulation time	Whether to include overlay text that shows the current simulation time.
Map legend	Whether to include a legend for the displayed map (if any).
Reference axes	Whether to include the reference axes in the top right corner.

4.5.9 Decorations

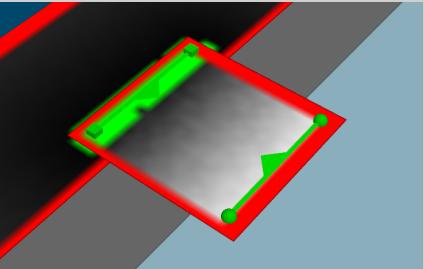
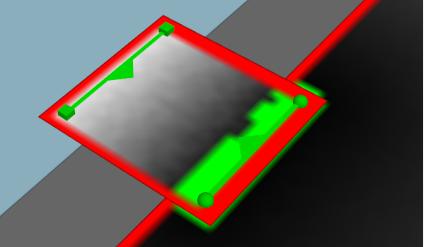
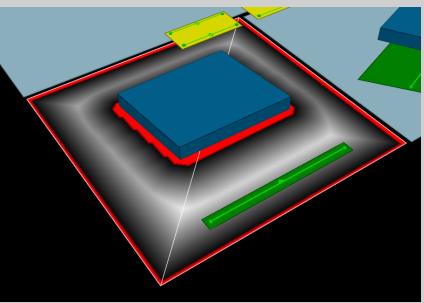
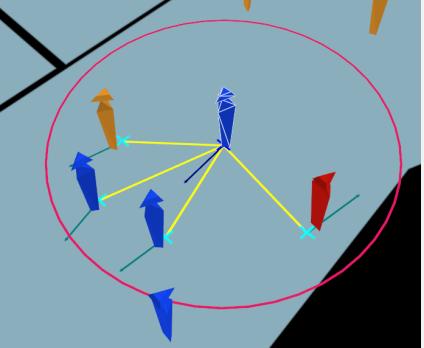
Decorations show properties of objects in the scene.

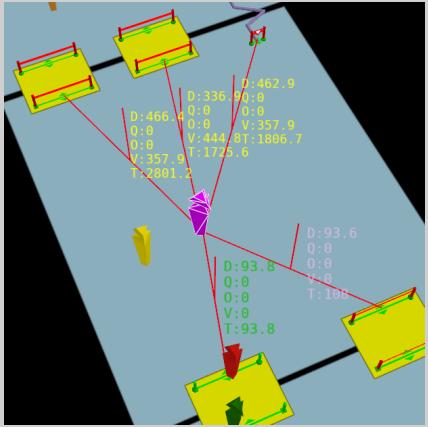
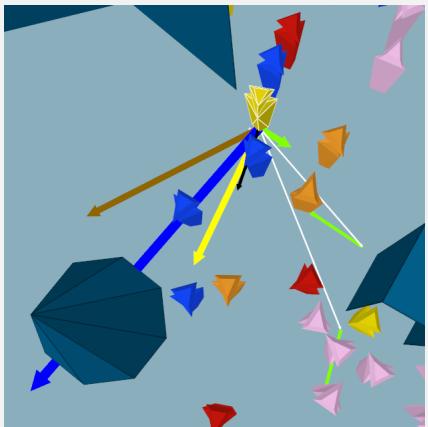
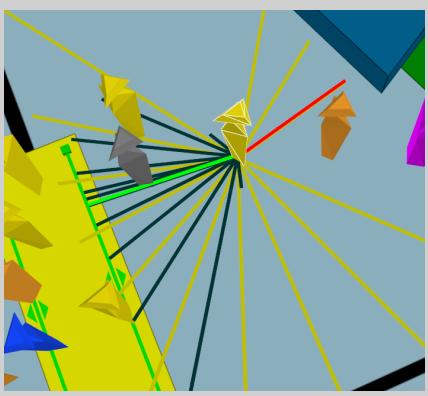
- General decorations appear on various scene objects.
- Map decorations can be applied to surface objects upon which agents can walk. Map decorations are not updated live and do not respond to geometry changes. Hide and show again to refresh them.
- Debug simulation decorations appear on agents during a debug simulation.

They can be toggled individually by right clicking the relevant object/agent and accessing the 'Display' sub-menu. General and debug simulation decorations can be toggled globally in a [Scene View](#)'s visibility options.

General Decorations	
Direction Arrows	 <p>Displays whether a connection object is unidirectional or bidirectional, allowing agents to cross in each direction.</p> <p>The triangle will be shown on the goal line(s) where agents can cross onto the object. The image on the left, therefore, shows a bidirectional link.</p> <p>See Links and Connection Objects for more information.</p>
Gate	 <p>Displays whether a connection object is gated. During authoring and playback the symbol is white. In simulation, the gate is coloured red when closed, yellow when open for some agents and green when open for all agents.</p> <p>See Links and Connection Objects for more information.</p>
Goal Line	 <p>Displays the goal lines of portals and connection objects. Goal lines are coloured green when connected to an underlying floor and grey otherwise. Connection objects have two goal lines, one with box terminals and one with balls. See Connecting Objects Together for more information.</p>

Portal Start Angle		Displays the start angle for portals . Agents created at this portal will be created facing this direction.
Priority Flow		Displays which side will yield when agents approach a connection object from both sides.
Server Entry Arrow		Displays the entry point and direction of a server as a green triangle. A ring will appear if the server is also the start of a process chain .
Server End Point		Displays the end point of a server as a blue box. A ring will appear if the server is also the end of a process chain .
Map Decorations		
Approach Map		Displays the approach map to a portal goal line on its floor. See Determining Walkable Space for more information.

Ball Approach Map		Displays the approach map to the ball goal line of a connection object on the floor and the object itself. See Determining Walkable Space for more information.
Box Approach Map		Displays the approach map to the box goal line of a connection object on the floor and the object itself. See Determining Walkable Space for more information.
Obstacle Map		Displays the obstacle map for surfaces. See Determining Walkable Space for more information.
Debug Simulation Decorations		
Neighbourhood		Displays an agent's neighbourhood in debug simulation. See Simulation Scene View for more information.

Route Costing		Displays how agents perceive the network in debug simulation. See the Simulation Scene View for more information.
Social Forces		Displays the forces which affect an agent's movement in debug simulation. See the Simulation Scene View for more information.
Surface Probe		Displays an agent's awareness of its immediate surrounding in debug simulation. See the Simulation Scene View for more information.

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Endnotes 2... (after index)

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