



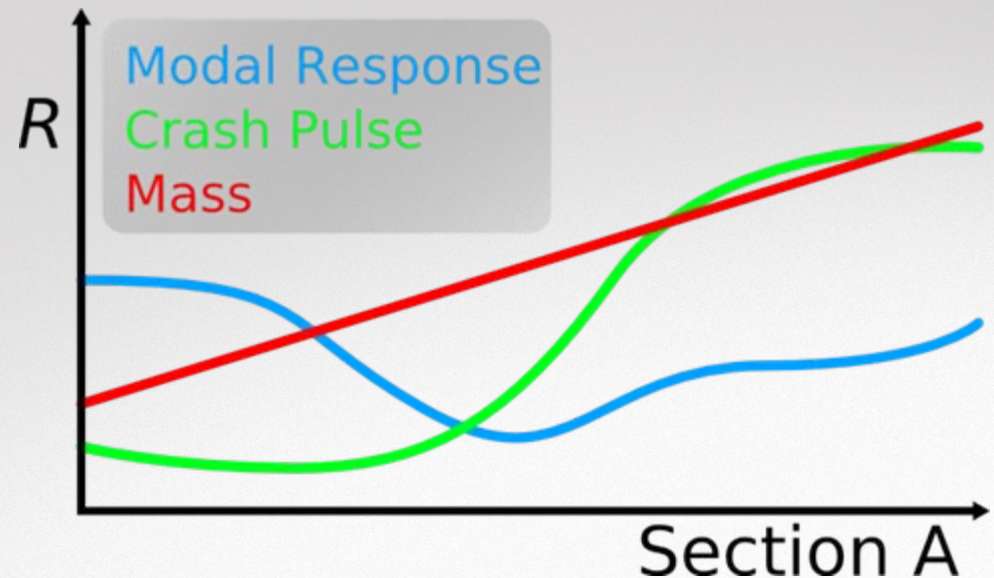
# Development of a Multidisciplinary Design Exploration Platform (MDEP)

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## *Multidisciplinary Design Optimisation (MDO)*

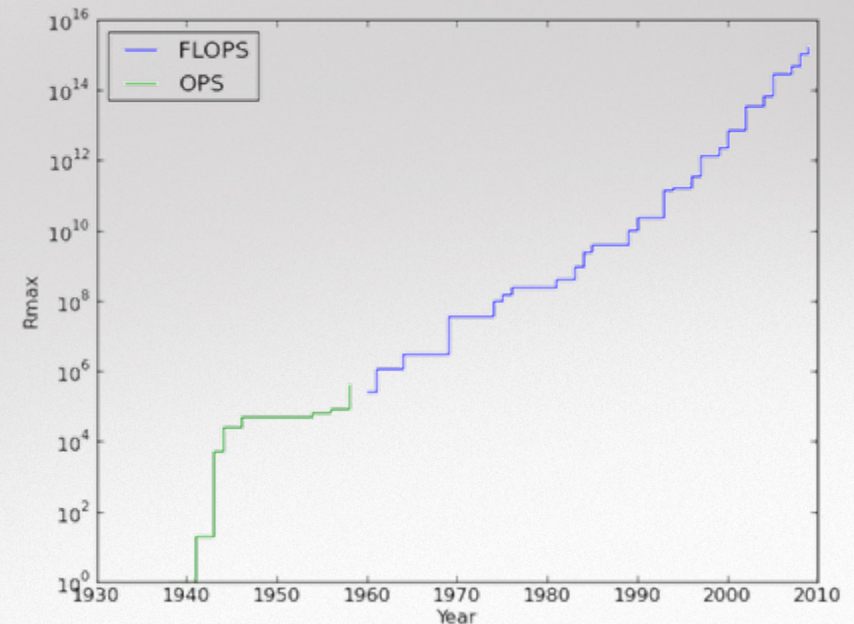
- MDO uses optimisation techniques to solve design problems across multiple disciplines
- Solving all relevant disciplines simultaneously provides a superior design as interactions across disciplines are considered.
- MDEP was developed to support the adoption of MDO techniques





## *Supporting MDO*

- Exponential growth in High Performance Computing (HPC) resources has been a key enabler for MDO analysis
- Limiting factors now more related to the development and setup of MDO analysis.
  - Shortening of Vehicle Development Process



<http://en.wikipedia.org/wiki/File:Supercomputing-rmax-graph.png>



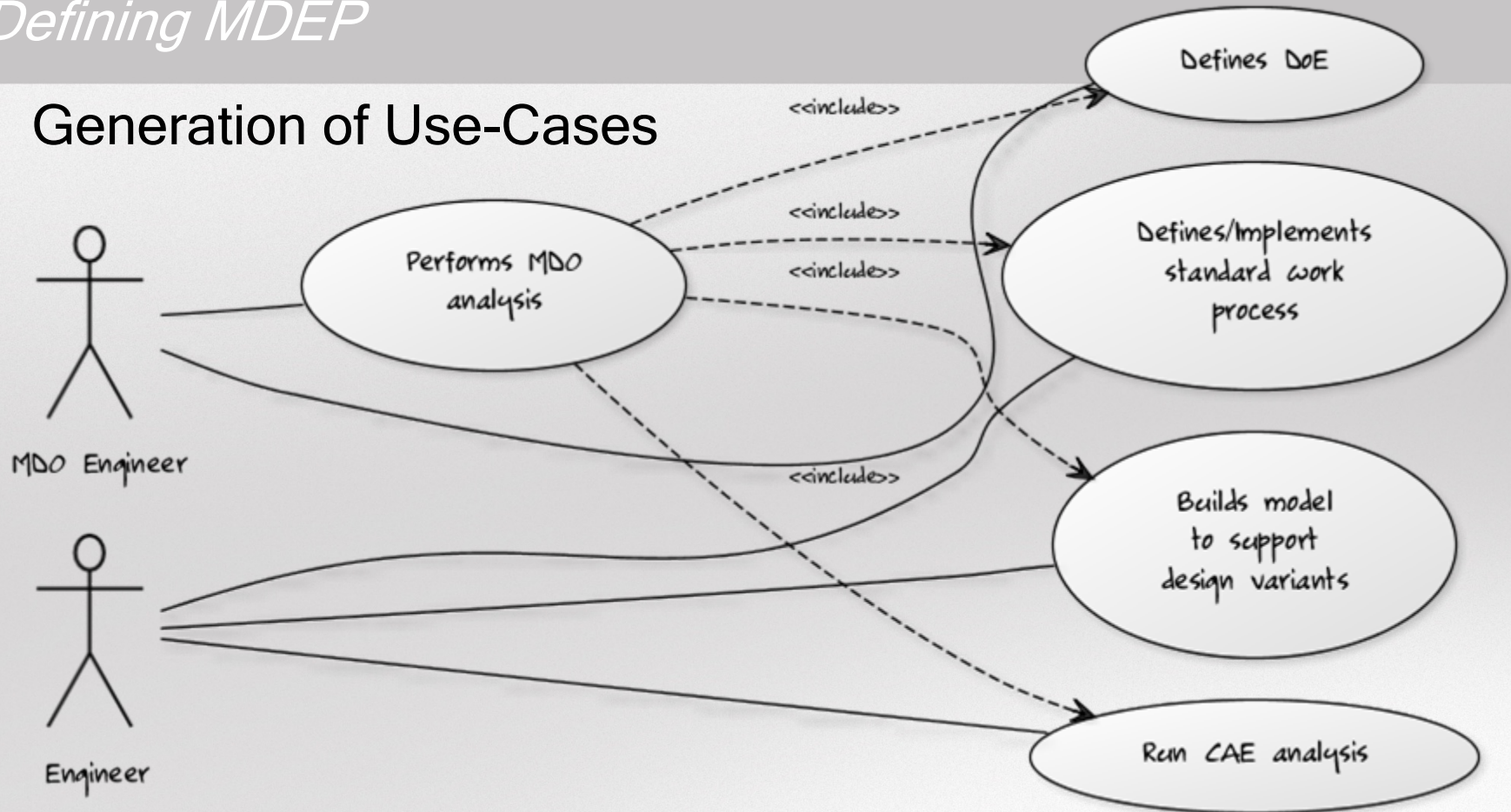
## *Supporting MDO*

- The Multidisciplinary Design Exploration Platform (MDEP) was created to simplify and streamline the use of computing based MDO analyses for “production engineering”



## Defining MDEP

- Generation of Use-Cases



- MDO Engineer undertakes same tasks as the 'typical' Engineer



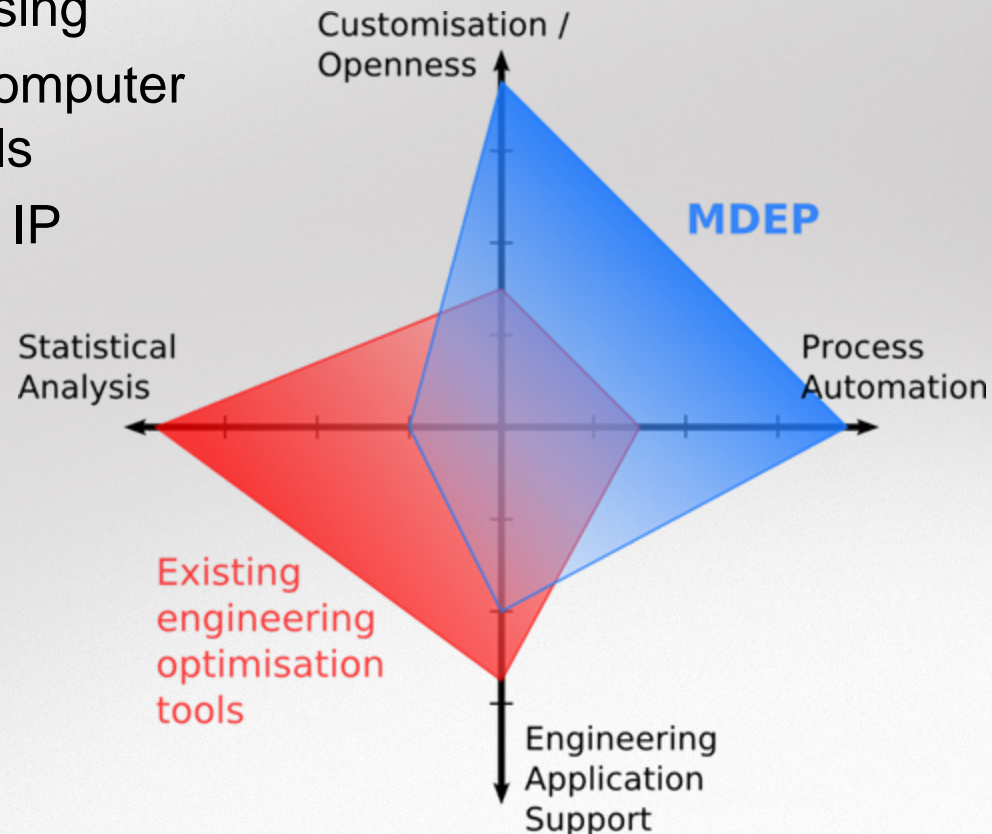
## *Defining MDEP*

- **Key requirements**
  - Support multiple platforms (Windows, Linux, etc)
  - Components must be accessible from a User Interface, Command Line, and Application Programming Interface (API)
  - Reduce reliance on single vendor solutions
  - Open and Extensible
  - Integrate existing tools
  - Be integrated within existing tools



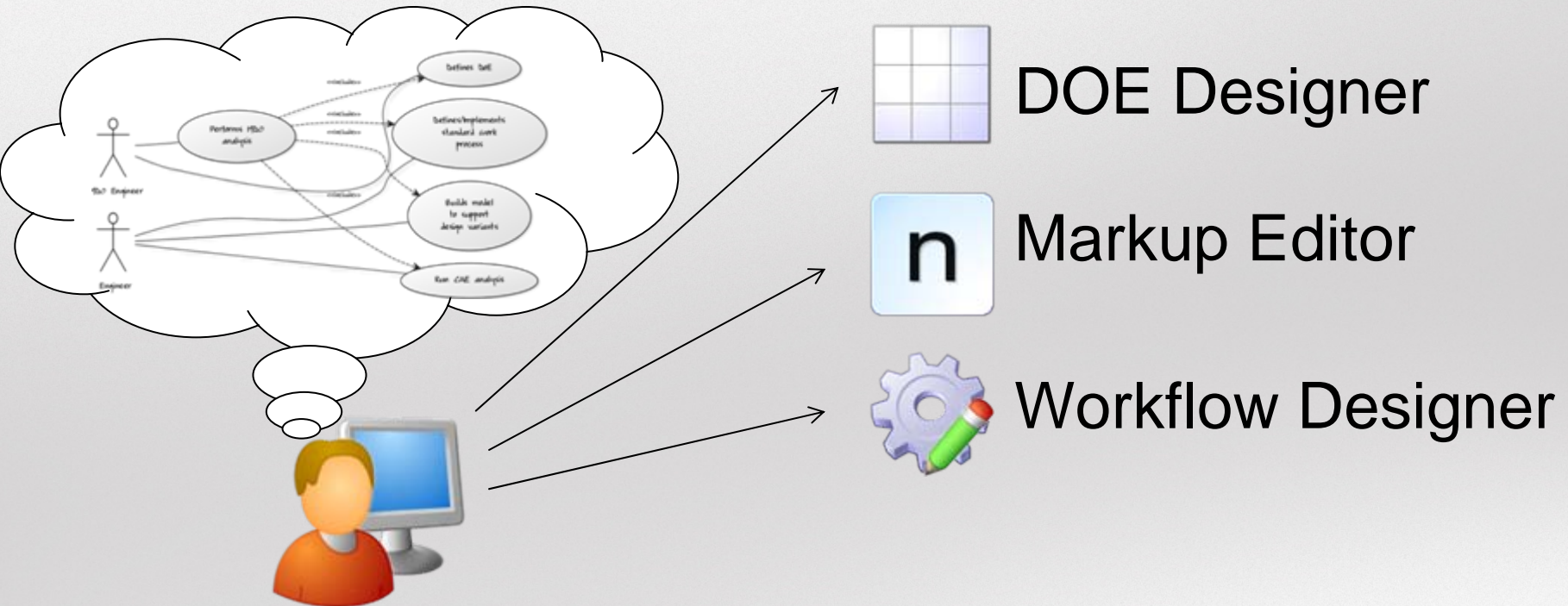
## Defining MDEP

- Review of existing tools
  - Very strong statistical processing
  - Support for many common Computer Aided Engineering (CAE) tools
  - Hard to be 'open' and protect IP
- MDEP (proposed)
  - Focus on being open
  - Process automation is key





## MDEP tool suite



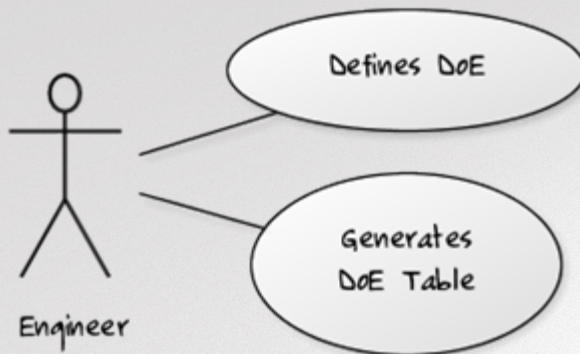
- An agile Software Development methodology was employed to implement the key requirements and use-cases.
  - Test driven development, continuous integration
  - Changing requirements



## MDEP DOE Designer

- Support for simple DoE methods
  - Complex methods implemented in 3<sup>rd</sup> Party and proprietary tools
- Equation editor/evaluator
- Validation
- Design parameters stored in XML
- Table data stored in Excel file format

Use	Run	area	length	material	width
<input checked="" type="checkbox"/>	1	18.5	9	bronze	2.056
<input checked="" type="checkbox"/>	2	13.667	6	sponge	2.278
<input checked="" type="checkbox"/>	3	5.778	8	bronze	0.722
<input checked="" type="checkbox"/>	4	17.5	7	bronze	2.5
<input checked="" type="checkbox"/>	5	10	5	tin	2
<input checked="" type="checkbox"/>	6	2.833	3	sponge	0.944
<input checked="" type="checkbox"/>	7	2.333	2	bronze	1.167
<input checked="" type="checkbox"/>	8	0.5	1	tin	0.5
<input checked="" type="checkbox"/>	9	8.056	5	tin	1.611
<input checked="" type="checkbox"/>	10	18.333	10	tin	1.833

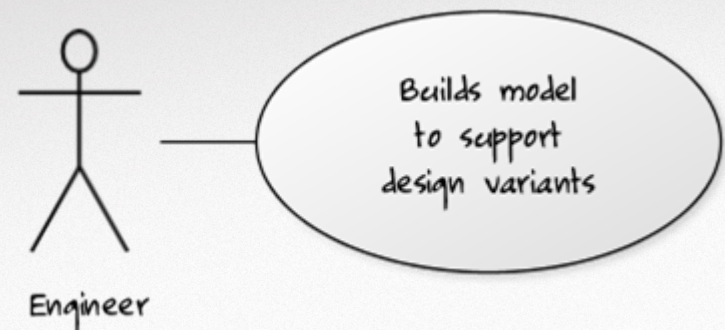
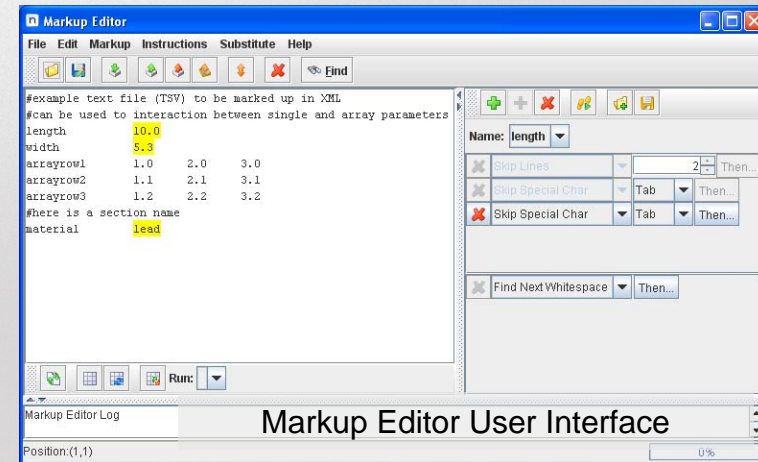


Re	LB	Value	UB	Allowed Values	Equation
	225.0	250.0	275.0		
Frt_Bumper_Beam_G		200		120,130,140,150,...	
Frt_Bumper_Beam_M		340		210,240,340,375,...	
Frt_Rail_Inr_Frt_G		180		120,130,140,150,...	
Frt_Rail_Inr_Frt_M		210		210,240,340,375,...	
Frt_Rail_Inr_Reinf_G		180		120,130,140,150,...	
Frt_Rail_Inr_Reinf_M		340		210,240,340,375,...	
Frt_Rail_Inr_Rr_G		220.0			Frt_Rail_Inr_Frt_...
Frt_Rail_Inr_Rr_M		340		210,240,340,375,...	
Frt_Rail_Otr_Frt_G		180		120,130,140,150,...	
Frt_Rail_Otr_Frt_M		210		210,240,340,375,...	
Frt_Rail_Otr_Reinf_G		250		120,130,140,150,...	



## MDEP Markup Editor

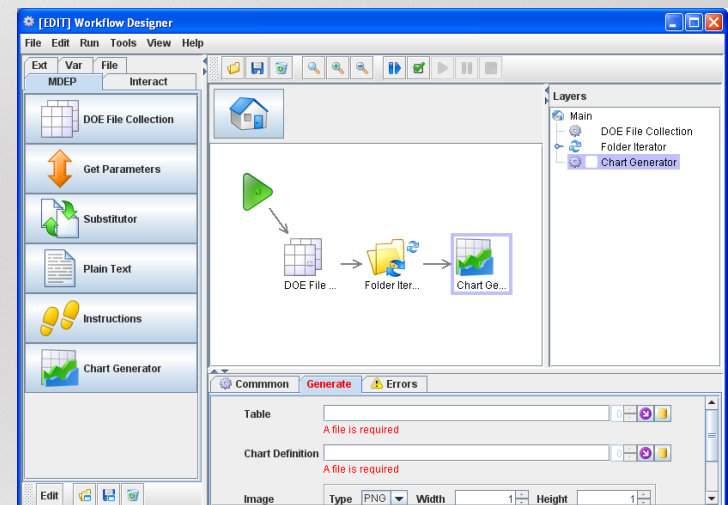
- Enable the parameterisation of common text based CAE input and output files
  - Generate multiple design variants from one model
- Can automatically identify and insert parameters of known file formats (LS-DYNA, NASTRAN)
- Limited to simple design variations; sheet metal thickness, material properties, etc
- Can be coupled with parametric geometry tools for more advanced design changes





## MDEP Workflow Designer

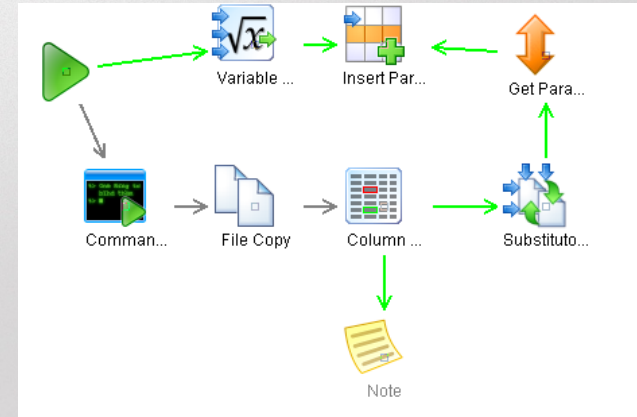
- Enables Process Automation
  - A series of components are linked together in a visual editor to define both process and data flow
- A component can be simple,
  - Create a new folder
- Advanced, or
  - Substitute design parameter X into markup file Y
- User defined
  - Component can be built from other components (subflow) or implemented with code





## MDEP Workflow Designer (continued)

- Workflow Designer is the 'glue' that holds the MDEP tool suite together
- Execution is also managed by the Workflow Designer
- Individual MDEP tools may offer multiple workflow components
- Enables automation of standard work processes
- Replaces need to generate 'scripts'
  - Poor reuse
  - Unnecessarily complex



```

echo "Search for $CURRENT_BINOUT"

if test -s $CURRENT_BINOUT
then
  grep "N o r m a l   t e r m i n a t i o n" ../../exp/Des
  if test -s tmp
  then
    echo "Found $CURRENT_BINOUT"
    cp $CURRENT_BINOUT ./
    ./script_crash_post crash_output_info.dat crash_output
    rm -f binout
    echo "Finish postprocessing $CURRENT_BINOUT"
  else
    echo "The run finish with error cannot postprocess res
  fi
  rm tmp
else
  echo "Can't find $CURRENT_BINOUT."
fi

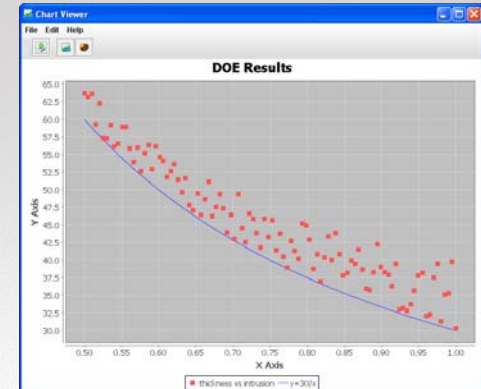
mv crash_output_${CURRENT_EXP}.dat ../../exp/DesExp_${CURRENT_E

echo ""
CURRENT_EXP=`expr $CURRENT_EXP + 1`
    
```



## *MDEP other components*

- File Server
  - Provides remote hosting of workflows and output/input files
- File Browser
  - Mechanism for MDEP tools to read files directly from HPC resources
- Chart Viewer
  - Post processing of MDO output
- Workflow Server
  - Execute workflows on remote HPC systems
- All components created to satisfy one or more use-cases

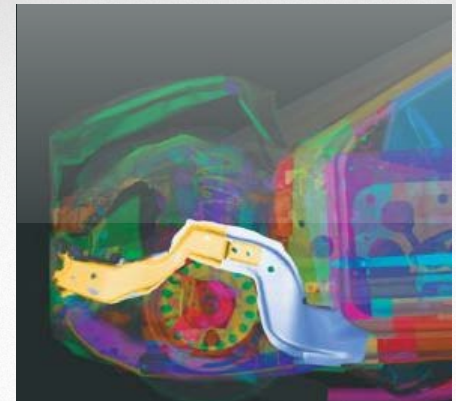




## *MDEP Outcomes*

- Major Test Case (Production Environment)
  - Design for Six Sigma project
  - MDEP used for setup, execution and analysis of several DoEs
    - Preparation of design variants
    - Submission of analysis to HPC resources
    - Post processing individual analysis models
    - Collation of results
  - In total 420 design variants were run (2 frontal crash load cases), all full vehicle models

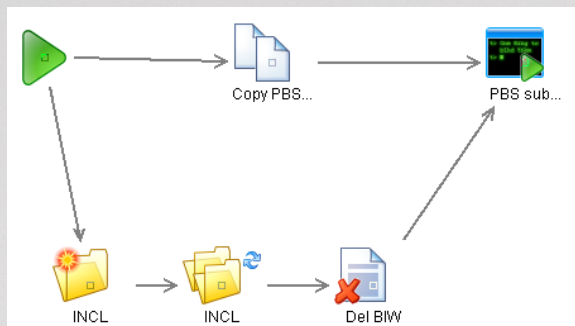
*“MDEP provides tangible benefits to undertaking Design of Experiments with CAE” – Production engineer*



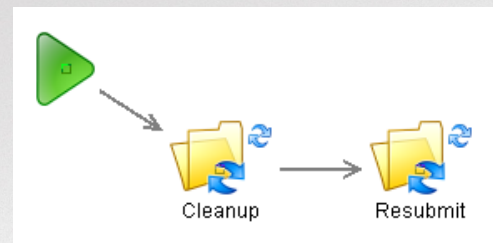


## MDEP Outcomes

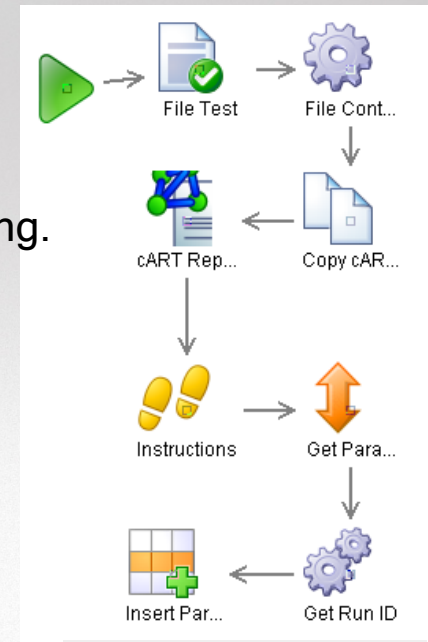
- **Faster process automation leads to better processes**
  - Production workflows typically split in two
    - Pre-processing and submission of analysis models to HPC
    - Post processing, collation of results
    - 2<sup>nd</sup> workflow assumes 1<sup>st</sup> completed successfully
  - Using MDEP another workflow was created
    - Check if analysis models completed successfully
    - Collate analysis model failure information to assist in debugging.
    - Re-launch failed analysis models where appropriate



Pre-processing workflow



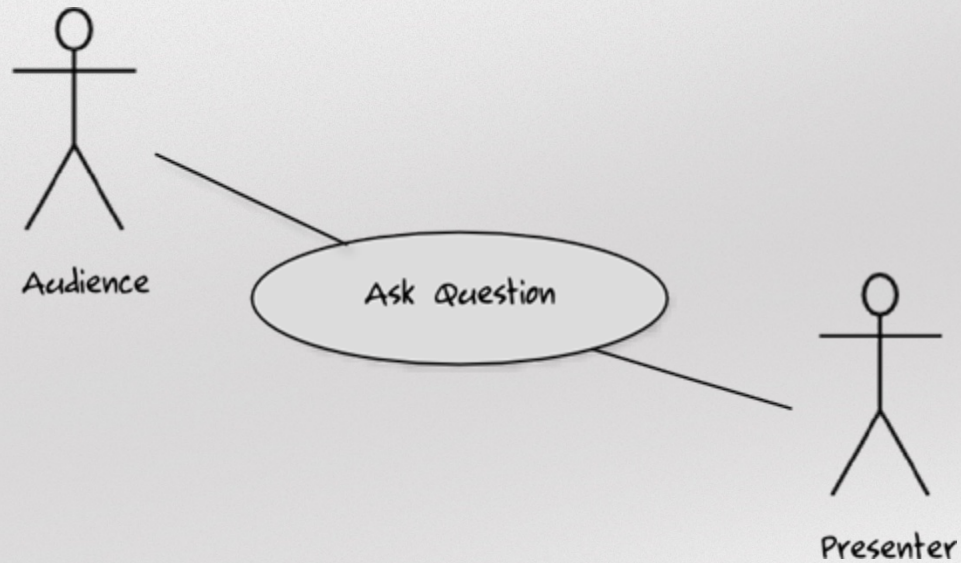
New Cleanup workflow



Post-processing workflow



# Questions



Thank you