

\*INCLUDE\_COSIM

Purpose: To define coupling interface across two models in different scales running on MPI based co-simulation. This feature needs the MPP LS-DYNA version R13.1, R14.0 and newer versions.

Card Summary:

Card Sets.

Card 1. This card is required.

FILENAME
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Data Card Definitions:

Card 1	1	2	3	4	5	6	7	8
Variable	FILENAME							
Type	C							
Default	none							

VARIABLE	DESCRIPTION
FILENAME	Name of an input file that contains the coupling information, which includes sets of segments in global scale model and sets of nodes in local scale one. See the remarks below.

Remarks:

This keyword defines the coupling interface to exchange kinematic and kinetic information between global (large-scale) and local (small-scale) models running on two LS-DYNA MPP jobs. In real application, the global model is usually large-scale structure, e.g. full car model or printed circuit board (PCB), while the local model, e.g. spotwelds, rivets and solders, is relatively much smaller in dimension that leads to smaller mesh and time step size in explicit analysis. To accelerate the computation across global and local scales, users are able to use two input files and run two LS-DYNA MPP jobs simultaneously with different time step sizes. The synchronization of time stepping information across coupling interface is performed

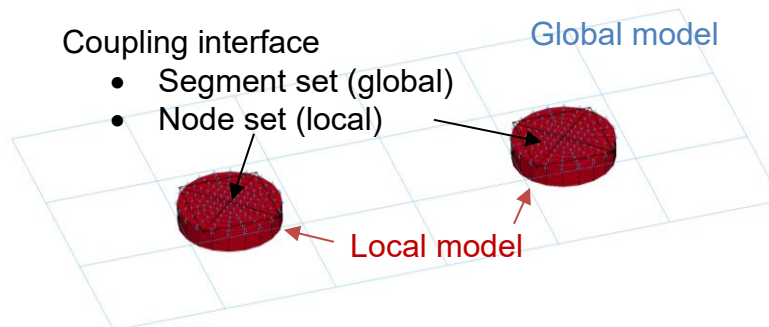
automatically at every time step of global model, while the time step size of local model is adjusted accordingly to guarantee the numerical consistency and accuracy of state variables at the coupling interface in spatial and temporal domain.

1. The coupling interface consists of two sets of entities:

- One set of segments using \*SET\_SEGMENT is defined for the global model at the coupling interface, and included in the global input deck using \*INCLUDE\_COSIM;
- The other set of nodes using \*SET\_NODE is defined for the local model at the coupling interface, and included in the local input deck using \*INCLUDE\_COSIM.

These two sets defined in global and local included files must have the same set ID (SID) to enable the coupling between global and local jobs. Multiple sets of segments and nodes can be defined in the included files using \*INCLUDE\_COSIM for different coupling interfaces. Two types of coupling algorithms are currently implemented:

- Tied contact, where the set of segments in global model drives the motion of the set of nodes in local model by imposing the kinematic constraints on nodal translational DOFs, and the local model returns the constraint forces interpolated onto the nodes of the set of global segments. In this case, it must specify the flag 'ITS' as 1 in both \*SET\_SEGMENT and \*SET\_NODE.
- Solid-in-shell immerse, where the local solid model occupies the same space as global shell model at the coupling interface. The set of nodes in local model follows both the translational and rotational motion of the set of shell segments in global model, while the nodes of the global segments obtain the constraint forces and moments as return. In this case, it must specify the flag 'ITS' as 2 in both \*SET\_SEGMENT and \*SET\_NODE.



Tied contact coupling

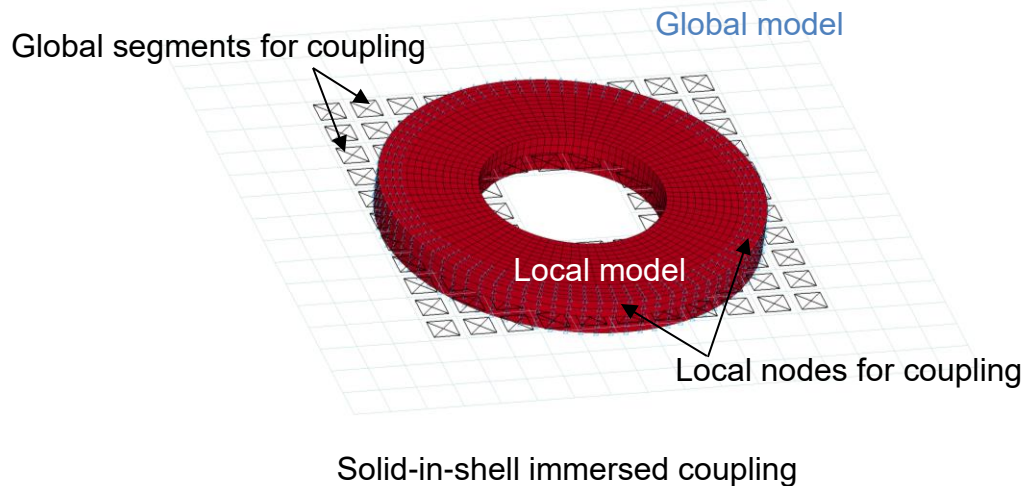


Figure 1. Two types of coupling supported by the two-scale co-simulation

2. The following is an example of running two LS-DYNA MPP jobs for two different scales, respectively:

- `mpirun -np 36 mppdyna i=input.k ncsp=24 jobid=jid`

The “ncsp” flag informs LS-DYNA that the local model runs on a separated job using 24 out of total 36 MPI processes. The main input file of the local model has to be named by that of the global model prefixed by ‘cs\_’, and the main input files of both global and local models have to be in the same working folder. There is a category named ‘Two-scale Cosim’ in timing information report of LS-DYNA message file at normal termination, which shows the CPU time spent on the data exchange between two jobs through MPI communication. To achieve the best performance with good load balance between two jobs, the number of MPI processes for two jobs needs to be adjusted according to the time step size difference and other factors, e.g. number of elements and contacts.

3. All the LS-DYNA output and temporary files are separated for two jobs. The ‘cs\_’ is prefixed to all those files of the local job run in order to avoid the conflict with those of the global one.
4. It is required to define the same termination time using \*CONTROL\_TERMINATION in global and local input files to achieve normal termination for both job runs. The time interval of d3plot output defined in both inputs must be the same to have time-consistent postprocessing database.



