

LS-DYNA Software

Version 971 (R4.2.1)

Release Notes



ARUP

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1. INTRODUCTION

LS-DYNA 971 release 4.2.1 is an enhanced and bug-fixed release built on LS-DYNA 971 release 3.

This release is not being issued to clients on CD. The software can be downloaded from the Oasys Ltd website at: www.oasys-software.com/dyna.

The version, revision (build) number and date of the LS-DYNA code are as follows:

Version ls971 R4.2.1
Revision 53450

The revision number, precision and version type can be checked in the test box printed at the top of the .OTF and MESSAG files as per the example below.

```
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LS-DYNA, A Program for Nonlinear Dynamic
Analysis of Structures in Three Dimensions
Version : ls971d R4.2.1 Date: 06/08/2009
Revision: 53450 Time: 07:09:25

Features enabled in this version:
  Shared Memory Parallel
  ANSYS Database format
  32 Bit IEEE Binary File

Licensed to: ATG OVE ARUP
Issued by : arup

Platform : PC WIN32
OS Level : Windows XP Pro SP3 B2600
Compiler : Intel Fortran Compiler 10.1
Hostname : MCCPC6CQHB4J
Precision : Double precision (I8R8)
Product ID : 53929

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2. ENHANCEMENTS AND MODIFICATIONS MADE TO VERSION 971 RELEASE 4.2.1

Please note; some definitions have been included in multiple sections for convenience.

2.1 AIRBAGS

- Fix to *AIRBAG_HYBRID leakage in case where some parts have negative CP23 and don't belong to airbag being considered.
- Disable CPM particle (*AIRBAG_PARTICLE) data output to D3THDT.
- Change of CPM particle to fabric PV work calculation by nodal velocity instead of fabric segment average velocity.
- Fix for CPM with MPP pre-decomposition.
- Make molar-fraction based inflator gas inflow available for *AIRBAG_HYBRID_JETTING.
- Implement molar-fraction based airbag inflator input for *AIRBAG_HYBRID.
- Bug fix for treating non-closed airbag volume (MPP only).
- Bug fix for read in *AIRBAG_PARTICLE cards and give warning message if nonlinear cp is not a monotonic function within gas temperature of operation (MPP only).
- Add particle friction for CPM.
- Fixed the volume calculation for control volume airbags that have holes in the mesh (MPP only).

2.2 ALE

- Added coupling of ALE ambient type 5 elements with *LOAD_BLAST_ENHANCED wherein pressure and velocity BC applied to ambient ALE elements are provided by *LOAD_BLAST_ENHANCED.
- Added *ALE_AMBIENT_HYDROSTATIC and *INITIAL_HYDROSTATIC_ALE for initializing and prescribing hydrostatic pressure in ALE liquids due to gravity.
- Implemented new ALE 2D capabilities and mapping to ALE 3D (*CONTROL_ALE2D)
- A bug fix for ALE ambient type 5 (*LOAD_BLAST).
- *LOAD_BLAST + ALE coupling with area weighted nodal velocity.
- Use area weighted nodal velocity for *LOAD_BLAST + ALE coupling to avoid edge effect.

2.3 CONSTRAINED OPTIONS

- Fix for *CONSTRAINED_INTERPOLATION so that division by zero is avoided when no rotational DOFs are present.
- Fix for MPP restart with *CONSTRAINED_TIED_NODES_FAILURE.
- Fix errors in implicit RBE3 constraints.
- Fixed affecting staged construction models containing nodal rigid bodies and shell elements.

2.4 CONTACT OPTIONS

- Added segment based (SOFT=2) contact options:
 - DEPTH=13. Behaviour is similar to DEPTH=3, but it has been tuned to improve energy conservation
 - DEPTH=23. Behaviour is similar to DEPTH=3, but contact detection uses a new algorithm intended to improve robustness.
 - Automatically split quad shell segments into 2 triangular segments.
 - Report penetrations of shell mid-planes.
 - Use a moving average of the current time step in the penalty stiffness calculation rather than the initial time step.
- Added new option to automatic tiebreak contact opt 9/11 (Dycoss): Parameters NFLS and/or SLFS can now be negative. The absolute value then defines a load curve for peak traction(s) vs. segment size. This should be helpful in case of coarse meshes.
- Added a new option c=-cputim.
The absolute value of cputim will be used to terminate the restart job based on the cpu time of the current run and not the cumulative cpu time. This negative cputim can be input as a command line option or in the first field of *CONTROL_CPU.
- *CONTROL_CONTACT
6th card, 3rd field
ithcnt < 0: conduction evenly distributed (pre-R4)
 - = 0: default set to 1
 - = 1: conduction weighted by shape functions, reduced integration
 - = 2: conduction weighted by shape functions, full integration
- Added friction and energy calculations to *CONTACT_GUIDED_CABLE. Friction is an option in the manual, but was not implemented in the coding.
- *CONTACT_2D_SLIDING_ONLY does not apply to 2D shell elements. An error message is printed at termination.
- Fixed a problem in 2D tied contact that cause a lack of force balance when more than one tied contact appears in a model.
- MPP fix for soft=4 contact along with adaptive constraints.
- Bugfix in beam-to-beam contact.

- Fix for soft=4 contact and adaptive constraints so soft=4 can be used in forming calculations.
- Fixed a memory error when two surface force transducers are used with MPP segment based contact. The bug could cause a segmentation fault in single precision versions.
- Corrected the airbag thickness by load curve option for segment based contact. It was offsetting the contact surface by the total thickness instead of half the thickness.
- Added support for interference contact with segment based contact.
- Fixed thermal work due to friction in segment based contact.
- MPP contact damping was only being applied when nodes are approaching the surface, instead of both ways (as SMP does). This should make the behaviours more consistent, and be more stable.
- Protect against divide by zero in new segment based contact penetration check and in new DEPTH=23 option.
- Fixed 2 surface force transducer contact when used with segment based contact. It was possible for segmentation violation to occur.
- Fixed 2D thermal contact. It was likely to segmentation fault.
- Skip reporting contact time step for segment based contacts.
- Bug fix for shell edge contact (MPP only).
- Fix problem in reading beam node list from wrong contact definition for single surface contact (MPP only).
- Improvements in MPP groupable contact:
 - Changes to improve stability.
 - Fixed problem whereby not all nodes were being considered in the energy calculation for groupable single surface contacts, and the sliding energy in GLSTAT was wrong.
- SMP tiebreak surface to surface was affected by node order.
- Possible floating point exception in groupable contacts, including AUTO_TIEBREAK.
- Fixes to MPP groupable contact and adaptivity.
- MPP fixes for groupable AUTOMATIC_TIEBREAK contacts.
- Fix for MPP groupable contact interface energy calculation.
- Fixed airbag thickness by load curve option for segment based contact (MPP only).
- Fix some MPP initialization problems related to interface linking and tied node pairs.

2.5 CONTROL OPTIONS

- Added D3HSP output of DTSTIF from Contact Optional Card C for SOFT=1.

- ***CONTROL_THERMAL_SOLVER**
2nd optional card, 8th field
TSF = thermal speedup factor (default 1.)
This parameter will scale all thermal velocity terms (e.g., heat transfer coefficient) for use with mechanical time scaling (e.g., artificially increasing the punch velocity).
- ***CONTROL_CONTACT**
6th card, 3rd field
ithcnt < 0: conduction evenly distributed (pre-R4)
= 0: default set to 1
= 1: conduction weighted by shape functions, reduced integration
= 2: conduction weighted by shape functions, full integration
- ***CONTROL_THERMAL_SOLVER**
SOLVER = -1: symmetric direct solver (ACTCOL)
SOLVER = 1: reset to use solver 11
- **Change the behavior of the command line option ncpu=#.**
Case 1: ncpu=-n negative number of CPU's
The code will always turn on the consistent option (CONST=1).
It will override the consistency flag on *CONTROL_PARALLEL
if it exists.
Case 2: ncpu= n positive
If there is no *CONTROL_PARALLEL, CONST=2 as default.
If there is *CONTROL_PARALLEL, it uses the value of CONST on
this card.
- **Disable NCPU option on *CONTROL_PARALLEL or control card 16.**
Print a warning if the user defines this option.
*** Warning in keyword *CONTROL_PARALLEL
NCPU option will be obsolete and ignored in the next release
Please use ncpu=# on the command line # or *KEYWORD card.
*** Warning in 16th control card:
NCPU option will be obsolete and ignored in the next release
Please use ncpu=# on the command line.
- **Added new option "NOSOL" for *CONTROL_TERMINATION (Column 6):**
 - Flag for a "non-solution" run, i.e. normal termination directly after initialization (transformation, mapping, trimming, mesh check, ...).
- **Added new option for *CONTROL_ADAPTIVE.**
ADPSIZE .LT.0 - absolute value defines the minimum characteristic element length to be adapted based on square root of element area. i.e. instead of comparing the shortest element edge with ADPSIZE, it compare the square root of element area with abs(ADPSIZE) if ADPSIZE is given by a negative value.
- **Added damping to stabilize the penalty formulation of sliding only contact.**
- **Bug fix for element sorting. Combination of *CONTROL_SOLID: ESORT=1 and *CONTROL_SHELL: ESORT=2 was not correctly working.**
- **Fixed PSTIFF=1 option on *CONTROL_CONTACT for SMP when mass scaling is used.**

- Added one control parameter in EFG fracture.

2.6 DATABASE & OUTPUT

- Added binary database for visualizing blast pressures applied to structures. (*DATABASE_BINARY_BLSTFOR)
- Added new options for *DEFINE_CURVE_FUNCTION:
 - ELHIST: monitors elemental quantities such as stress and strain
 - RCFORC: monitors contact interface forces
 - Possible to prescribe the acceleration of a rigid body as function of model response.
- Added command *INTERFACE_COMPONENT_FILE to specify name and format (LSDA is now the default format) of interface database that is written. "z=" on execution line will override this command. Similarly, added command *INTERFACE_LINKING_FILE to specify name of interface database that is read. "l=" on execution line will override the command.
- Added damping energy calculation for *DAMPING_FREQUENCY_RANGE
- Added IOOPT option for *DATABASE_BINARY_INTFOR (Card 3).
- Added new keyword *DATABASE_EXTENT_D3PART to control the output of d3part.
- *DATABASE_EXTENT_BINARY
 - 4th optional card, 1st field
 - dttd=0, no action
 - dttd=1, dump nodal temperature rate dT/dt to D3PLOT
- Fix for rigidwall energy calculation when two rigid bodies impact.
- Added rigid surface contact output to rcforc file.
- Fixed for output of 10-node tet nodes to D3PLOT (only SMP).
- Fixed sign error in BNDOUT forces for implicit.
- Fixed bug related to *DATABASE_HISTORY_DISCRETE_SET and *SET_DISCRETE.
- Fixed problem with GLSTAT reports incorrect controlling element.
- Write solid formulations -1 and -2 to D3HSP.
- Disable CPM particle (*AIRBAG_PARTICLE) data output to D3THDT.
- Added output of SWFORC file (and BINOUT) for the nugget pull-out failure function and fracture failure function of option 9 beam spot weld failure.
- Minor fix to D3PROP output.
- Disable NCPU option on *CONTROL_PARALLEL or control card 16.
Print a warning if the user defines this option.

*** Warning in keyword *CONTROL_PARALLEL
NCPU option will be obsolete and ignored in the next release
Please use ncpu=# on the command line # or *KEYWORD card.

*** Warning in 16th control card:
NCPU option will be obsolete and ignored in the next release
Please use ncpu=# on the command line.

- Fix implicit's output to RCFORC file.
- Fix for crazy accelerations in NODOUT file if the interface force file is active.
- Write density rather than temperature to BLSTFOR.
- Fix for D3HSP output of *PARAMETER names.
- MPP fix for KE inconsistencies in GLSTAT due to summation of rotational energy on shared nodes.
- Improvements in MPP groupable contact:
 - Changes to improve stability.
 - Fixed problem whereby not all nodes were being considered in the energy calculation for groupable single surface contacts, and the sliding energy in GLSTAT was wrong.
- Fix bug which causes discrete element forces not to be added to the D3PLOT file.
- Fix for MPP full deck restart and slippings, and force output plot state at beginning of second run for full deck restart.
- Save/restore plot times for ASCII files in full deck restart file. This fixes a problem where the ACSII files were output EVERY CYCLE for a while on restart.

2.7 DEFINE OPTIONS

- Make *MAT_156 parameter ALM compatible with *DEFINE_CURVE_FUNCTION.
- Allow *MAT_SPRING_MUSCLE parameter "A" (activation level) to reference *DEFINE_CURVE_FUNCTION.
- Allow number of points in *DEFINE_CURVE greater than 99999.
- Added error termination if SIDR in *DEFINE_CURVE has an illegal value.
- Fix a restart problem with *DATABASE_BINARY_BLSTFOR.
- Added *DEFINE_CURVE_DUPLICATE.
- Fix related to contact generation. The error was caused by confusion between *DEFINE_BOX and *DEFINE_CONTACT_VOLUME.
- *DEFINE_BOX_DRAWBEAD with CID>0 was broken in some cases.

- New option "POS6P" for *DEFINE_TRANSFORMATION. This is an affine transformation (rotation and translation, no scaling, no shear) given by 3 start points and 3 target points.

2.8 EFG

- Improvements to EFG (Element Free Galerkin):
 - Added adaptivity for solid EFG and shell EFG in MPP.
 - Implemented an explicit version of stabilized EFG method for 8-noded and 6-noded integration cells.
 - Implemented a formulation switch from stabilized method to conventional EFG method controlled by time and other parameters.
 - Implemented an EFG fracture formulation for 4-noded integration cell.
 - Added MPP for adaptive EFG method for solid formulation and shell formulation.
 - Included MPP thermal solver in the adaptive EFG formulation for solids.
- Fix for restart in 3D EFG adaptivity with formulation 7.
- Bug fixed in EFG local adaptivity.
- Added MPP support for EFG solid restart (solid part).
- Bug fixed in restart for adaptive EFG.
- MPP support for EFG shell 41 restart (shell part).
- Add options in data transfer for adaptive EFG method.
- Fix for time step control in EFG 3D adaptivity from hex to tet.
- Added pressure smoothing in adaptive EFG in 4/8noded switch.
- An improved adaptive EFG in local boundary integration.
- Bug fixed in irreversible unloading for EFG fracture.
- Bug fixed in crack closure (EFG).
- Bug fixed for fracture in elastic material (EFG).
- Bug fixed in EOS for EFG 2D and 3D (hex).
- Added one control parameter in EFG fracture.

2.9 ELEMENTS

- Added capability for a "skew angle" option in slirings for better friction modelling. It requires the input of an orientation node, and a second friction coefficient (or a user defined friction function), and computes friction based on the wrap angle (as seen when looking "down the slirping axis", ie the cylinder the belt passes over) and the skew angle (how much the belt twists as it passes over the slirping).
- Added thick shell formulation 5 (ELFORM=5 on *SECTION_TSHELL). It has 1 integration point per layer and calls 3D stress update routines. It uses an assumed strain field for accurate bending stiffness and improved behaviour with layered anisotropic materials.

- New fully integrated solid elements to reduce transverse shear stiffness for elements with poor aspect ratio (element types -1 and -2).
- Fixed for output of 10-node tet nodes to D3PLOT (SMP).
- Fixed related to improper solid element deletion with auto sorting on.
- Correct a bug calculating shell stress in a stress-activated *SENSOR.
- Fixed 2D beam element failure for material types *MAT_3, *MAT_15, *MAT_54, *MAT_58, *MAT_158, *MAT_65, *MAT_165 and *MAT_106.
- Fix for bug related to beam to hex weld conversion when only a subset of beams are changed.
- Fix energy bug in *MAT_187 for shells.
- *CONTACT_2D_SLIDING_ONLY does not apply to 2d shell elements. An error message is printed at termination.
- Fixed bug affecting staged construction models containing nodal rigid bodies and shell elements.
- Correct some minor 2D (4-node) seatbelt element issues.
- Made 2D seatbelt improvements, triggered by setting COMP, the 6th column of *MAT_SEATBELT, to 2. Improvements include synchronization between 1D and 2D belt, automatic adjusting compression elimination, and seatbelt section force output.
- Added seatbelt slipping friction decay constant.
- Combination of *INCLUDE_TRANSFORM offset and *ELEMENT_SEATBELT_ACCELEROMETER parameters IGRAV and INTOPT.
- Fixed bug related to large oscillations and instability in single precision on some machines when zero length springs are present.
- Fix a potential problem with pressure loading being applied to shell element segments after they have failed. This could only have happened if there was more than one pressure load applied to a segment or if the element was a 2D continuum element with more than 1 edge loaded.
- Fixes to MPP groupable contact and adaptivity.
- Error terminate when scalar nodes are not defined in warped beams.
- Fix typo that caused MPP full deck restart to not properly re-initialize thick shell elements when using more than 1 processor.
- Fix for hexahedron remeshing.

2.10 EOS

- Make user material and EOS work together in shells for 2D plane strain and axisym.
- Bug fixed in EOS for EFG 2D and 3D (hex).

2.11 IMPLICIT

- Added the ability to generate superelement representations of parts using Static Condensation, see *CONTROL_IMPLICIT_STATIC_CONDENSATION.
- Extended *CONTROL_IMPLICIT_MODES to include eigenmodes and optionally generate the superelement representation of the part. This enables the LS-DYNA to build the Craig-Bampton linear representation of a part using constraint and eigenmodes.
- Superelements constructed by *CONTROL_IMPLICIT_STATIC_CONDENSATION and *CONTROL_IMPLICIT_MODES are written in either the Nastran extended format for DMIG files or a LS-DYNA binary format, which reduces the size of the file. *ELEMENT_DIRECT_MATRIX_INPUT has been extended to read the binary format.
- *CONTROL_IMPLICIT_TERMINATION has been extended to allow user control over termination the simulation in ways other than the end time. Energy based tests have been added to the original displacement control.
- Enhanced the robustness and speed of the nonlinear solution process for implicit mechanical transient simulation. An area of special focus has been metal forming applications. We have added a contact penetration checking option (see *CONTROL_IMPLICIT_SOLUTION) and a new keyword *CONTROL_IMPLICIT_FORMING.
- Simple one-step, implicit solution for gravity loading of models which may even include contacts and unattached parts is now possible. Available in SMP and MPP. (*CONTROL_IMPLICIT_FORMING (may be renamed later)
- Fixed sign error in BNDOUT forces for implicit.
- Fix for discrete beam problem which did not converge implicitly.
- Fix for restart for implicit joints.
- Fix implicit's output to RCFORC file.
- Make implicit 2D-type solid, type 13 and type 15, available for *MAT_076 and *MAT_175.
- Fix errors in implicit RBE3 constraints.
- In implicit, added kinder, gentler logic for processing of
(1) prescribed motion on globally constrained nodes and rigid bodies,
(2) redundant local spc constraints
- Rigorous treatment of shell-to-solid interface for implicit.
- Fixed minor bug related to solid element type 18. Type 18 is for linear statics, not explicit.
- Add implicit support for *CHANGE_BOUNDARY_CONDITION
- Remove inappropriate warning from implicit about *INTERFACE_COMPONENT.
- Enhance Implicit's treatment of shell-to-solid constraint.
- Add info when thermal linear solver 3 fails.
- Implicit's treatment of shell-to-solid constraint.

2.12 INCLUDE OPTIONS

- Added optional thickness scaling for *INCLUDE_STAMPED_PART (new real parameter on Card 3, Column 8).
- Fix for symmetric mapping (*INCLUDE_STAMPED_PART... with ISYM>0). When mirroring the stress/strain tensor, 2 of the 3 shear stresses change sign. It was changed for all 3 shear stresses before, which was wrong.
- Added option to enable a 'mapping only' run by setting INCOUT=4 in *INCLUDE_STAMPED_PART.
- Allowed multiple entries for *INCLUDE and *INCLUDE_PATH.

For example,

```
*INCLUDE
include_file1
include_file2
include_file3
*INCLUDE_PATH
include_path1
include_path2
include_path3
```

- Fixes for mapping with *INCLUDE_STAMPED_PART.
- *MAT_ARUP_ADHESIVE - Unit conversion of density was missed out for *INCLUDE_TRANSFORM.
- Fix for mapping with *INCLUDE_STAMPED_PART.
- Fix for combination of *INCLUDE_TRANSFORM offset and *ELEMENT_SEATBELT_ACCELEROMETER parameters IGRAV and INTOPT.
- Fix for combination of *INCLUDE_TRANSFORM offset and *MAT_057 load curves.
- Whereas material stress relaxation curves are defined in the input as stress versus time, *INCLUDE_TRANSFORM incorrectly transformed the curves as stress vs. log(time).

2.13 INITIAL CONDITIONS

- Added *ALE_AMBIENT_HYDROSTATIC and *INITIAL_HYDROSTATIC_ALE for initializing and prescribing hydrostatic pressure in ALE liquids due to gravity.
- Fix for reading of *INITIAL_STRESS_SOLID with EOS history variables.
- New large format for *INITIAL_STRESS_SHELL.
- Permute angular rates for yaw, pitch and roll in *INITIAL_VEHICLE_KINEMATICS so they are in agreement with the user's specification of body-fixed axis sequence. Some adjustments to rigid body mass center positioning with regard to gravity direction. Calculation of velocity field is based on the final mass center position.
- Allow for gravity to point in positive global directions and maintain max coordinate values in that direction when repositioning with initial vehicle kinematics.

- Fixed the reading of *INITIAL_STRESS_TSHELL and *INITIAL_STRESS_SOLID when the history data contains integers.
- Fixed reading *INITIAL_STRESS_TSHELL history data in large problems.

2.14 INTERFACE

- Remove inappropriate warning from implicit about *INTERFACE_COMPONENT.
- Allow printing of nodal contact forces in *INTERFACE_SSI and *INTERFACE_SSI_STATIC.
- Allow *INTERFACE_SSI for purely dynamic analysis, i.e. without starting from an initial state and add tensor viscosity coefficient to *MAT_PML_ELASTIC_FLUID.
- MPP fixes for INTERFACE LINKING "tied node pairs" option.
- Fixed keyword read of FTENSR in *INTERFACE_SPRINGBACK.
- Fix problem of SMP writing interface linking file.
- Fix some MPP initialization problems related to interface linking and tied node pairs.

2.15 LOADS

- Added empirical pressure loading module for treating multiple blast sources. Also now possible to define the location of the blast using a node ID. Also, a death time for blast can be specified. (*LOAD_BLAST_ENHANCED)
- Added airburst blast loading which takes into account ground reflected waves and formation of a Mach stem wave. (*LOAD_BLAST_ENHANCED)
- Added blast loading from missile delivered warhead (shaped charge or explosively forged projectile) which produces a non-spherical blast front. (*LOAD_BLAST_ENHANCED)
- Added binary database for visualizing blast pressures applied to structures. (*DATABASE_BINARY_BLSTFOR)
- New keyword *LOAD_THERMAL_VARIABLE_BEAM – similar to *LOAD_THERMAL_VARIABLE_SHELL – allows temperatures in beam elements to vary piecewise-linearly over the cross-section.
- Staged construction – dormant elements now written to D3PLOT file as “deleted”
- Steady state rolling analysis is a generalization of *LOAD_BODY, allowing the user to apply body loads to part sets due to translational and rotational accelerations in a manner that is more general than the *LOAD_BODY capability. This capability is useful for initializing the stresses and velocity of tires during dynamic relaxation, and rolling processes in manufacturing. Still undergoing development. New keywords: *LOAD_STEADY_STATE_ROLLING *CONTROL_STEADY_STATE_ROLLING
- Added option to *LOAD_MOVING_PRESSURE to scale the pressure based on the distance between the nozzle and the surface.
- MPP support for NIDBO in *LOAD_BLAST_ENHANCED.
- A bug fix for ALE ambient type 5. (*LOAD_BLAST)

- *LOAD_BLAST + ALE coupling with area weighted nodal velocity.
- Use area weighted nodal velocity for *LOAD_BLAST + ALE coupling to avoid edge effect.
- Compute density in the shock front and post-shock for *LOAD_BLAST_ENHANCED.
- A fix to the Mach stem incident pressure (*LOAD_BLAST_ENHANCED).

2.16 MATERIAL MODELS

- Added *MAT_220/*MAT_ORTHOTROPIC_ADVANCED_DAMAGE, for solid elements.
- *MAT_171 (*MAT_STEEL_CONCENTRIC_BRACE) – hysteretic algorithm improved to avoid the possibility of a step change of result for small changes of input. New input field EPTCRIT. Also, fixed bug in loadcurve option.
- *MAT_169 (*MAT_ARUP_ADHESIVE) – added new optional input parameter BTHK (bond thickness – by default, this is taken from the element dimension). Also, fixed bug that would have prevented wedge elements from working correctly. Also added input parameter THKDIR to allow thickness direction to be taken from element topology rather than smallest element dimension.
- *MAT_172 (*MAT_CONCRETE_EC2) – less conservative timestep calculation; enable stiffness-method hourglass control; new option for concrete compressive behavior following Mander's algorithm (TYPE=6); new input parameter UNLFAC controlling unload stiffness; shear capacity calculations; reinforcement directions may be specified using AOPT inputs.
- End-releases for *MAT_191 (*MAT_SEISMIC_BEAM) now tolerant of being connected to constrained nodes.
- New *MAT_202 (*MAT_STEEL_EC3) for use in fire analysis – integrated beam elements only.
- Modifications for *MAT_017 (*MAT_ORIENTED_CRACK). Crack propagation to adjacent elements via two new input parameters: SOFT and CVELO.
- Improvements to *MAT_187 (*MAT_SAMP-1):
 - Handling of strain rates and damage.
 - Bug fix when used with penta elements.
 - New parameter RBCFAC (Card 1, Column 7) is the ratio of yield in biaxial compression vs. yield in uniaxial compression.
- Added new option to cohesive *MAT_138 (*MAT_COHESIVE_MIXED_MODE): parameters T and/or S can now be negative. The absolute value then defines a load curve for now be negative. The absolute value then defines a load curve for peak traction(s) vs. element size. This should be helpful in case of coarse meshes.
- Read reference geometry flag (REF) for *MAT_183 (*MAT_SIMPLIFIED_RUBBER_WITH_DAMAGE): Card 3, Column 2.

- Extension of *MAT_120_JC (*MAT_GURSON_JC): new material parameters KW, BETA, and M are read on new optional Card 7, Columns 1, 2 and 3. KW and BETA are used in Hutchinson model (void growth under shear) and M is for enhanced JC failure (nonlinear damage evolution).
- New options for *MAT_054 (*MAT_COMPOSITE_DAMAGE_ENHANCED) for shells:
 - New parameter PFL (Card 7, Column 1) defines the percentage of layers which must fail until crashfront is initiated (reduced strengths in neighbor elements).
 - Linear damage for transverse shear defined by 3 new input parameters: damage initiation strain, final rupture strain, and transverse shear maximum damage.
- Enable hourglass control type 6 for solid element material *MAT_123 (*MAT_MODIFIED_LINEAR_PIECEWISE_PLASTICITY).
- Changes to *MAT_077 (*MAT_HYPERELASTIC_RUBBER, *MAT_OGDEN_RUBBER):
 - Enable to work with tet formulation 13.
 - Added reference geometry option (Card 1, Column 8).
- Fix for *MAT_089(*MAT_PLASTICITY_POLYMER), solids were not eroded after failure.
- Improvements to *MAT_036 and *MAT_133 (*MAT_3-PARAMETER_BARLAT and *MAT_BARLAT_YLD2000):
 - Added Chaboche-Roussilier kinematic hardening.
 - Added consistent viscoplasticity from tables.
- Material parameters defined by load curves in *MAT_006 (*MAT_VISCOELASTIC).
- Added *MAT_*MAT_UHS_STEEL, an advanced material for hot stamping simulations including 5 phases, 4 phase transitions and trip effects. This model is available for both for solids and shells.
- Improvements to *MAT_103 (*MAT_ANISOTROPIC_VISCOPLASTIC):
 - Multiphase description, i.e., the material can consist of several phases where each has its own set of constitutive parameters.
 - Added consistent viscoplasticity (directly) from tables.
 - User damage available (not only failure).
- Added viscoplastic model to *MAT_124 (*MAT_PLASTICITY_COMPRESSION_TENSION).
- Added option to *MAT_83 (*MAT_FU_CHANG_FOAM) to reload on original loading curve when damage is active.
- Changed damping in *MAT_181 (*MAT_SIMPLIFIED_RUBBER/FOAM) foam option to correct nonphysical transverse deformation under compression.
- Fix for *MAT_133 (*MAT_BARLAT_YLD2000) load curve option.
- Fixed *MAT_ADD_EROSION to work properly with multiple failure criteria.

- Added rate effects to *MAT_003 (*MAT_PLASTIC_KINEMATIC) for beam elements for the option VP=0.
- Fix for *MAT_105 (*MAT_DAMAGE_2) to fail element on plastic strain as documented in the users manual.
- Fix for multiple failure criteria in *MAT_ADD_EROSION applied to type 2 solids.
- Fixed 2D beam element failure for material types *MAT_3, *MAT_15, *MAT_54, *MAT_58, *MAT_158, *MAT_65, *MAT_165 and *MAT_106.
- Fixed shell *MAT_116 input so that it cannot segmentation fault.
- Fix for *MAT_ARUP_ADHESIVE and restarts.
- Fix energy bug in *MAT_187 for shells.
- Modify muscle materials so that user defined curves can be used for activation levels.
- Made 2D seatbelt improvements, triggered by setting COMP, the 6th column of *MAT_SEATBELT, to 2. Improvements include synchronization between 1D and 2D belt, automatic adjusting compression elimination, and seatbelt section force output.
- Added output of SWFORC file (and BINOUT) for the nugget pull-out failure function and fracture failure function of option 9 beam spot weld failure.
- Fix for *MAT_055 shear term in Tsai-Wu failure criterion.
- Fixed thick shells when used with orthotropic user-defined materials. Material direction transformations were wrong resulting in bad stress.
- Make *MAT_156 parameter ALM compatible with *DEFINE_CURVE_FUNCTION.
- Allow *MAT_SPRING_MUSCLE parameter "A" (activation level) to reference *DEFINE_CURVE_FUNCTION.
- Make implicit 2D-type solid, type 13 and type 15, available for *MAT_076 and *MAT_175.
- Minor change for name of *MAT_224: *MAT_TABULATED_JOHNSON_COOK. Old name *MAT_TABULATED_VISCOPLASTICITY_WITH_FAILURE still works.
- Fixes and minor modifications for *MAT_100_DA requested by Daimler.
- Miscellaneous fixes for *MAT_224.
- Fix for *MAT_153.
- Fixed bug in *MAT_024 user-defined failure (could result in improper material constants being used in failure subroutine).
- Fixed brick element stress initialization of *MAT_057, *MAT_073, *MAT_083.
- Bug fix for user material with thermal coupling.
- Fix for *MAT_077 when used with tet type 13 in single precision.

- Fix bug in *MAT_083.
- Fix bug in *MAT_187.
- Fix for *MAT_159 related to internal energy calculation.
- Fix for *MAT_081 and parameter TDEL.
- *MAT_192 fixes for the initialization process; the most significant is that the density used for calculating maximum over consolidation is now the buoyant density as per 971 R3. In previous releases of LS971 R4, the full density was used.
- Set *MAT_083 time step choice back to 971 R3 value.
- Allowed *MAT_ADD_THERMAL for metal only.
- Bug fix for *MAT_187 time step calculation (solid elements only).
- Bug fix for combination of *MAT_187 and hourglass type 6 (solids).
- *MAT_089: damping calculation was, in some cases, referencing an undefined variable.
- SPH Update
 - 1: Fix bug in START and DEATH time per part for SPH.
 - 2: Fix a bug for *MAT_059 for SPH elements.
 - 3: Implement *MAT_022 (*MAT_COMPOSITE_DAMAGE) for SPH 3D elements.
 - 4: *SECTION_SPH_TENSOR : Write an error message in case this option is used with material other than *MAT_NULL
- Fix related to *MAT_126 related to switching solid element formulation to type 1 from 0 erroneously.
- Fix for *MAT_195.
- *MAT_ARUP_ADHESIVE - Unit conversion of density was missed out for *INCLUDE_TRANSFORM.
- Small change for *MAT_100_DA with DG_TYP=4.
- Accuracy fixes in single precision for C-S strain rate in *MAT_036 and *MAT_133.
- Allow *INTERFACE_SSI for purely dynamic analysis, i.e. without starting from an initial state and add tensor viscosity coefficient to *MAT_PML_ELASTIC_FLUID.
- Small modification for *MAT_106: use last point in curve lrc instead of extrapolation to avoid possible negative base in Cowper-Symonds.
- Fix for *MAT_COMPOSITE, didn't work for adaptivity run.
- Combination of *INCLUDE_TRANSFORM offset and *MAT_057 load curves.
- Bug fix affecting problems with highly nonlinear heat capacity such as phase change problems.
- Make pore air available for solid formulation=0.
- Fixed bug in pore pressure analysis that could prevent convergence of steady-state analysis type on MPP systems.

- Fix bug that caused steady-state pore pressure analysis to terminate early when end of construction stage was reached.
- Bug fix for pore pressure analysis – stability calculation for steady-state was not always correct.
- Fix bug in pore pressure analysis. If suction builds up first, then the analysis is switched to steady-state, it could fail to converge.
- Fix bug in pore pressure analysis when nodal rigid bodies are present and the model contains wedges or tets with automatic sorting.
- Fix initial and ambient hydrostatic pressure setup (MPP only).
- Compute blast wind velocity directly from the incident wave decay parameter rather than ratio of pressures.
- Fixed initialization bug for umats using both ortho + part damping.
- Fixed bug in cohesive element warning message for thick shells.

2.17 PERAMETER

- Fix for D3HSP output of *PARAMETER names.

2.18 PERTURBATION

- *PERTURBATION_SHELL_THICK: fix bug for different section properties

2.19 RIDGEWALL

- Better fix for MPP input problem with rigid walls having stick conditions.

2.20 SECTION OPTIONS

- SPH Update
 - 1: Fix bug in START and DEATH time per part for SPH.
 - 2: Fix a bug for *MAT_059 for SPH elements.
 - 3: Implement *MAT_022 (*MAT_COMPOSITE_DAMAGE) for SPH 3D elements.
 - 4: *SECTION_SPH_TENSOR : Write an error messag in case this option is used with material other than *MAT_NULL
- Fix for large ID's in EDGSET of *SECTION_SHELL.
- Fix related to multiple failure criteria in *MAT_ADD_EROSION applied to type 2 solids.
- Fix for discrete beam problem which did not converge implicitly.
- MPP support for EFG shell 41 restart (shell part).

- Write solid formulations -1 and -2 to D3HSP.
- Added output of SWFORC file (and BINOUT) for the nugget pull-out failure function and fracture failure function of option 9 beam spot weld failure.
- Fixed thick shells when used with orthotropic user-defined materials. Material direction transformations were wrong resulting in bad stress.
- Solved the stability problem of nonlinear discrete elements and beams by using the max slope of the stress-strain curve even if it is the last segment of the curve.
- Make implicit 2D-type solid, type 13 and type 15, available for *MAT_076 and *MAT_175.
- Fixed bug in Hughes-Liu shell so strains are output if more than 10 integration points are specified.
- Fix for degenerate solid type 3 into wedge elements.
- Modify step calculation for discrete beam element to correct instability seen when nodal masses differ by a large amount.
- Fixed minor bug related to solid element type 18. Type 18 is for linear statics, not explicit.
- Fix for *MAT_077 when used with tet type 13 in single precision.
- Fixed extra history data output for type 2 and 3 thick shell elements.
- Fix related to *MAT_126 related to switching solid element formulation to type 1 from 0 erroneously.
- Fix for discrete cable beam time step calculation.
- Fixed wrong strain output for one-point integration shell.
- Fix for full deck restart. This involved solid type 5.
- Fixed a possible stability problem with discrete beams that have non-linear stress-strain curves and the final curve segment is stiffer than the others. This could result in such models running at a smaller time step.
- Fixing reading bug for shell types 25,26,27.
- Fixed a bug in type 17 shell: update thickness only after convergence.
- Fixed *MAT_123 for the case that ES7 or ES8 or EPS7 or EPS8 was a non-zero value. Elements were being deleted prematurely.
- Update the valid material check for forms 3 and 5 thick shells.
- Fixed the calculation of angles for fully integrated thick shells to prevent seg fault.

2.21 SENSOR

- Correct a bug calculating shell stress in a stress-activated *SENSOR.

2.22 SET OPTIONS

- Fixed for *DATABASE_HISTORY_DISCRETE_SET and *SET_DISCRETE.
- Bug fix for trimming: When deleting trimmed nodes, *SET_NODE_LIST_TITLE was not correctly read.

2.23 SPH

- Added thermal effects for 2D and 3D SPH elements (*MAT_THERMAL_ISOTROPIC).
- Added a Lagrangian kernel for 3D SPH elements (IFORM=7 and IFORM=8 for the enormalized lagrangian kernel).
- Fix bug in 3D SPH lagrangian formulation (MPP only).
- Implement 3D total lagrangian formulation for SPH elements (MPP only).
- SPH Update
 - 1: Fix bug in START and DEATH time per part for SPH.
 - 2: Fix a bug for *MAT_059 for SPH elements.
 - 3: Implement *MAT_022 (*MAT_COMPOSITE_DAMAGE) for SPH 3D elements.
 - 4: *SECTION_SPH_TENSOR : Write an error messag in case this option is used with material other than *MAT_NULL

2.24 TITLE

- Allowed the user to define parameters in *TITLE or _ID line. The code will try to translate all defined parameters. If any error encountered, no error message will be issued and it will continue.

2.25 RESTART_INPUT_DATA

- Add implicit support for *CHANGE_BOUNDARY_CONDITION
- Fix MPP restart for thermal using direct solver.
- Fix for restart with ground motion.
- MPP support for accelerometers in full deck restart, which were not properly preserving history.
- Fix typo that caused MPP full deck restart to not properly re-initialize thick shell elements when using more than 1 processor.
- Fix MPP full deck restart bug related to minimum timestep.
- Fix for MPP full deck restart and slippings, and force output plot state at beginning of second run for full deck restart.
- Save/restore plot times for ASCII files in full deck restart file. This fixes a problem where the ACSII files were output EVERY CYCLE for a while on restart.
- MPP fixes for retractors and sensors with full deck restart.