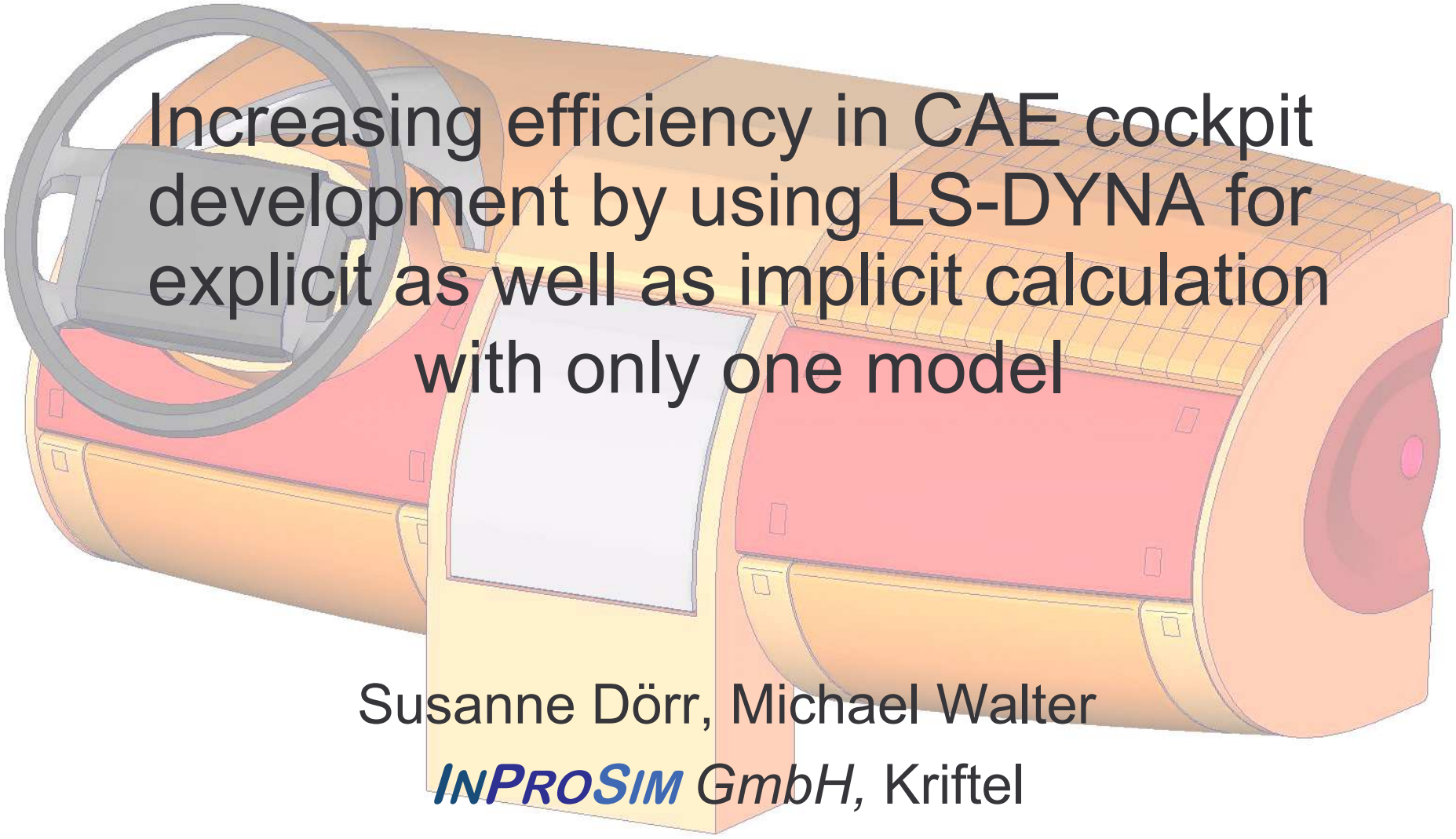
INPROSIM
Innovative Produkt Simulation



Increasing efficiency in CAE cockpit development by using LS-DYNA for explicit as well as implicit calculation with only one model

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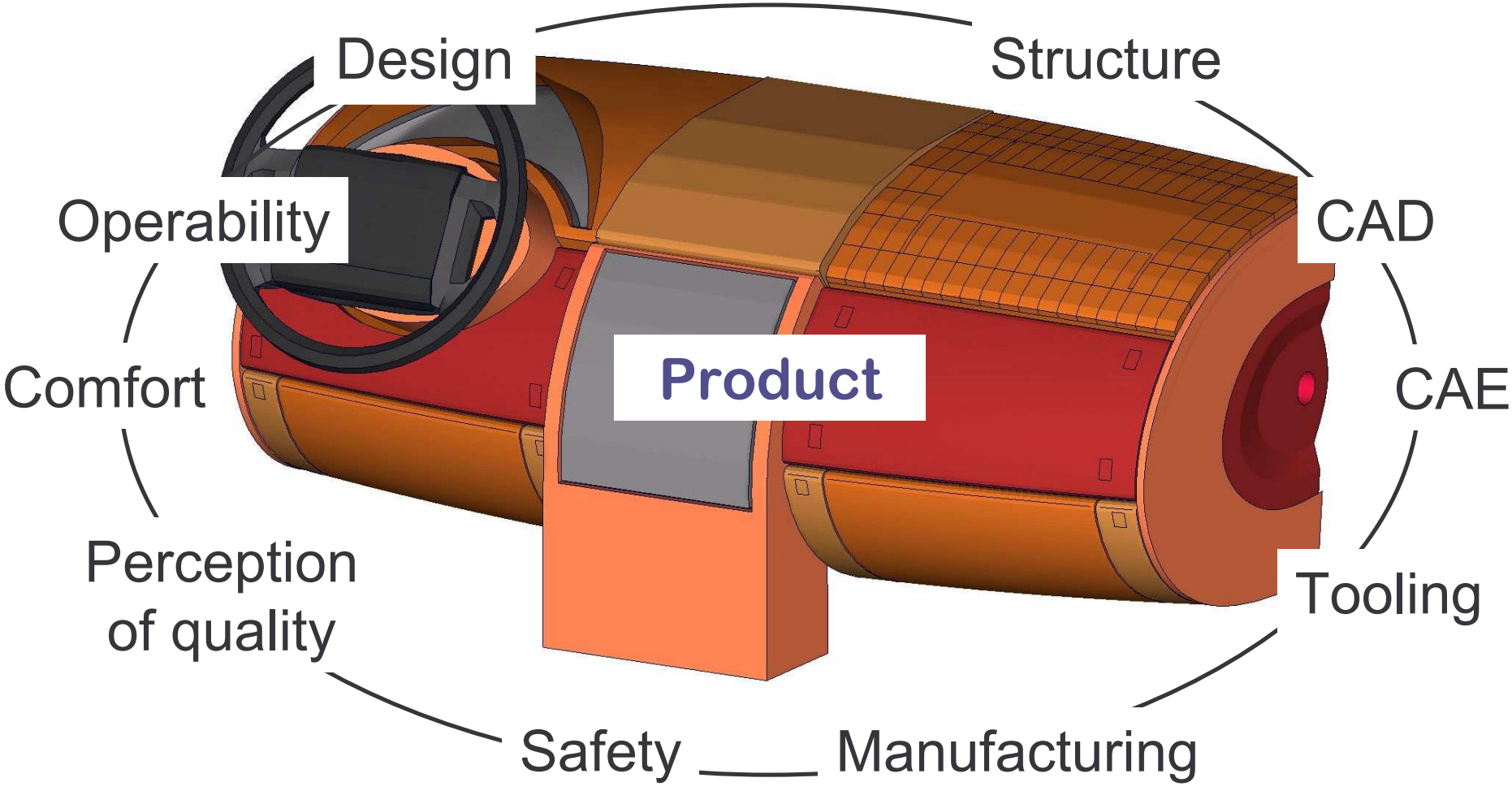
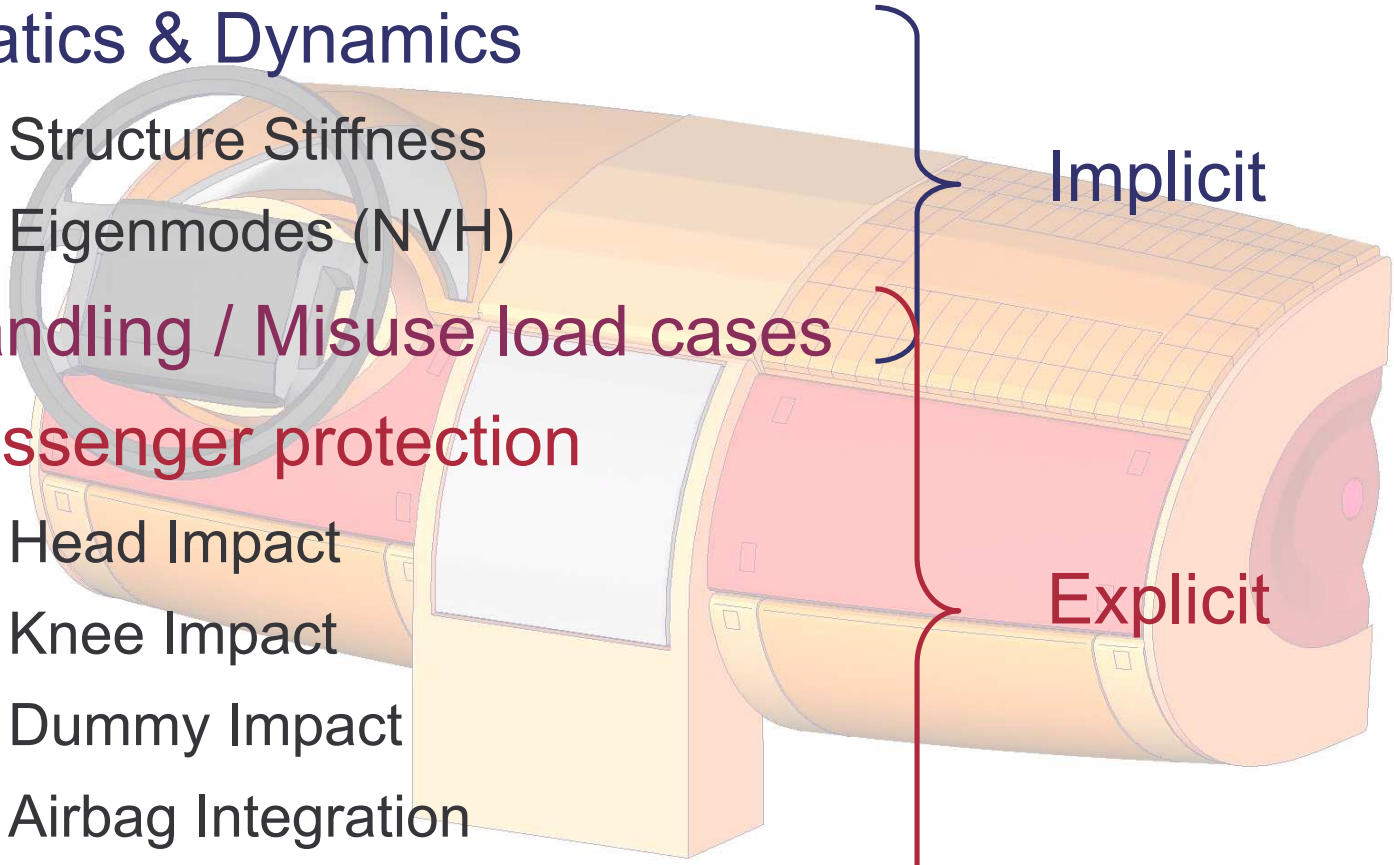
- Motivation
  - INPROSIM
    - Small company providing CAE services
    - Main focus on Crash Simulation
    - Fields of application
      - Consumer goods (notebooks, telephones,…)
      - Turbochargers, compressors, turbines
      - Automotive component supplier industry
      - …..
  - Customers' requirement
    - Examination of implicit load cases besides explicit analysis

- Motivation
  - Requirement
    - Provide service of implicit and explicit analysis
  - Considerations
    - Fields of application of both methods
    - Advantages / disadvantages and limitations
    - Present-day handling of interaction
    - Possibilities of efficient handling
  - Example
    - Automotive subsystem: cockpit

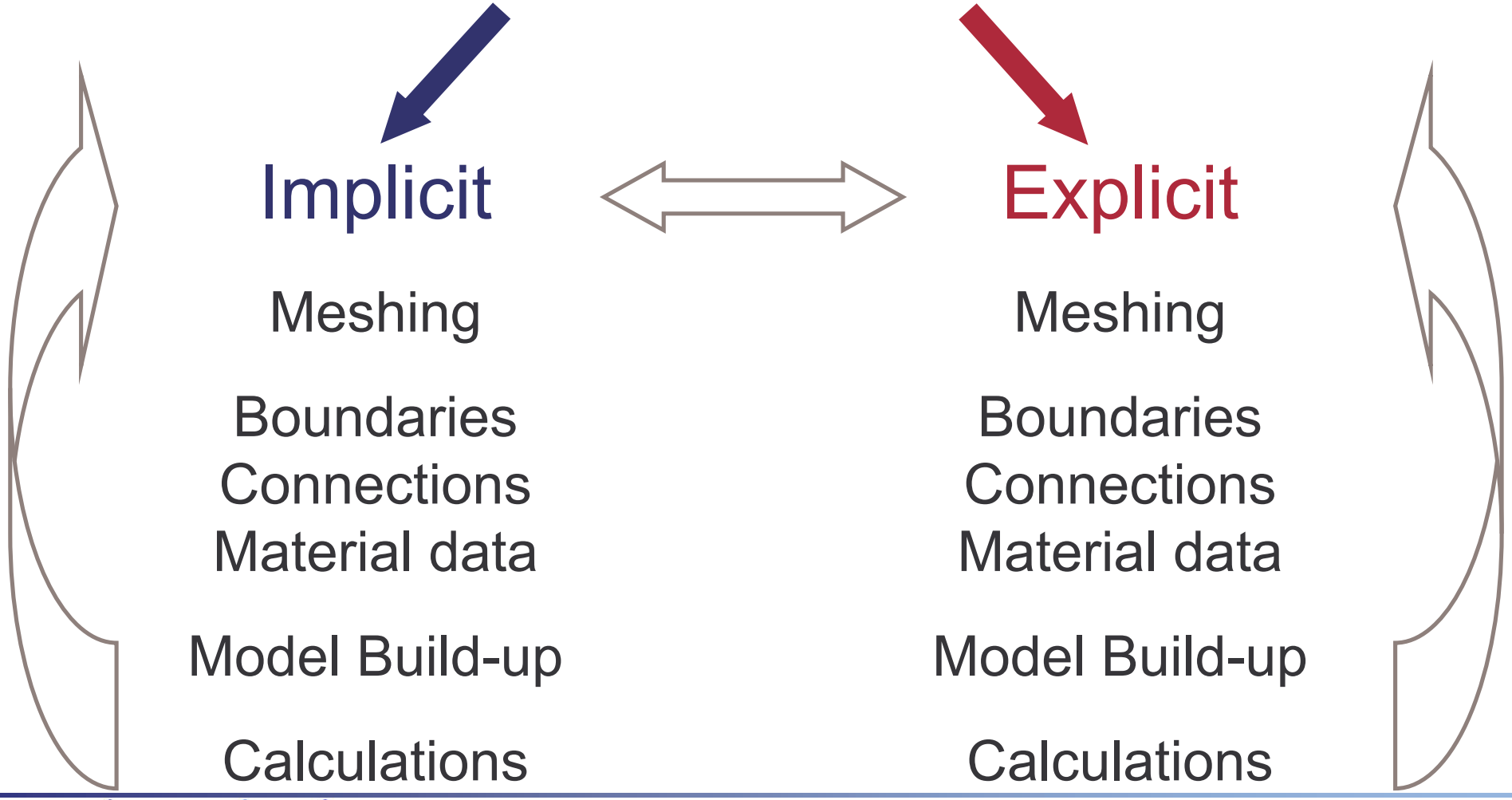
- Cockpit development



- Application of CAE calculation
  - Statics & Dynamics
    - Structure Stiffness
    - Eigenmodes (NVH)
  - Handling / Misuse load cases
  - Passenger protection
    - Head Impact
    - Knee Impact
    - Dummy Impact
    - Airbag Integration
    - Design of restraint systems



- Handling: often carried out apart



- Handling: changes in model
  - During the process of development the FE models are modified frequently
    - Changes due to requirements of other scopes (e.g. design, costs, producibility,...)
    - Changes due to actions implemented because of CAE results and CAE developed enhancements

      Interdependency of CAE work
  - Sometimes a complete rebuild is necessary
  - This leads to further loops

- Consequences
  - Increased amount of work to be done
    - In meshing
    - In definition of connections and boundaries
    - In model build-up
  - Uncertainties
    - Up-to-date CAD data
    - Up-to-date information about boundaries etc
  - Increase in risk of mistakes
  - Increase in time and expenses

- Status Quo
  - Use of different models for implicit and explicit
  - Use of different codes for implicit and explicit
    - Explicit: LS-Dyna©, PamCrash©, Radioss©, etc.
    - Implicit: Nastran©, Abaqus©, ANSYS©, etc.
- Object
  - Enhancement of efficiency in subsystem development
  - Use of one model and one code for implicit and explicit
    - LS-Dyna© Implicit / Explicit

- Use of one model and one code

One Mesh

Carry-over of most boundaries
Carry-over of most connections
One material database

One Model Build-up in the same Code

Implicit

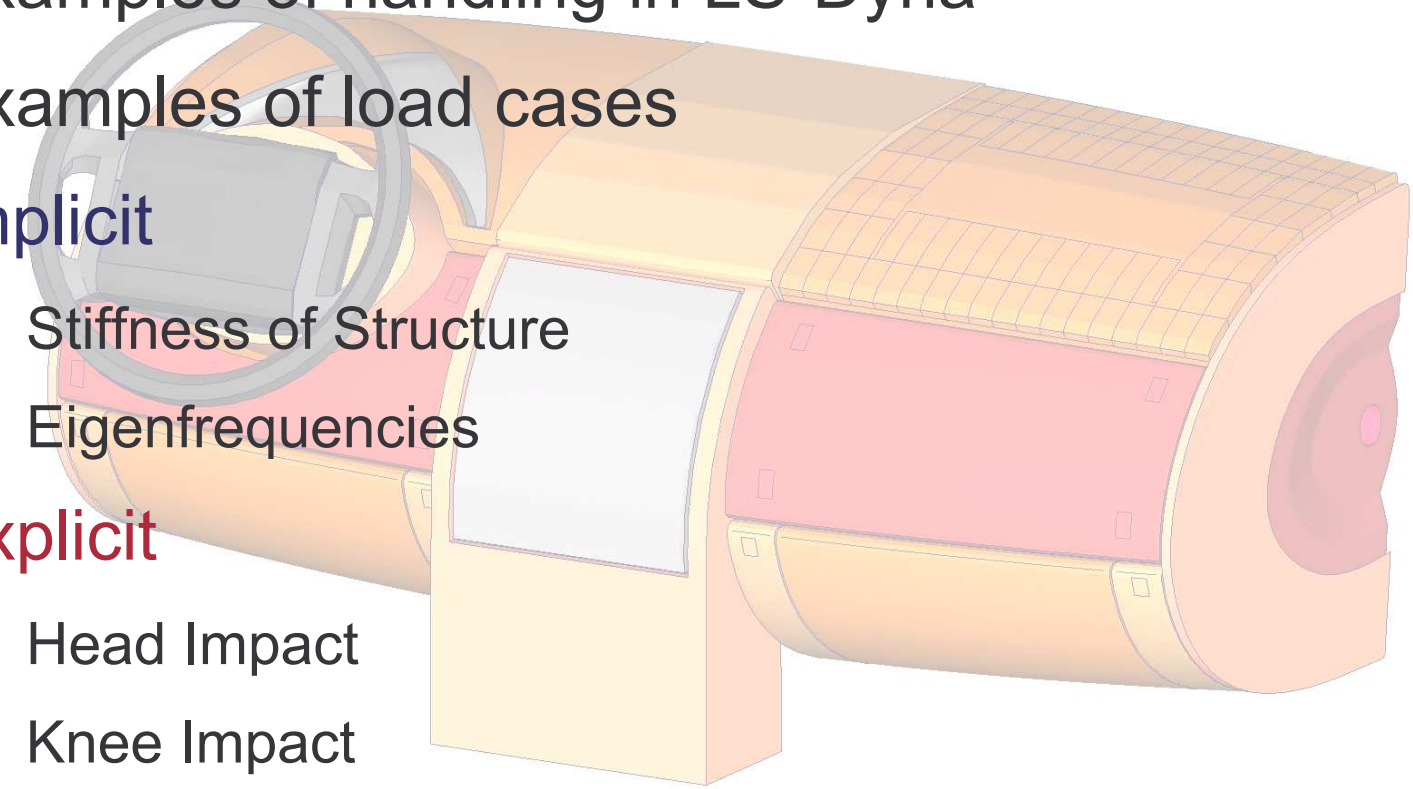
Explicit

Calculations

Calculations

- Consequences
  - Reduction in work
  - Reduction in time and cost
  - Reduction risk of mistakes
  - Increase in efficiency
- Example
  - Automotive subsystem
  - Simplified model of a cockpit system

- Cockpit development
  - Examples of handling in LS-Dyna
  - Examples of load cases
  - Implicit
    - Stiffness of Structure
    - Eigenfrequencies
  - Explicit
    - Head Impact
    - Knee Impact
  - Handling / Misuse



- Stiffness of structure of beam
  - LS-Dyna Control Cards

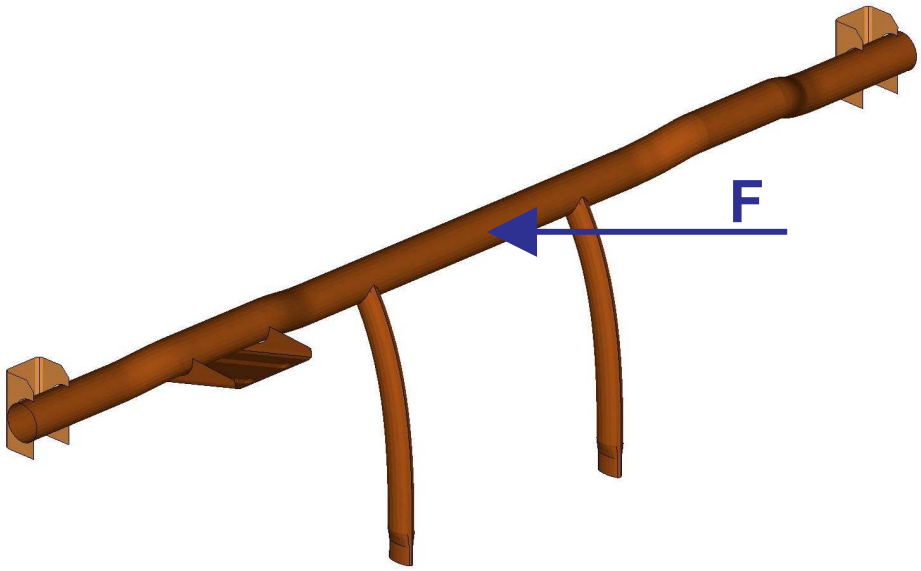
```
$---------------------------------------------------------------------|
*CONTROL_IMPLICIT_GENERAL
$---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|
$   imflag       dt0    imform      nsbs       igs     cnstn      form
          1       0.1
$---------------------------------------------------------------------|
```

- Flag for Implicit / Explicit

```
$---------------------------------------------------------------------|
*CONTROL_IMPLICIT_SOLUTION
$---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|
$   nsolvr    ilimit    maxref     dctol     ectol     rctol     lstol
          1
$---------------------------------------------------------------------|
```

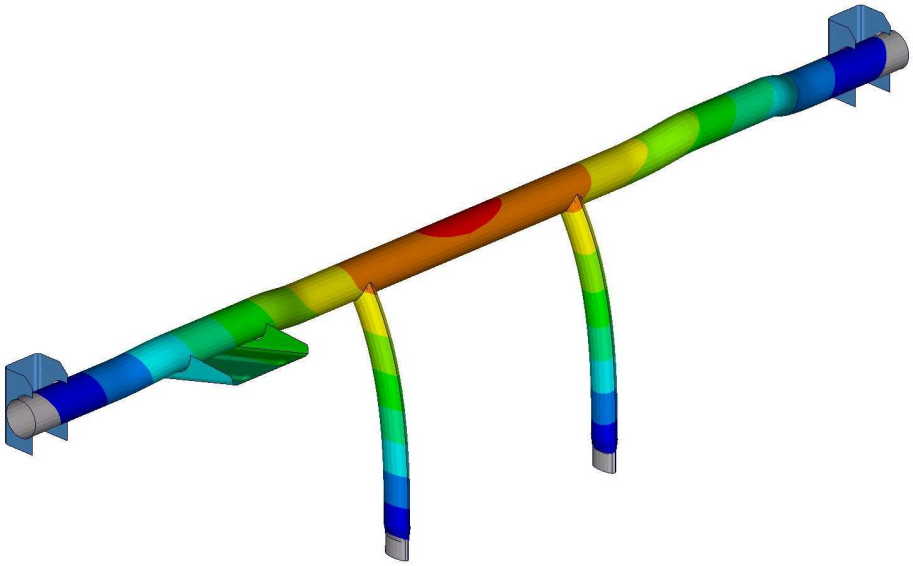
- Flag for linear / nonlinear analysis

- Stiffness of structure of beam
  - Static load in x direction applied at y = 0

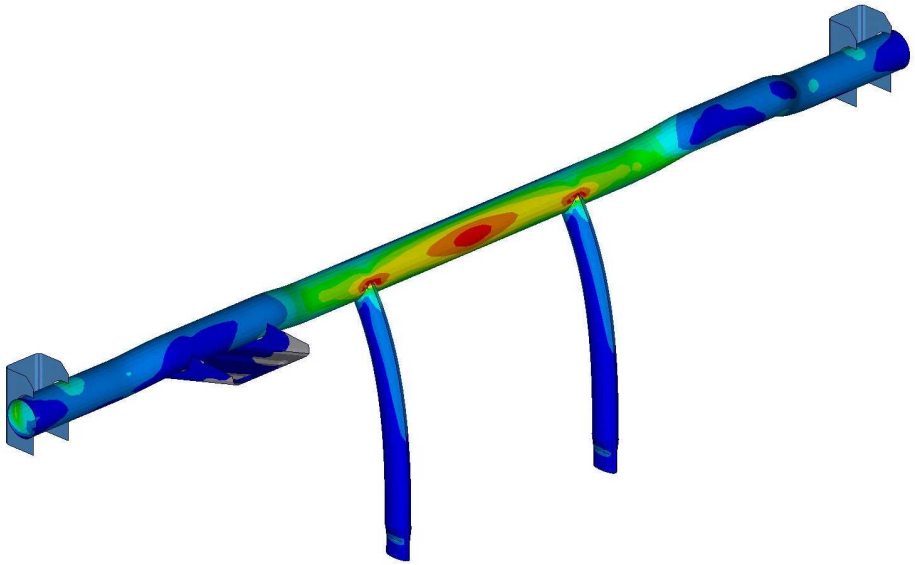


$$\text{Stiffness of structure} = \frac{\text{Force}}{\text{Displacement}}$$

- Stiffness of structure of beam
  - x displacement



van Mises stress



- Eigenfrequency analysis of beam
  - LS-Dyna Control Cards

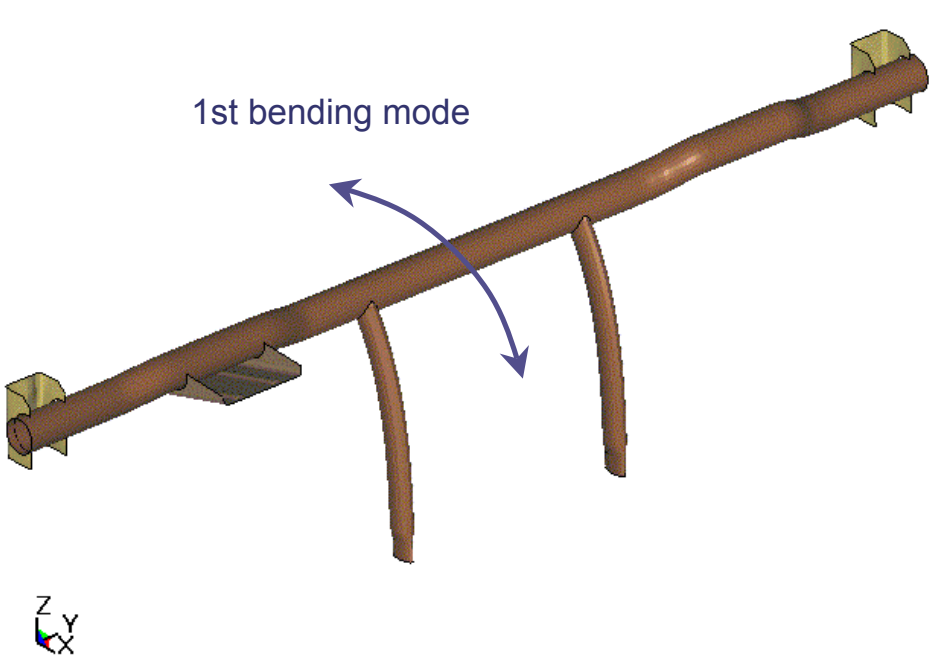
```
$---------------------------------------------------------------------|
*CONTROL_IMPLICIT_GENERAL
$---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|
$   imflag       dt0    imform      nsbs       igs     cnstn      form
        (1)      0.1
$---------------------------------------------------------------------|
```

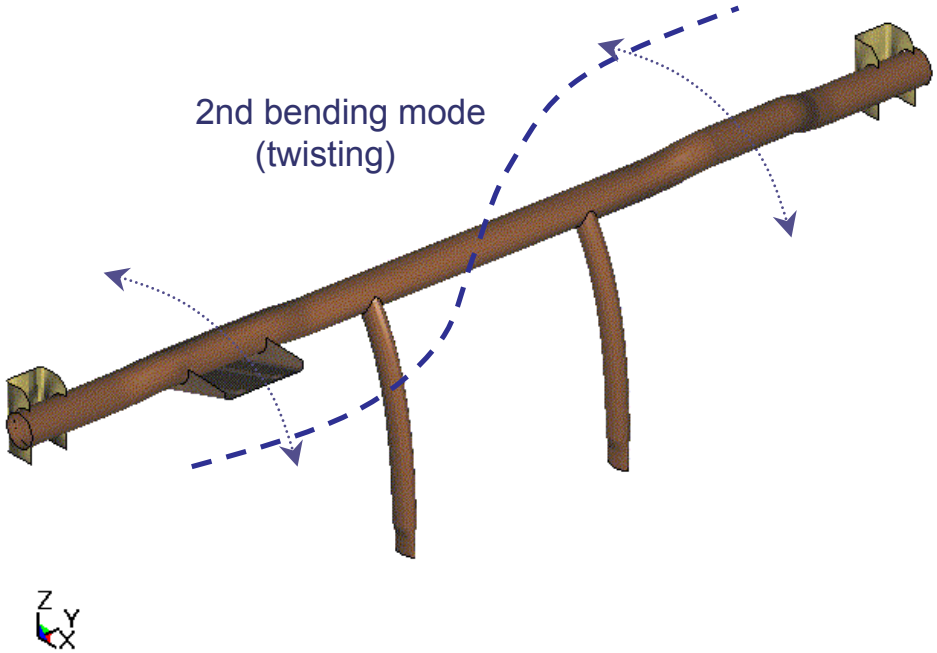
- Flag for Implicit / Explicit

```
$---------------------------------------------------------------------|
*CONTROL_IMPLICIT_EIGENVALUE
$---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|
$     neig    center     lflag    lftend     rflag    rhtend    eigmth    shfscl
        (6)
$---------------------------------------------------------------------|
```

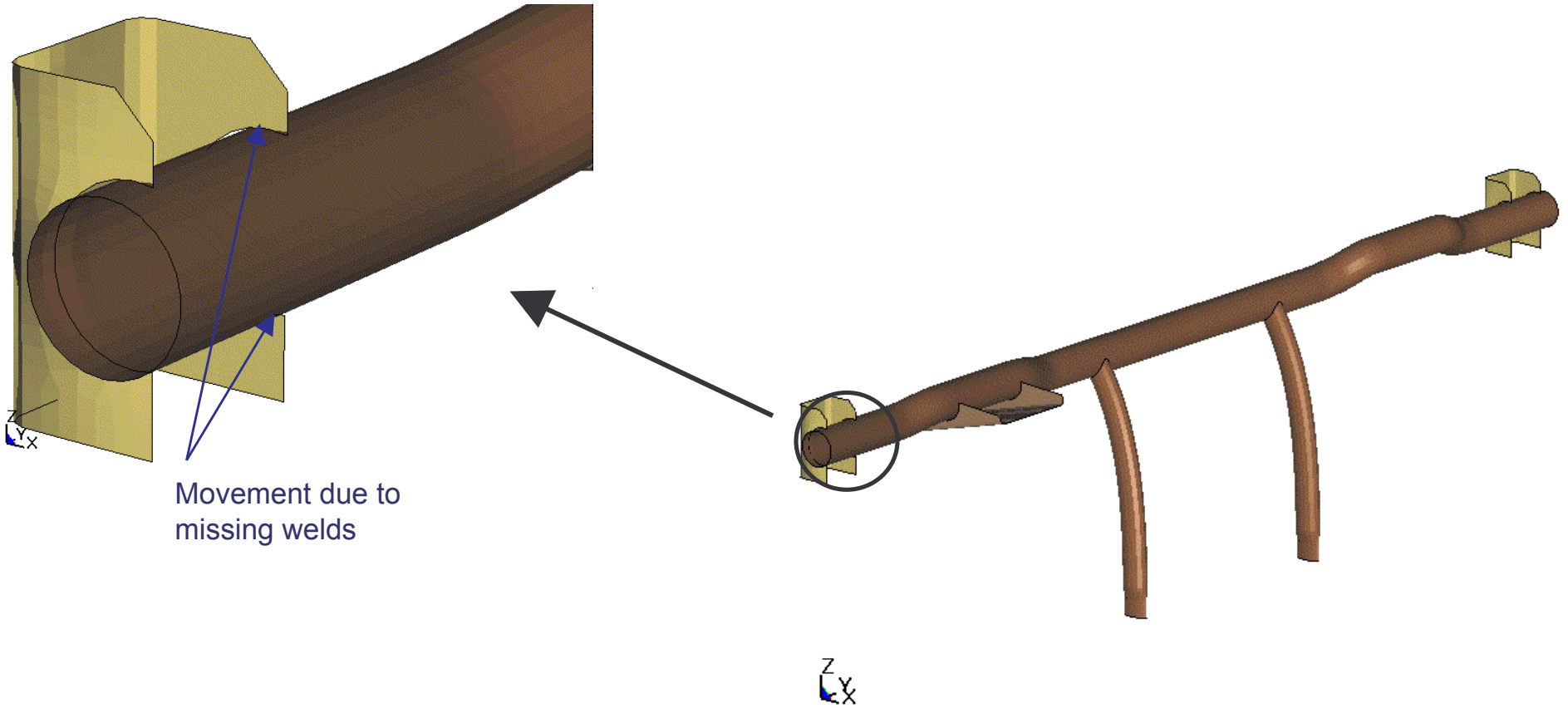
- Number of eigenvalues to calculate

- Eigenfrequency analysis of beam
  - Example of two eigenmodes

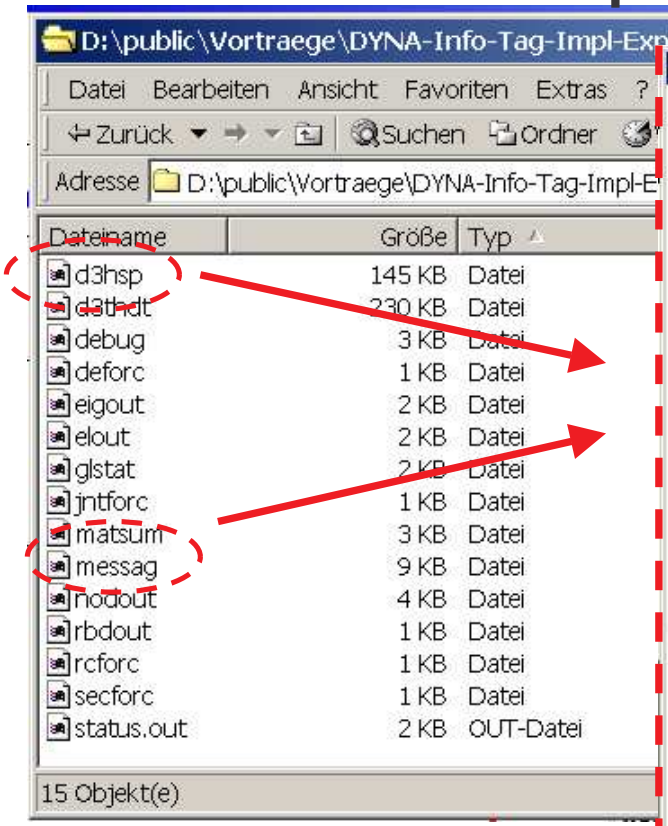




- Eigenfrequency analysis - debugging:
  - Helps to find deficient connections



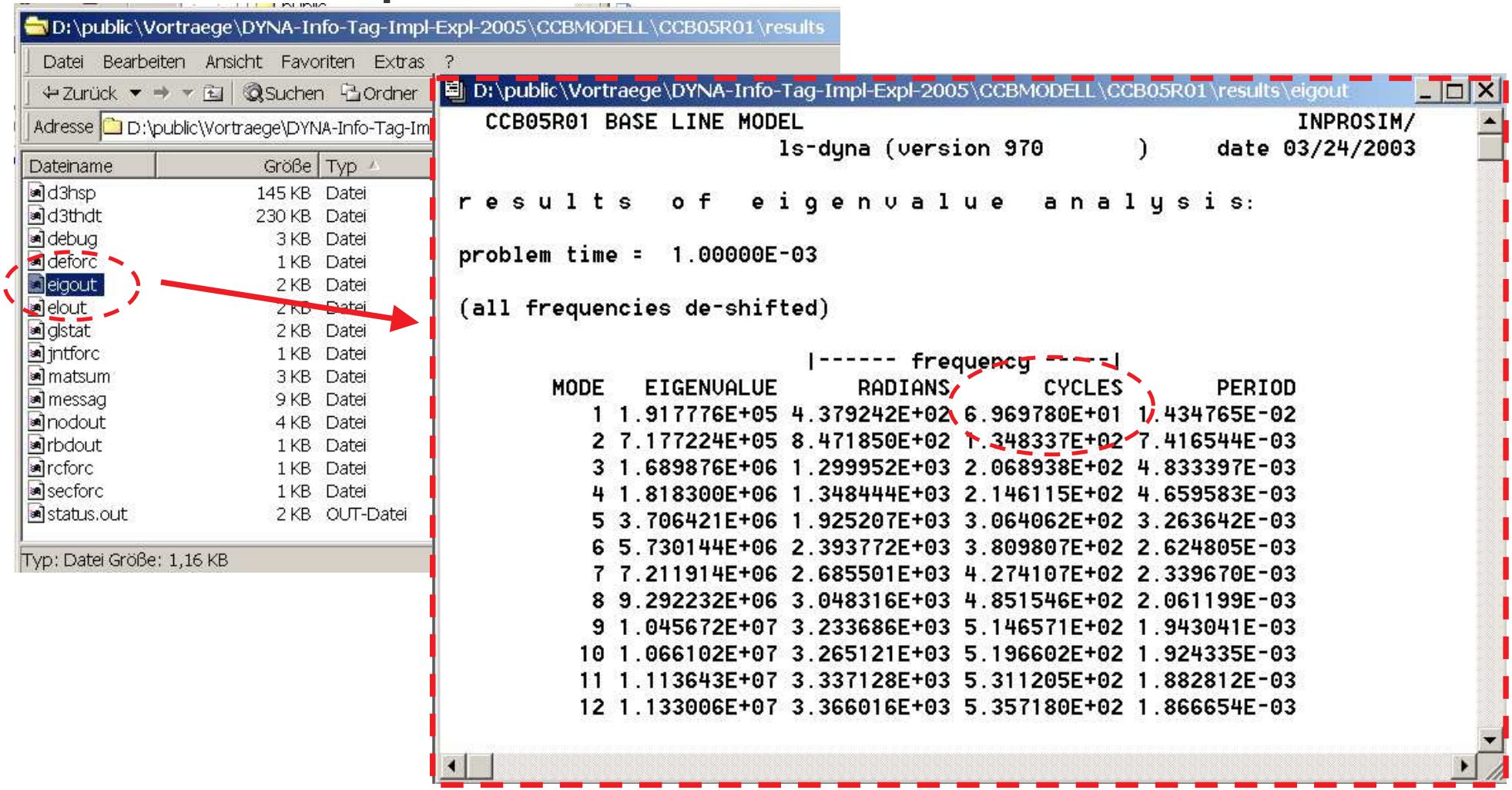
- Control Output



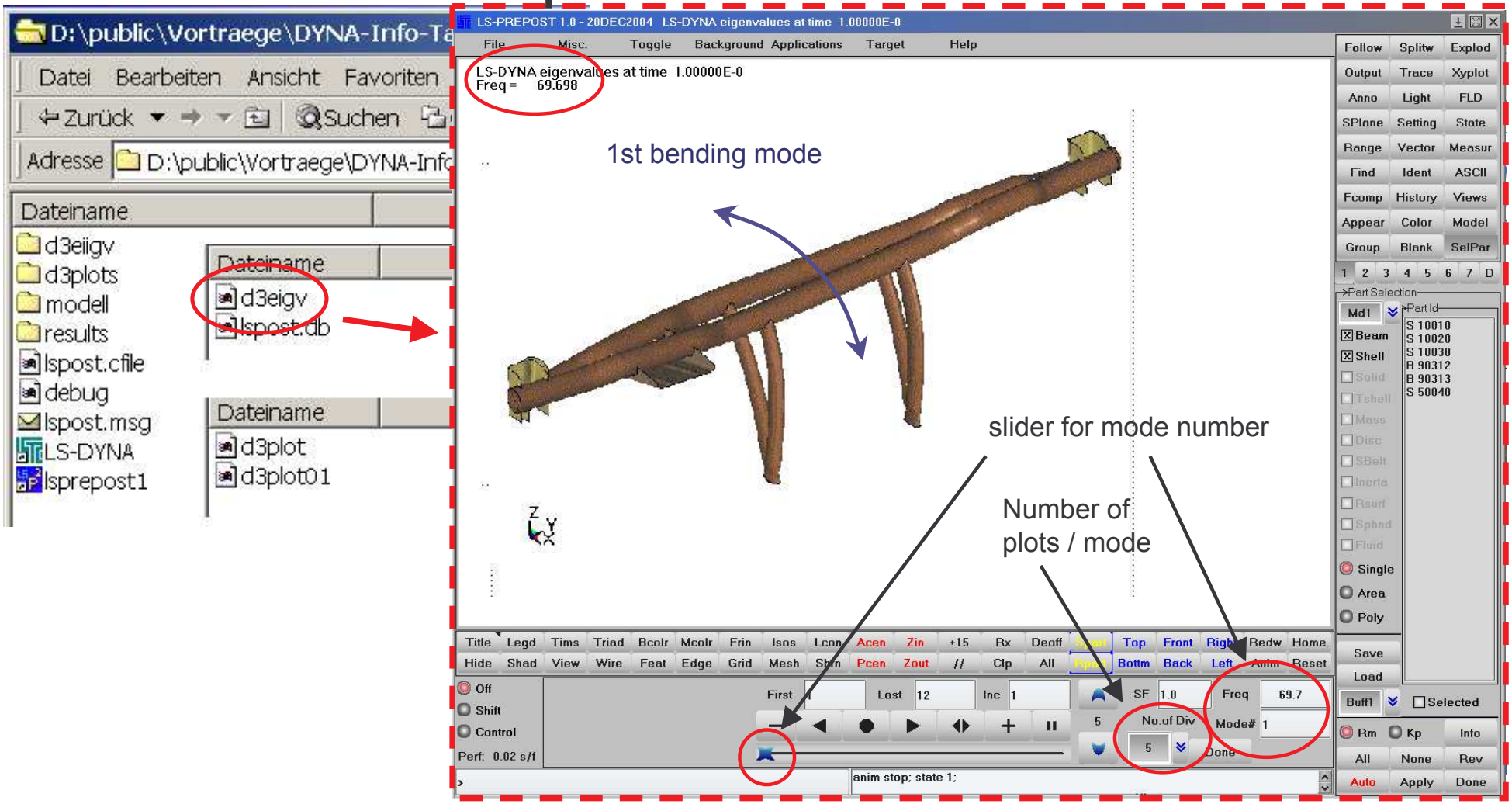
D:\public\Vortraege\DYNA-Info-Tag-Impl-Expl-2005\CCBMODELL\CCB05R01\results\messag

```
 IMPLICIT RIGID BODY mass data
 ============================================================
   material ID    nodes       mass          x-cm          y-cm          z-cm
   -----------    -----    ----------    ----------    ----------    ----------
      50040          18    1.9872E-06   7.5333E+02 -5.1192E-05   5.6748E+02
       3938          12    1.9244E-06   6.4900E+02   7.2463E+02   7.1919E+02
       3939          12    1.8567E-06   6.4900E+02   7.2511E+02   6.2060E+02
       3940          10    1.7764E-06   6.4900E+02  -7.2369E+02   7.1932E+02
       3941          11    1.8316E-06   6.4900E+02  -7.2507E+02   6.2058E+02
       3942          13    5.9552E-06   9.7245E+02  -1.4690E+02   3.6178E+02
       3943          13    5.9372E-06   9.7245E+02   1.4690E+02   3.6177E+02
       0 t 0.0000E+00 dt 0.00E+00 flush i/o buffers
       1 t 0.0000E+00 dt 1.00E-03 flush i/o buffers
       1 t 0.0000E+00 dt 1.00E-03 write d3plot file

 BEGIN implicit time step       1
 ============================================================
                  time =   1.00000E-03
    current step size =   1.00000E-03
expanding    memory to      1197401

 Check on unconstrained mass seen by Lanczos solver:
 nodal mass = 4.7695E-03 rigid mass = 1.9282E-05 total mass = 4.7888E-03
expanding    memory to      3943112
expanding    memory to      8736520
expanding    memory to     22870470

  Eigenvalue ascii file "eigout" created at problem time =   1.00000E-03
  Eigenvalue  plot file (d3eigv) created at problem time =   1.00000E-03

       3 t 1.0000E-03 dt 5.73E-08 write d3plot file

 N o r m a l    t e r m i n a t i o n
```

- Ascii Output



- Animation Output



- Head Impact / Knee Impact
  - LS-Dyna Control Cards

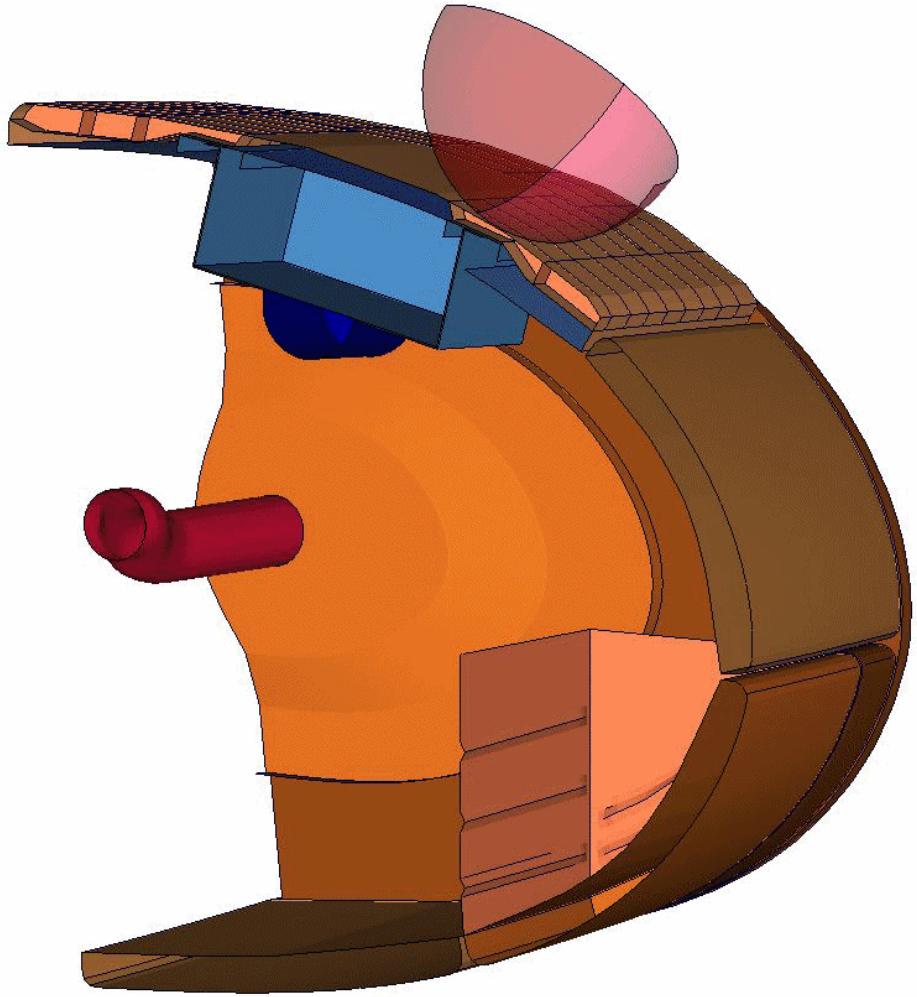
```
$---------------------------------------------------------------------|
*CONTROL_IMPLICIT_GENERAL
$---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|
$   imflag       dt0    imform      nsbs       igs     cnstn      form
         0       0.1
$---------------------------------------------------------------------|
```

- Flag for Implicit / Explicit

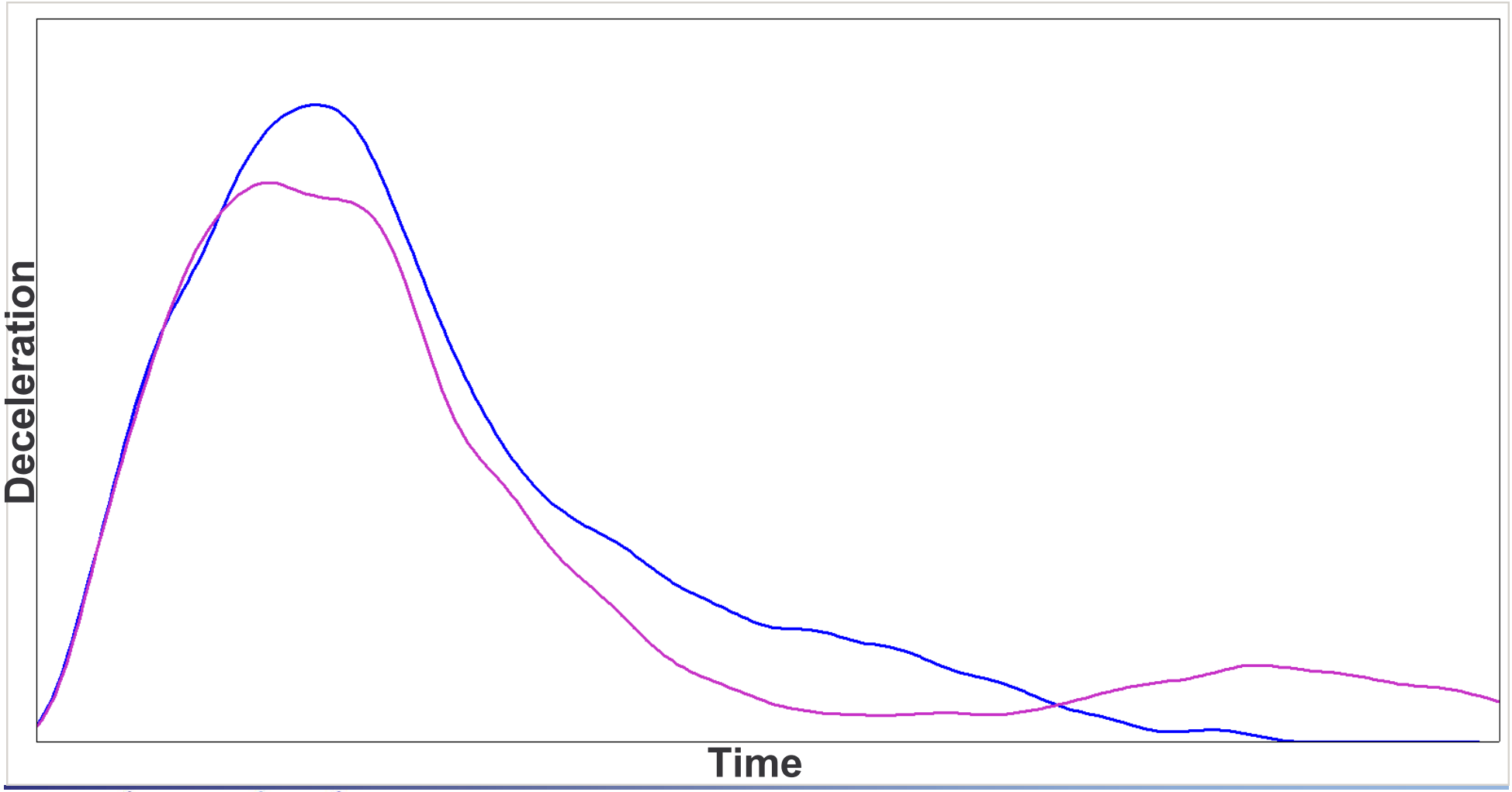
```
$---------------------------------------------------------------------|
*CONTROL_TIMESTEP
$---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|
$   dtinit    tssfac      isdo   tslimit     dt2ms      lctm     erode     msist
              0.90         0      0.00 -0.50E-03         0         0         0
$---------------------------------------------------------------------|
```

- Modulation of time step size

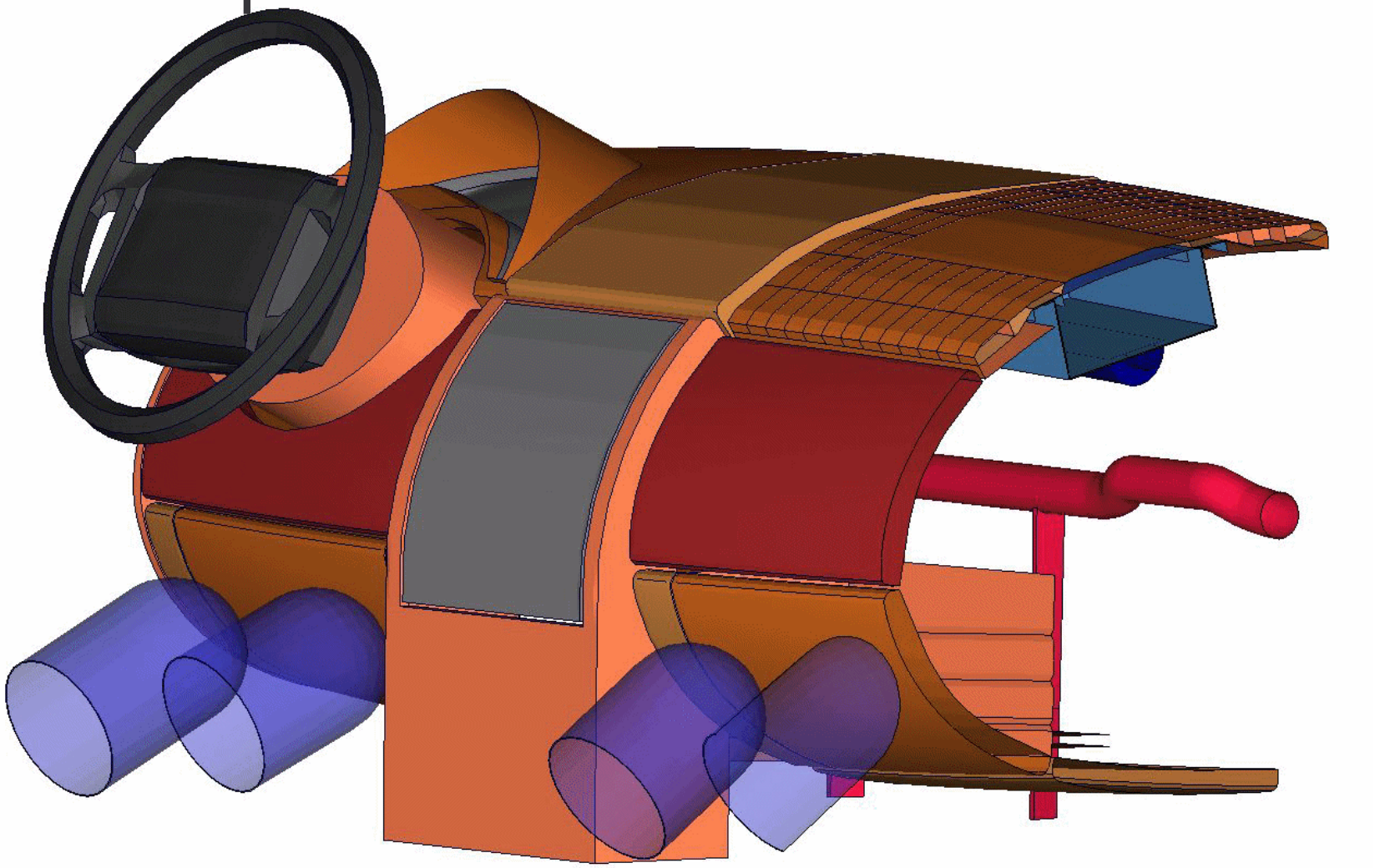
- Head Impact on airbag module



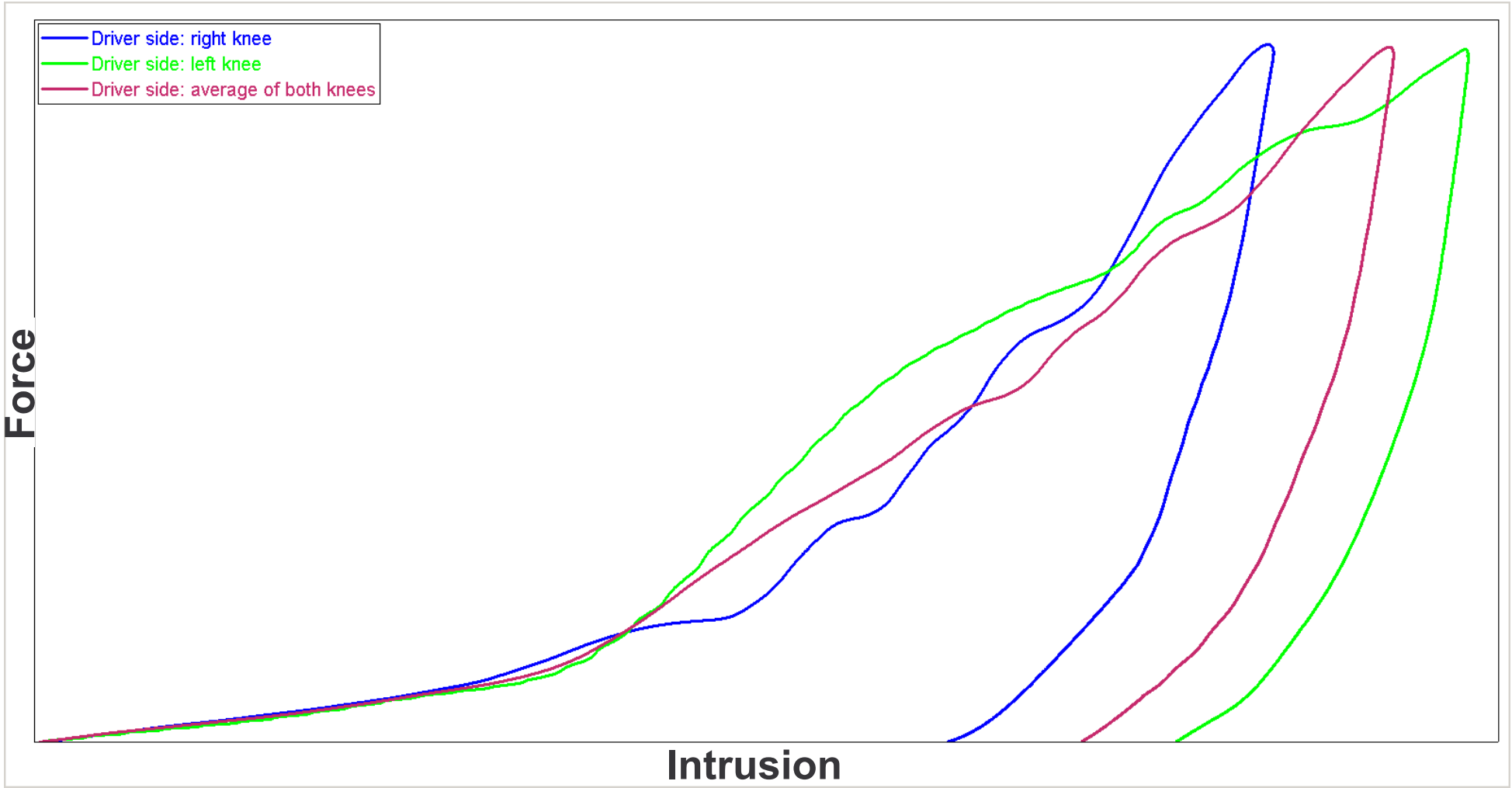
- Deceleration of head impactor



- Knee Impact

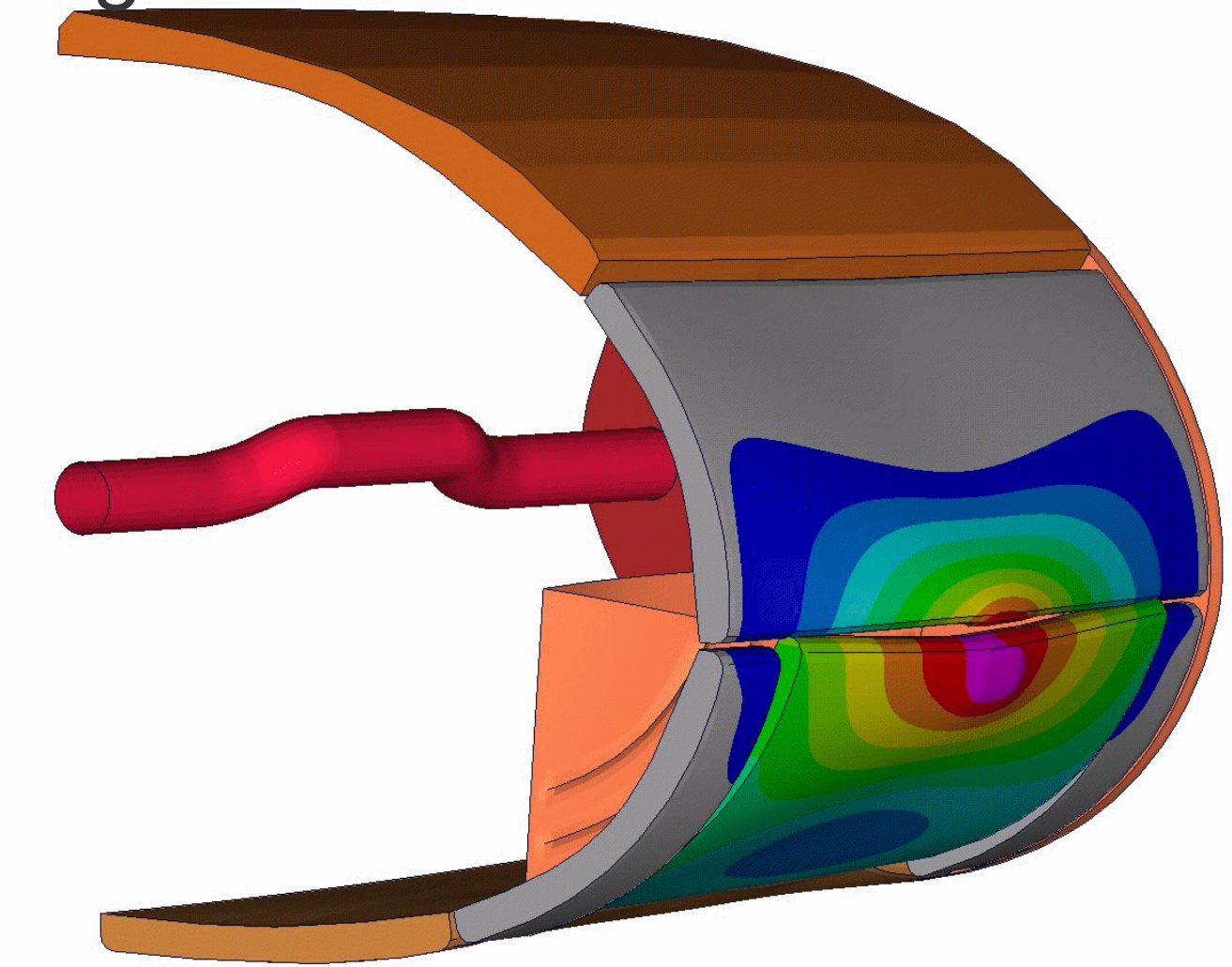


- Forces on driver‘s knees

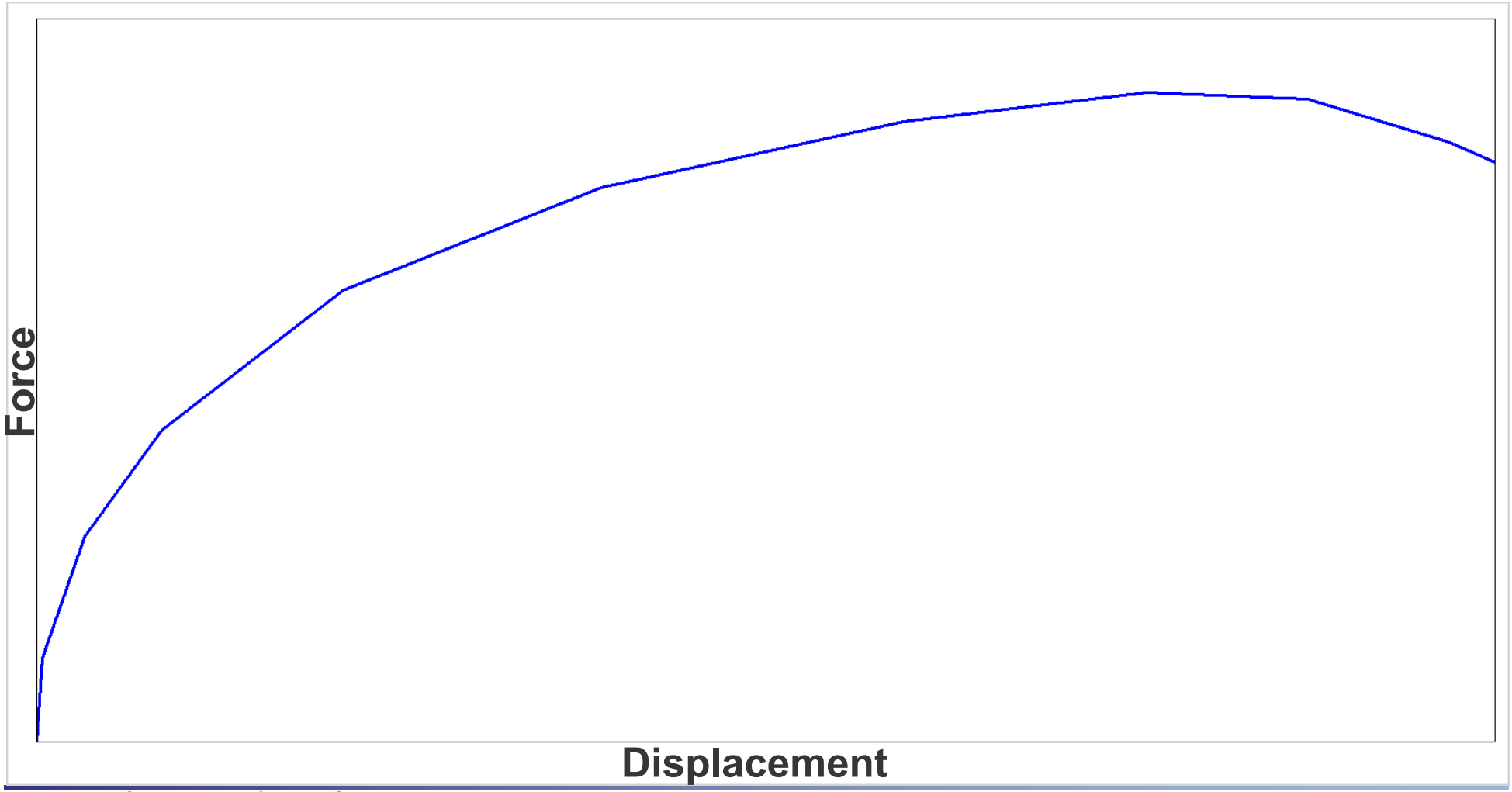


- Forces on passenger‘s knees

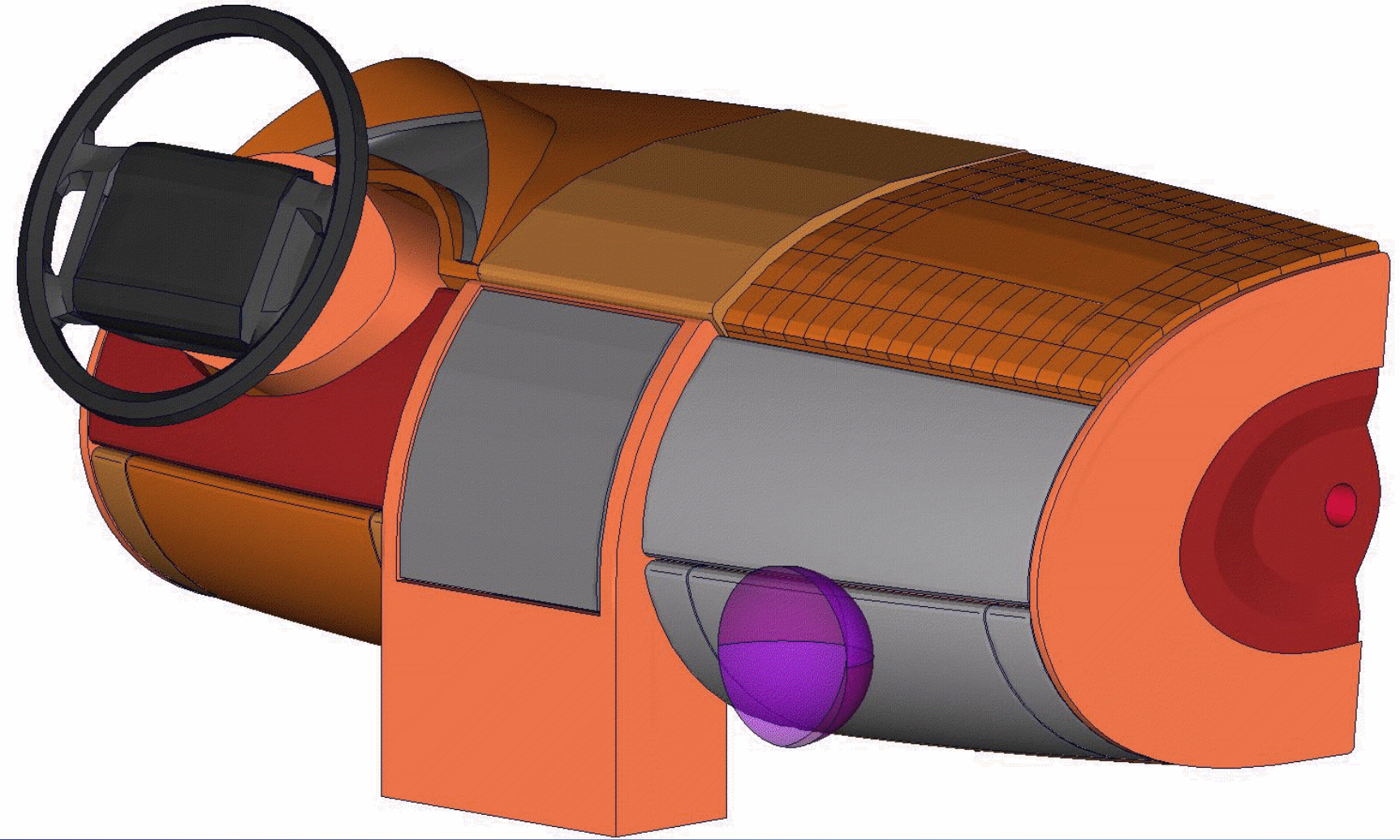
- Handling load



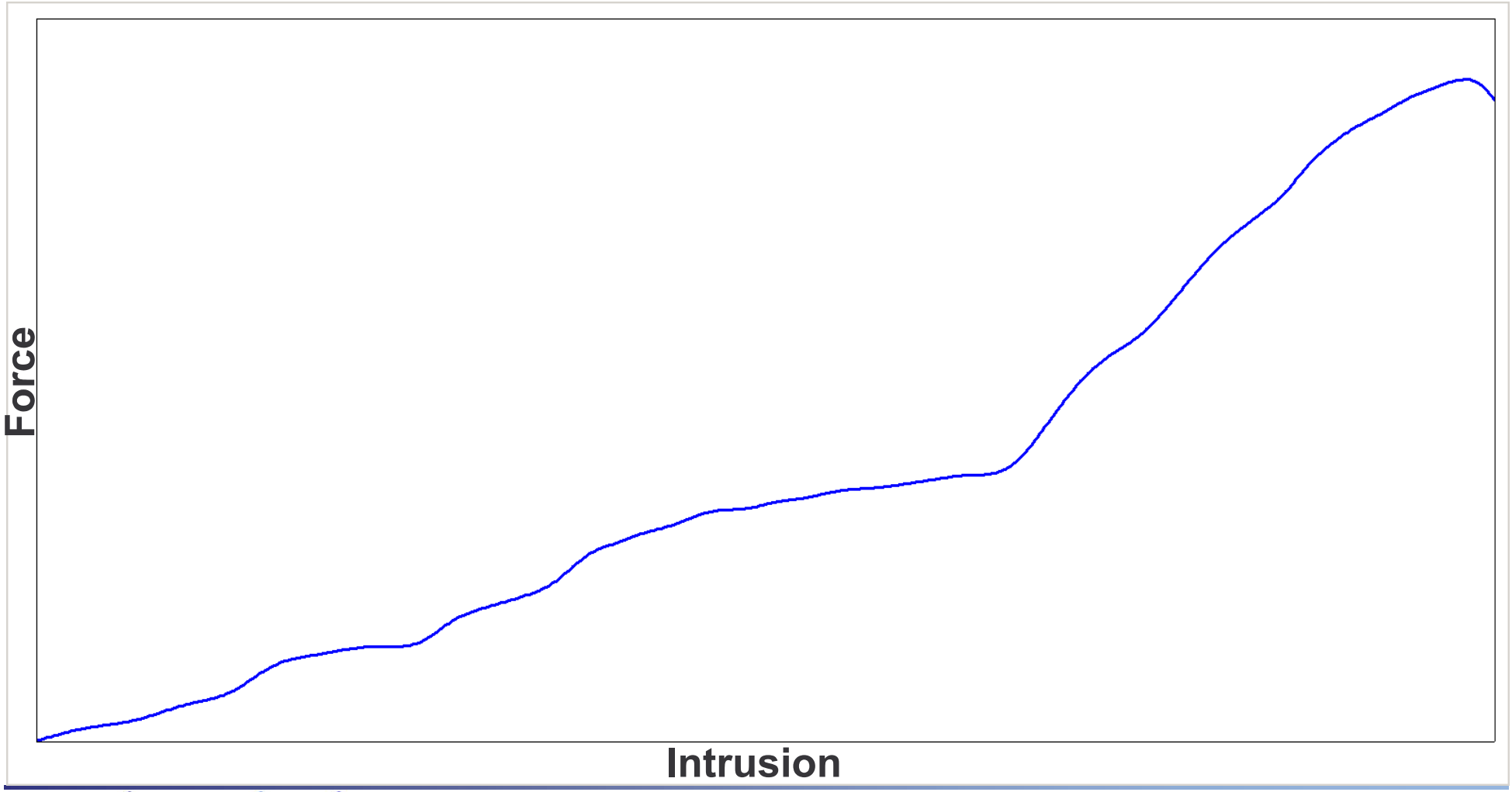
- Handling – stiffness of cockpit



- Misuse load case



- Misuse – stiffness of cockpit



- Limitation
  - Problems with time-consuming load cases, high grade non-linearities and complex contact situations
  - Disadvantage of explicit calculation
    - High duration of calculation due to small timestep size
  - Problems in implicit calculation
    - High grade non-linearities
    - Contact definition
  - Choice of calculation method
    - Dependent of respective load case and model complexity

- Requirement
  - Accomplishment of implicit and explicit analysis
- Implementation
  - Use of one model and one code
    - LS-Dyna Implicit / Explicit
  - Increase in efficiency
  - Limitations
- Forecast
  - Ongoing enhancement of implicit / explicit code

One Code to rule them all,

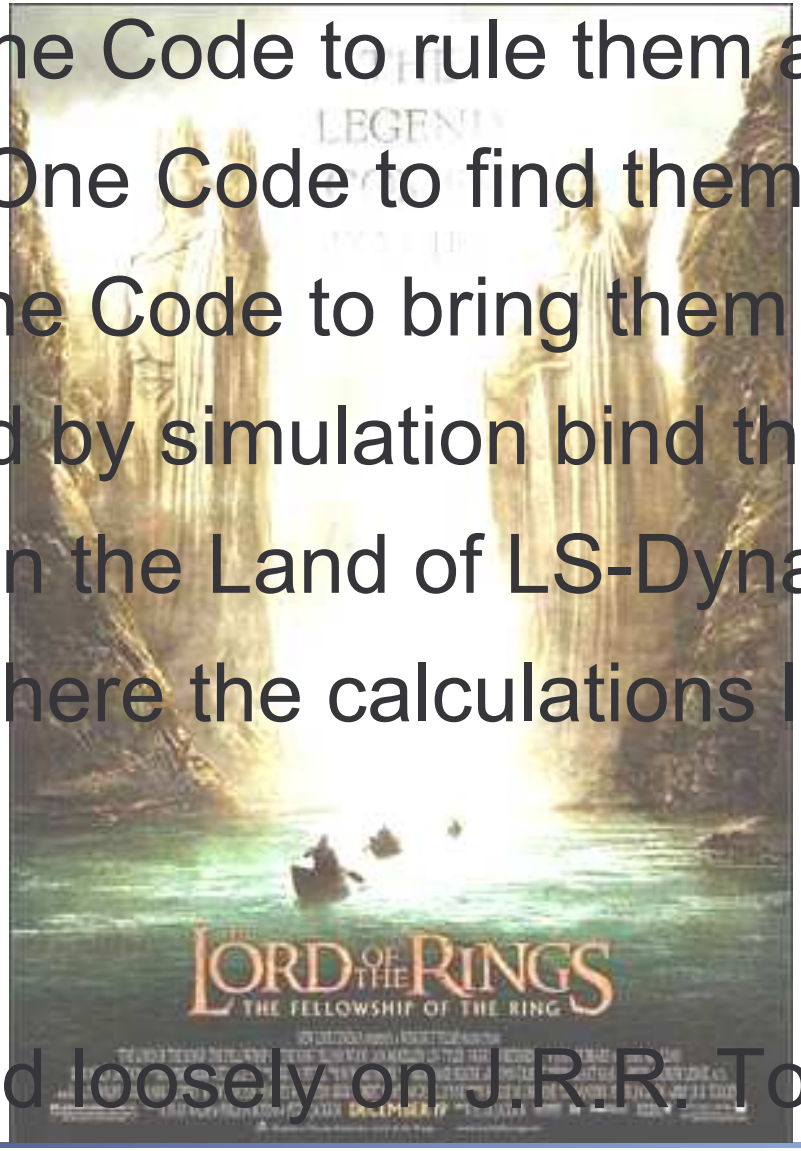
One Code to find them,

One Code to bring them all

and by simulation bind them

In the Land of LS-Dyna

where the calculations lie



based loosely on J.R.R. Tolkien