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# FEMZIP



07/2013

- Fraunhofer Spinn-Off starting January 1st, 2013

- FEMZIP – Compression of Simulation results



- DIFFCRASH – Robust Design: Identification of areas in geometry causing scatter of simulation results



- Marketing, support, new application areas

6 ex-Fraunhofer people



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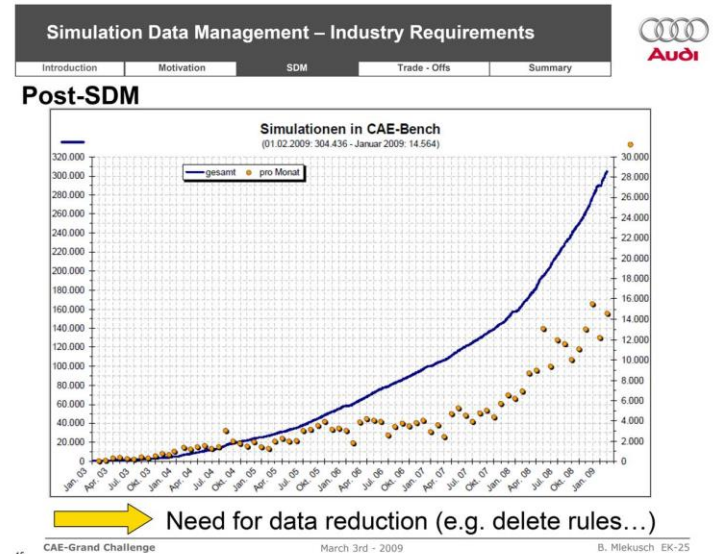
# CHALLENGE

# Challenge

- In order to improve engineering design ...
  - more simulations are performed
  - larger, more detailed Models are used
- » Large amounts of data are generated!

The data has to be ...

- analyzed
  - exchanged
  - archived
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- » Network connections and storage space can become bottlenecks!



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# SOLUTION

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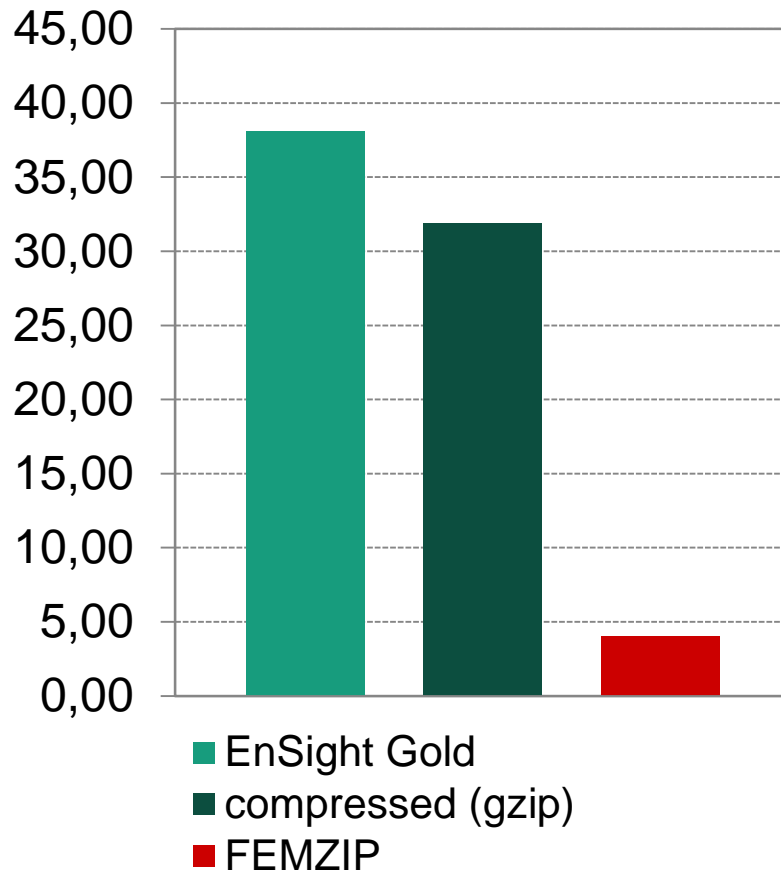
# Data Compression

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- Two fundamentally different compression approaches:
  - **Lossless Data Compression**  
The original data can be restored identically from the compressed data
  - **Lossy Data Compression**  
The original data **cannot** be restored identically from the compressed data
  
- With lossy data compression schemes a much stronger reduction can be achieved!

# Data Compression

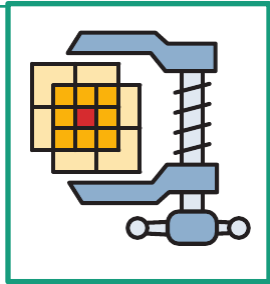
■ Floating-point data **cannot** be efficiently compressed losslessly:



- » A compression factor of only 1.2 is obtained
- » The solution is **FEMZIP**

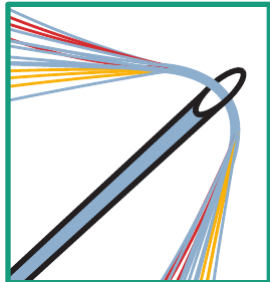
*Airflow simulation around a car:  
6 variables, 43 million elements,  
21 time steps*

# Advantages



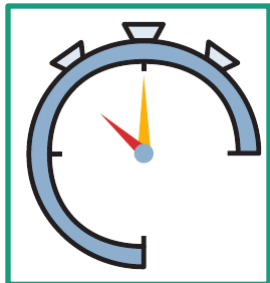
## Reduced Archive Size

Storage and backup capacities can hold more simulation results



## Shorter Data Transfer Times

Simulation results can be transferred significantly faster



## Quicker Data Loading

Compressed data can be loaded quicker into post processors



# Products

## ■ CRASH

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- FEMZIP-L for LS-DYNA™
- FEMZIP-P for PAM-CRASH™
- FEMZIP-R for Radioss™ Explicit
- FEMZIP-ERFH5 for PAM-CRASH™ new format (beta)
- FEMZIP-a4db for GNS Animator4 database (July 2013)

## ■ CFD

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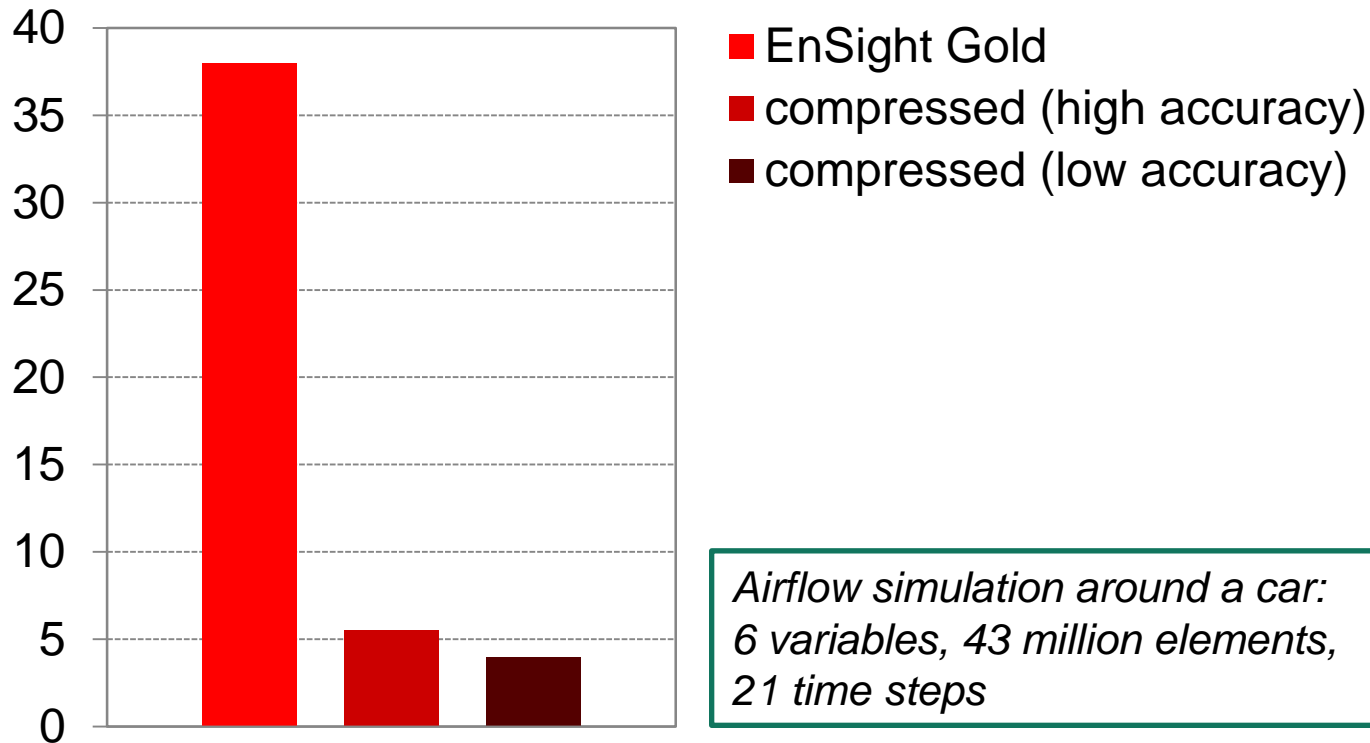
- FEMZIP-ENSG for EnSight™ Case Gold
- FEMZIP-CCM for StarCD™ (.ccm data format)
- FEMZIP-OF for OPENFOAM (incremental and distributed data handling)

## ■ NVH

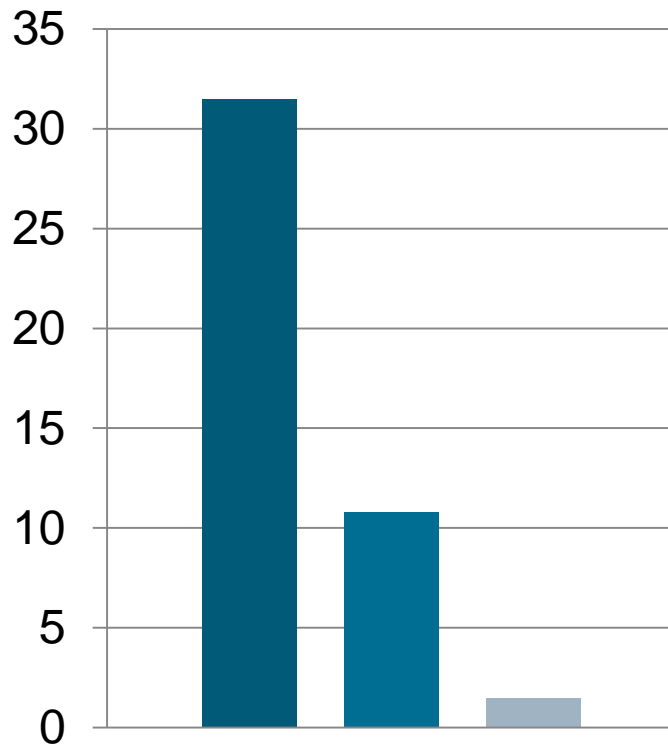
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- FEMZIP-N for OP2 (NASTRAN™ / Radioss™ Implicit)

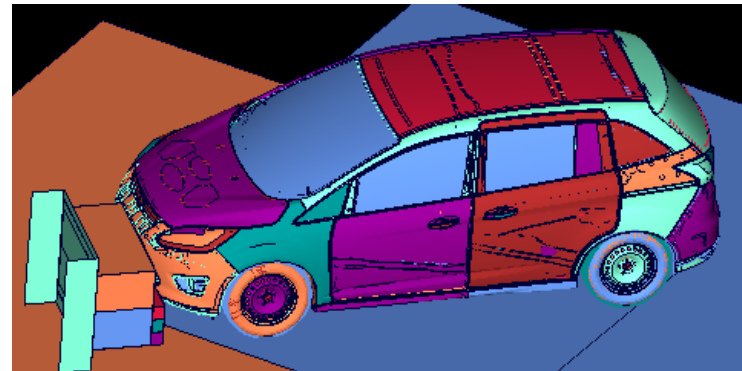
# Compression Factors



# Compression Factors



- Full results
- Geometry only
- FEMZIP



Usually higher compression factor

- coarser geometry precision
- more functions

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# FUNCTIONALITY

# Lossy Data Compression

- **Quantization**

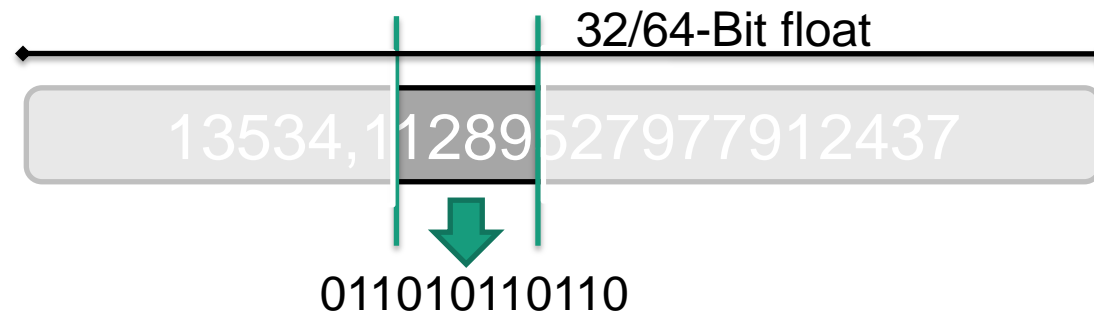
Floating point data is rounded to a given precision and mapped into the integer domain.

- **Prediction**

A bijective transformation is performed to prepare those integers for encoding purposes (reduce entropy).

- **Encoding**

Afterwards an entropy encoding method is used which removes redundant bits.



» **FEMZIP** achieves compression factors of about 10!

- Can be used to specify application relevant precisions
- FEMZip generates a standard file for a given input case :

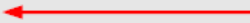
**femzip -I <data> -P <parameter\_file\_name>**

```
Number of extra values per shell:          1
Number of extra values per thick shell:    1
Node values: precision
  coordinates          :          0.01
  velocities           :          2033.
  accelerations        :          0.3105E+10
Shell values: precision
  effective_plastic_strain :          4.339
  thickness              :          0.1140
  element_dependent_variable_1 :          0.1000E-19
  element_dependent_variable_2 :          0.2886E-07
  internal_energy        :          10.55
  extra_value_per_element :          0.5057E-01
```

- Can be used to specify application relevant precisions
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  internal_energy        :          10.55
  extra_value_per_element :          0.5057E-01
```



- Parameter files can be then used to specify the precisions for compression

**femzip -I <data> -O <output\_file\_name> -C <parameter\_file\_name>**

- FEMZip provides a compression log to summarize the overall performance
- A verbose log can be generated using:

**femzip -I <data> -O <output\_file\_name> -V**

**Compression Analysis**

Header	99860236	3553189	28.10
Active	102841074	1577	65213.11
CFD	0	0	0.00
Global data	961548	961548	1.00

Component name	Increment	Min value	Max value	Size uncomp	Size comp	Ratio
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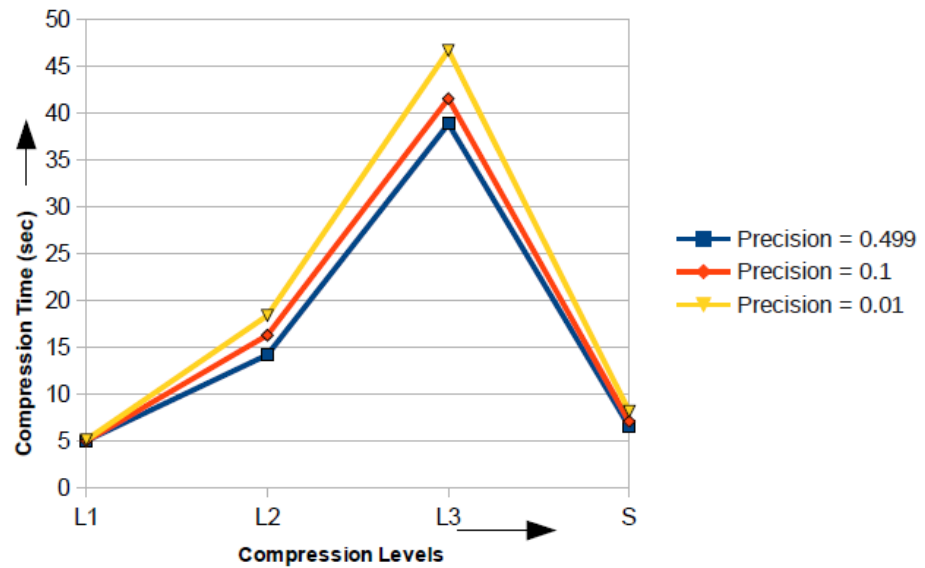
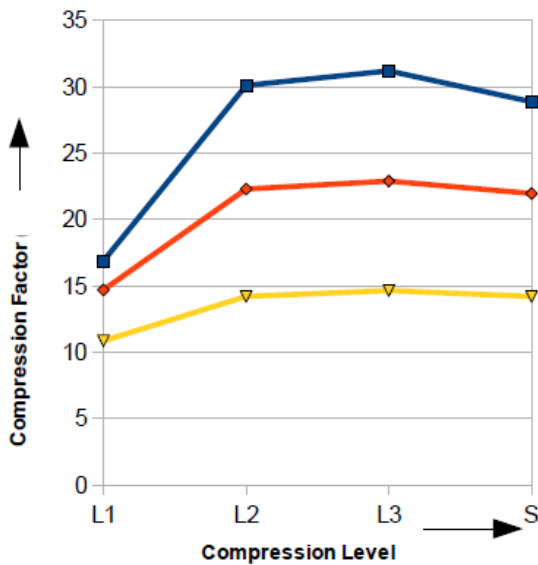
**Nodevalues**

Coordinates	0.1000	-5354.	5368.	106405740	14460711	7.4
Velocities	2033.	-0.164E+06	0.203E+06	106405740	3415974	31.
Accelerations	0.305E+10	-0.87E+11	0.946E+11	106405740	142876	0.74E+03
Thickness	0.1140	0.000	11.40	101482290	107463	0.94E+03

**1D element values**

axial_force	481.3	-0.481E+05	0.27E+05	2940	904	3.3
s_shear_resultant	496.4	-0.238E+05	0.49E+05	2940	748	3.9





Effect of coordinate precision on compression factor and compression time

- Less precise ~ Better compression ratio
- Compression time mainly relates to compression level used



Original Data

( Size: 1.1 GB )



Compressed Result

Coordinate Precision = 0.01

( Size: 0.052 GB ) ~ 21 factors



Compressed Result

Coordinate Precision = 0.5368

( Size: 0.038 GB ) ~ 28 factors

## Effects of Precision on Simulation Results

Data Used – „GM: Explorer“

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- 
- Supported pre- and post- processor tools :
    - D3plot (ARUP)
    - GNS Animator 3/4
    - ESI Crashviewer
    - Hyperview
    - LS - PrePost
    - μETA

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# Postprocessor performance: Animator 4

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- Benchmark Data - „GM- Explorer“
  - Original Data Size : 1,1 GB
  - Number of states : 26
  - Compression Parameter : Coordinates (Precision 0.01)
  - Compressed Size : 0.052 GB

	Original Data	Compressed Data
Opening Time (sec)	10	6
Traversing Time (state 1 to state 26)	Negligible	Negligible

# Postprocessor performance: OASYS d3plot11

- Benchmark Data - „Car2Car“
  - Original Data Size : 7,9 GB
  - Number of states : 42
  - Coordinates (Precision 0.1)
  - Compressed Size : 0.052 GB
  - Time for pre-fetching : 8 sec
  - Prefetching refers to looping through all possible states before analysis is done

	Original Data	Compressed Data
Opening Time (sec)	~ 2	~2
Without Prefetched States		
Traversing Time (state 1 to state 42)	negligible	7
Traversing Time (state 42 to state 20)	negligible	4
With Prefetched States		
Traversing Time (state 1 to state 42)	negligible	negligible
Traversing Time (state 42 to state 20)	negligible	negligible

Benchmarked data accessed from local disk

# Postprocessor performance: OASYS d3plot11

- Benchmark Data - „Car2Car“
  - Original Data Size : 7,9 GB
  - Number of states : 42
  - Coordinates (Precision 0.1)
  - Compressed Size : 0.052 GB
  - **Time for pre-fetching :**
    - **Original : ~ 10 minutes**
    - **Compressed: 8 sec**

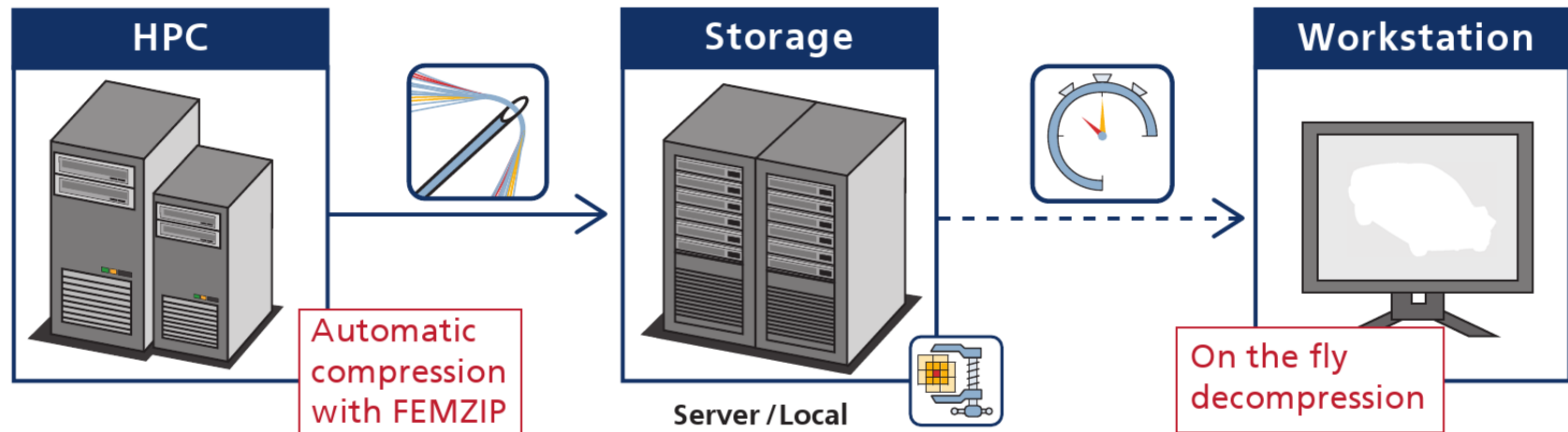
	Original Data	Compressed Data
Opening Time (sec)	55	~ 60
Without Prefetched States		
Traversing Time (state 1 to state 42)	15	7
Traversing Time (state 42 to state 20)	15	4
With Prefetched States		
Traversing Time (state 1 to state 42)	negligible	negligible
Traversing Time (state 42 to state 20)	negligible	negligible

Benchmarked data accessed from server over a 100 Mbps network (24Mbps effective transfer speed)

# Process Integration

- **FEMZIP** is designed to be integrated into existing processes
- **FEMZIP** made to work in batch processes

Company wide standard parameter file



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# FEMZIP

The logo icon for FEMZIP features a blue mechanical spring on the right, connected to a blue frame. On the left, a yellow square contains a red grid pattern, representing a finite element mesh.

07/2013