

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

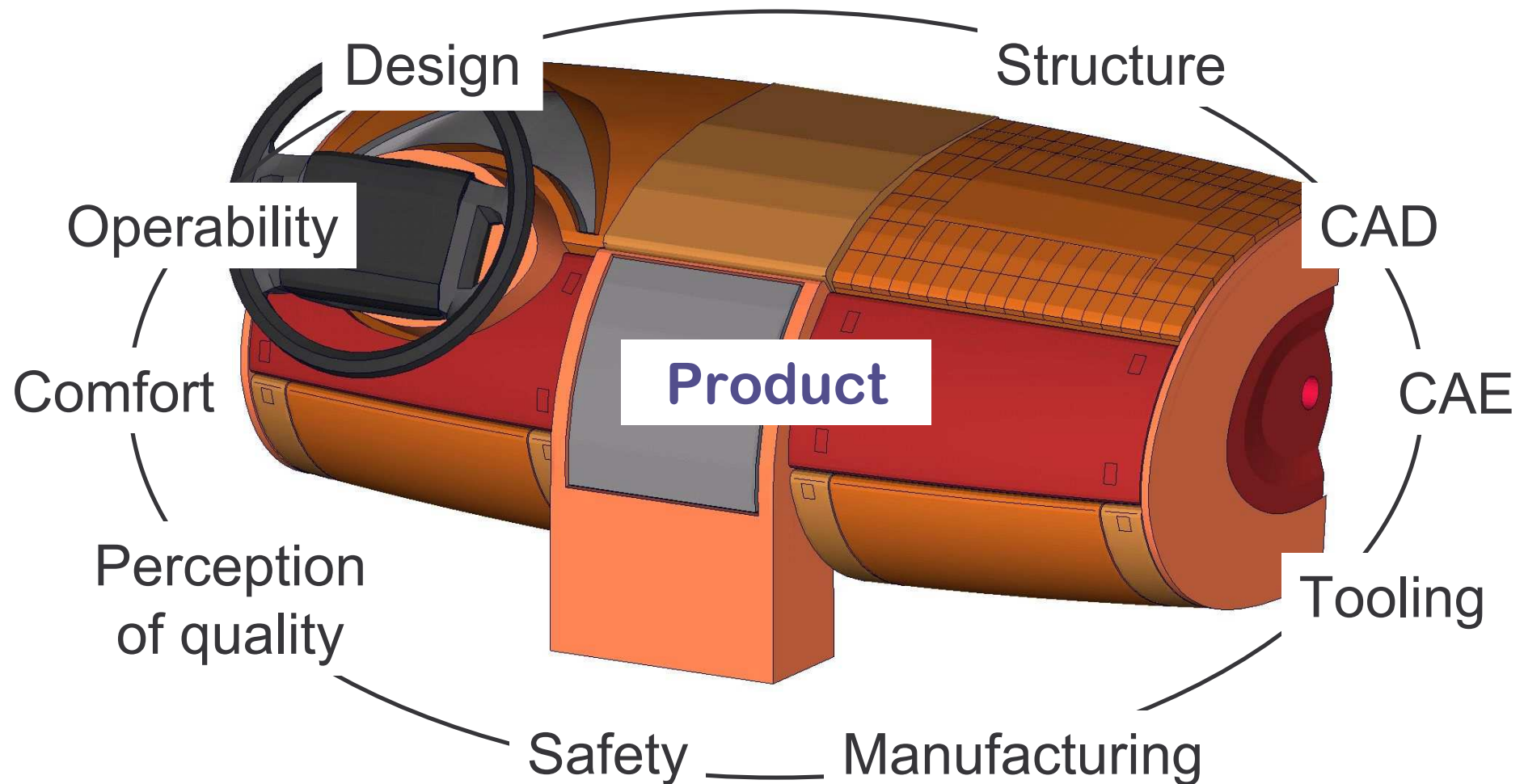
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INPROSIM GmbH, Kriftel

- 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

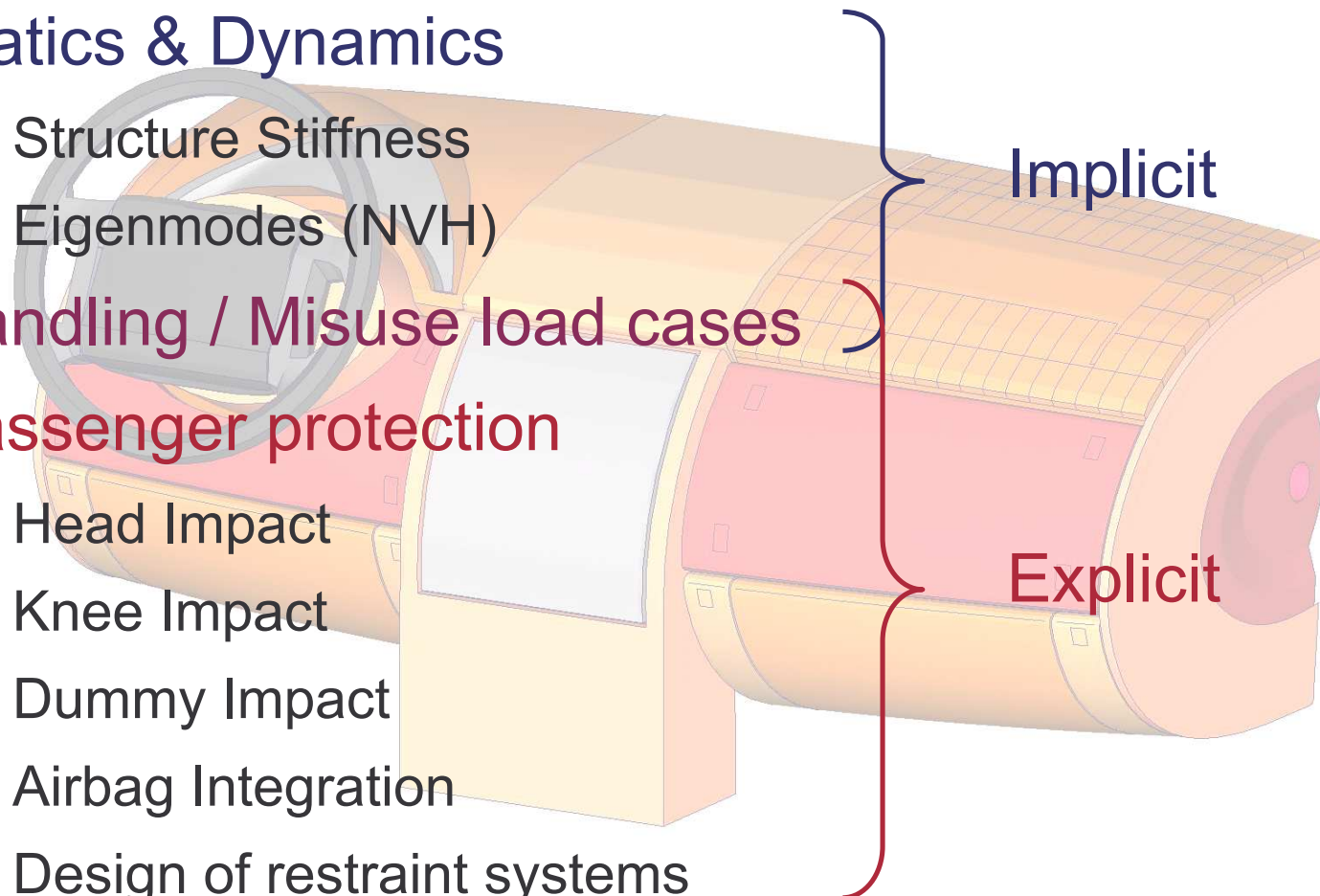
- Statics & Dynamics

- Structure Stiffness
- Eigenmodes (NVH)

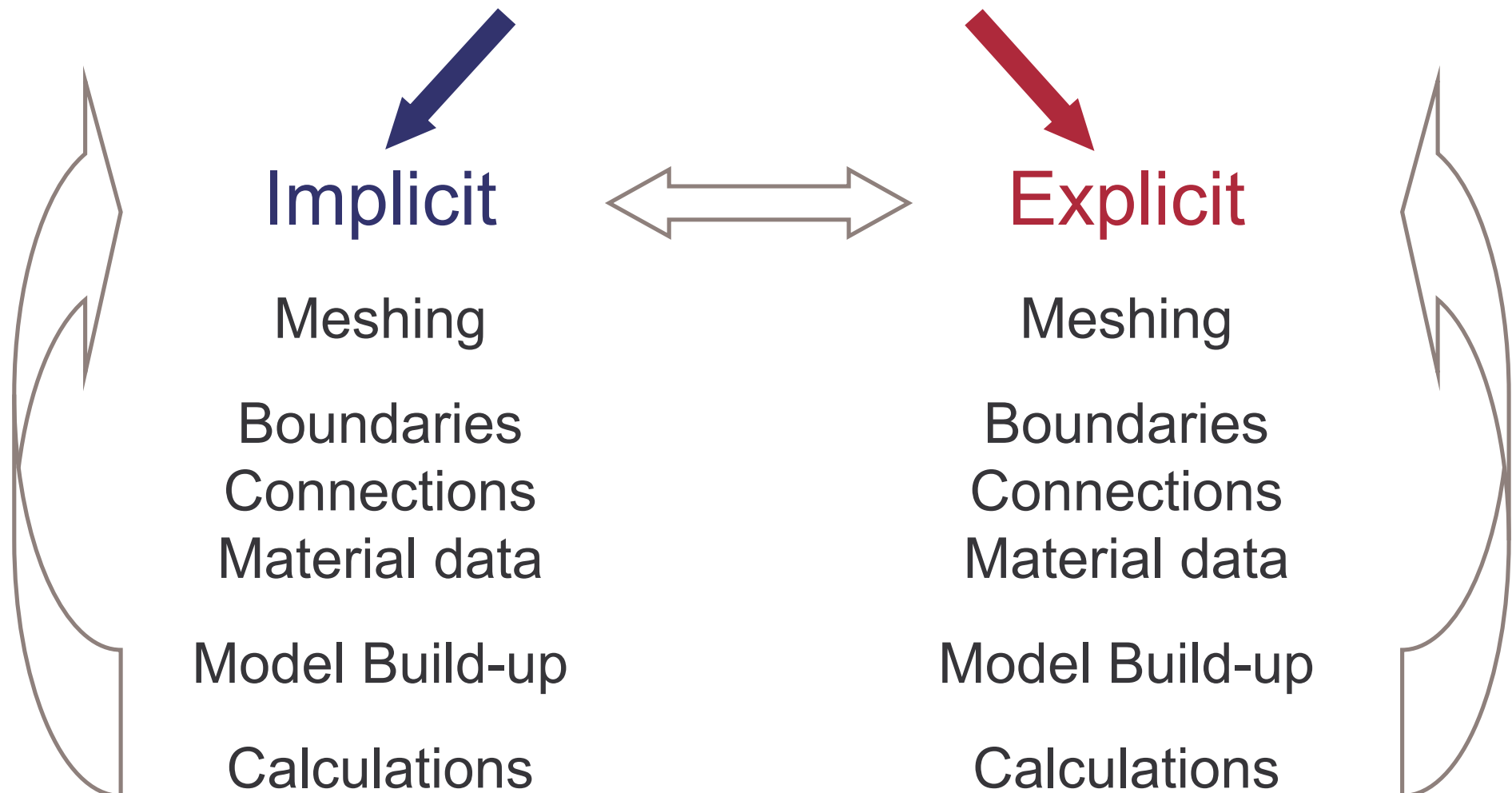
- Handling / Misuse load cases

- 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

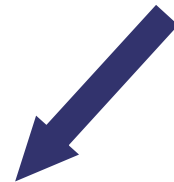
One Mesh

Carry-over of most boundaries

Carry-over of most connections

One material database

One Model Build-up in the same Code



Implicit

Calculations

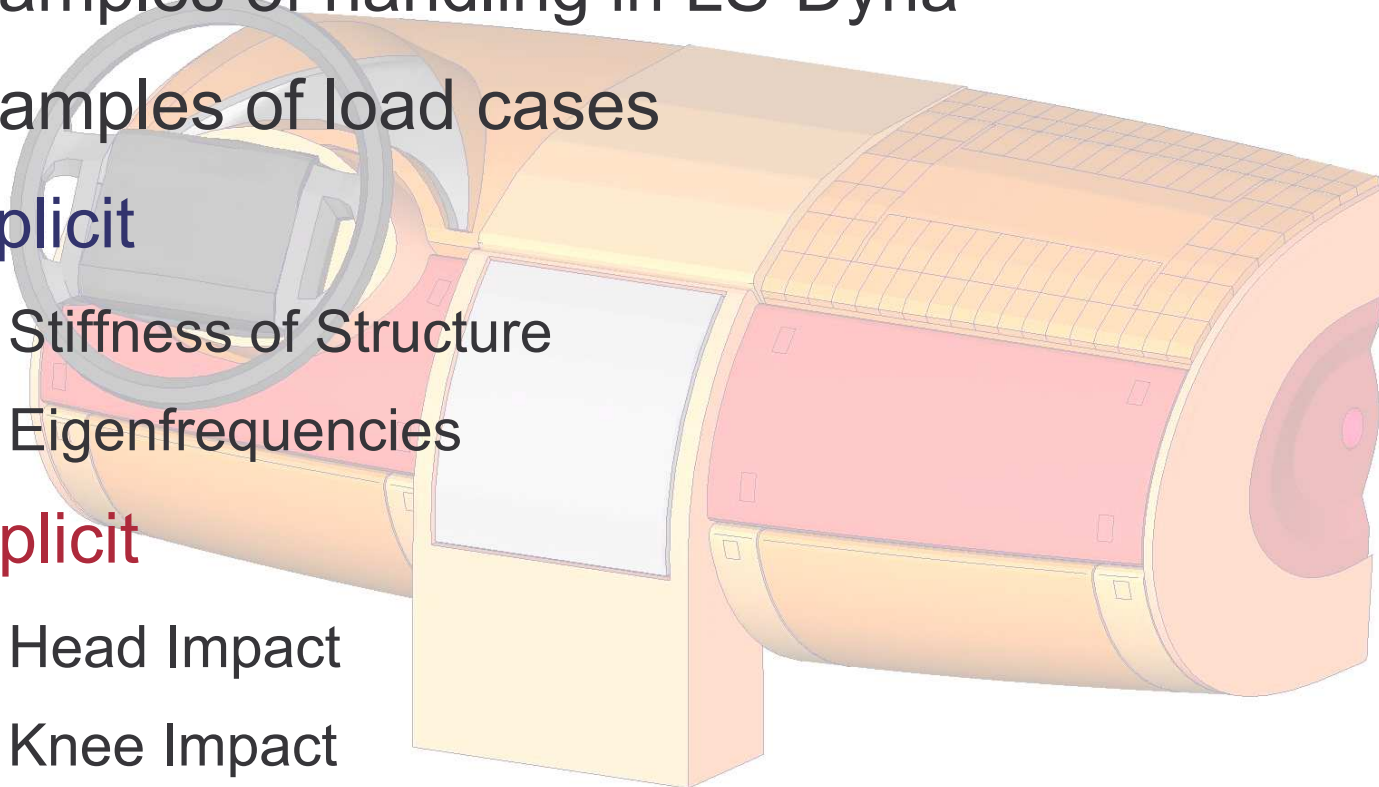


Explicit

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
$-----|
```



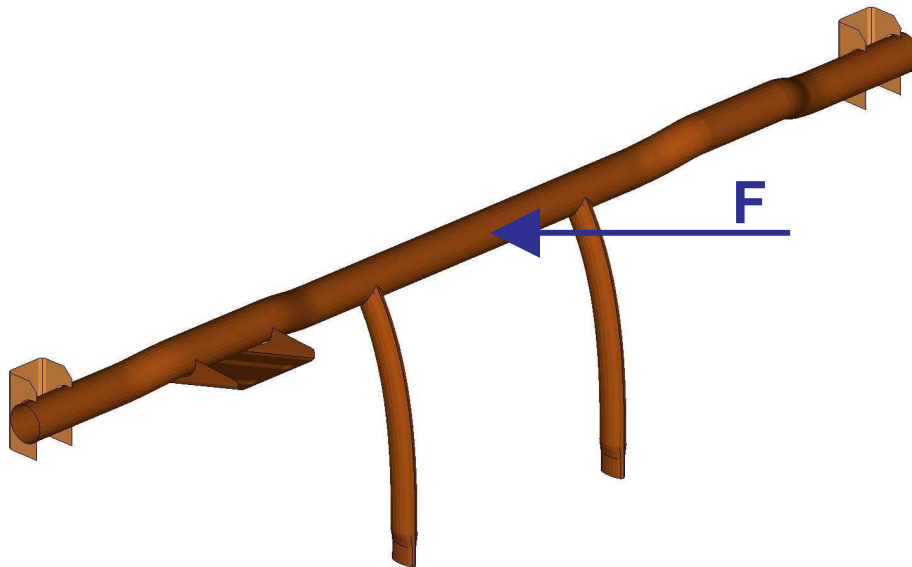
- Flag for Implicit / Explicit

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



- Flag for linear / nonlinear analysis

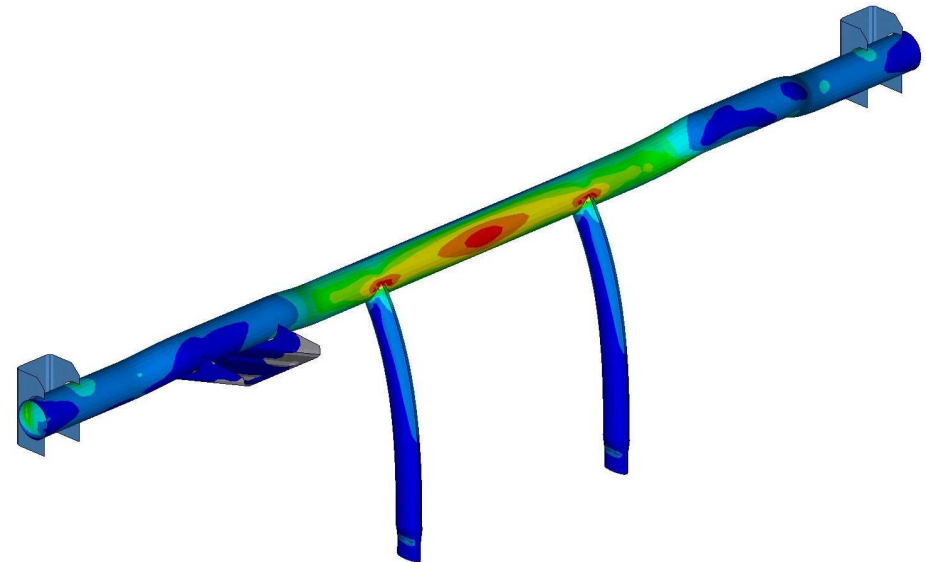
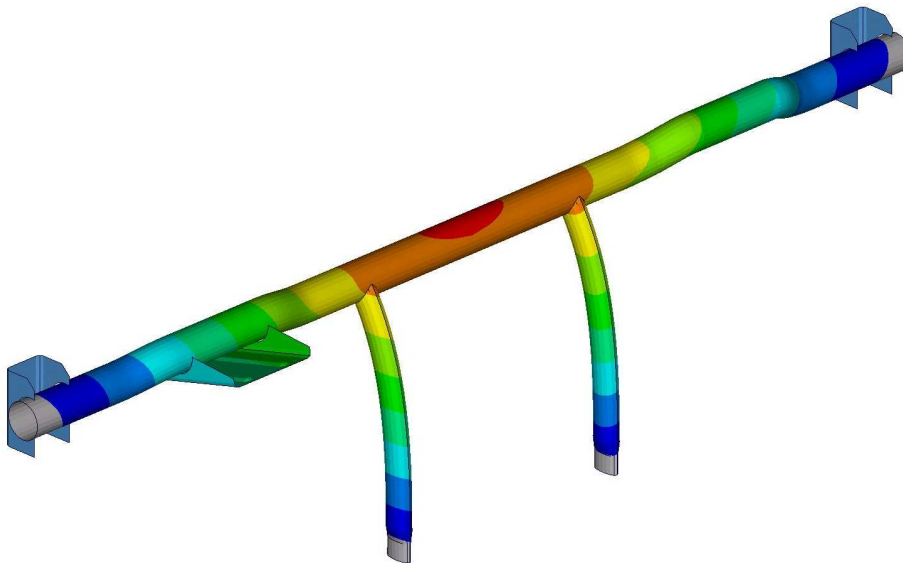
- Stiffness of structure of beam
 - Static load in x direction applied at y = 0



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


- 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
$-----|
```



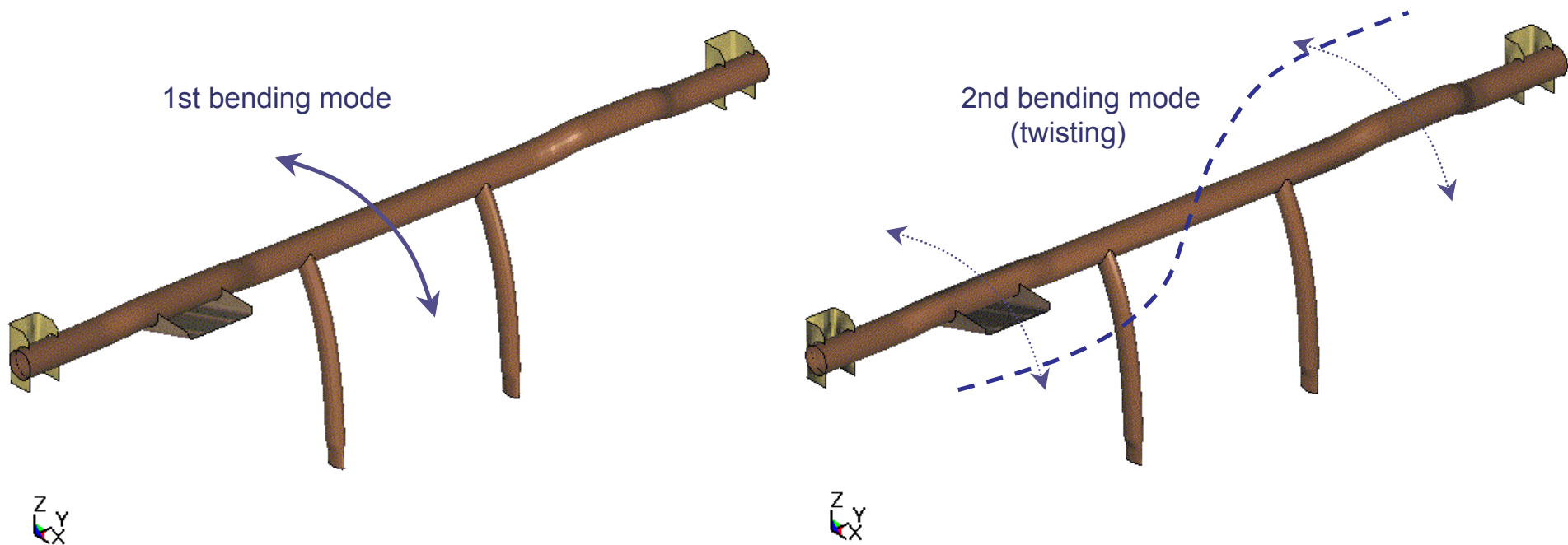
- Flag for Implicit / Explicit

```
$-----|
×CONTROL_IMPLICIT_EIGENVALUE
$--1---|---2---|---3---|---4---|---5---|---6---|---7---|---8---|
$  neig      center      lflag      lftend      rflag      rhtend      eigmth      shfsc1
$          ⑥
$-----|
```

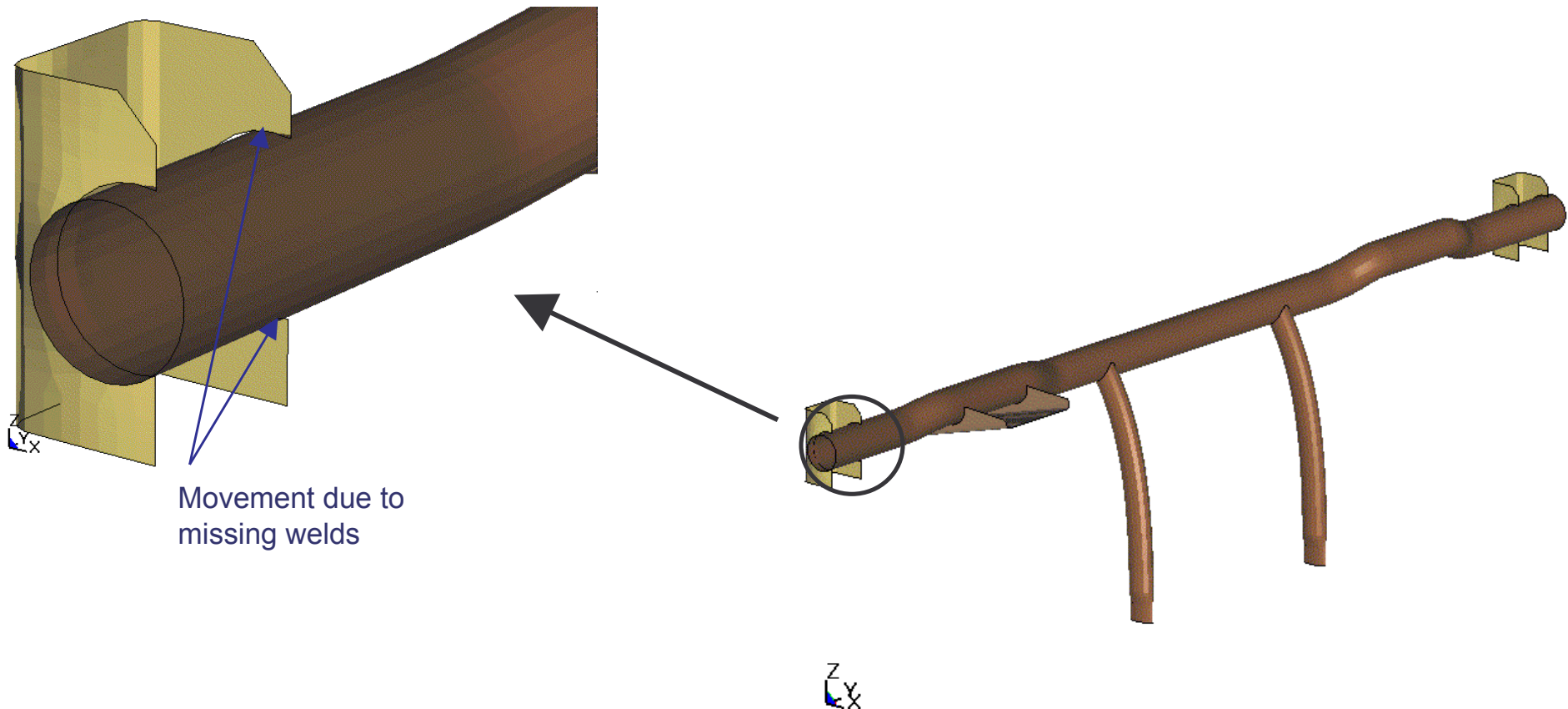


- Number of eigenvalues to calculate

- Eigenfrequency analysis of beam
 - Example of two eigenmodes



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



- Control Output

The screenshot shows a Windows Explorer window on the left and a text editor window on the right. The Explorer window displays a directory of files, with 'd3hsp', 'd3tndt', and 'matsum' circled in red. Red arrows point from these files to the corresponding sections in the text editor. The text editor window shows the output of an implicit rigid body mass calculation, including a table of material properties and time step details.

IMPPLICIT 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

The screenshot shows a Windows file explorer window on the left and a text editor window on the right. The file explorer shows a directory listing with files like d3hsp, d3thdt, debug, deforc, eigout, elout, glstat, jntforc, matsum, messag, nodout, rbdout, rcforc, secforc, and status.out. The file 'eigout' is highlighted with a red dashed circle and a red arrow pointing to the text editor. The text editor window displays the output of an eigenvalue analysis for 'CCB05R01 BASE LINE MODEL' using 'ls-dyna (version 970)'. The output includes the problem time and a table of results for 12 modes, with columns for MODE, EIGENVALUE, RADIANS, CYCLES, and PERIOD. The 'CYCLES' column for mode 2 is highlighted with a red dashed circle.

```
CCB05R01 BASE LINE MODEL                                INPROSIM/
ls-dyna (version 970)                                   date 03/24/2003

r e s u l t s   o f   e i g e n v a l u e   a n a l y s i s :

problem time = 1.00000E-03

(all frequencies de-shifted)

|----- frequency -----|
MODE  EIGENVALUE    RADIANS    CYCLES    PERIOD
  1  1.917776E+05  4.379242E+02  6.969780E+01  1.434765E-02
  2  7.177224E+05  8.471850E+02  1.348337E+02  7.416544E-03
  3  1.689876E+06  1.299952E+03  2.068938E+02  4.833397E-03
  4  1.818300E+06  1.348444E+03  2.146115E+02  4.659583E-03
  5  3.706421E+06  1.925207E+03  3.064062E+02  3.263642E-03
  6  5.730144E+06  2.393772E+03  3.809807E+02  2.624805E-03
  7  7.211914E+06  2.685501E+03  4.274107E+02  2.339670E-03
  8  9.292232E+06  3.048316E+03  4.851546E+02  2.061199E-03
  9  1.045672E+07  3.233686E+03  5.146571E+02  1.943041E-03
 10  1.066102E+07  3.265121E+03  5.196602E+02  1.924335E-03
 11  1.113643E+07  3.337128E+03  5.311205E+02  1.882812E-03
 12  1.133006E+07  3.366016E+03  5.357180E+02  1.866654E-03
```

- Animation Output

LS-DYNA eigenvalues at time 1.00000E-0
Freq = 69.698

1st bending mode

slider for mode number

Number of plots / mode

LS-DYNA PREPOST 1.0 - 20DEC2004 LS-DYNA eigenvalues at time 1.00000E-0

File Misc. Toggle Background Applications Target Help

Datei Bearbeiten Ansicht Favoriten

Zurück Suchen

Adresse D:\public\Vortraege\DYNA-Info

Dateiname

- d3eigv
- d3plots
- modell
- results
- lspost.cfile
- debug
- lspost.msg
- LS-DYNA
- lsprepost1

Dateiname

- d3eigv
- lspost.db

Dateiname

- d3plot
- d3plot01

Follow Splitw Explod

Output Trace Xyplot

Anno Light FLD

SPlane Setting State

Range Vector Measur

Find Ident ASCII

Fcomp History Views

Appear Color Model

Group Blank SelPar

1 2 3 4 5 6 7 D

Part Selection

Md1 Part Id

- S 10010
- S 10020
- S 10030
- B 90312
- B 90313
- S 50040

Beam

Shell

Solid

Tshell

Mass

Disc

SBeit

Inerta

Rsur

Sphnd

Fluid

Single

Area

Poly

Save

Load

Buff1 Selected

Rm Kp Info

All None Rev

Auto Apply Done

Title Legd Tims Triad Bcolr Mcolr Frin Isos Lcon Acen Zin +15 Rx Deoff Top Front Right Redw Home

Hide Shad View Wire Feat Edge Grid Mesh Stn Pcen Zout // Clp All Bottom Back Left Anim Reset

Off

Shift


Control

Perf: 0.02 s/f

anim stop; state 1:

- 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
$-----|
```

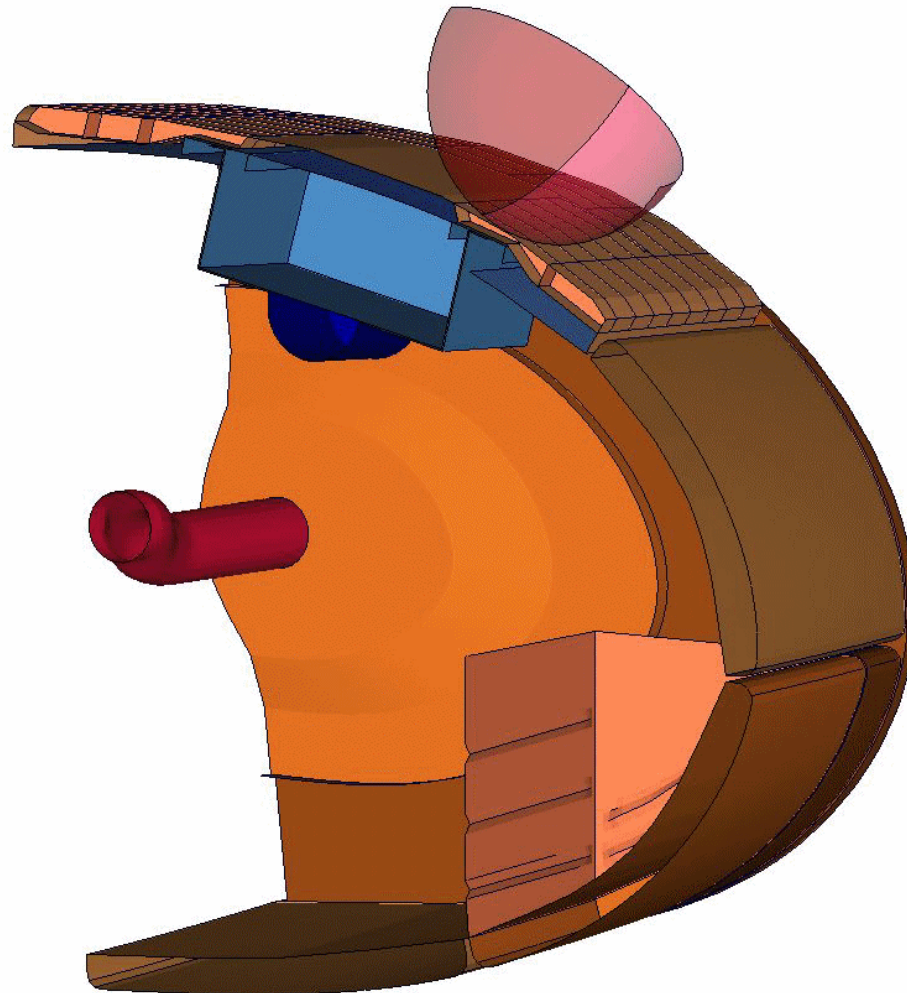


- Flag for Implicit / Explicit

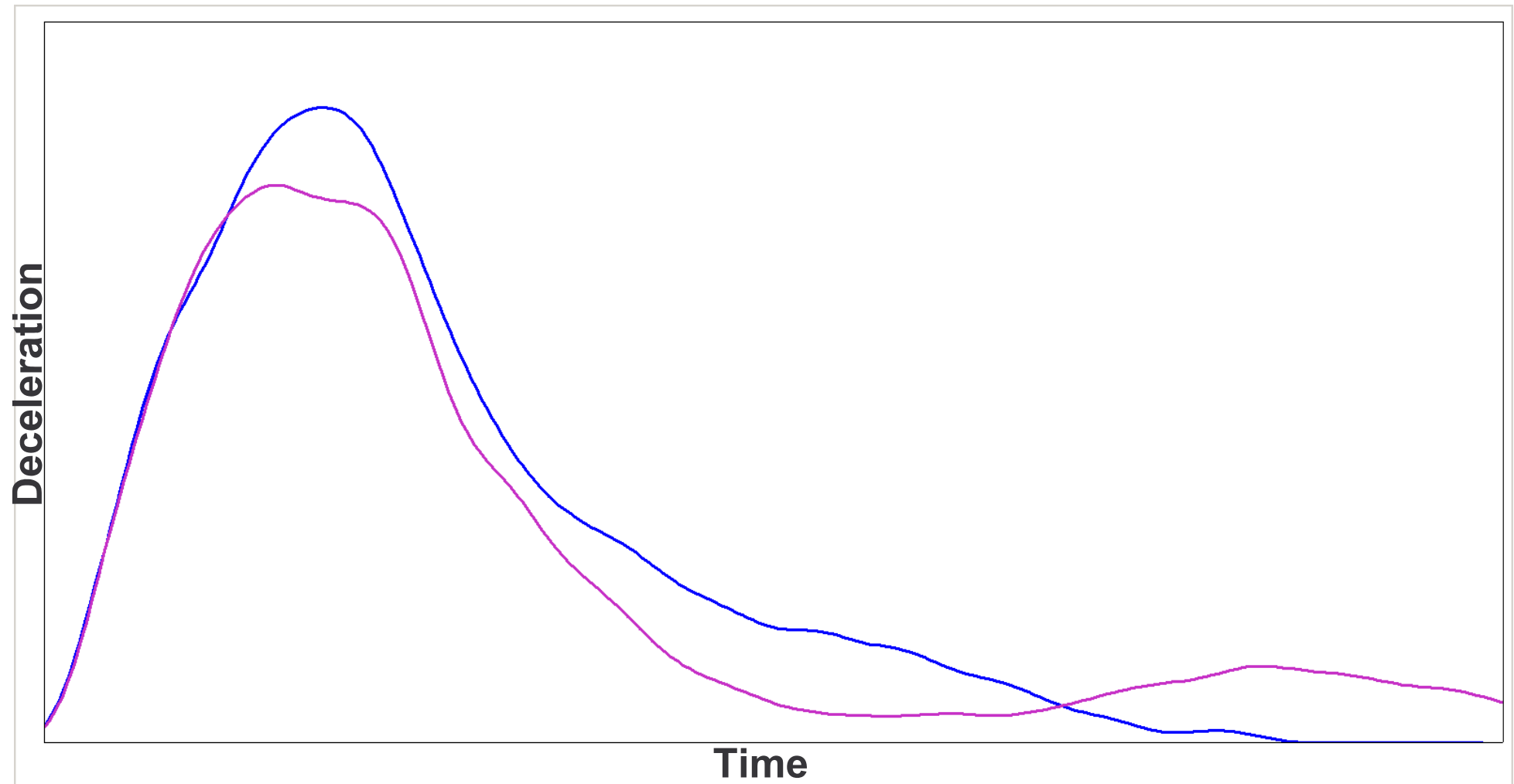
```
$-----|
*CONTROL_TIMESTEP
$--1---|---2---|---3---|---4---|---5---|---6---|---7---|---8---|
$  dtinit      tssfacs      isdo      tslimit      dt2ms      lctm      erode      msist
$           0.90           0           0.00 -0.50E-03           0           0           0
$-----|
```

- Modulation of time step size

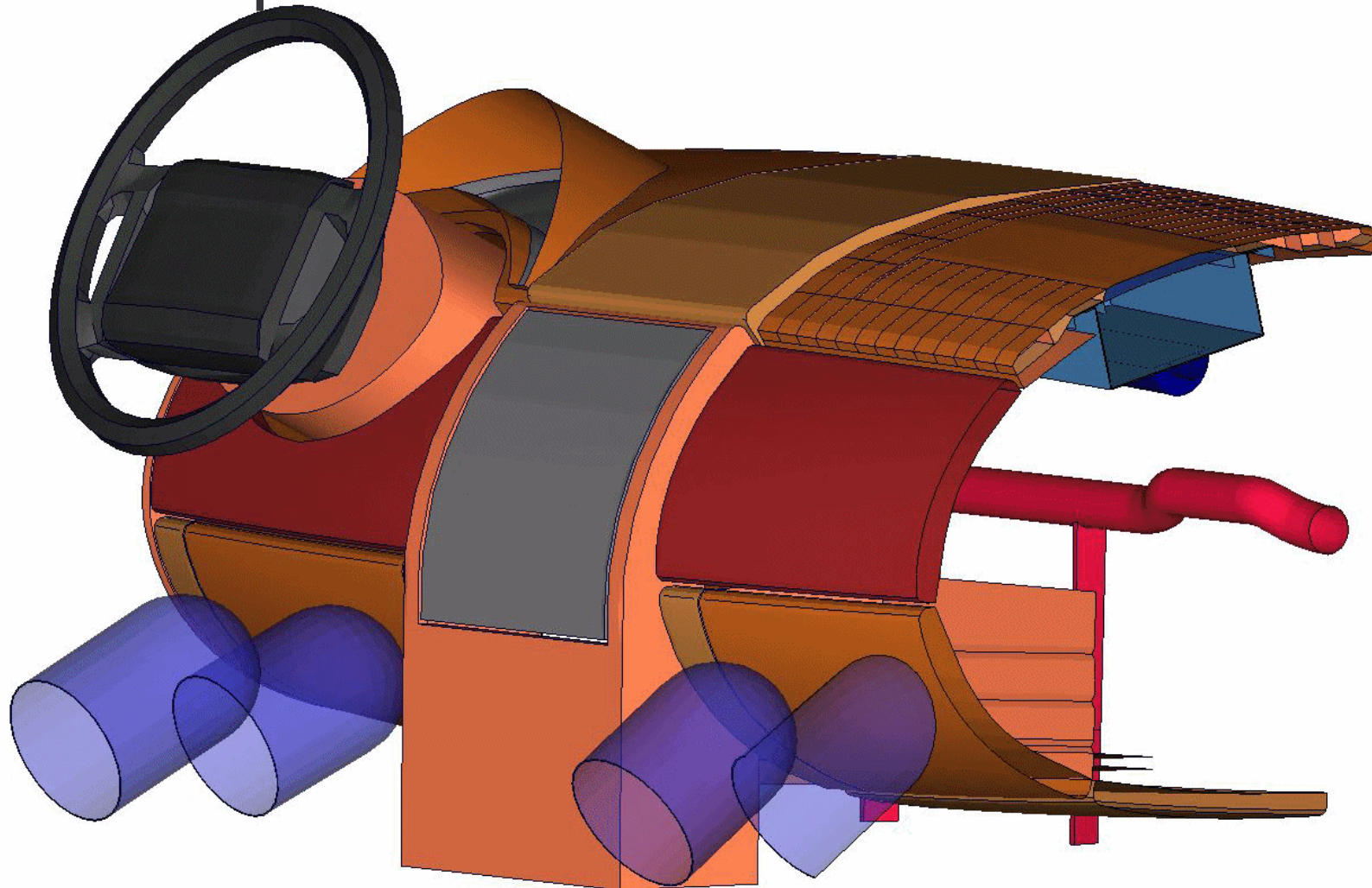
- Head Impact on airbag module



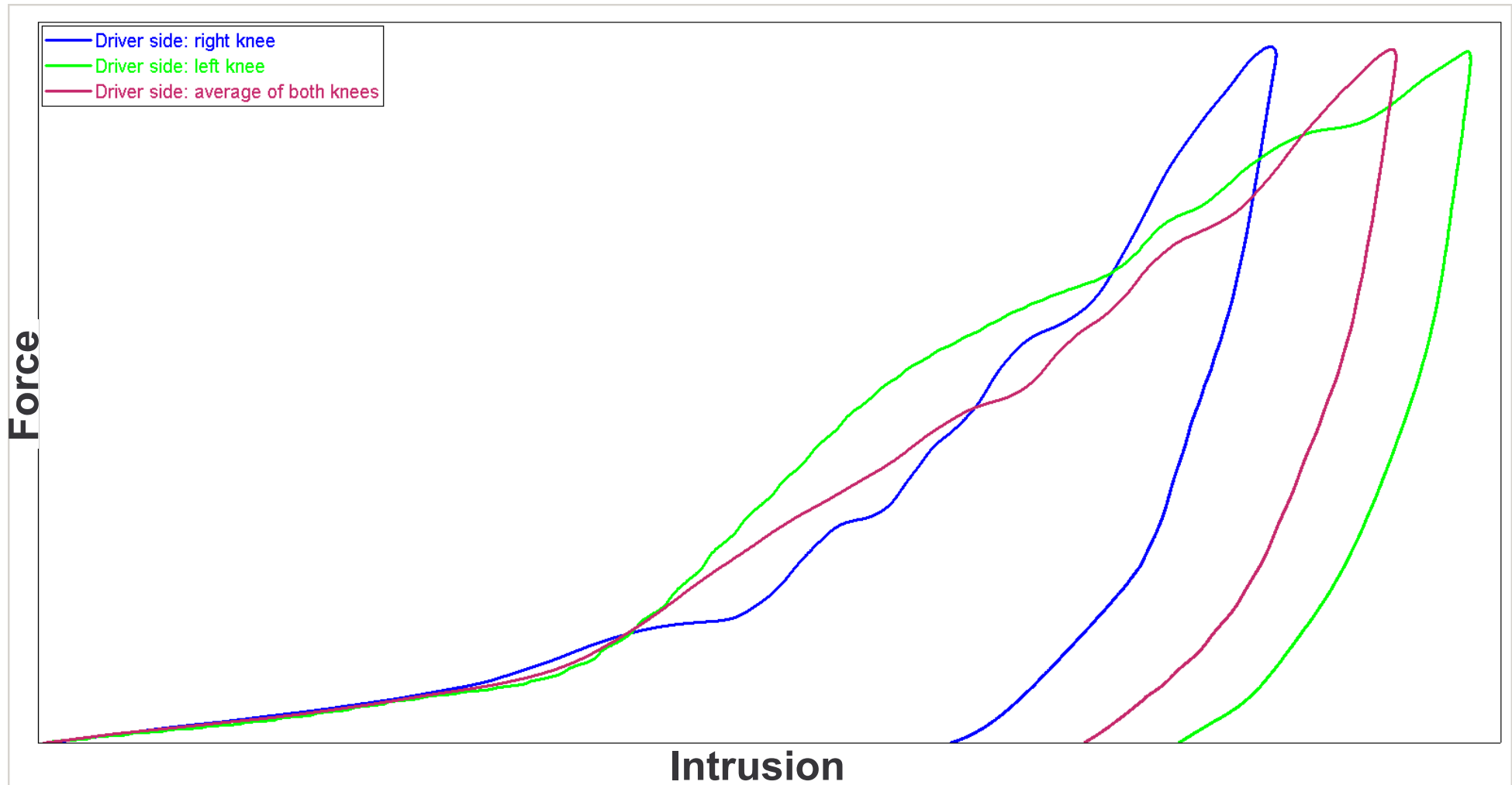
- Deceleration of head impactor



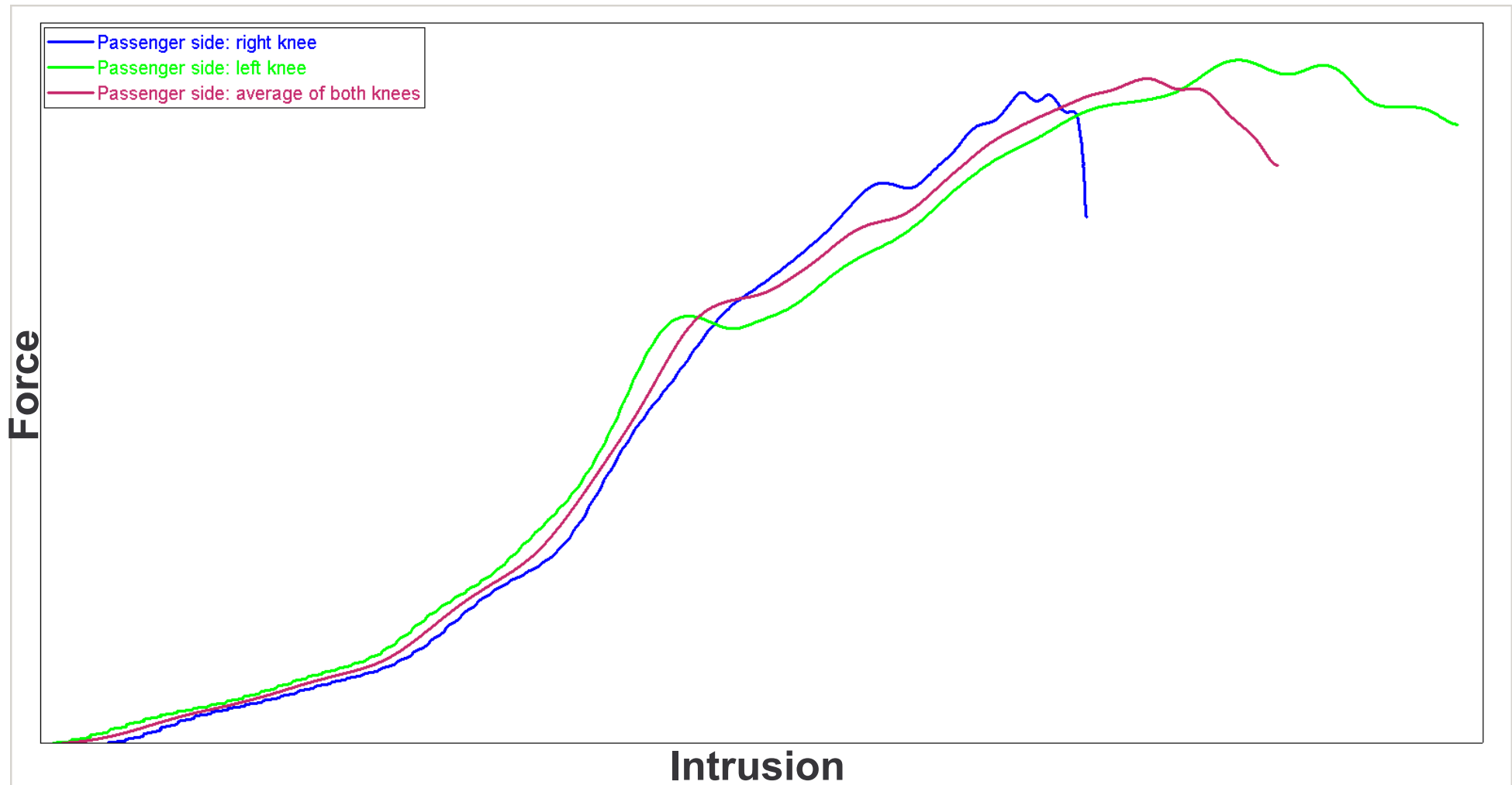
- Knee Impact



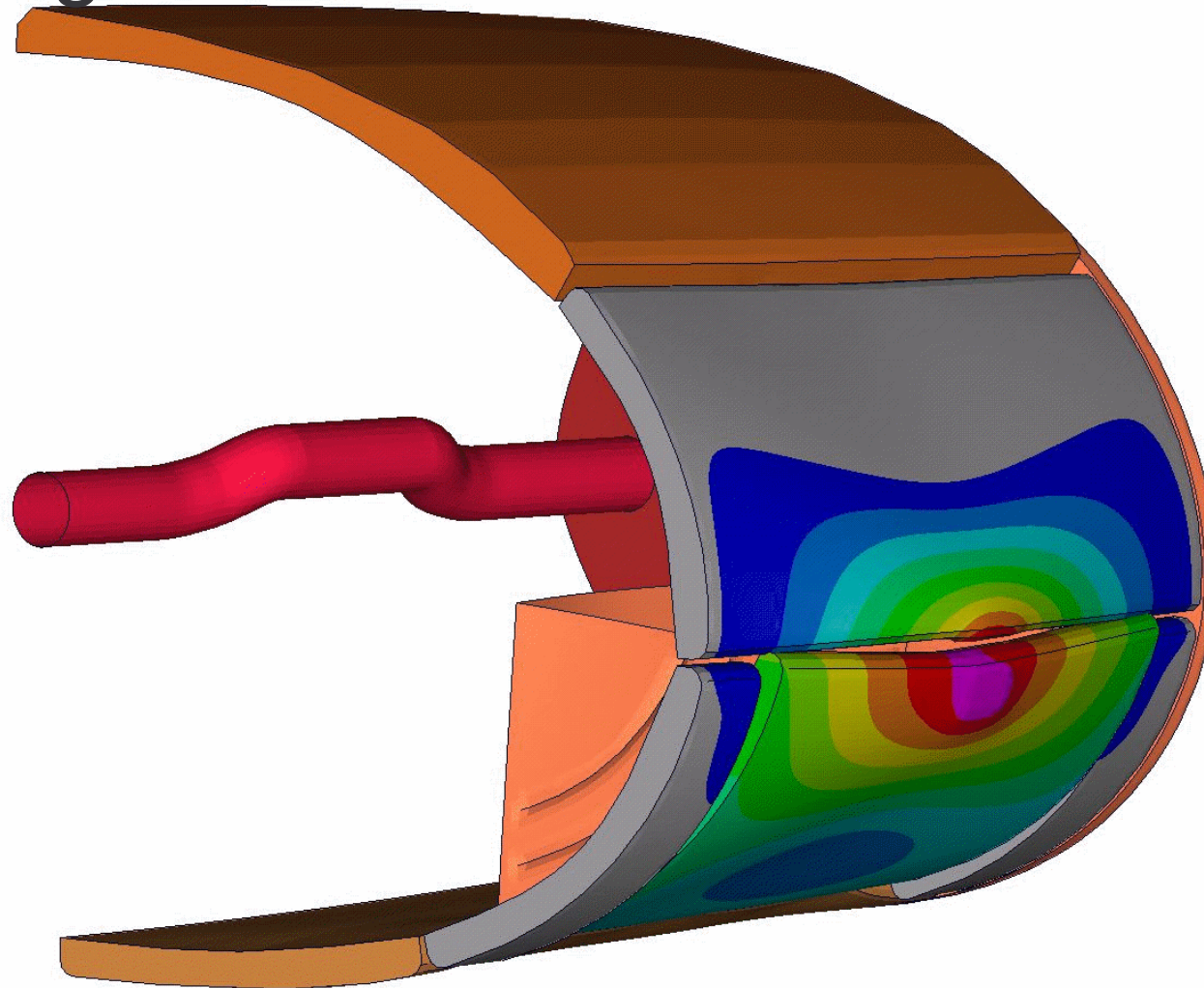
- Forces on driver's knees



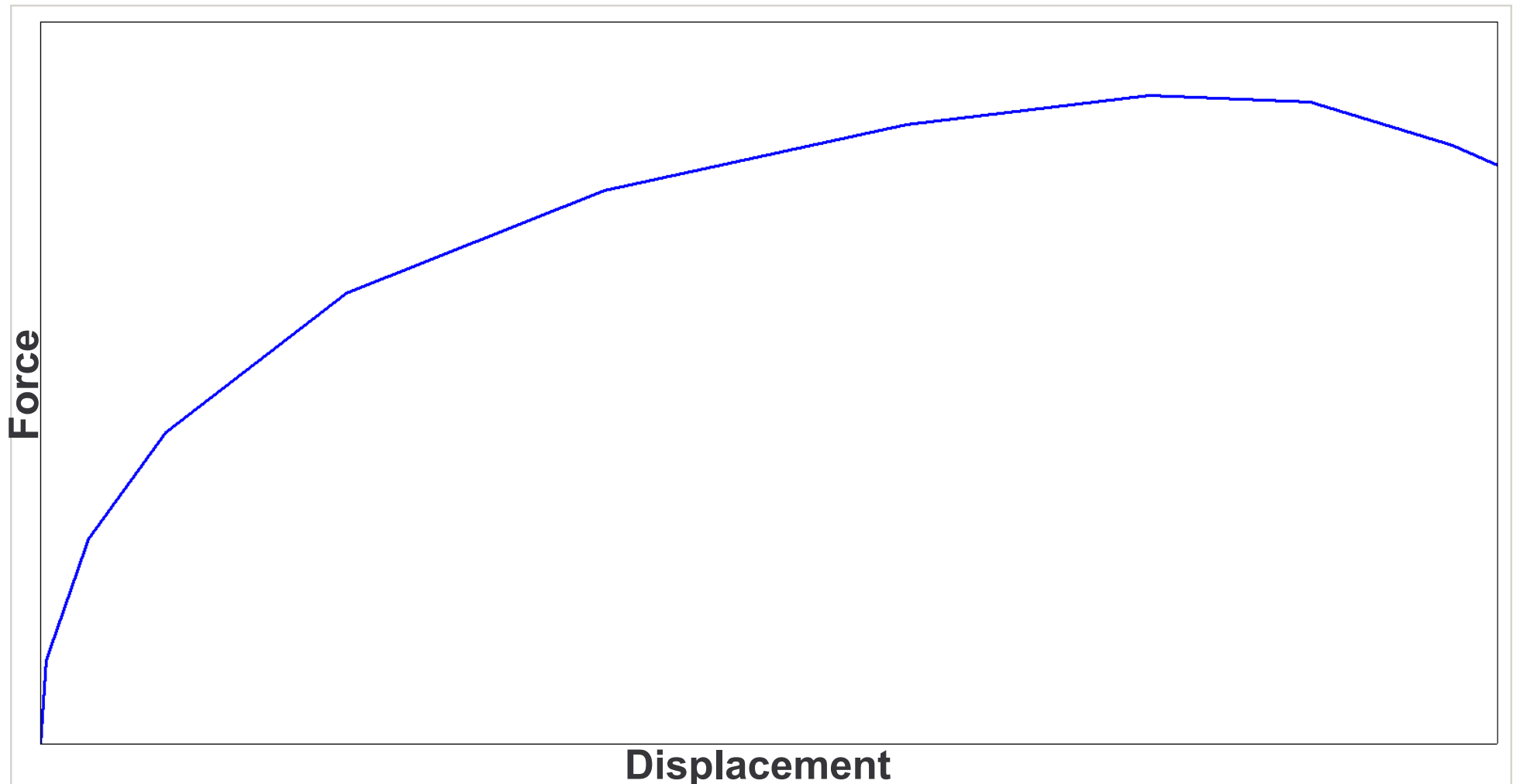
- Forces on passenger's knees



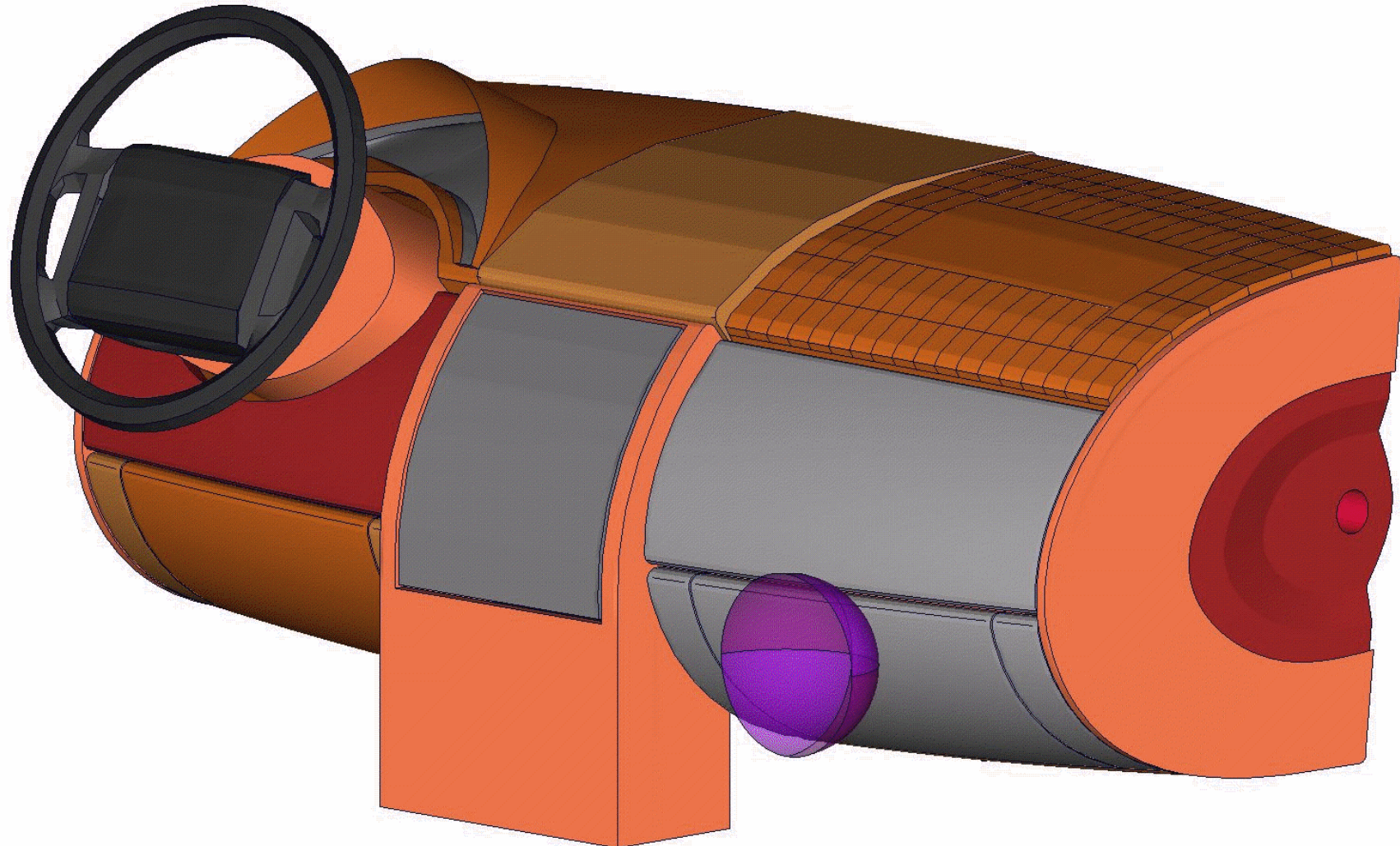
- Handling load



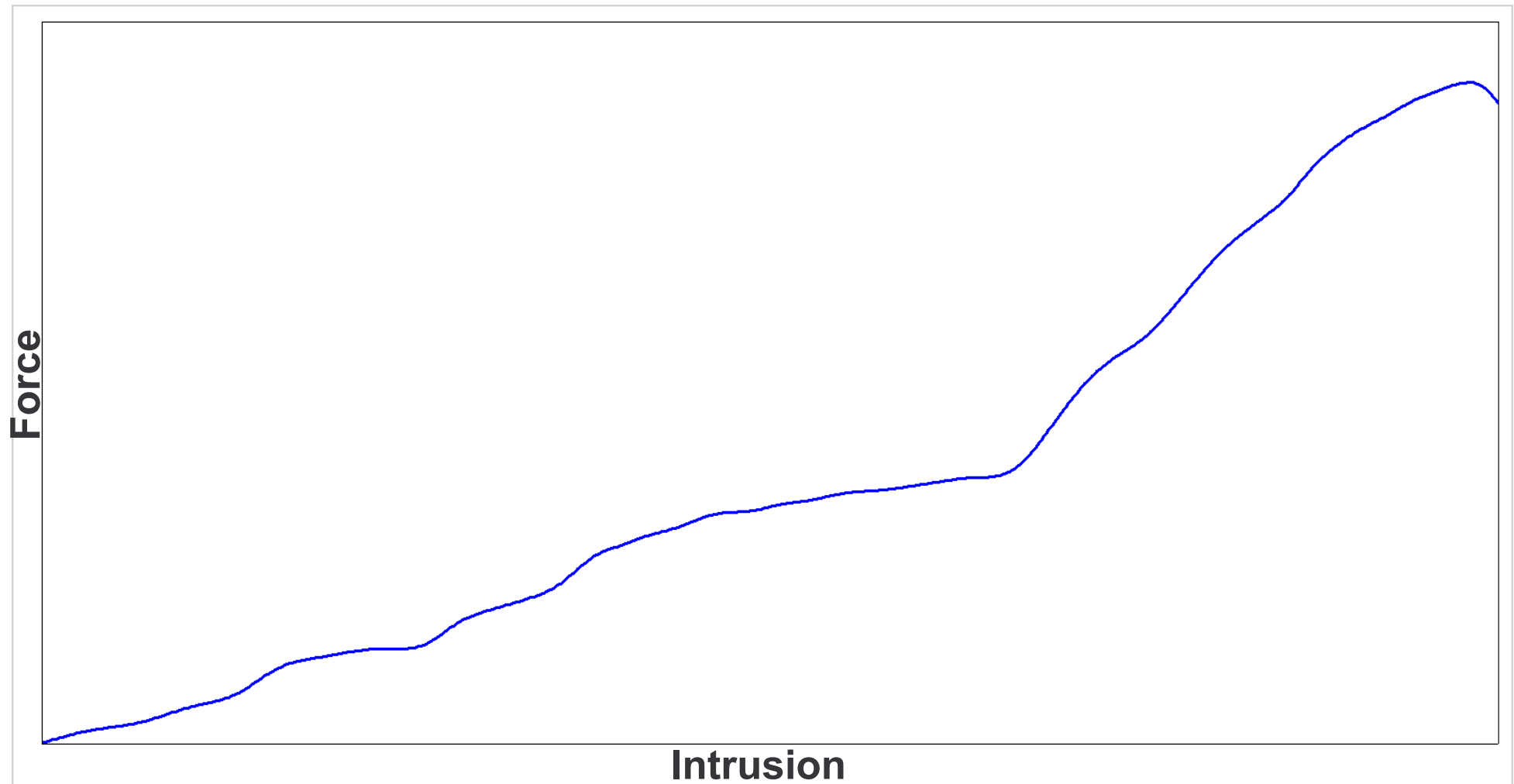
- Handling – stiffness of cockpit



- Misuse load case



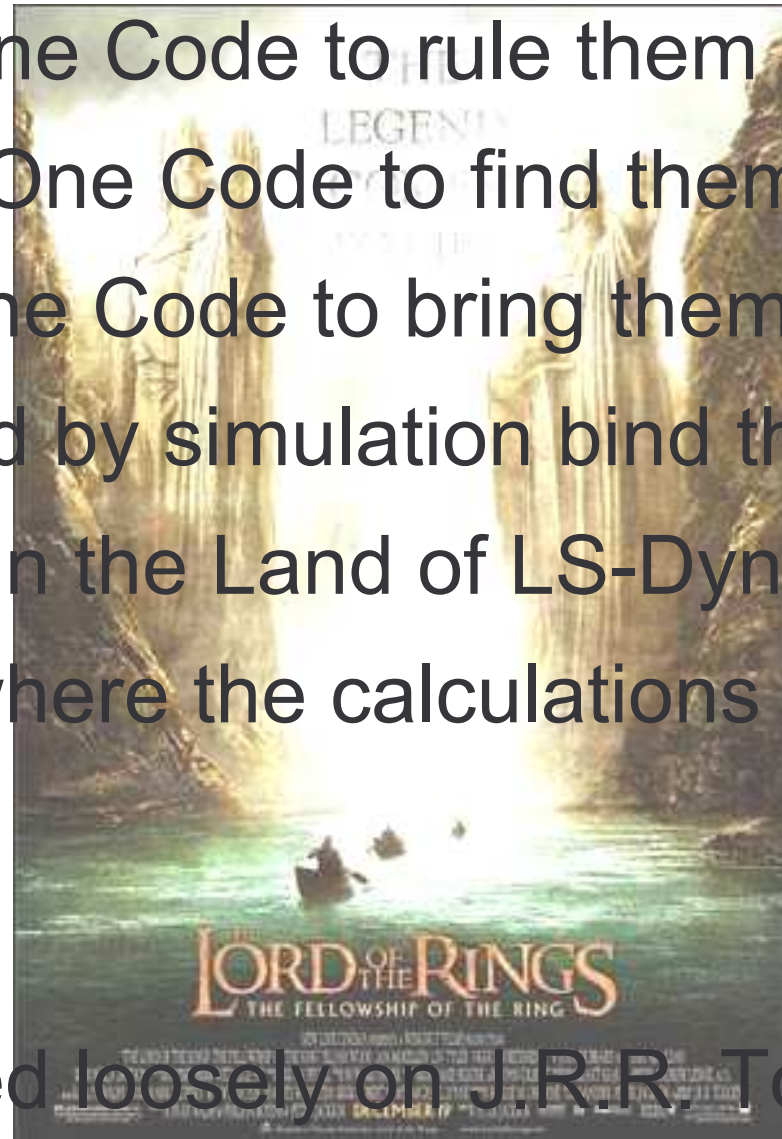
- Misuse – stiffness of cockpit



- 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