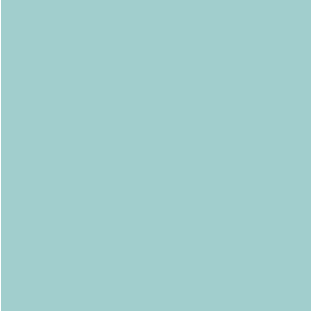


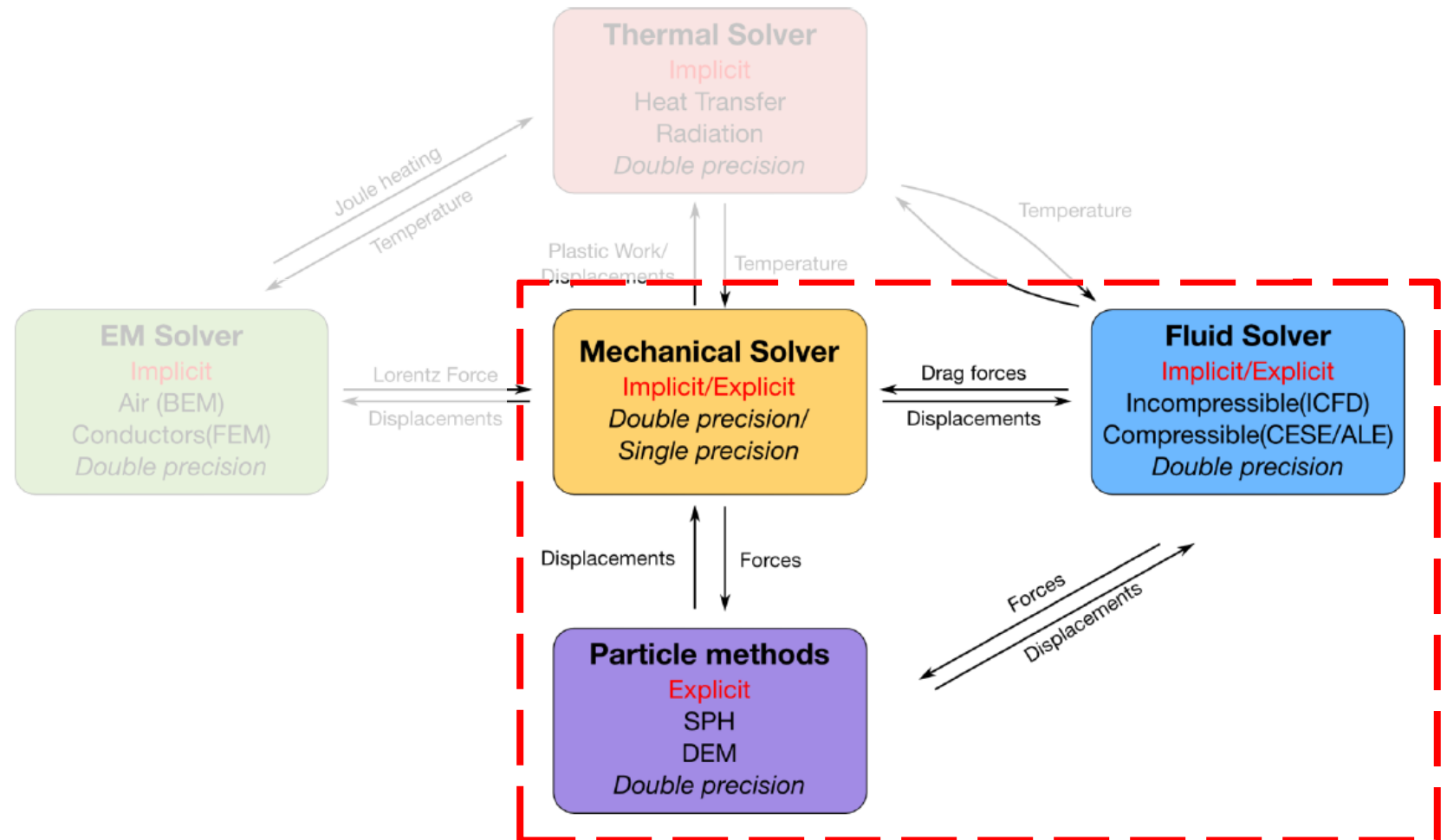


Multiphysics simulation in LS-DYNA: Coupling of the ICFD and DEM solvers

Rasmus Schützer
DYNAmore Nordic

LS-DYNA

- One code strategy
- Today's focus area
 - Mechanical solver
 - DEM
 - ICFD



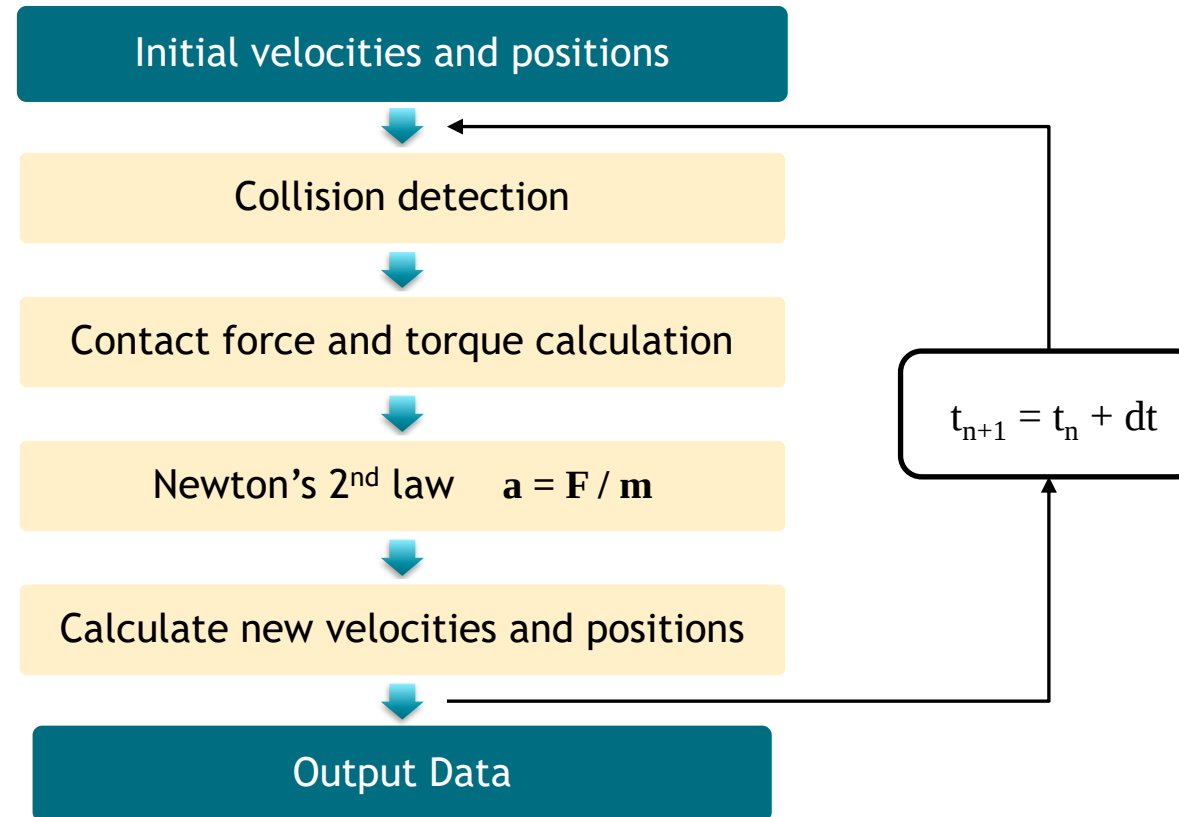
DEM



- Granular materials are not easily described as fluids, nor are they easily described as solids.
- Jelly beans, sesamy seeds, coffee beans, sand, coarse gravel, medical pills, fertilizers, coal ...
- Numerical simulations could help in the design of:
 - Storage
 - Silos, Piles
 - Transportation
 - Conveyor belts, screws, pumps, trucks
 - Processing
 - Sorting, mixing, segregation
 - Filling
 - Hopper/funnel flow, packaging
 - ...

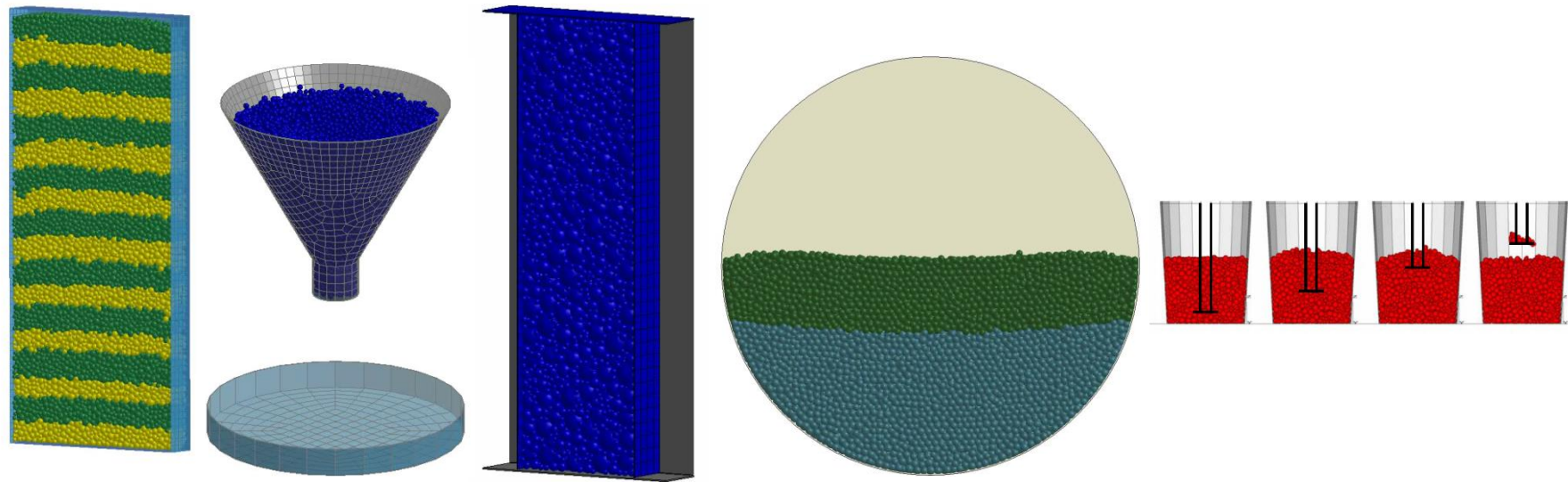
Principle of DEM simulations

- The rigid spherical particles with mass, radius and six degrees of freedom, follow Newton's laws of motion and interact through contact.

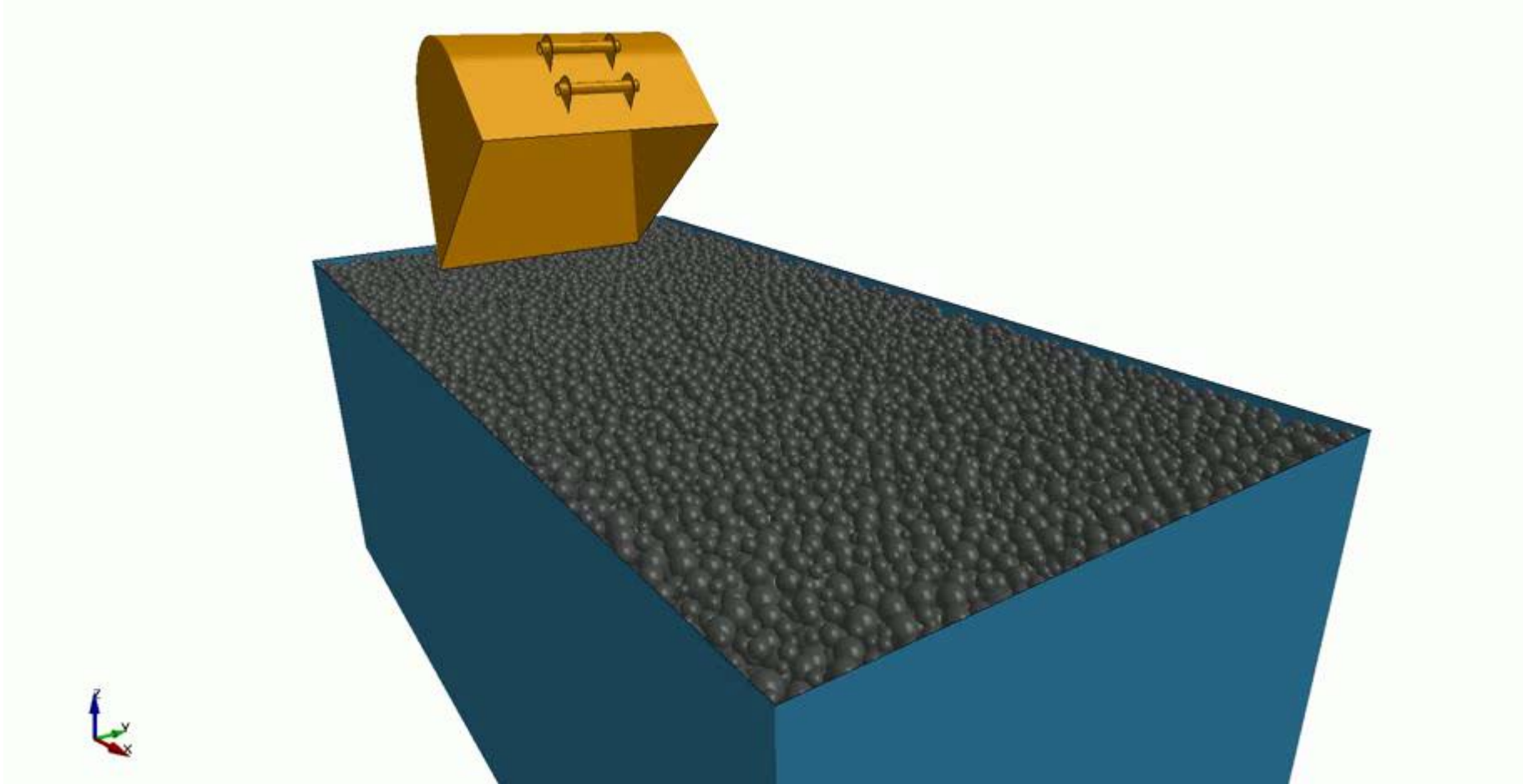


Calibration of parameters

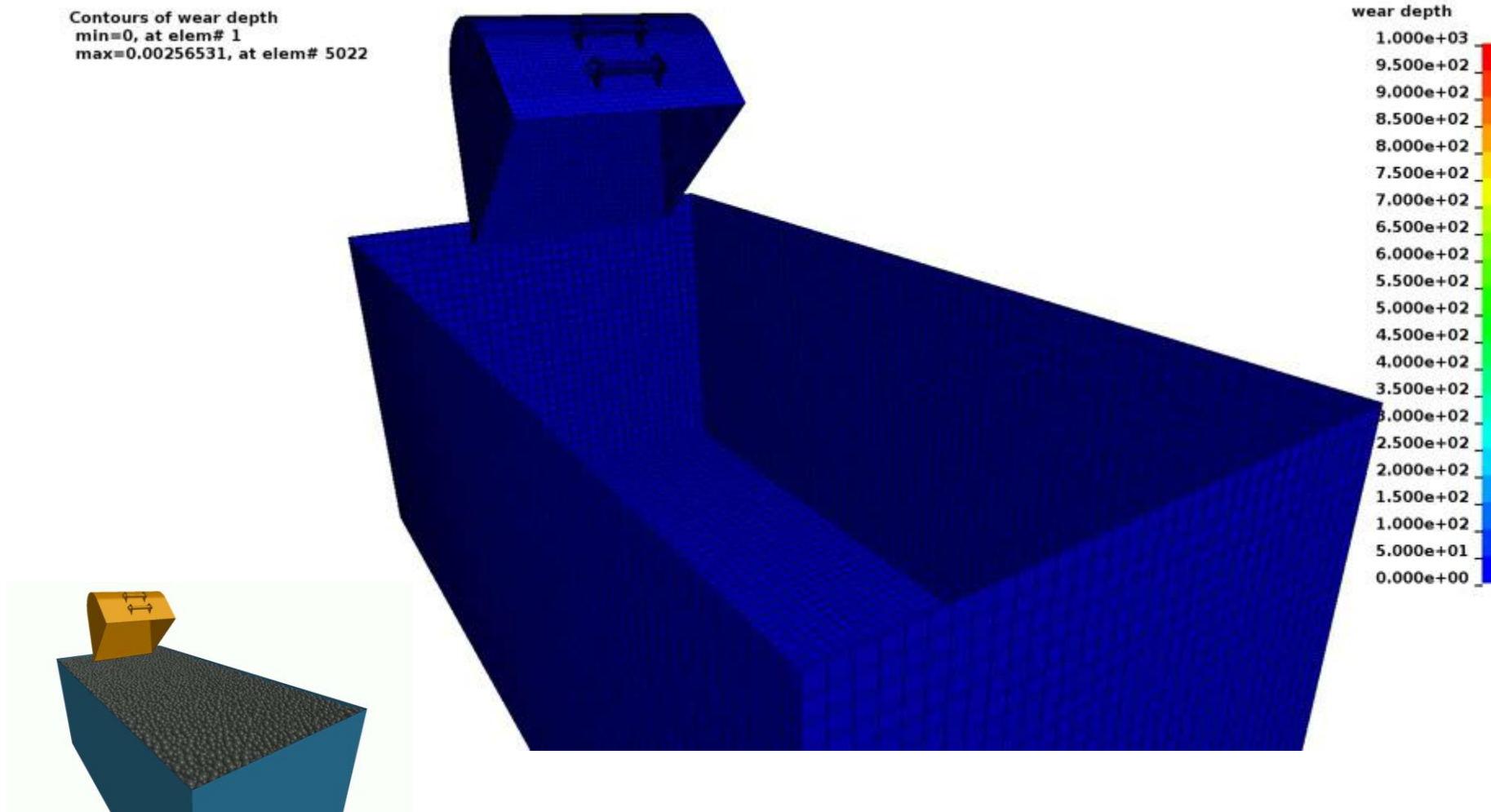
- Calibration of the DEM to DEM interaction parameters can e.g. be made through inverse modelling of bulk experiments.



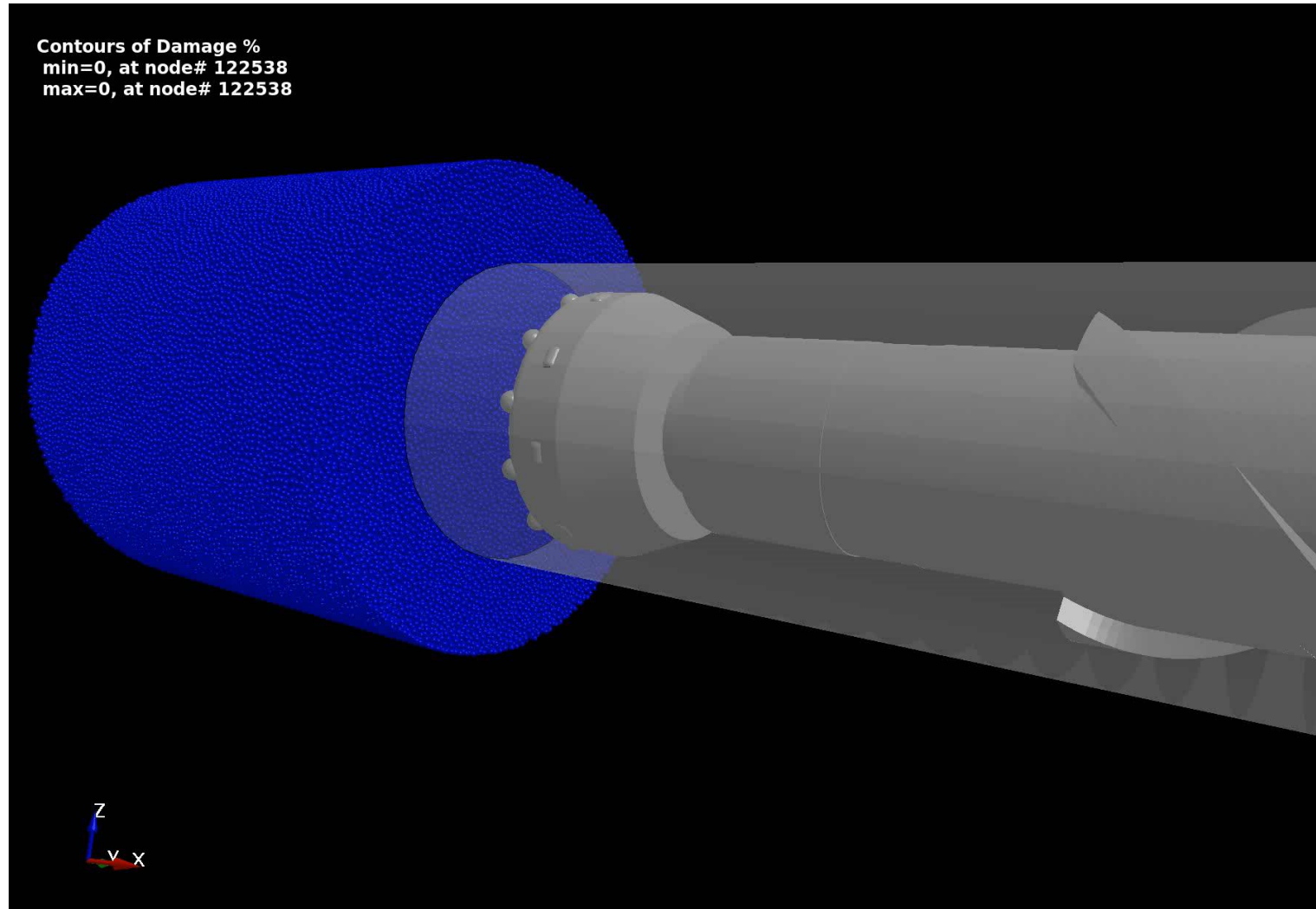
Example: Excavation bucket



Post-processing - Wear (*DATABASE_BINARY_DEMFOR)

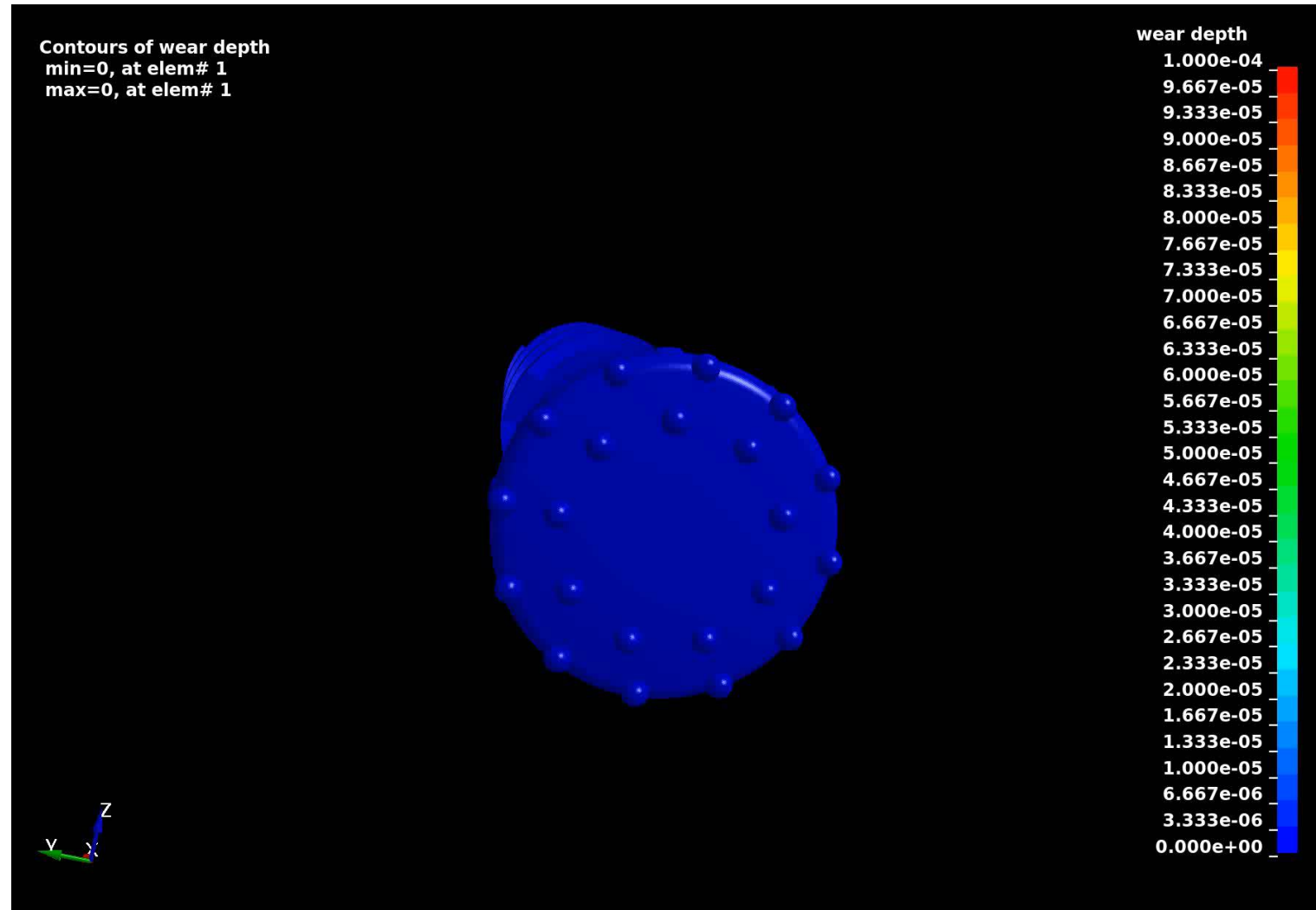


Simulation of percussive drill bit



Courtesy of:
Albin Wessling, PhD
Student Solid
Mechanics - LTU

Simulation of percussive drill bit



Courtesy of:
Albin Wessling, PhD
Student Solid
Mechanics - LTU

LS-DYNA

■ Mechanical - DEM coupling

*DEFINE

*DEFINE_DE_TO_SURFACE_COUPLING

*DEFINE_DE_TO_SURFACE_COUPLING_{OPTION}

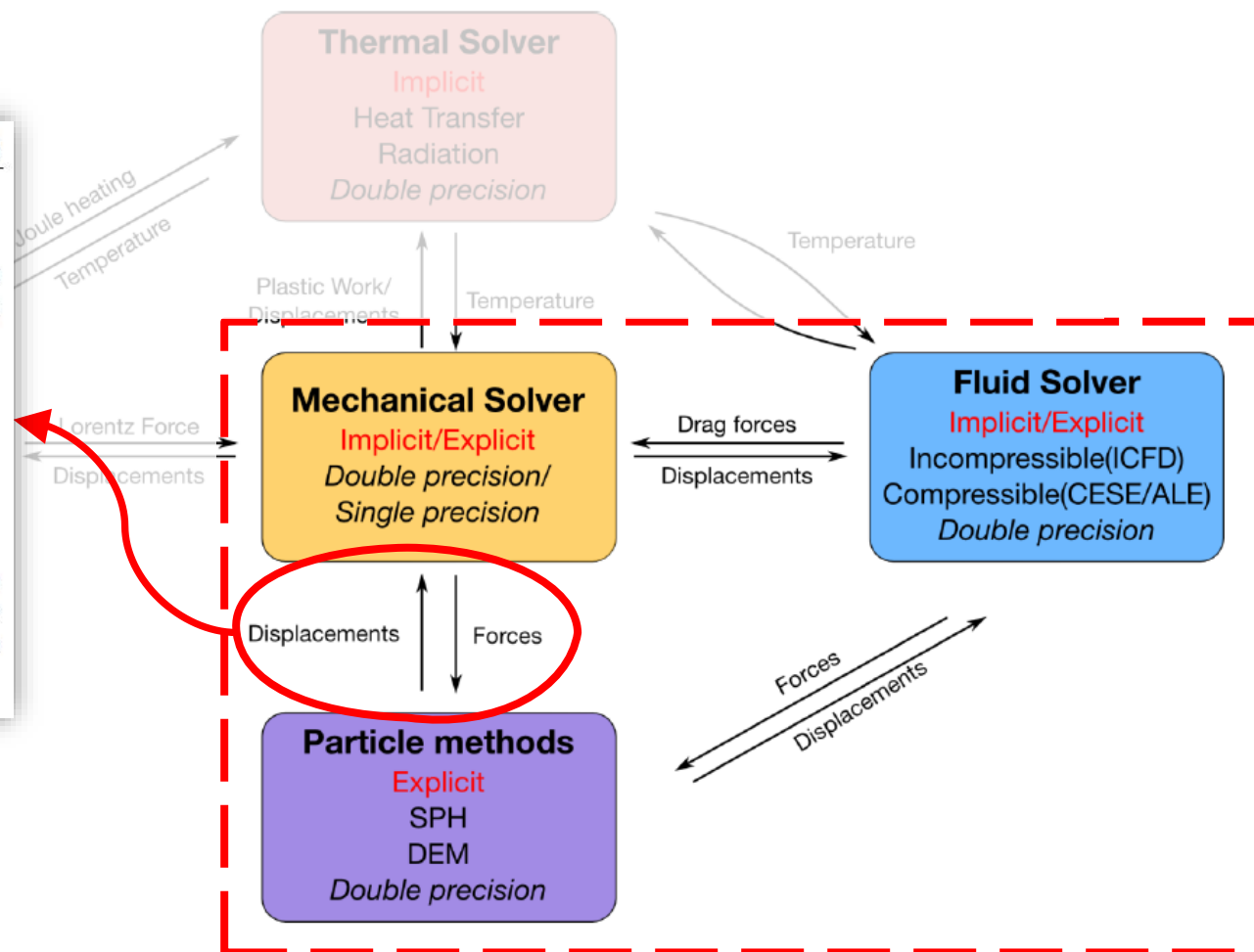
Purpose: To define a non-tied coupling interface between discrete element spheres (DES) and a surface defined by shell part(s) or solid part(s). This coupling is currently not implemented for tshell part(s).

Available options include:

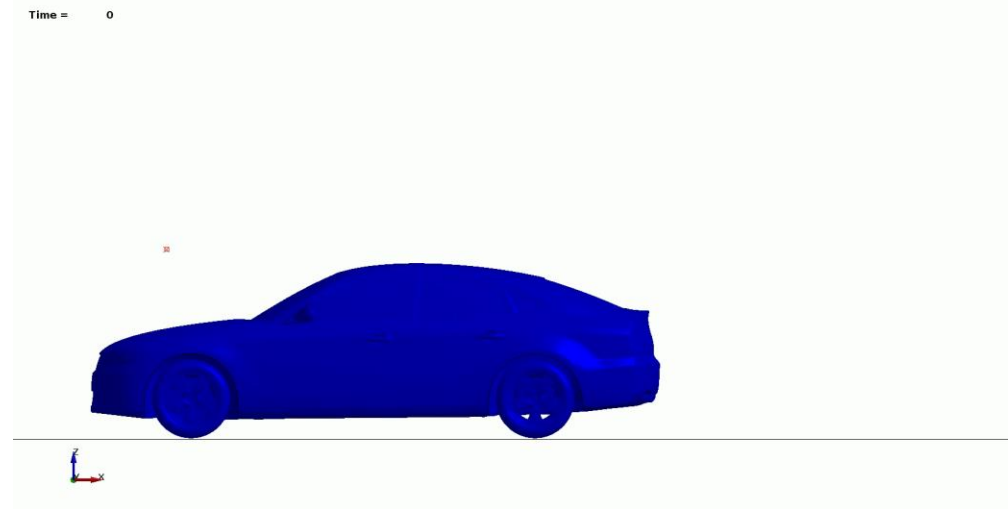
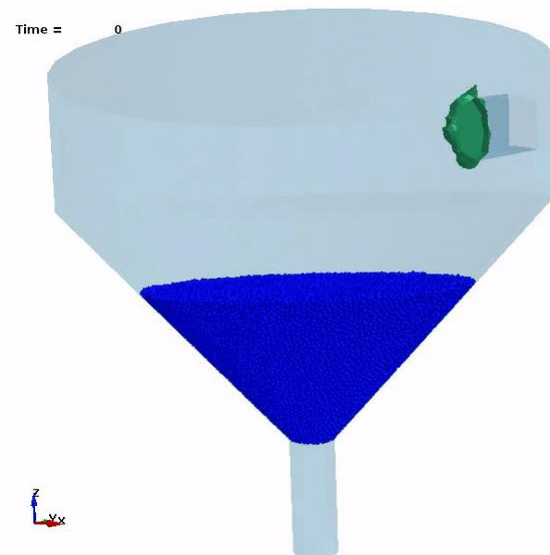
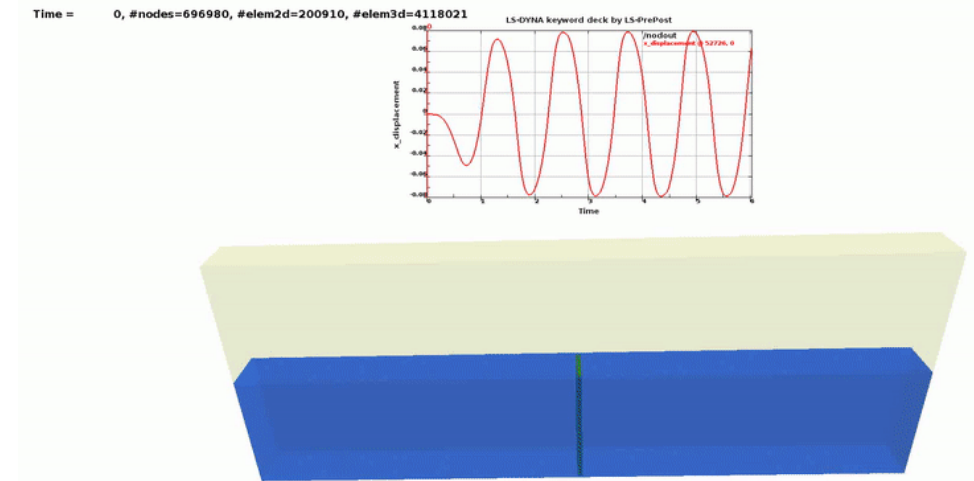
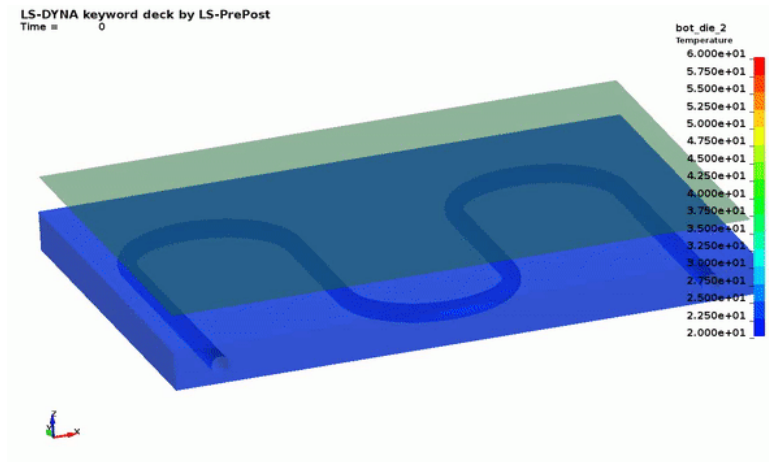
<BLANK>

TRANSDUCER

The TRANSDUCER keyword option creates a force transducer for measuring the coupling interface forces. With this option, LS-DYNA outputs the translational forces from the active surface coupling interfaces to dem_rcforc. The *only* fields read when using this option are MASTER, MTYPE and CID_RCF. See [Remark 5](#).



ICFD solver



LS-DYNA

■ DEM - ICFD coupling

*ICFD_CONTROL_DEM_COUPLING

*ICFD

*ICFD_CONTROL_DEM_COUPLING

Purpose: This keyword is needed to activate coupling between the ICFD and DEM solvers.

Card 1	1	2	3	4	5	6	7	8
Variable	CTYPE	BT	DT	SF	MAXVEL	DTYPE		
Type	I	F	F	F	F	I		
Default	0	0.	10 ⁻²⁸	1.	none	0		

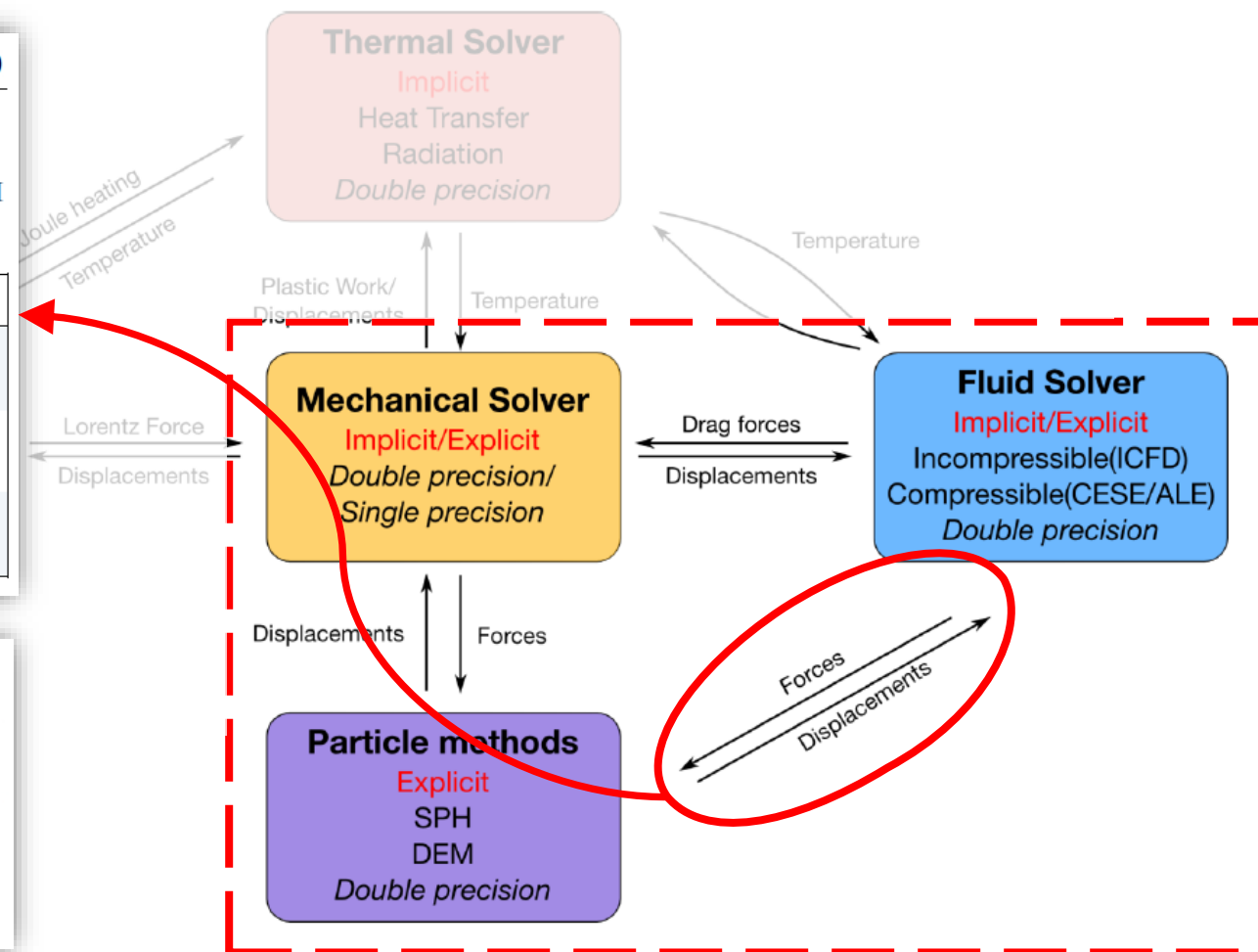
CTYPE

Indicates the coupling direction to the solver:

EQ.0: Two-way coupling between the fluid and the solid particles.

EQ.1: One-way coupling. The DEM particles transfer their location to the fluid solver.

EQ.2: One-way coupling. The fluid solver transfers forces to the DEM particles.



LS-DYNA

■ DEM - ICFD coupling

*ICFD_CONTROL_DEM_COUPLING

*ICFD

*ICFD_CONTROL_DEM_COUPLING

Purpose: This keyword is needed to activate coupling between the ICFD and DEM solvers.

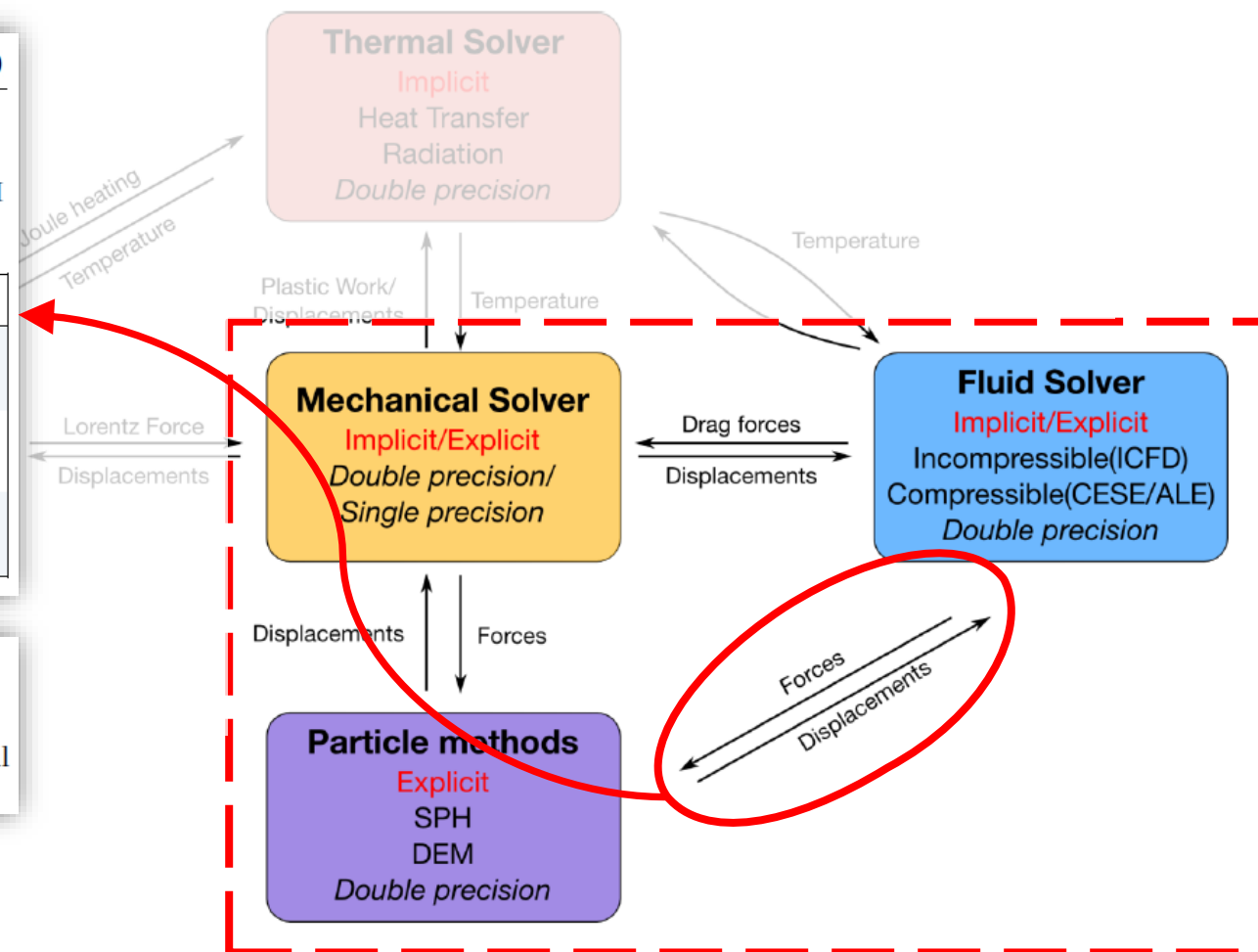
Card 1	1	2	3	4	5	6	7	8
Variable	CTYPE	BT	DT	SF	MAXVEL	DTYPE		
Type	I	F	F	F	F	I		
Default	0	0.	10 ²⁸	1.	none	0		

DTYPE

Drag calculation type:

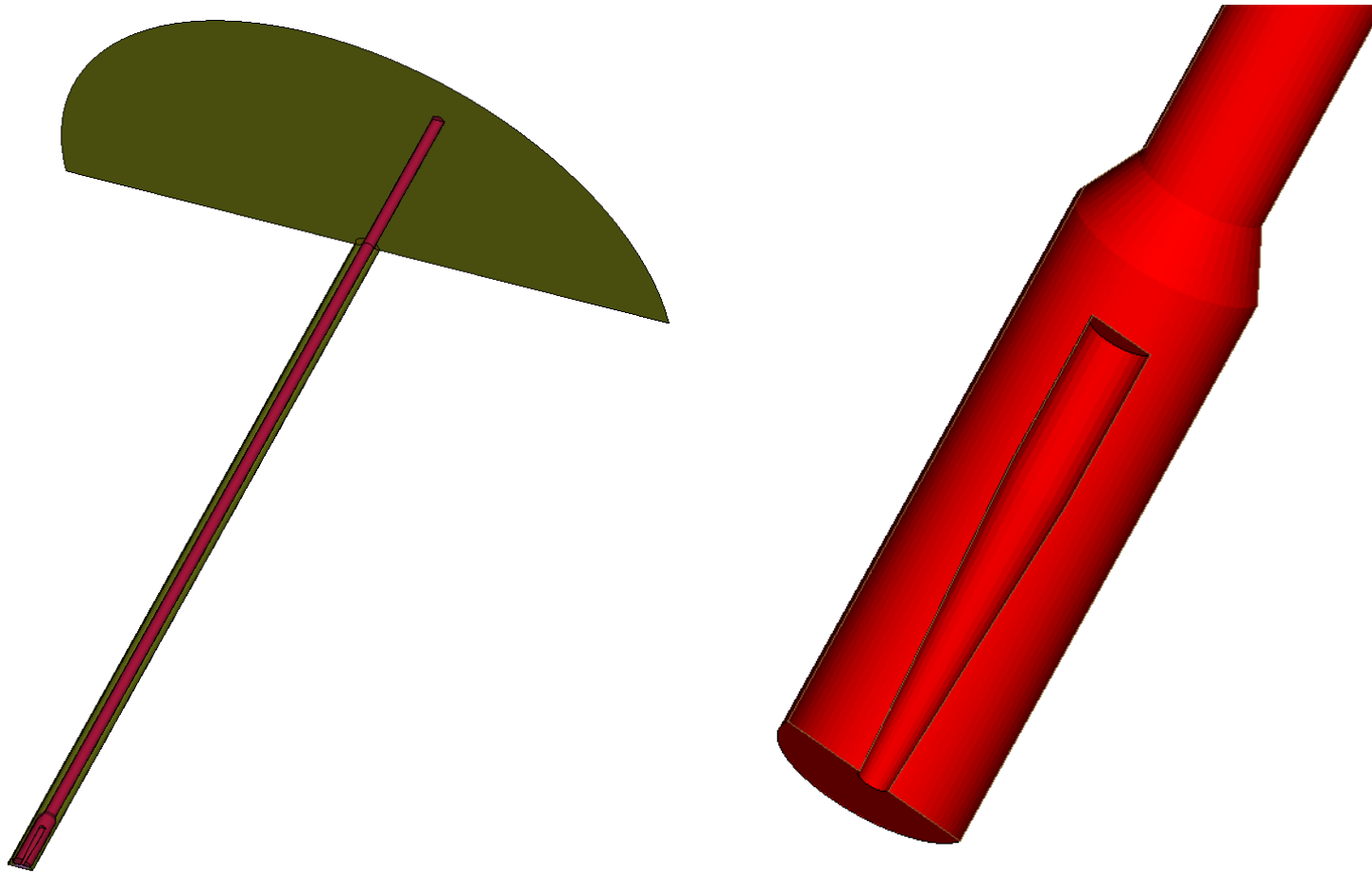
EQ.0: Constant C_d value 0.5 scaled by SF

EQ.1: Morrison formula for C_d calculation based on local Reynolds number value scaled by SF. See Remark 1.



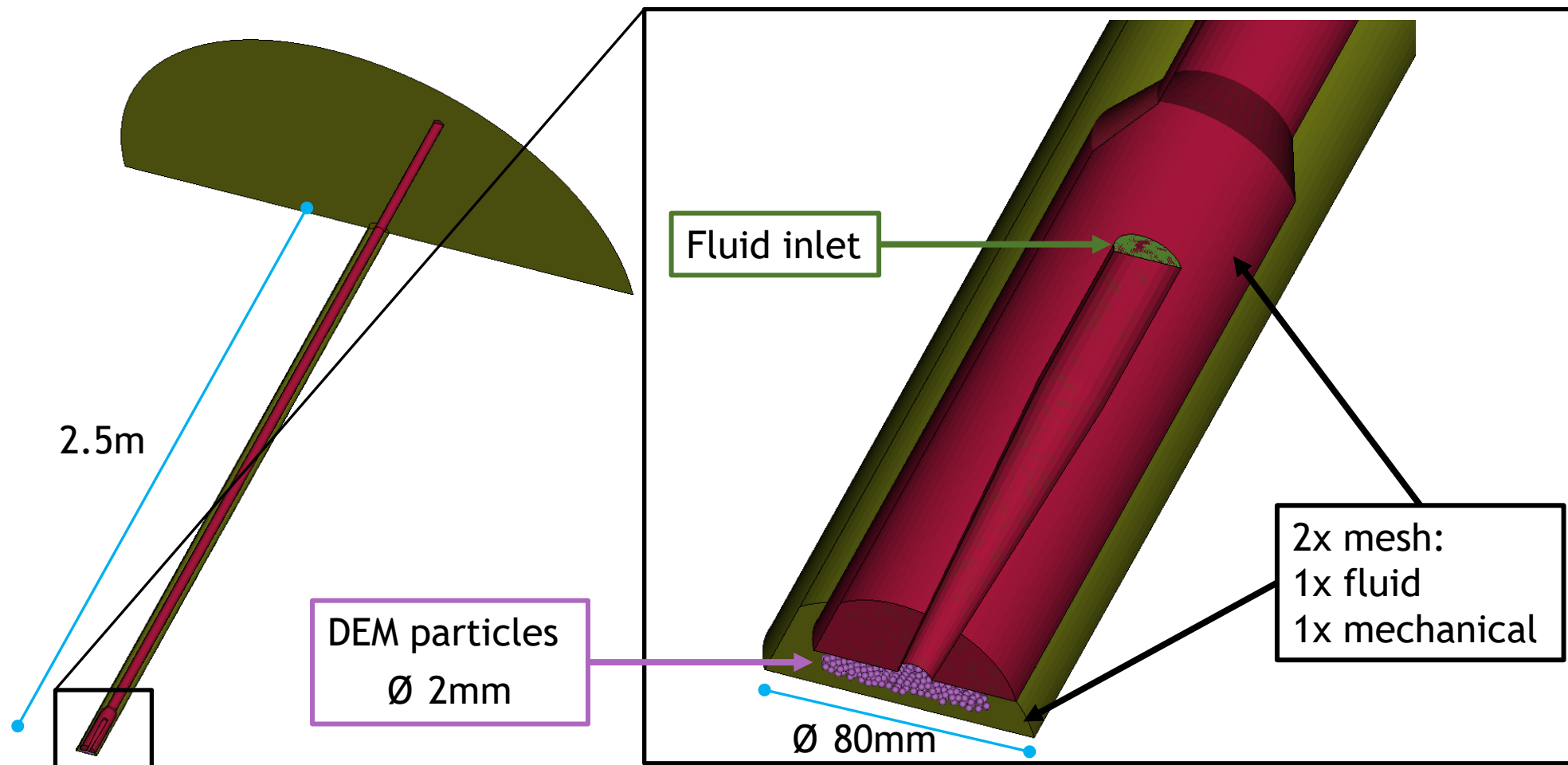
Example case

- Flushing DEM rock particles from drilling hole



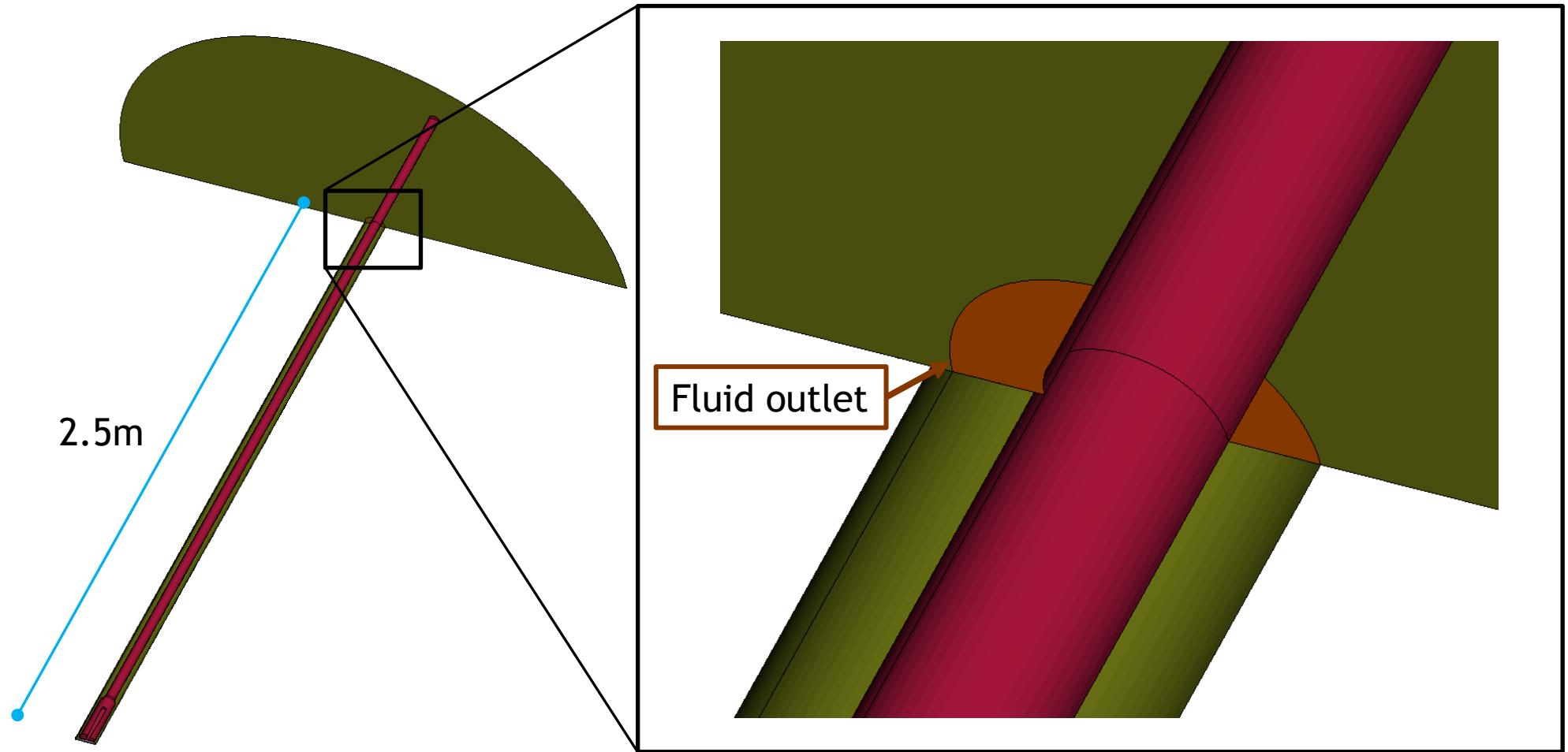
Example case

- Flushing DEM rock particles from drilling hole

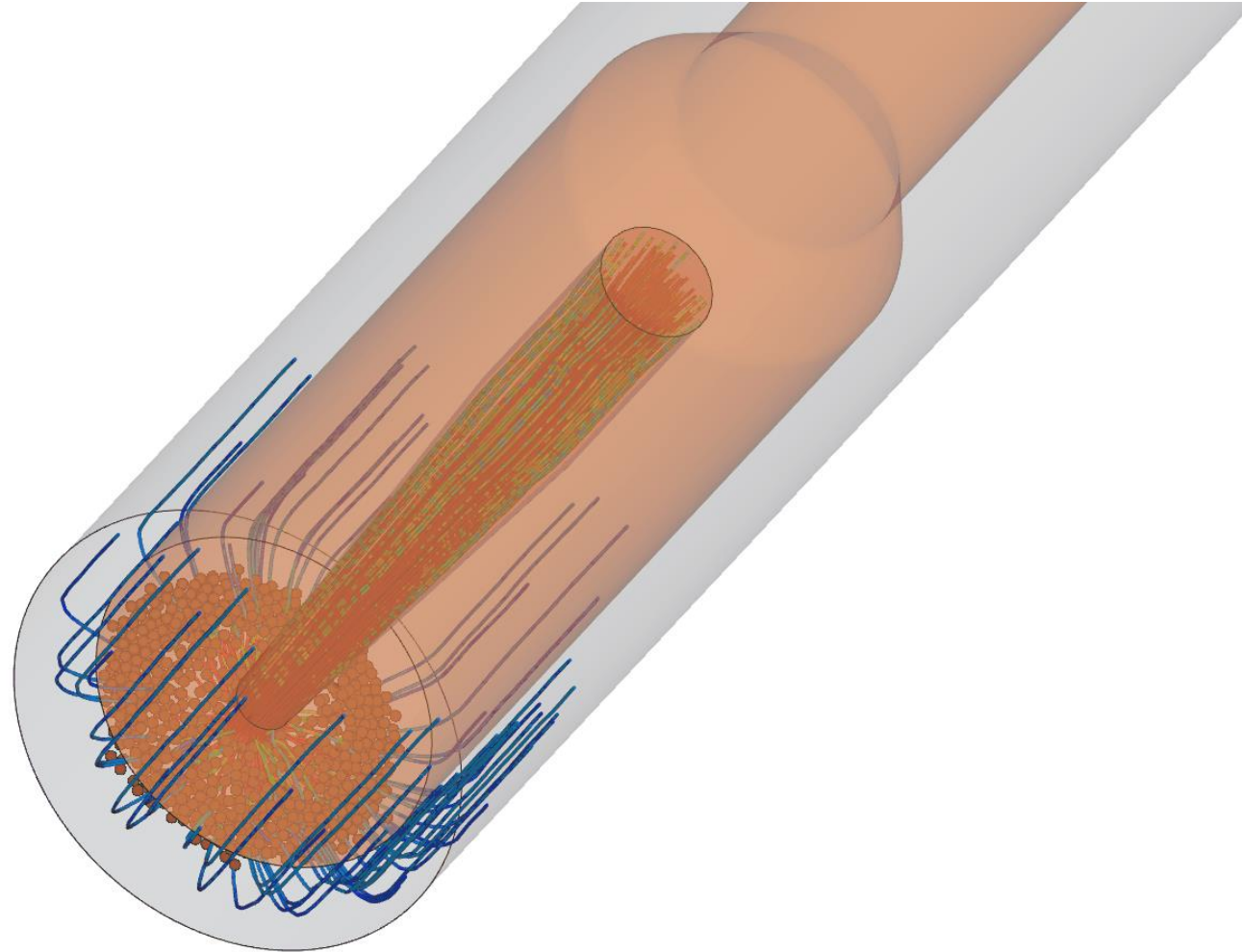


Example case

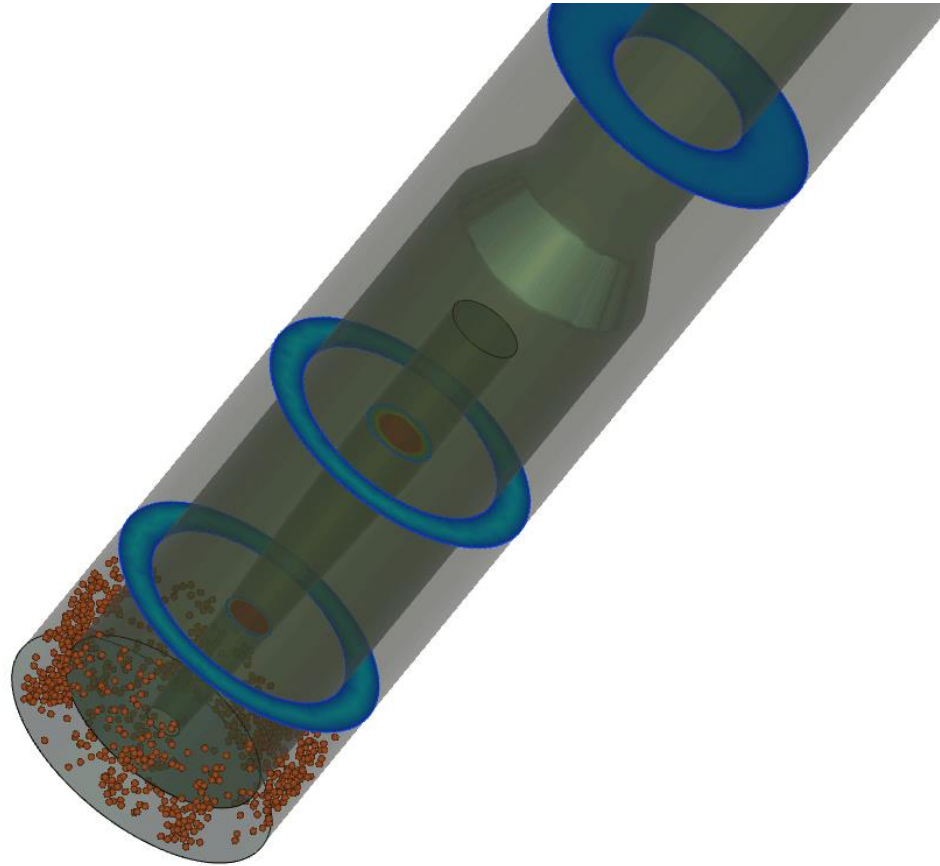
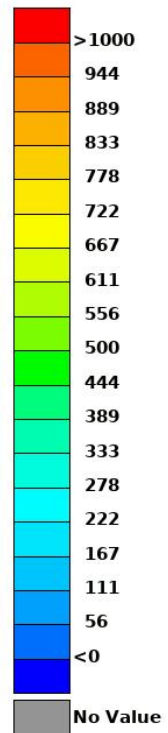
- Flushing DEM rock particles from drilling hole



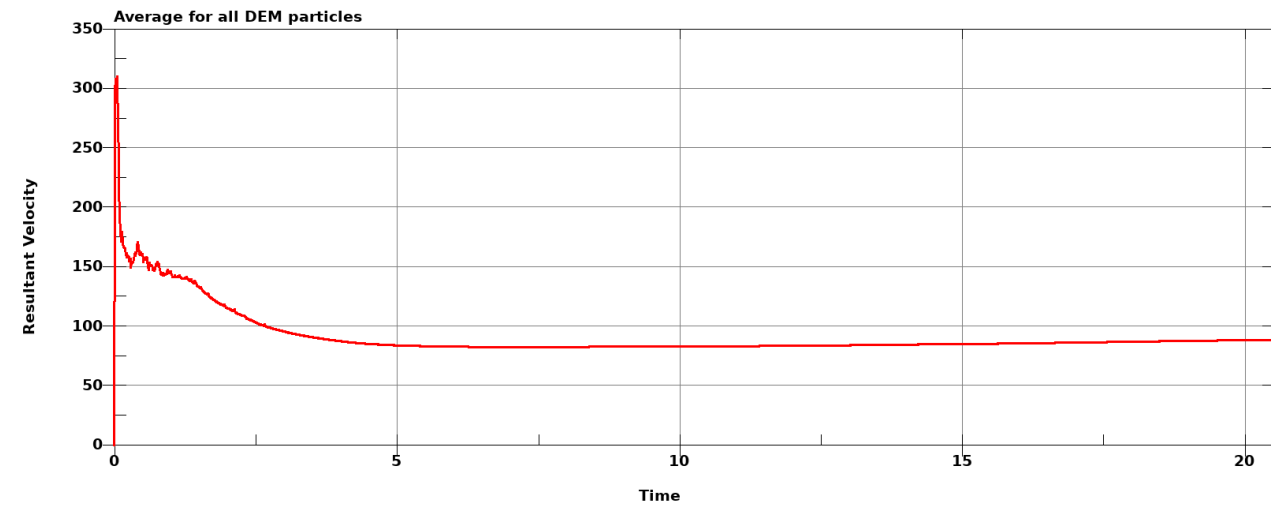
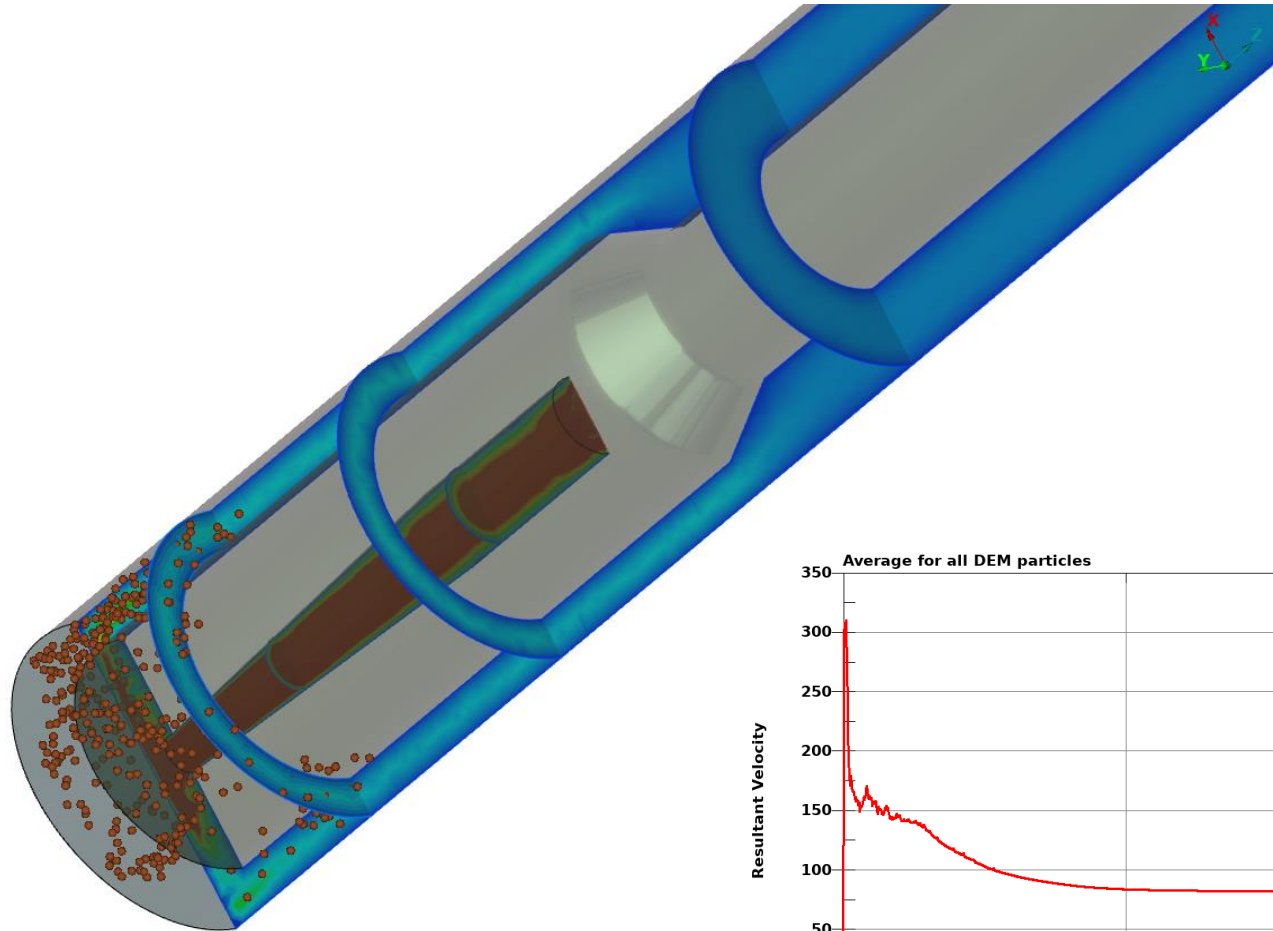
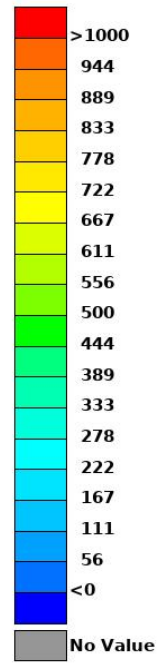
Example case



Example case

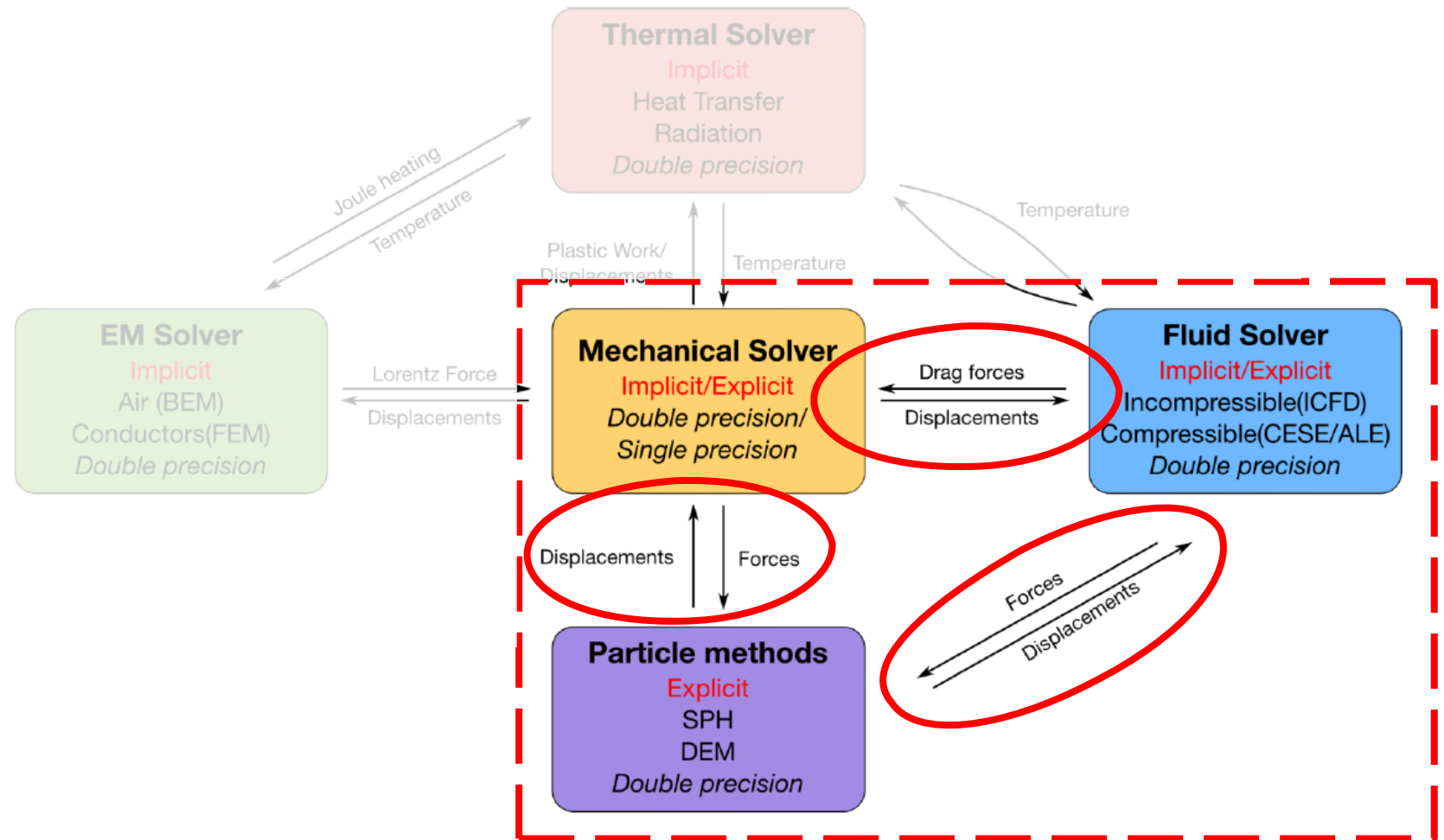


Example case



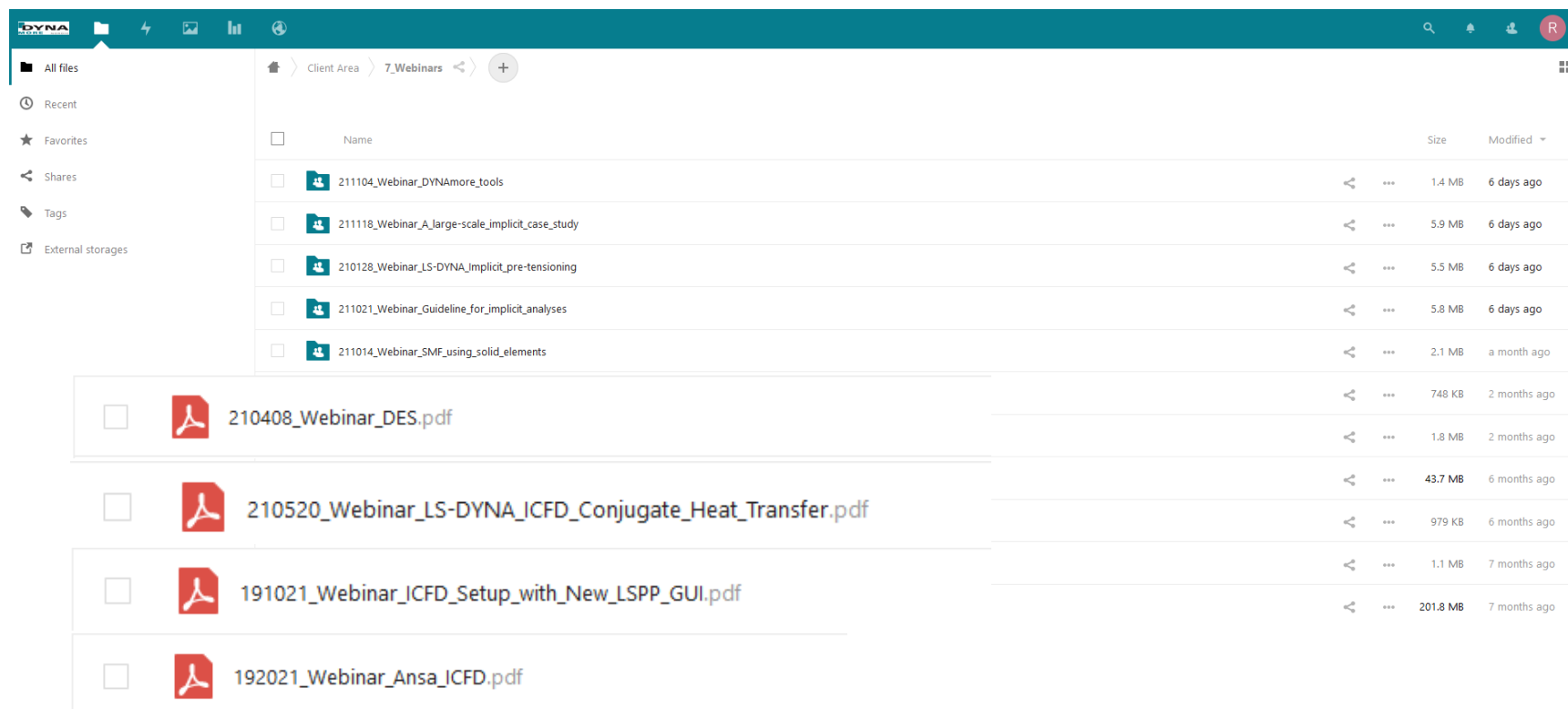
Future

- Adding FSI coupling between the mechanical solver and ICFD



More information

- Client area on files.dynamore.se for costumers - webinars



The screenshot shows a web interface for a file storage service. The top navigation bar is teal with the 'DYNA MORE' logo on the left and search, user, and notification icons on the right. A left sidebar contains navigation links: 'All files', 'Recent', 'Favorites', 'Shares', 'Tags', and 'External storages'. The main content area shows the breadcrumb 'Client Area > 7_Webinars' and a table of files. The table has columns for 'Name', 'Size', and 'Modified'. The files listed are:

Name	Size	Modified
211104_Webinar_DYNAmore_tools	1.4 MB	6 days ago
211118_Webinar_A_large-scale_implicit_case_study	5.9 MB	6 days ago
210128_Webinar_LS-DYNA_implicit_pre-tensioning	5.5 MB	6 days ago
211021_Webinar_Guideline_for_implicit_analyses	5.8 MB	6 days ago
211014_Webinar_SMF_using_solid_elements	2.1 MB	a month ago
210408_Webinar_DES.pdf	748 KB	2 months ago
210520_Webinar_LS-DYNA_ICFD_Conjugate_Heat_Transfer.pdf	1.8 MB	2 months ago
191021_Webinar_ICFD_Setup_with_New_LSPP_GUI.pdf	43.7 MB	6 months ago
192021_Webinar_Ansa_ICFD.pdf	979 KB	6 months ago
	1.1 MB	7 months ago
	201.8 MB	7 months ago

More information

The screenshot displays the DYNAmore website interface. At the top right, there are links for 'Links', 'Downloads', and a 'Search Site' bar. A navigation menu includes 'Products', 'Services', 'Support', 'Training', 'Company', and 'News'. A dropdown menu is open under 'Training', showing 'Seminars', 'Conferences', and 'Video Library', with a red arrow pointing to the 'Video Library' option. The main content area features a large banner for 'Now launching Video Library!' with a central text block: 'Now launching DYNAmore Nordic's Video Library! Free compact training videos, making it easier than ever to tap into the knowledge and expertise of DYNAmore ... more'. Below this, there are sections for 'LS-DYNA Explicit', 'LS-DYNA Implicit', 'LS-DYNA Material & Failure Modelling', 'Process Simulation', 'LS-PrePost', 'Optimization', 'ANSA', and 'META'. The bottom section, titled 'DYNAmore News', contains five news items: 'Meet DYNAmore Nordic at Elmia Subcontractor', 'Now launching Video Library!', 'Total Human Model for Safety', 'LinkedIn', and 'DYNAmore supports BMW with LS-DYNA'.

DYNAmore

Links Downloads Search Site

Products Services Support Training Company News

Seminars
Conferences
Video Library

LS-DYNA Explicit
LS-DYNA Implicit
LS-DYNA Material & Failure Modelling
Process Simulation

LS-PrePost Optimization ANSA META

Now launching Video Library!

Now launching DYNAmore Nordic's Video Library! Free compact training videos, making it easier than ever to tap into the knowledge and expertise of DYNAmore ... more

DYNAmore News

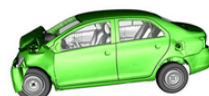
Meet DYNAmore Nordic at Elmia Subcontractor
Now launching Video Library!
Total Human Model for Safety
LinkedIn
DYNAmore supports BMW with LS-DYNA

More information

You are here: [Home](#) / [Training](#) / [Video Library](#)

Video Library

Welcome to DYNAmore Nordic's Short Training Video Library! Here you find short training videos and tutorials about numerous LS-DYNA applications and all other products that DYNAmore Nordic provide. All for free, all you have to do is enter your contact info before accessing a category, access is valid for 72 h.



LS-DYNA Explicit

LS-DYNA Explicit & General

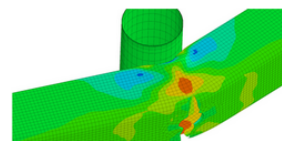
Here you'll find videos about explicit simulation and more general information for LS-DYNA, such as introductions to our guidelines, tips on how to getting started, exa... [more](#)



LS-DYNA Implicit

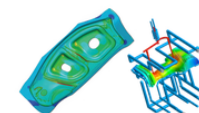
LS-DYNA Implicit

Here you'll find videos about implicit simulation in LS-DYNA, such as introductions to our guidelines, tips on how to getting started, examples on common app... [more](#)



LS-DYNA Material & Failure Modelling

Here you'll find videos about material & failure modelling in LS-DYNA.



Process Simulation

Here you'll find videos about process simulation and related software, sheet metal forming, welding, forging, and injection molding using LS-DYNA and other s... [more](#)



LS-PrePost

Here you'll find videos about pre- and post-processing for LS-DYNA in LS-PrePost, tutorials on general use, scripting, and more.



ANSA

Here you'll find videos about pre-processing your LS-DYNA models with Beta CAE's ANSA, everything from how to getting started to more advanced scripting.



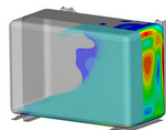
META

Here you'll find videos about post-processing your LS-DYNA results with Beta CAE's META, everything from how to getting started to more advanced scripting.



Optimization

Here you'll find videos about optimization-related topics, focusing on the Ansys LST products LS-OPT and LS-TaSC.



LS-DYNA Multi-Physics

Here you'll find videos about LS-DYNA multi-physics, for example, SPH, DEM, ICFD, thermal, and more.



DYNAmore Tools

Here you'll find videos about DYNAmore's own tools for pre- and post-processing, everything from tools for checking models prior to simulation to handling a... [more](#)



Moldex3D (External Resource)

You will be sent to Moldex3D on-demand webinars, at www.moldex3d.com, courtesy of CoreTech System Co., Ltd.

Thank you!



Your LS-DYNA distributor and
more

