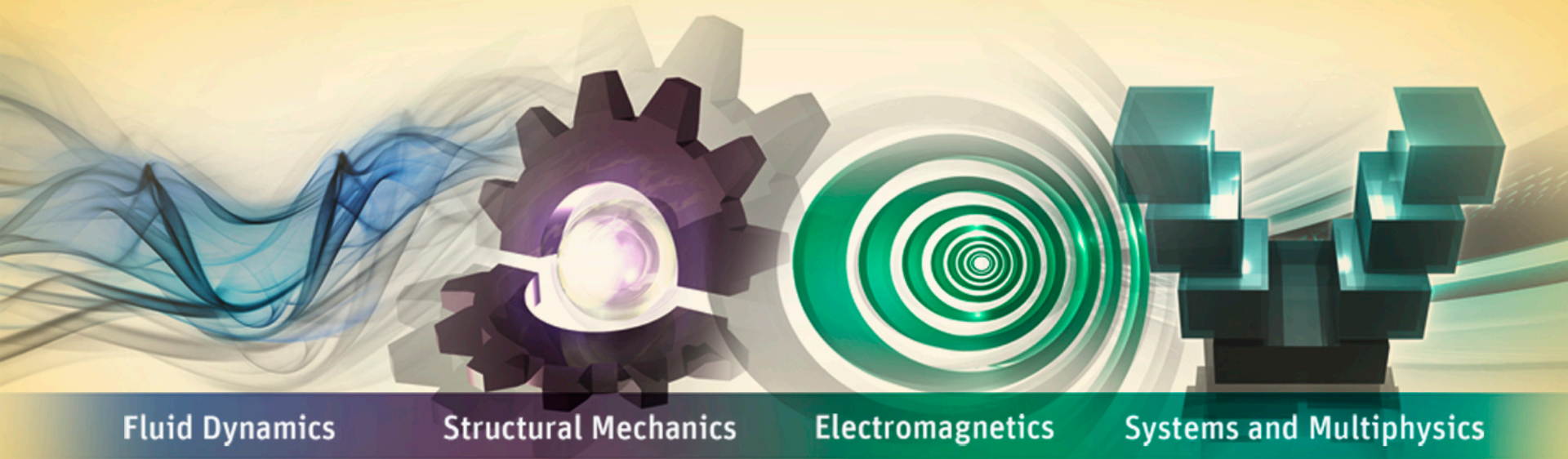


Recent Advances in ANSYS Toward RDO Practices Using optiSLang



Fluid Dynamics

Structural Mechanics

Electromagnetics

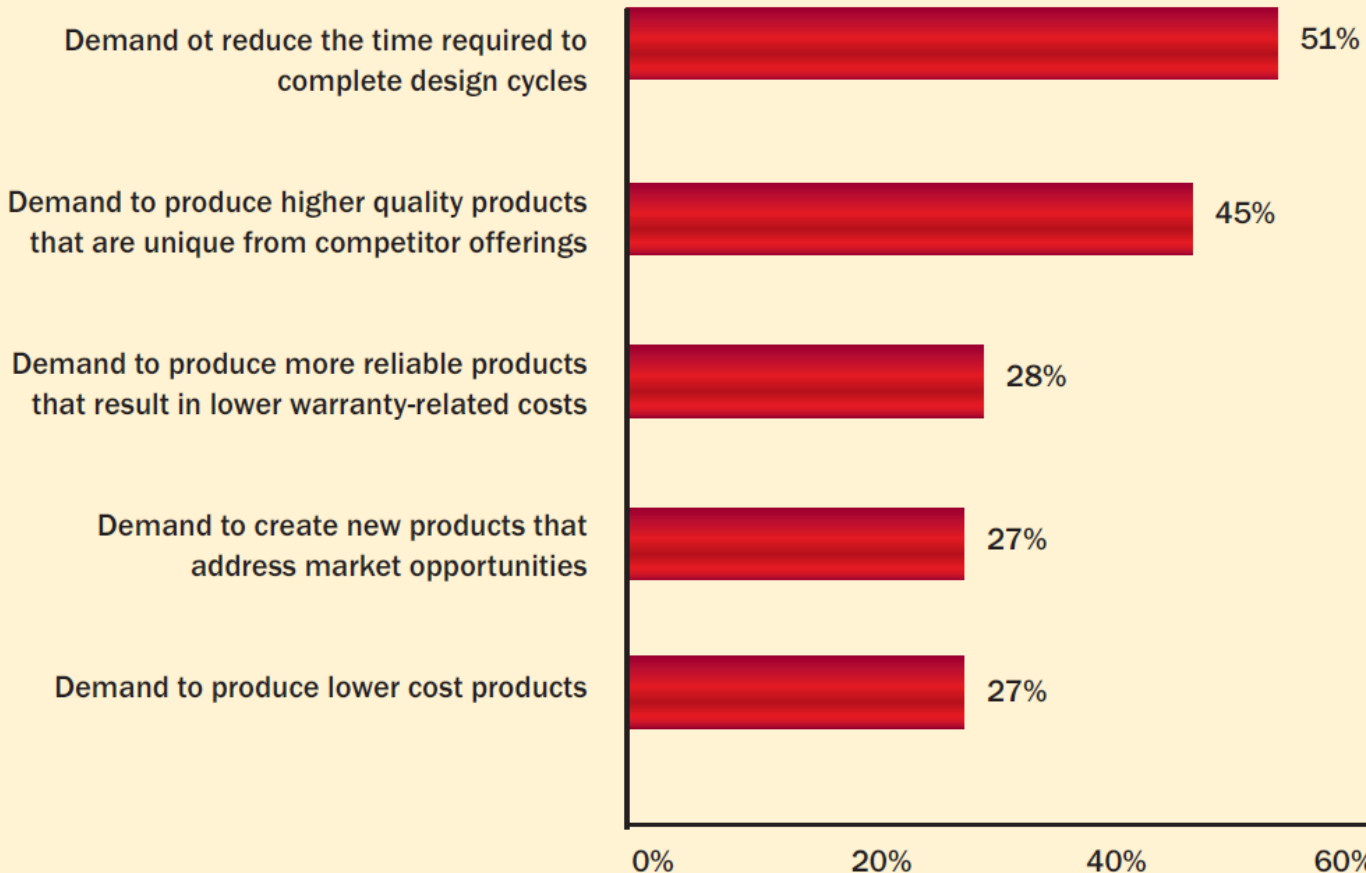
Systems and Multiphysics

Wim Slagter, ANSYS Inc.

Herbert Güttler, MicroConsult GmbH

Product Development Pressures

Business Needs That Exert The Most Pressure/Importance on Your Design Activities



Source: Engineering Simulation & HPC Usage Survey with over 1,800 ANSYS respondents (Feb 2013)

“The Cost of Being Wrong”

Manufacturer	Date	Number of vehicles
Subaru	Jan. 3	633,000
GM	Jan. 4	68,000
Toyota	Jan. 30	1.3M
GM	Jan. 31	150,000
Chrysler	Feb. 14	360,000
Ford	March 7	230,000
Subaru	March 7	50,000
Hyundai/Kia		
Chrysler		
Toyota		
GM	April 11	55,000
Honda	April 11	560,000
Nissan	April 11	480,000
Honda	April 18	205,000

Source: The Detroit News, April 27, 2013

Bloomberg Businessweek News From Bloomberg

Like 257k

Global Economics

Companies & Industries

Politics & Policy

Technology

Markets & Finance

Innovation & Design

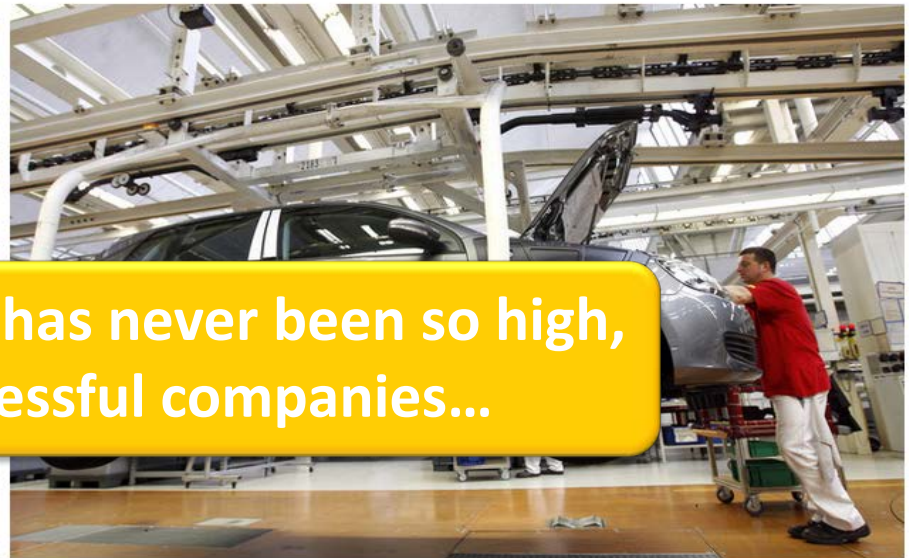
Lifestyle

Biggest in China

By Christoph Rauwald | November 14, 2013



SEND TO kindle



About 800,000 Tiguan compact sport-utility-vehicles worldwide may have lighting defects and 239,000 Amarok pickups could experience fuel leaks, the Wolfsburg, Germany-based manufacturer said today in two statements. Photographer: Adam Berry/Bloomberg

Volkswagen AG (VOW) is recalling about 2.64 million vehicles globally, including its biggest such recall in China, to fix electronic and drive-system flaws in some of its most popular models.

Practices toward Robust Design

Best in Class

Practice
Maturity Level

4

- Using six sigma and robust design optimization analysis; seeking a design with a probabilistic goal
- Using proprietary or third-party design optimization algorithms or tools
- Integrated system design and optimization of hardware, electronics and software
- Deploying adjoint solver techniques

3

- Simultaneous execution of automated updates of multiple design points for design optimization studies
- Established job scheduling strategy for optimized use of both local and remote hardware
- Multi-goal analyses with multiple design input parameters

2

- Multiple physics, design point analysis for conceptual design studies
- Parameterized models for what-if analyses, with automation
- Input/output parameter relationship based on design exploration tools

1

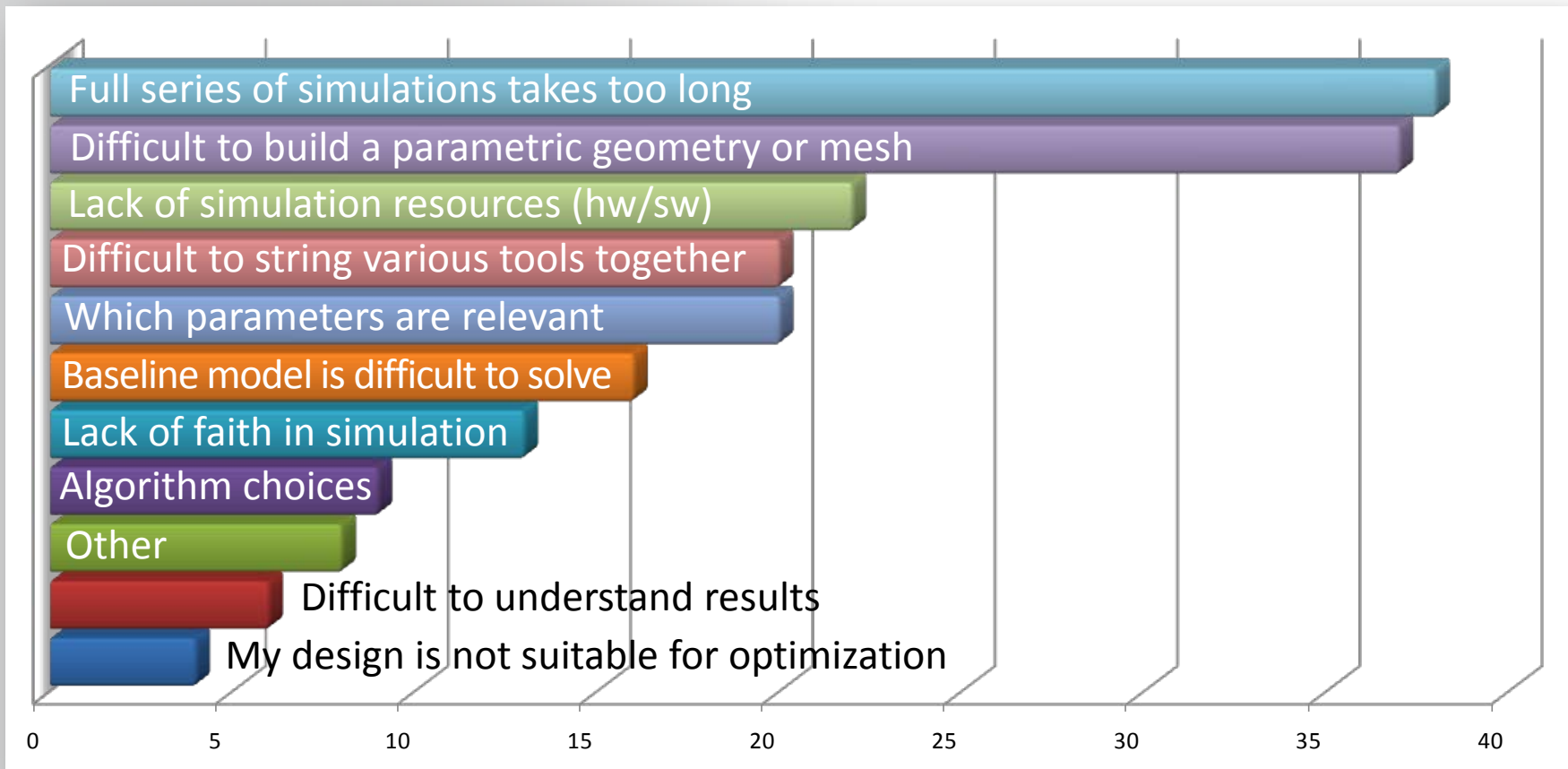
- Single analysis for validation purposes
- Manual adjustment of design parameters
- Single physics

Beginner

Increasing impact on
product integrity



Challenges to Adopt Robust Design Practices



Source: ANSYS Survey, Q1 2011

Recent Advances to Overcome Top Challenges

A 3D rendered white stick figure wearing a black tie, running towards the right. It is positioned on top of the first sign.

Time to Insight

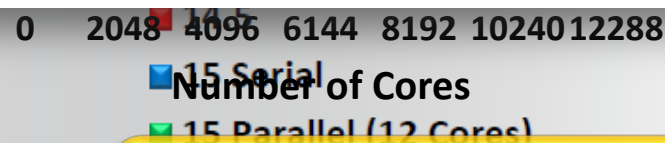
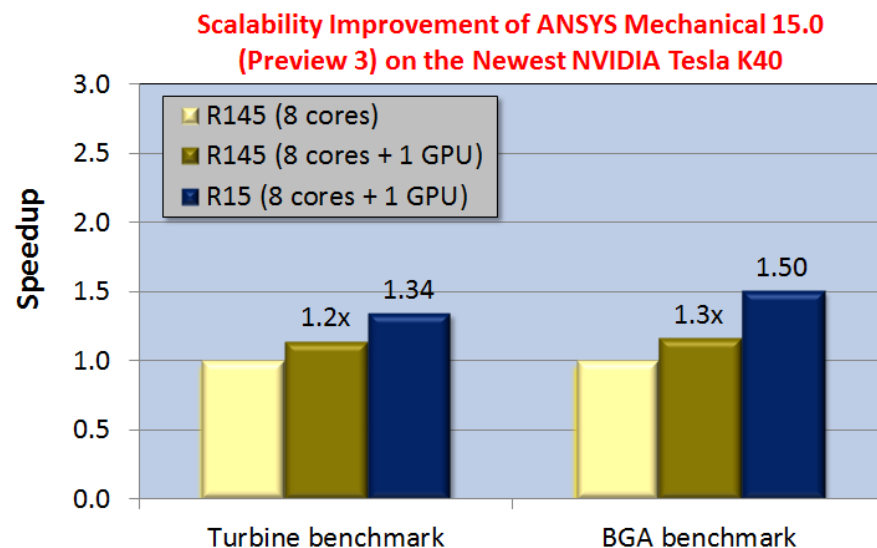
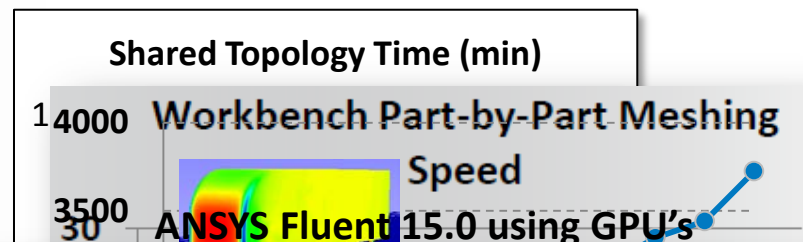
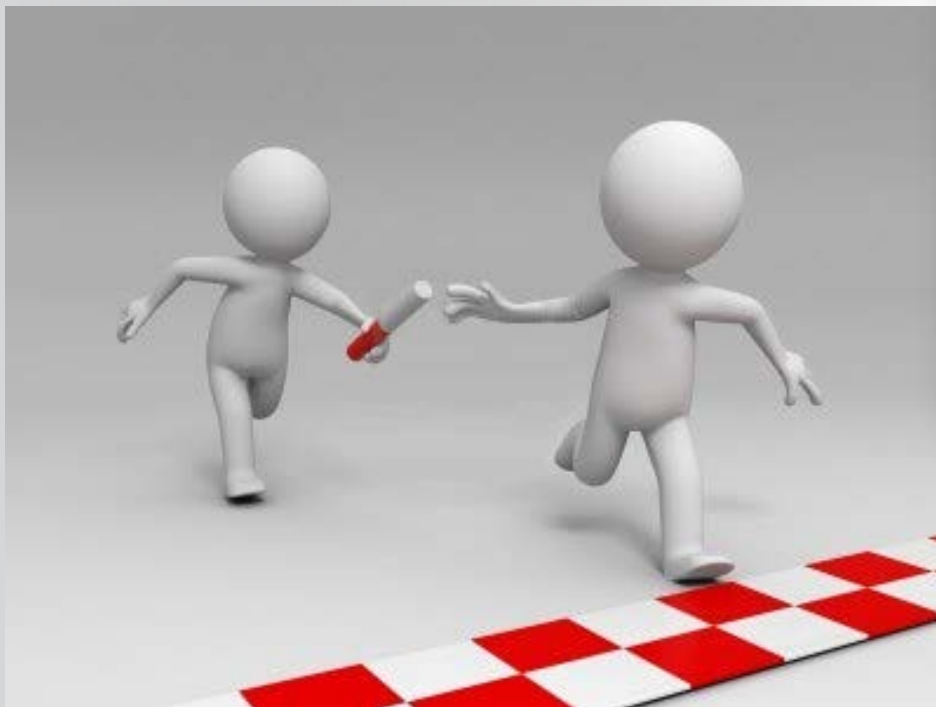
Parametric Modeling

Hardware / Software

Reduced Time to Insight



**Faster startup,
geometry import,
meshing, solving,
parallel, ...**



- 111 million cell (truck) model
- Pre-release results
- Scalable at ~10K cells per core!

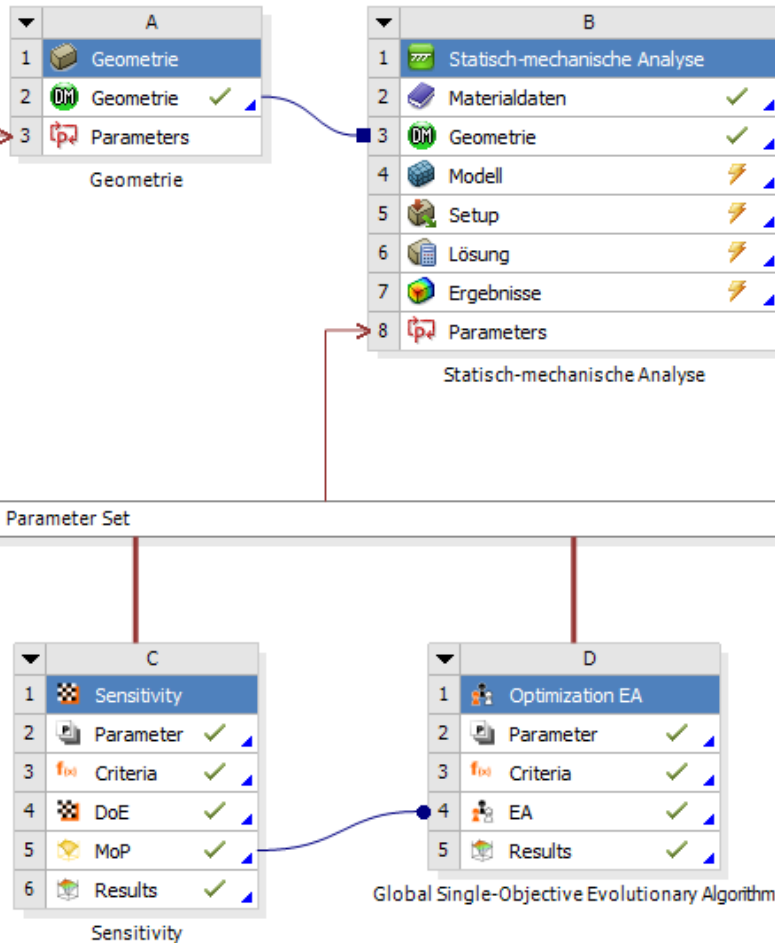
optiSLang inside ANSYS Workbench

optiSLang modules *Sensitivity*, *Optimization* and *Robustness* are directly available in ANSYS Workbench



Easy to use:

- Minimize user input
- Best practice default modules
- Pre-defined post processing modes

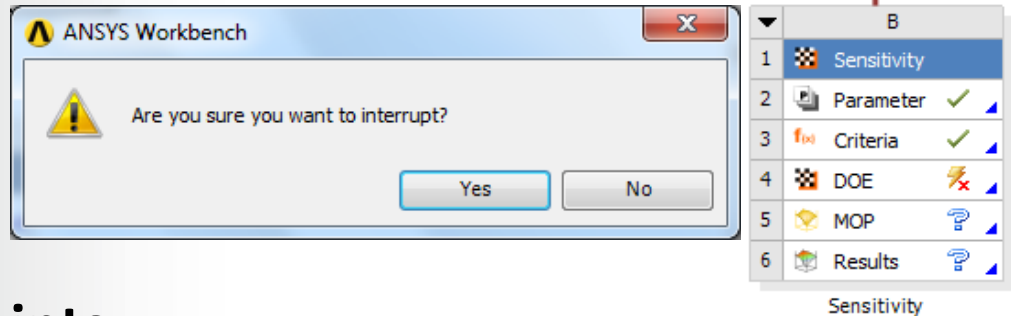


Outline of All Parameters			
	A	B	C
1	ID	Parameter Name	Value
2	Input Parameters		
3	Geometrie (A1)		
4	P1	DS_Thickness	15
5	P2	DS_Depth	20
6	P3	DS_LowerRadius	50
7	P4	DS_Angle	130
*	New input parameter	New name	New expression
9	Output Parameters		
10	Statisch-mechanische Analyse (B1)		
11	P5	Vergleichsspannung Maximum	0
12	P6	Geometrie Masse	0,75244
*	New output parameter		New expression
14	Charts		

Some Recent optiSLang/Workbench Updates

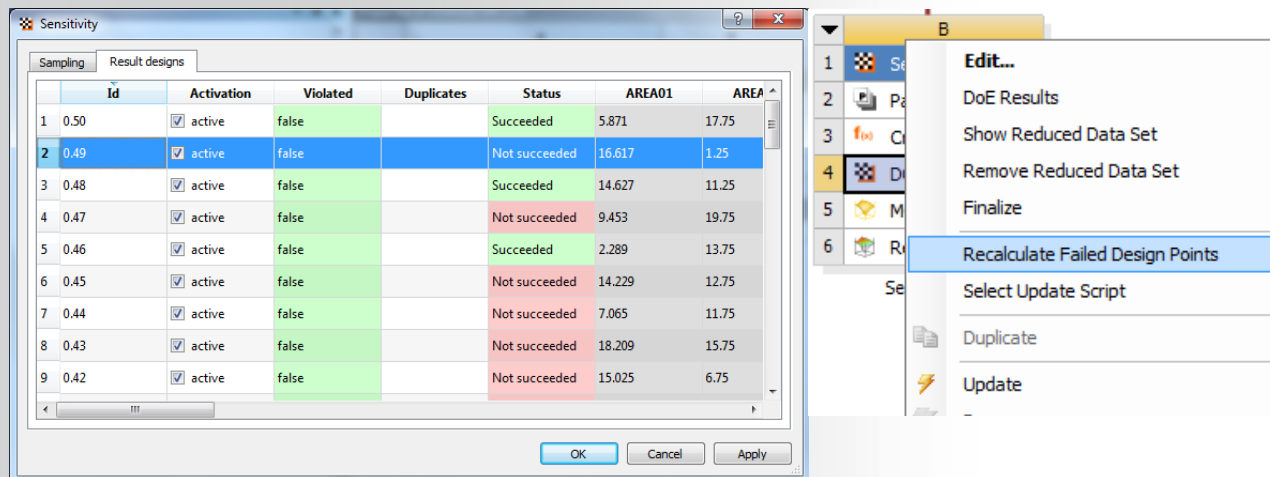
Interrupt, save, send & continue:

- If needed stop your analysis, save Workbench, and continue analysis later

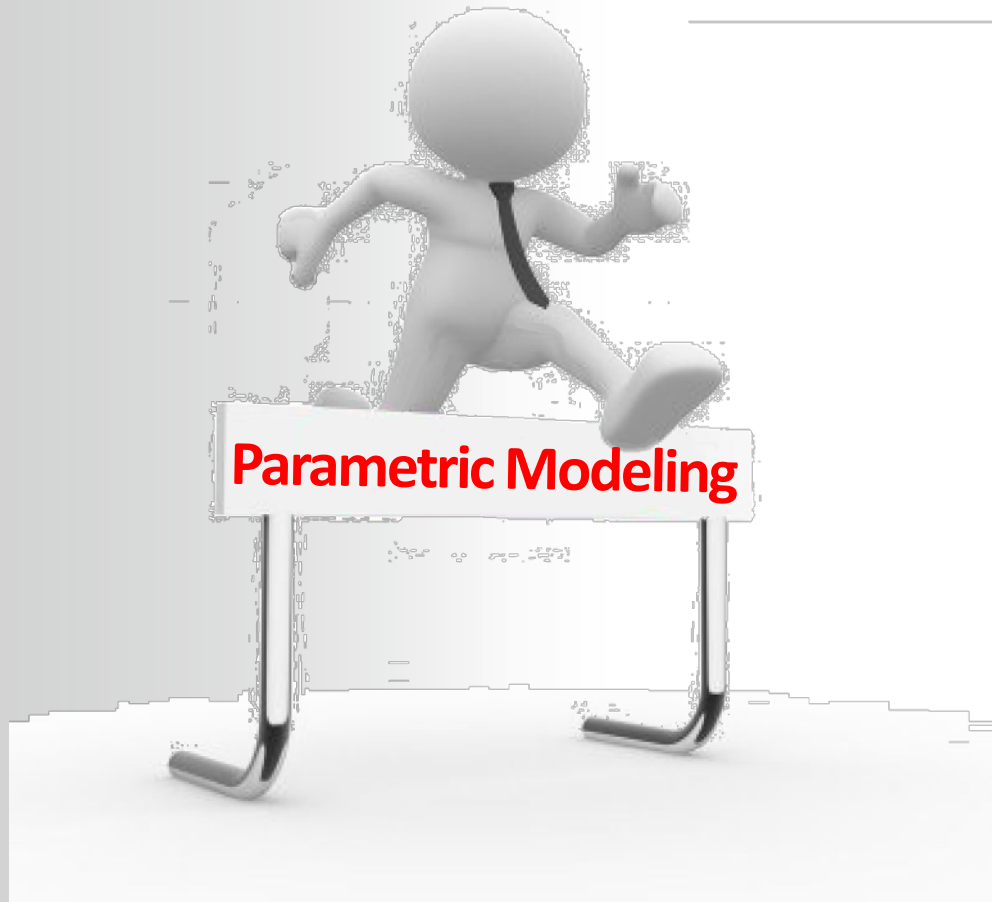


Recalculate Failed Design Points:

- Restart when design evaluations may fail

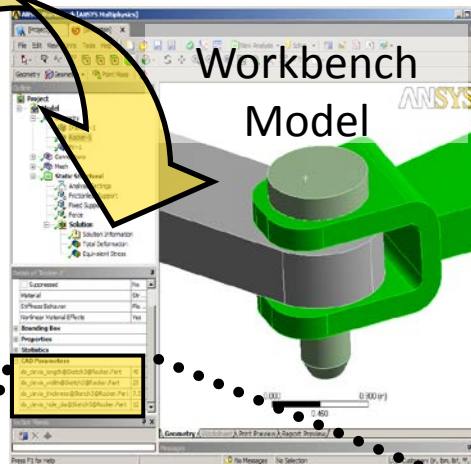
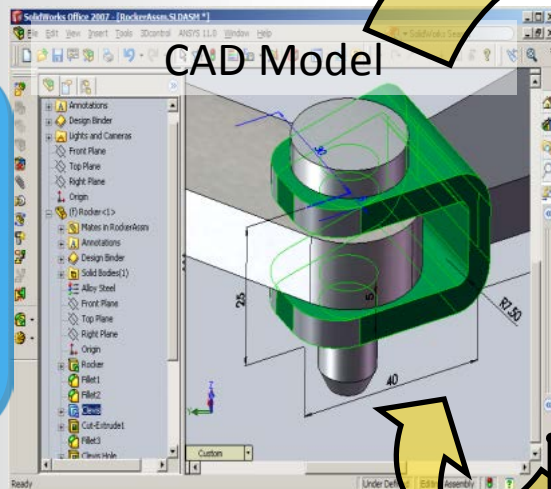


Building a Parametric Model



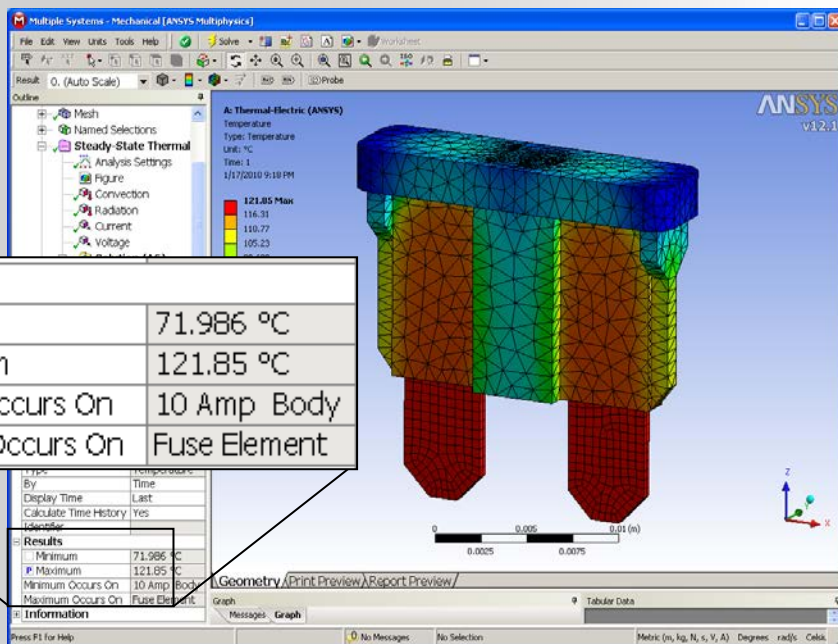
Parametric CAD

Bi-directional CAD interfaces



CAD Parameters

ds_devis_length@Sketch3@Rocker.Part	40
ds_devis_width@Sketch3@Rocker.Part	25
ds_devis_thickness@Sketch3@Rocker.Part	7.5
ds_devis_hole_dia@Sketch5@Rocker.Part	12

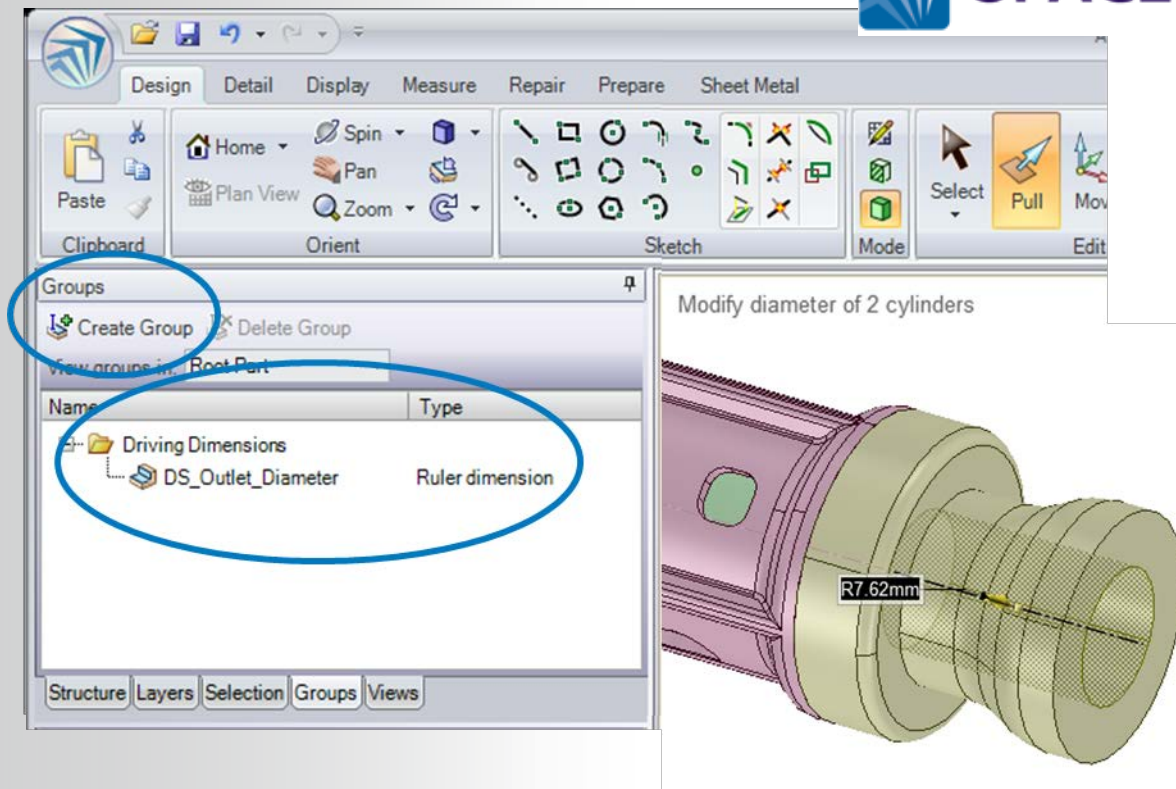


Workbench is a Parametric and Persistent platform

Parameterize with just a click

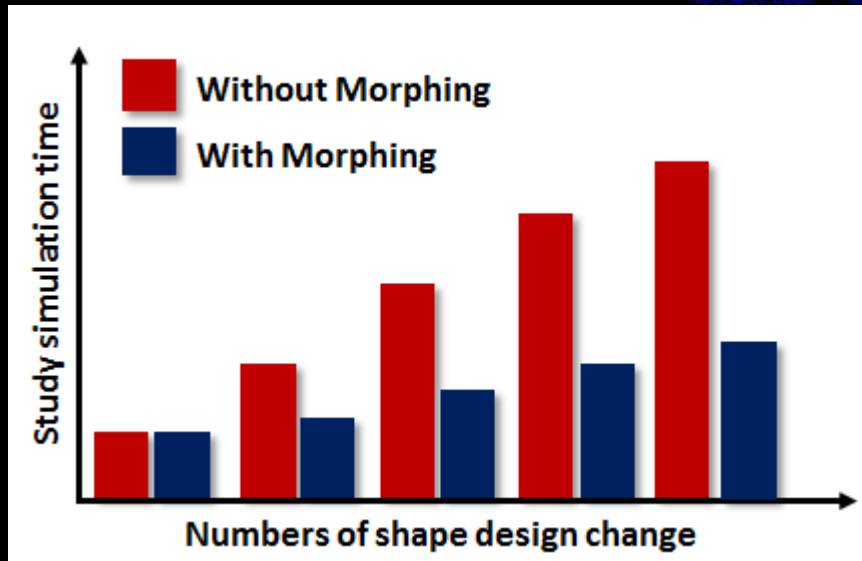
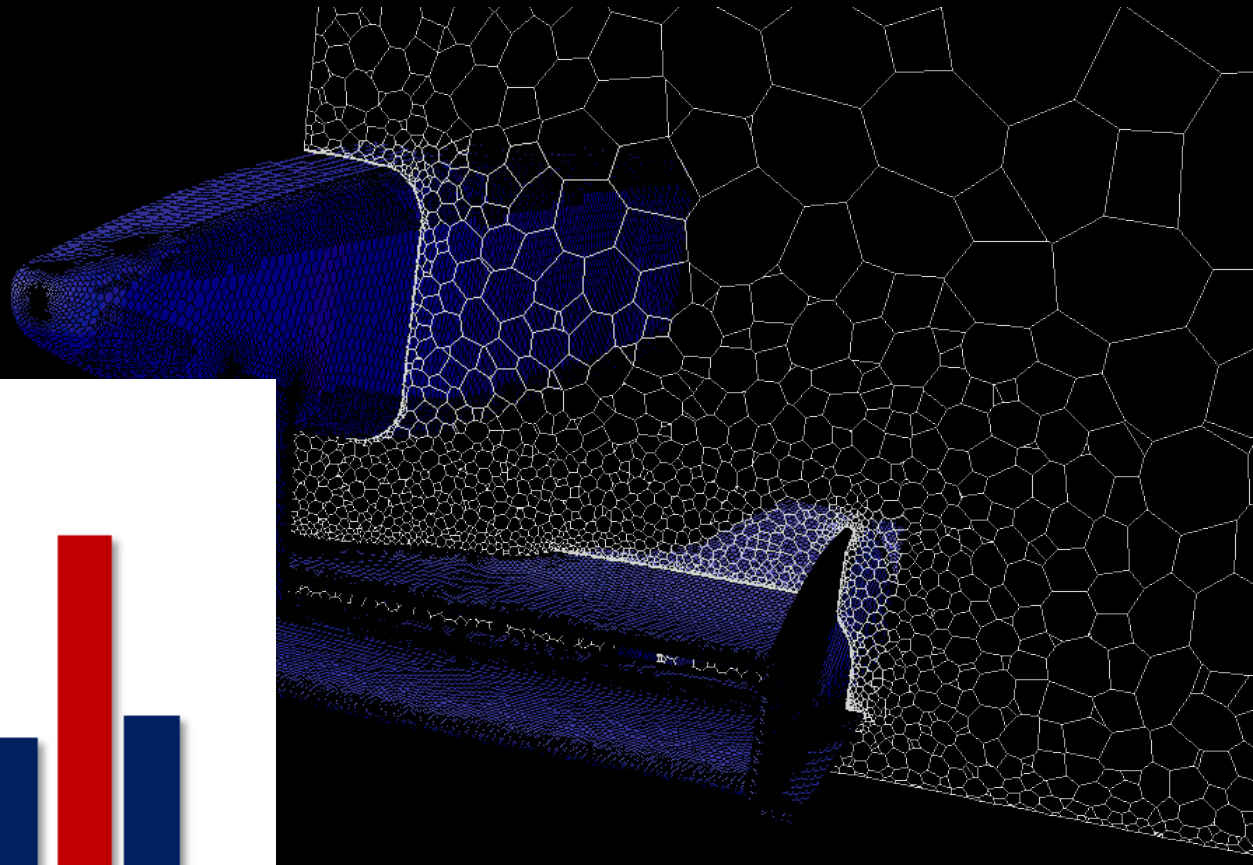
What if Your Model is “Dead”?

- Use SpaceClaim to easily create parameters from neutral files
 - STEP, IGES, Parasolid, ACIS, etc.



- Use Mesh Morphing to modify geometry without parameters

Adjust the Mesh for each design variation!

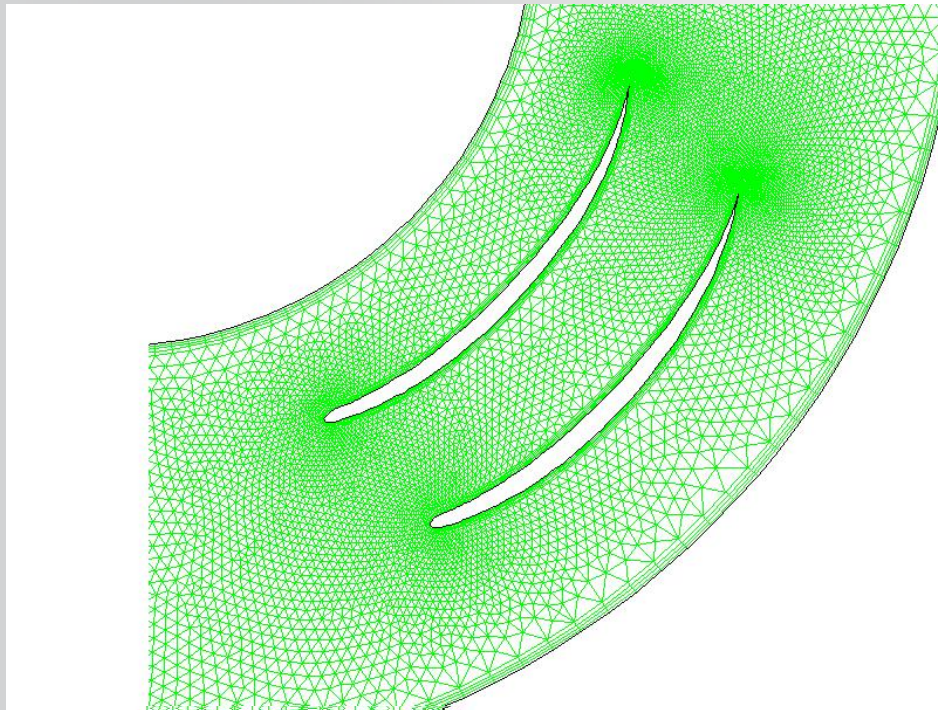


Smart Optimization with the Adjoint Solver

The Adjoint solver directly computes a more optimal shape depending upon the optimization goal

The Adjoint solver directly predicts the gain in performance

The mesh is morphed to the more optimal shape specified by the Adjoint solver



Goal: Minimizing Pressure Drop

Iteration 1

- $DP = -232.8$
- Expect change 10.0

Iteration 2

- Actual change 9.0
- $DP = -223.8$
- Expect change 8.9

Iteration 3

- Actual change 6.9
- $DP = -216.9$
- Expect change 7.0

Iteration 4

- Actual change 3.1
- $DP = -213.8$

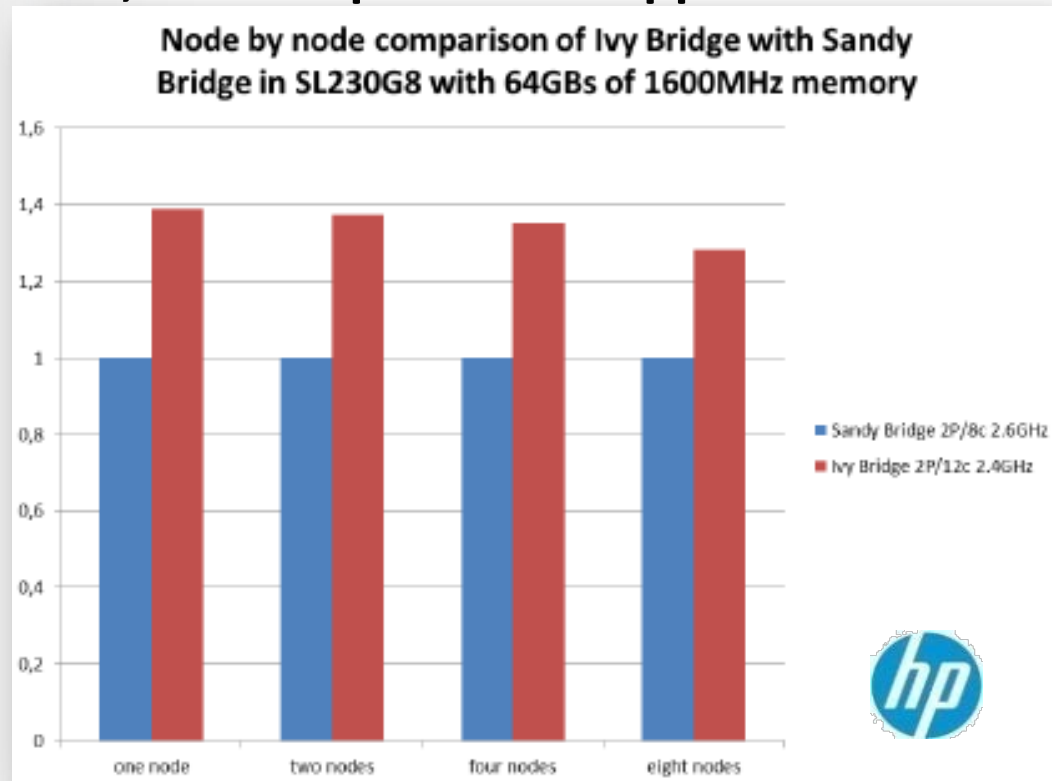
Total improvement of 8%

Fast and Affordable Design Studies



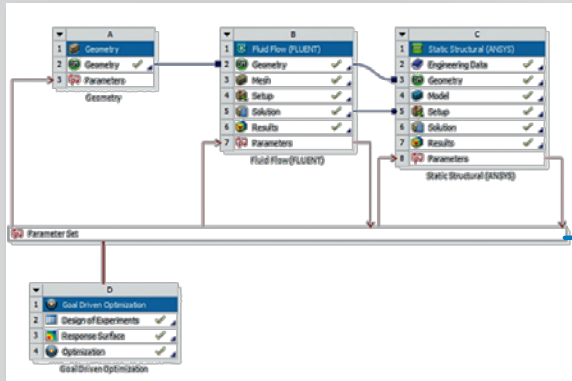
Partnerships with IT industry leaders, ensuring optimized HPC performance, a roadmap to the future, and wrap-around support

- ANSYS and Intel – 60% speed-up on Xeon E5-serie processors; ANSYS Mechanical 15.0 is the 1st release on Intel Xeon Phi
- ANSYS and NVIDIA – GPU acceleration of ANSYS Mechanical and Fluent; AMG solver of ANSYS Fluent 15.0 will support GPU's
- ANSYS and HP – Benchmarking, HPC Best Practices

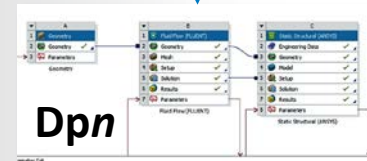
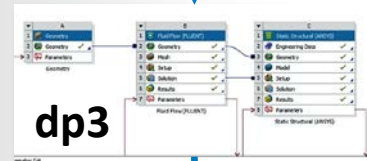
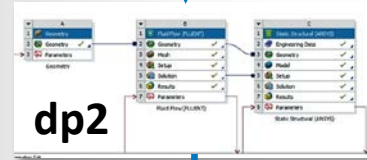
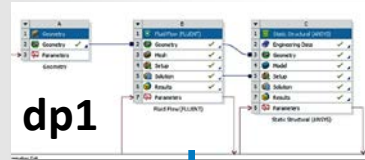


HPC performance optimizes the utilization of licenses, hardware, and people

Sequential Design Point Update

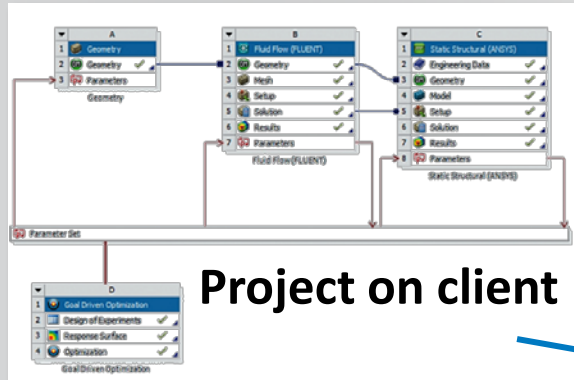


Serial Queue



*Serial queues
can be
time prohibitive*

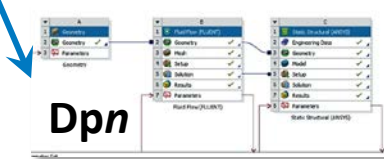
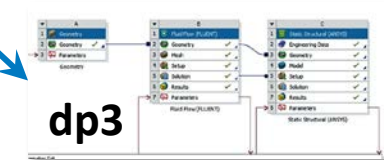
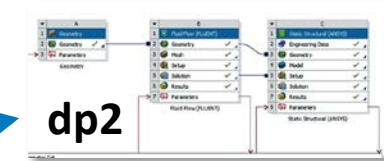
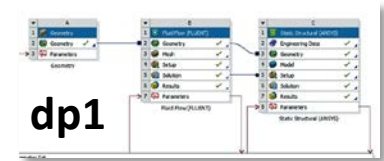
Simultaneous Design Point Update



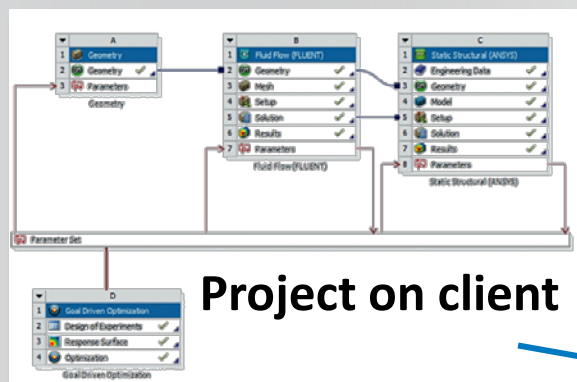
*Simultaneous
Solve can
dramatically
reduce **time to
insight***



RSM
Remote
Solve
Manager



Simultaneous Design Point Update



Project on client

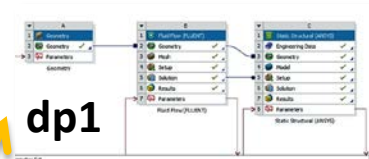
*Simultaneous
License usage can
be cost prohibitive*



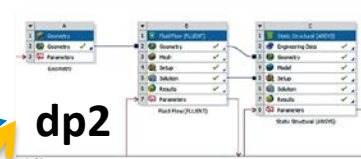
RSM



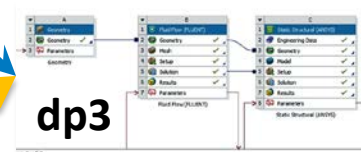
License
Server



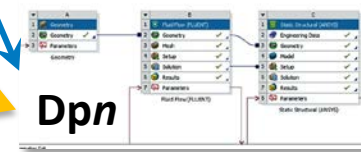
dp1



dp2



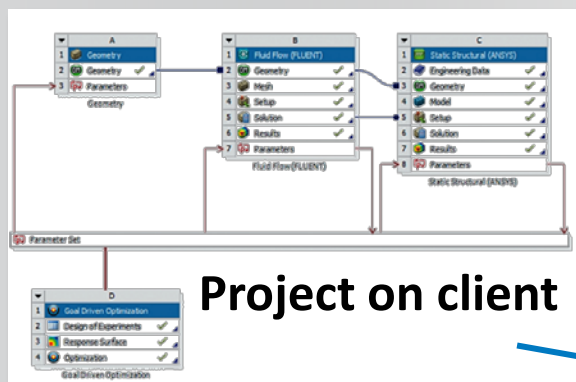
dp3



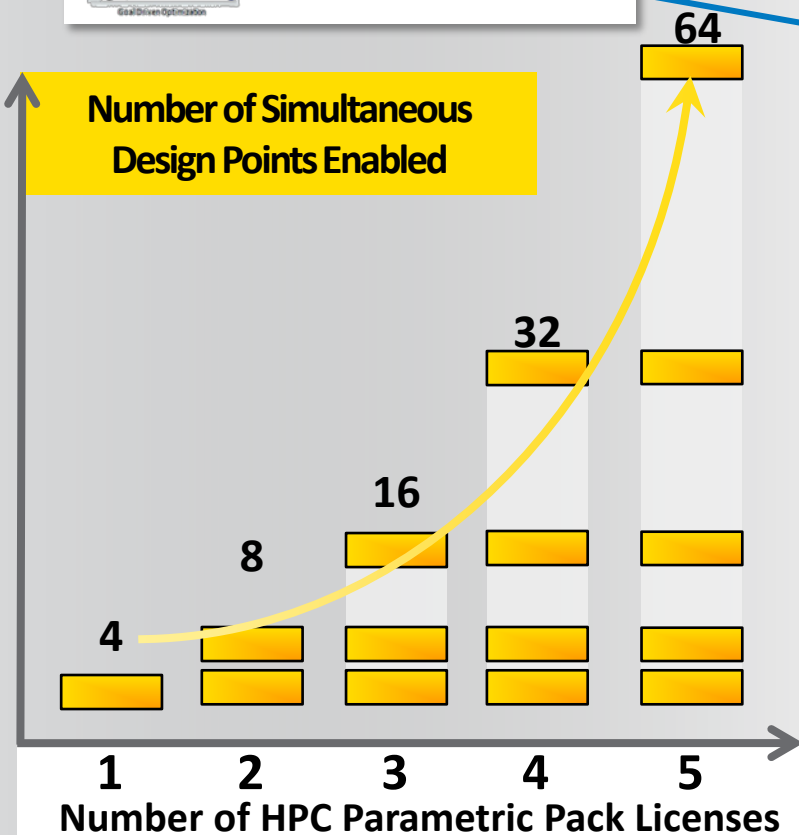
Dpn

But!

HPC Parametric Packs



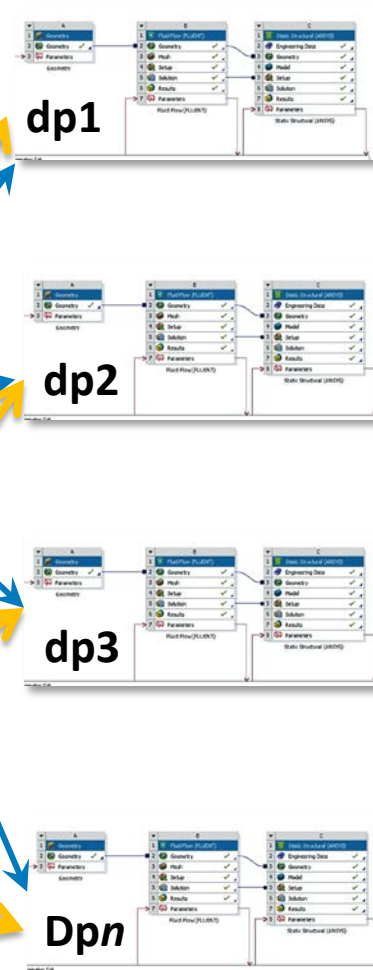
Rapid and affordable updates



RSM



**License Server
With HPC Parametric Packs**

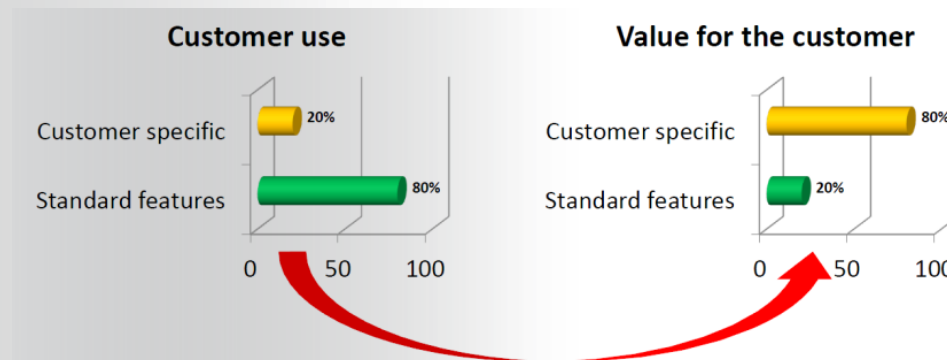
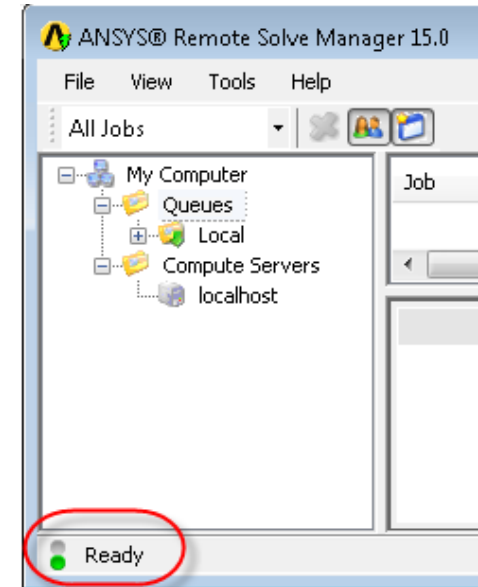


Advances in Workbench R15.0

- For Managing Large Number of Design Configurations

RSM Enhancements

- Improved efficiency of RSM Design Point updates
- Improved robustness and scalability
- Added support for Univa Grid Engine 
- Added component override for design point update
- Added support for Mechanical/MAPDL restart
- Non-root users on Linux can now use RSM wizard
- Enriched support for RSM customization
- ...

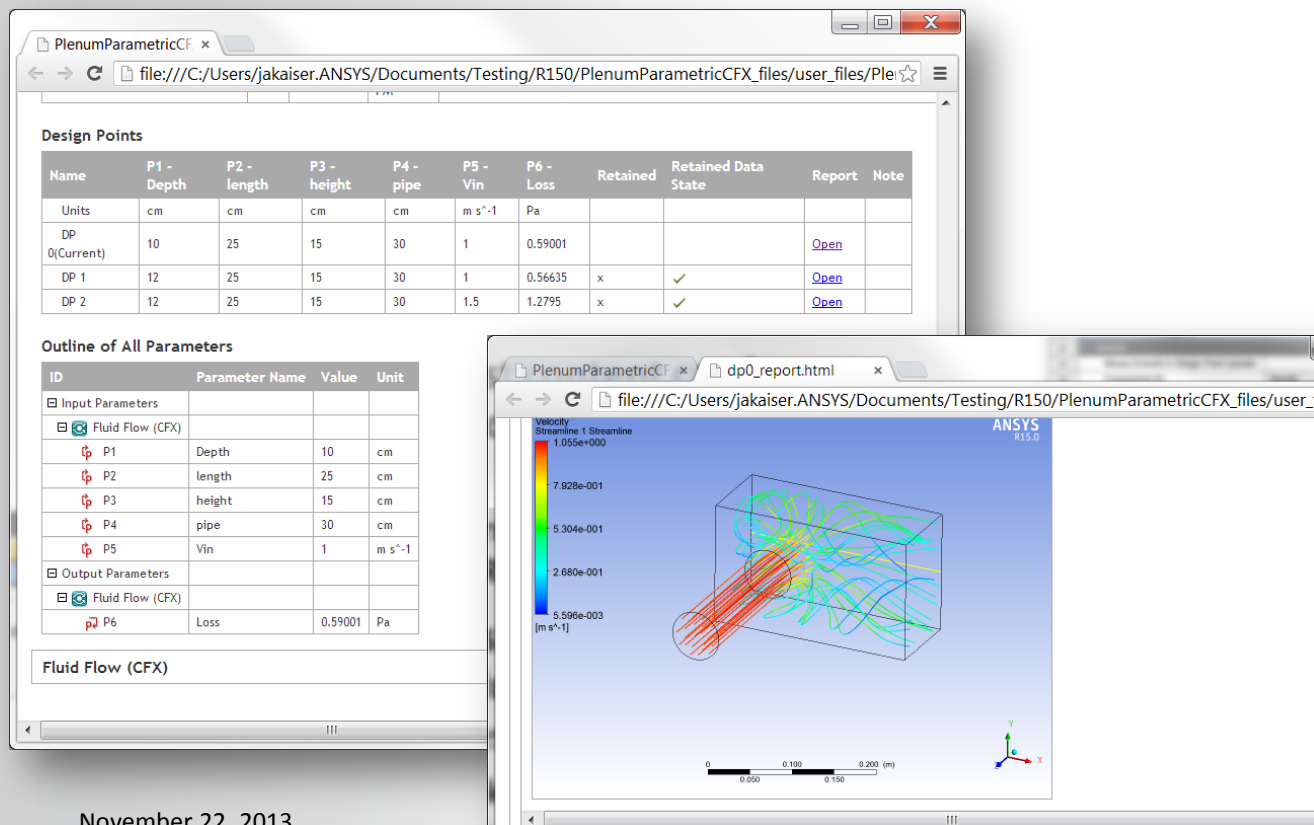


Advances in Workbench R15.0

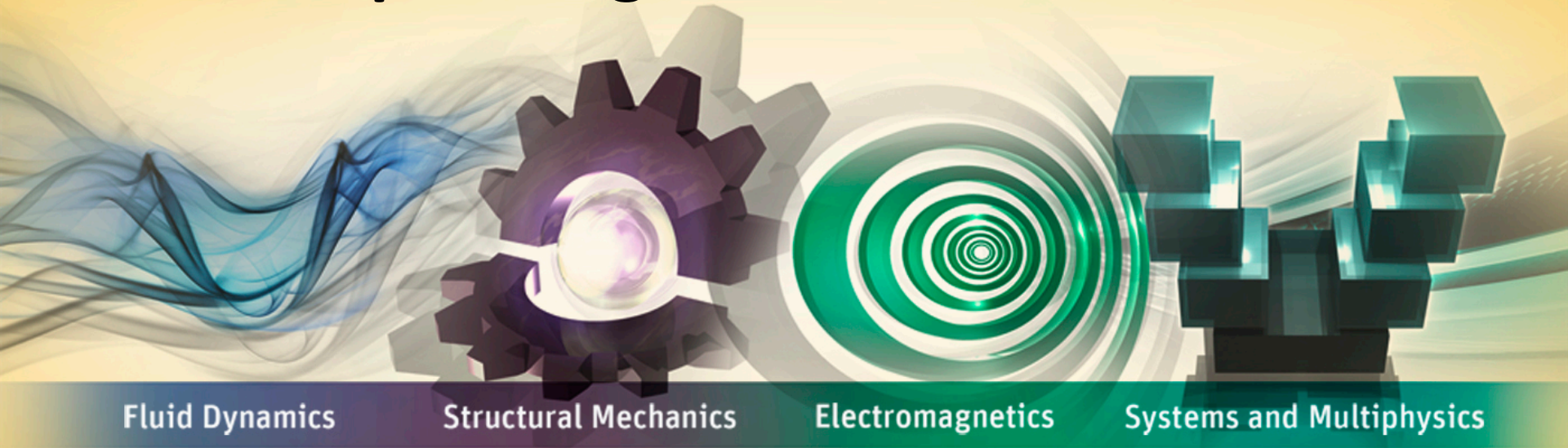
- Enriched Project Report Content

Projects with Design Points will include a sub-report for each Design Point

- Link shown in Report column in the Design Points table in the main report
- Get detailed results for every Design Point!



Examples Using ANSYS Workbench 14.5.7 and optiSLang 4.0.6 on a HPC Cluster



Herbert Güttler, MicroConsult

Tools (Hardware: Oct 2013)



160 E5 V2 Ivy Bridge cores @ 3.0 GHz
304 E5 Sandy Bridge cores @2.9 GHz

6..16 GB / core RAM (4,0 TB Total)

Accelerators:

22 Fermi M207x ,
10 Kepler K20x
2 Xeon Phi 7210P

Peak Performance ANSYS

single job: 3.1 TFLOPs
accumulated / 24 Jobs: 10 TFLOPs

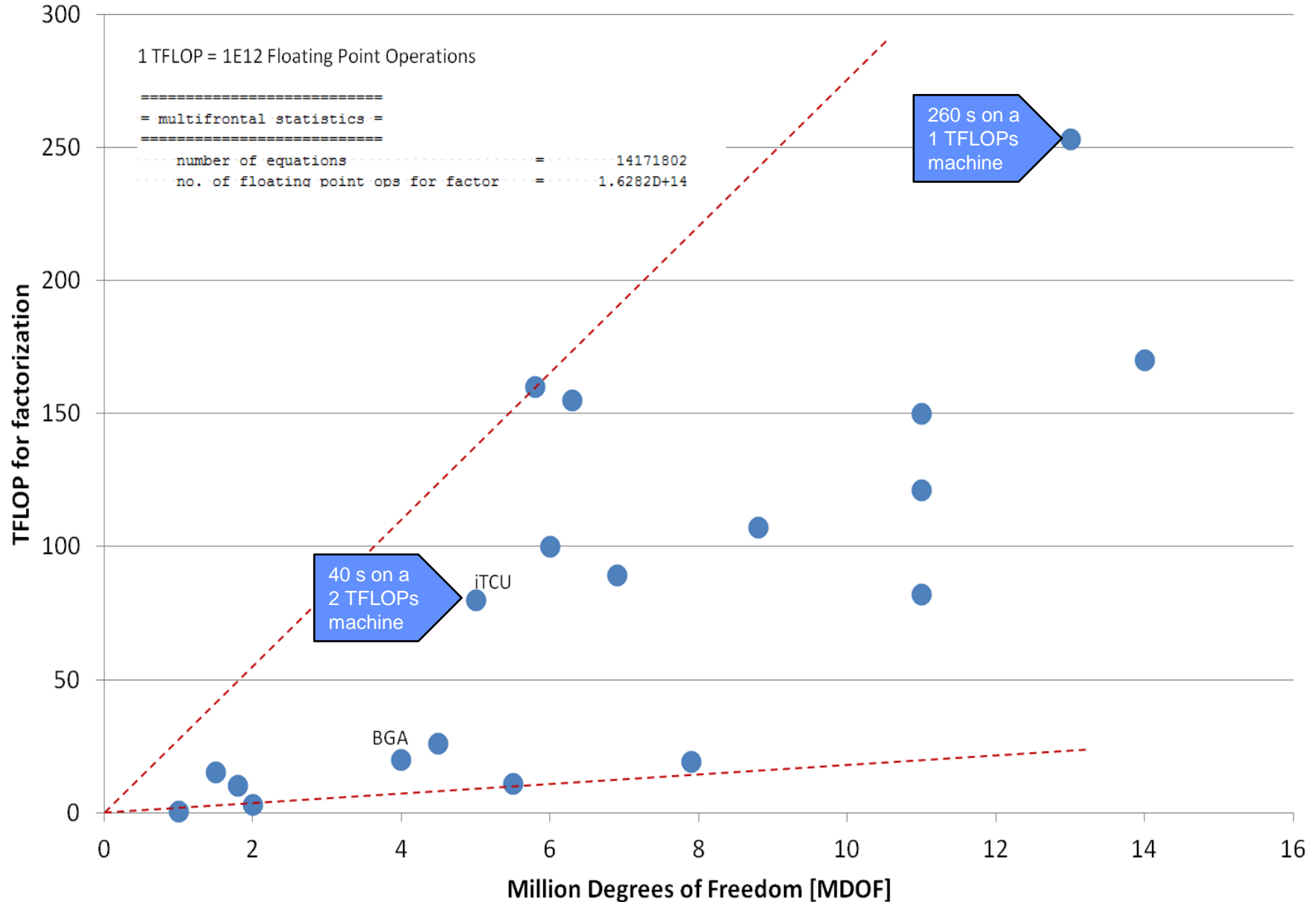
Infiniband interconnect

Compute servers SSD only
Remote Access: 3x HP-RGS

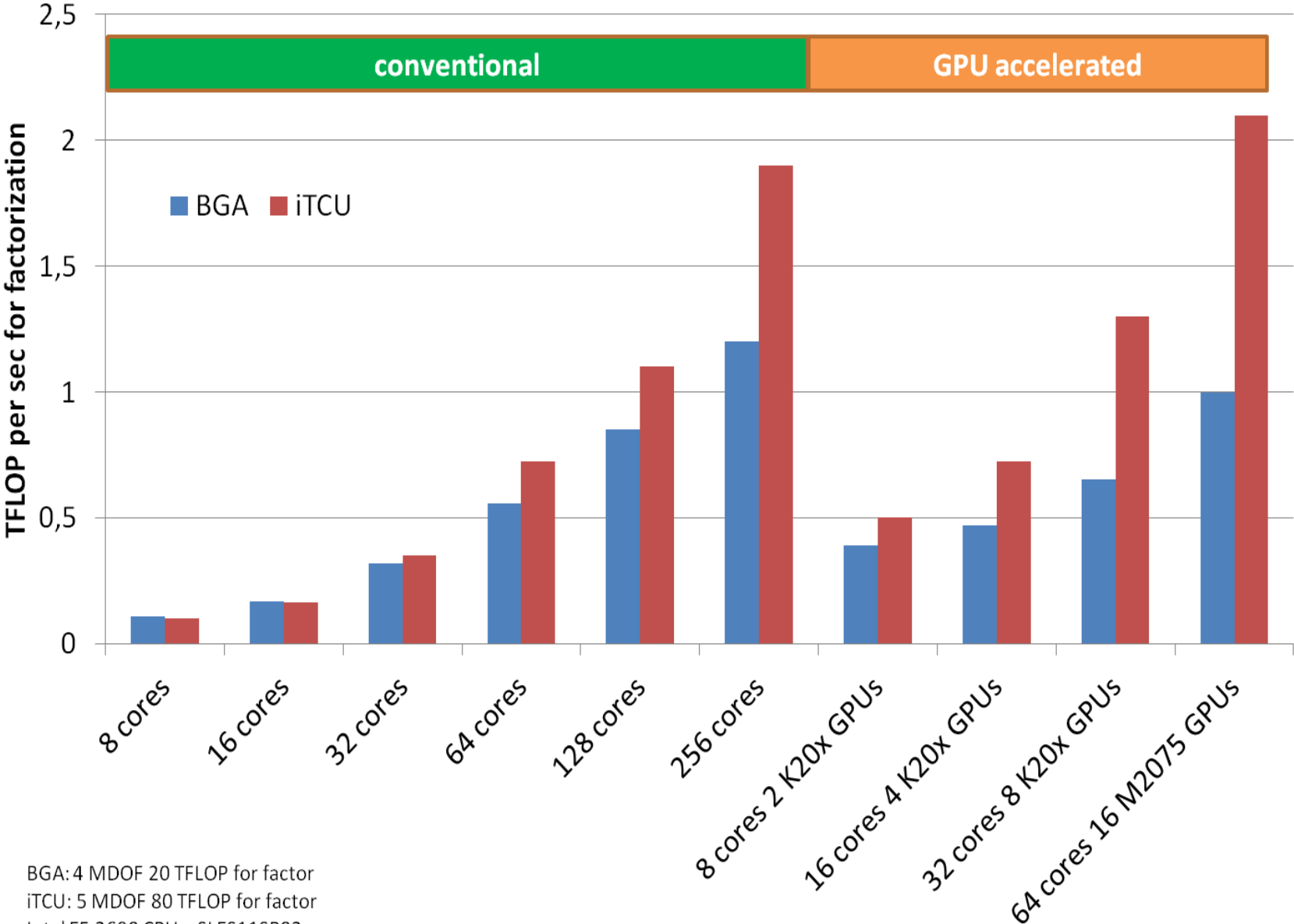
SLES 11 SP02 for compute nodes

Closed loop aircooled rack

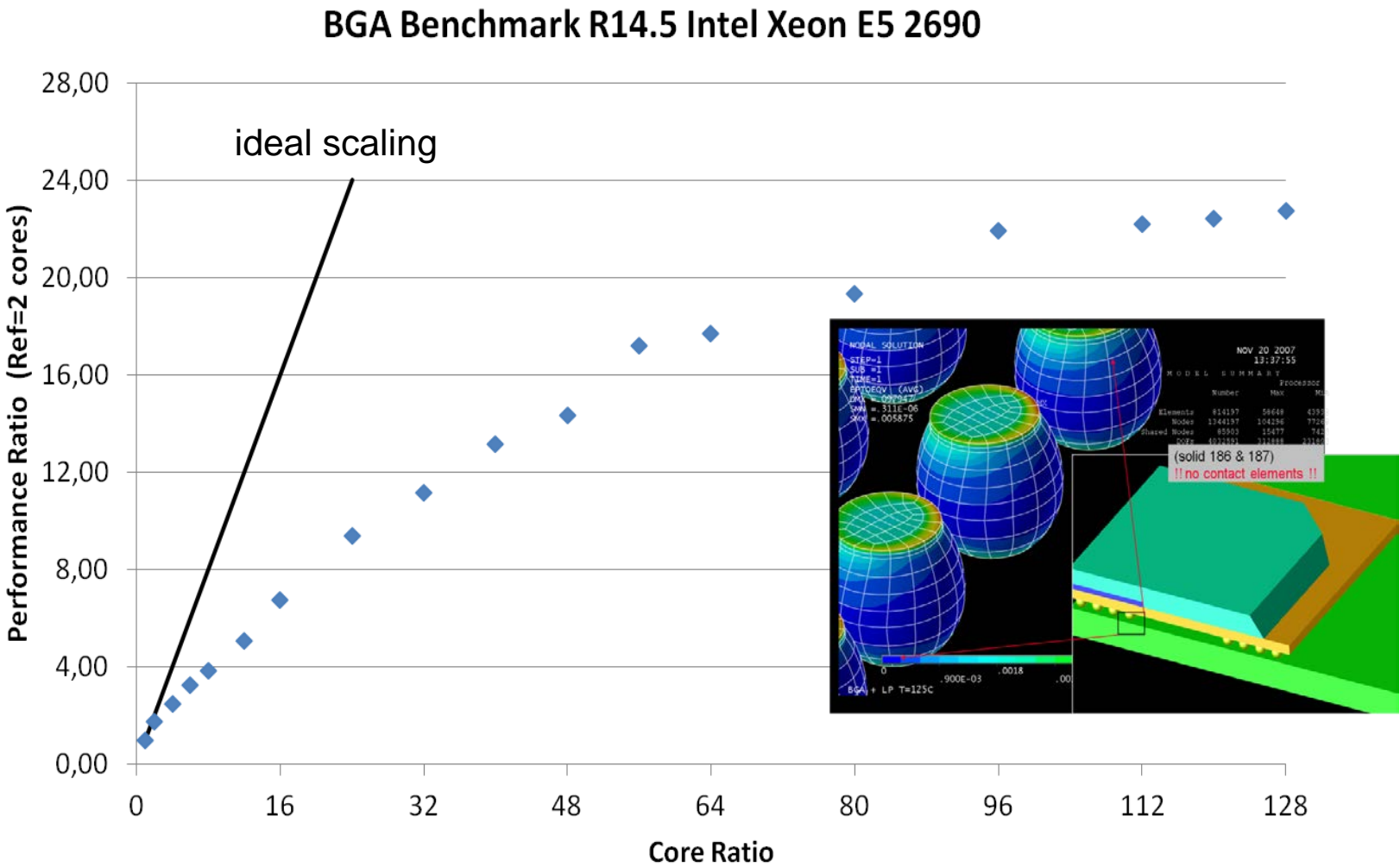
Numerical Effort for a random selection of MCE Projects ANSYS MAPDL, sparse solver



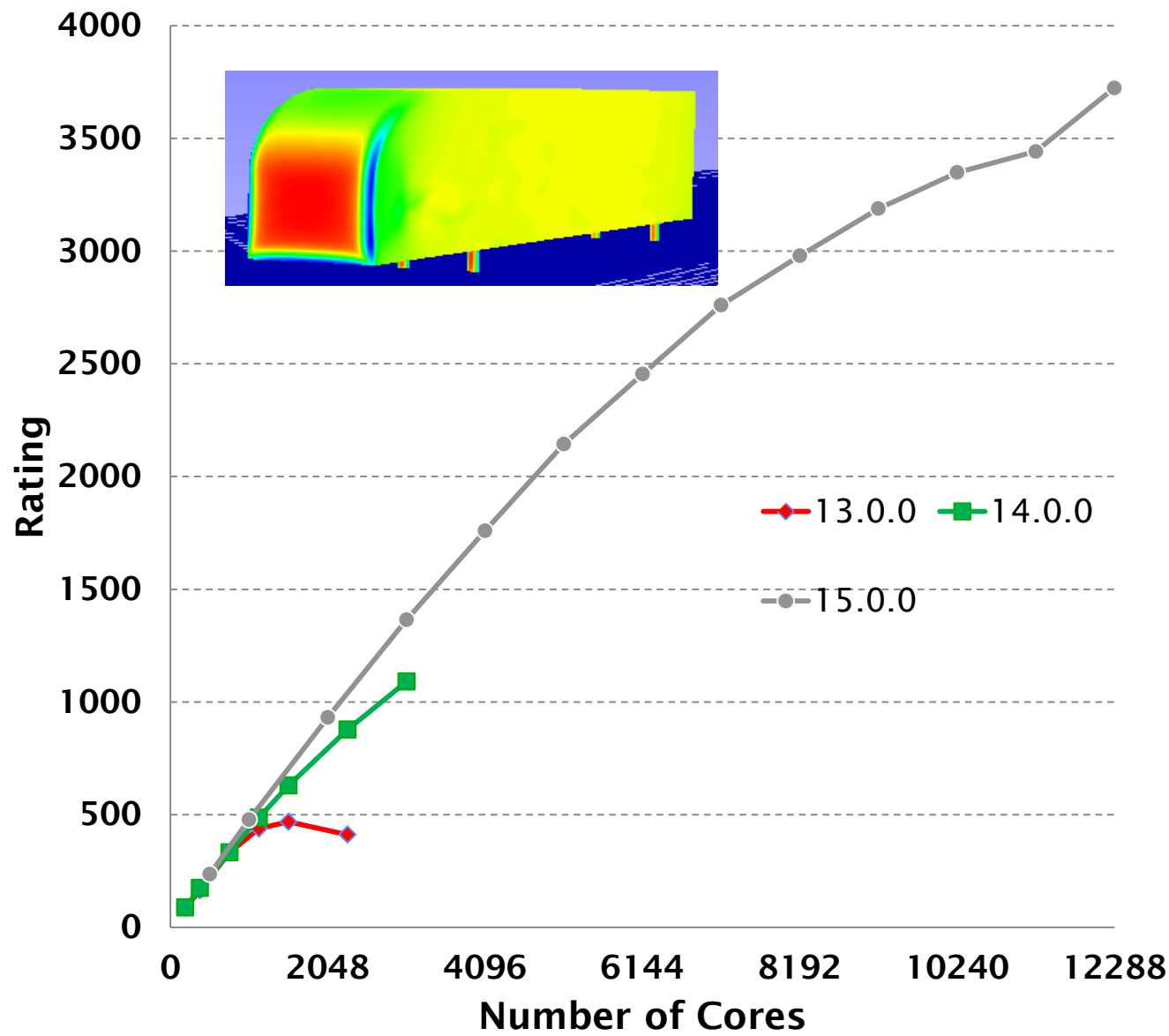
Performance Results



Benchmarking (ANSYS Mechanical)



Benchmarking (ANSYS Fluent)



Essentials:

- Performance is very case dependent
- Looking at DOFs won't tell you much about the actual performance
- GPUs accelerate numbercrunching
- Scaling for ANSYS Mechanical is much different compared to CFD
- A cluster can run a single big job or many small jobs
- Optimization requires solving many designs
- Many design require many licenses
- With R14.5 came HPC Parametric Pack licenses (license multipliers)
- HPC Parametric Pack licensing works only via Workbench Design Points

How it's done

Import... Reconnect Refresh Project Update Project Resume Update All Design Points Project Compact Mode optiPlug...

Project Schematic

A

1 Statisch-mechanische Analyse

2 Technische Daten ✓

3 Geometrie ✓

4 Modell ✓

5 Setup ✓

6 Lösung ✓

7 Ergebnisse ✓

8 Parameters

Statisch-mechanische Analyse

Parameter Set

B

1 Sensitivity

2 DOE ✓

3 MOP ⚡

4 Results ?

Sensitivity

Properties of Schematic: Parameter Set

	A	
1	Property	
2	Design Point Update Process	
3	Update Option	Submit to Remote Solve Manager
4	Job Submission	Specify Maximum Number of Jobs
5	Maximum Number of Jobs	16
6	Design Point Update Order	Update Design Points in Order
7	Pre-RSM Foreground Update	None
8	License Checkout	Reserved
9	Reserved License Set	Select Licenses
10	Component Execution Mode	Parallel
11	Max Number of Processes Per Job	16
12	Keep Failed Design Point Files (Beta)	
13	Solve Manager	localhost
14	Queue	Local

No feature to activate GPUs

How it's done

	A	B	C	D	E	F	G
1	Name ▾	P6 - Laenge ▾	P4 - Hoehe ▾	P5 - Breite ▾	P2 - Gesamtverformung Maximum ▾	<input type="checkbox"/> Exported	Note ▾
2	Units				m		
3	Current	100	5	20	0,022188		
4	DP 1	122,66	7,9063	18,438	0,011324	<input type="checkbox"/>	Sensitivity -- Design #1
5	DP 2	89,844	7,1563	17,813	0,0062049	<input type="checkbox"/>	Sensitivity -- Design #2
6	DP 3	103,91	6,9688	14,688	0,012636	<input type="checkbox"/>	Sensitivity -- Design #3
7	DP 4	111,72	6,5938	22,188	0,012187	<input type="checkbox"/>	Sensitivity -- Design #4
8	DP 5	92,969	4,7188	13,438	0,031756	<input type="checkbox"/>	Sensitivity -- Design #5
9	DP 6	114,84	5,2813	15,938	0,035996	<input type="checkbox"/>	Sensitivity -- Design #6
10	DP 7	102,34	5,6563	14,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #7
11	DP 8	77,344	4,5313	29,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #8
12	DP 9	121,09	2,6563	20,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #9
13	DP 10	107,03	3,9688	19,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #10
14	DP 11	75,781	4,3438	10,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #11
15	DP 12	99,219	7,3438	28,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #12
16	DP 13	94,531	7,5313	27,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #13
17	DP 14	86,719	2,4688	21,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #14
18	DP 15	96,094	5,4688	25,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #15
19	DP 16	83,594	3,2188	27,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #16
20	DP 17	117,97	6,0313	22,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #17
21	DP 18	124,22	2,2813	20,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #18
22	DP 19	80,469	4,9063	23,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #19
23	DP 20	85,156	7,7188	10,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #20
24	DP 21	88,281	2,8438	12,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #21
25	DP 22	110,16	3,0313	11,063	0,023547	<input type="checkbox"/>	Sensitivity -- Design #22

ANSYS DesignModeler Licenses **cannot be multiplied**

Select Licenses

Select the Available Licenses you want to use and add them to your set of Reserved Licenses

License Name	Total	Available
ANSYS CFD PrepPost*	1	1
ANSYS DesignModeler	3	3
ANSYS FLUENT Solver*	1	1
ANSYS HPC Pack*	14	14
ANSYS HPC Parametric Pack	3	3
ANSYS Mechanical PrepPost*	1	1
ANSYS Mechanical Solver*	1	1
ANSYS Mechanical*	2	2
ANSYS Multiphysics*	4	4
ANSYS SpaceClaim CATIA V5 Interface	1	1
ANSYS SpaceClaim Direct Modeler	1	1
ANSYS Structural Solver*	2	2
ANSYS Structural*	1	1
Geometry Interface for Parasolid	1	1
Geometry Interface for Pro/ENGINEER	1	1
Geometry Interface for SolidWorks	1	1

* - Indicates that this license can be multiplied by ANSYS HPC Parametric Pack license(s).

License Name	Reserved	Concurrent Licenses
ANSYS DesignModeler	2	2
ANSYS HPC Pack*	2	32
ANSYS HPC Parametric Pack	3	-
ANSYS Multiphysics*	1	16

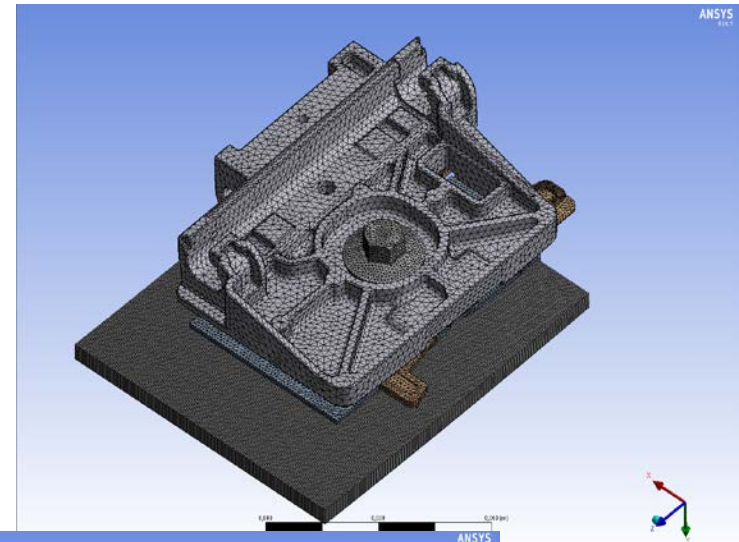
Change Number Selected: 1

OK Cancel

Cases used for benchmarking

Power Window Actuator:

6 bodies, 15 contacts,
3.3 MDOF, 18 TFLOP / iteration
Sensitivity study,
Uses Geometry Updates



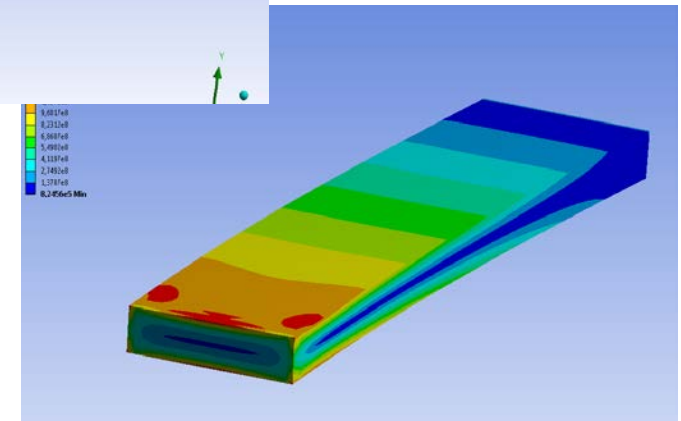
Mountain Bike Frame:

1 body, no contacts,
2.1 MDOF, 0.8 TFLOP / iteration
Sensitivity study,
Uses Geometry Updates

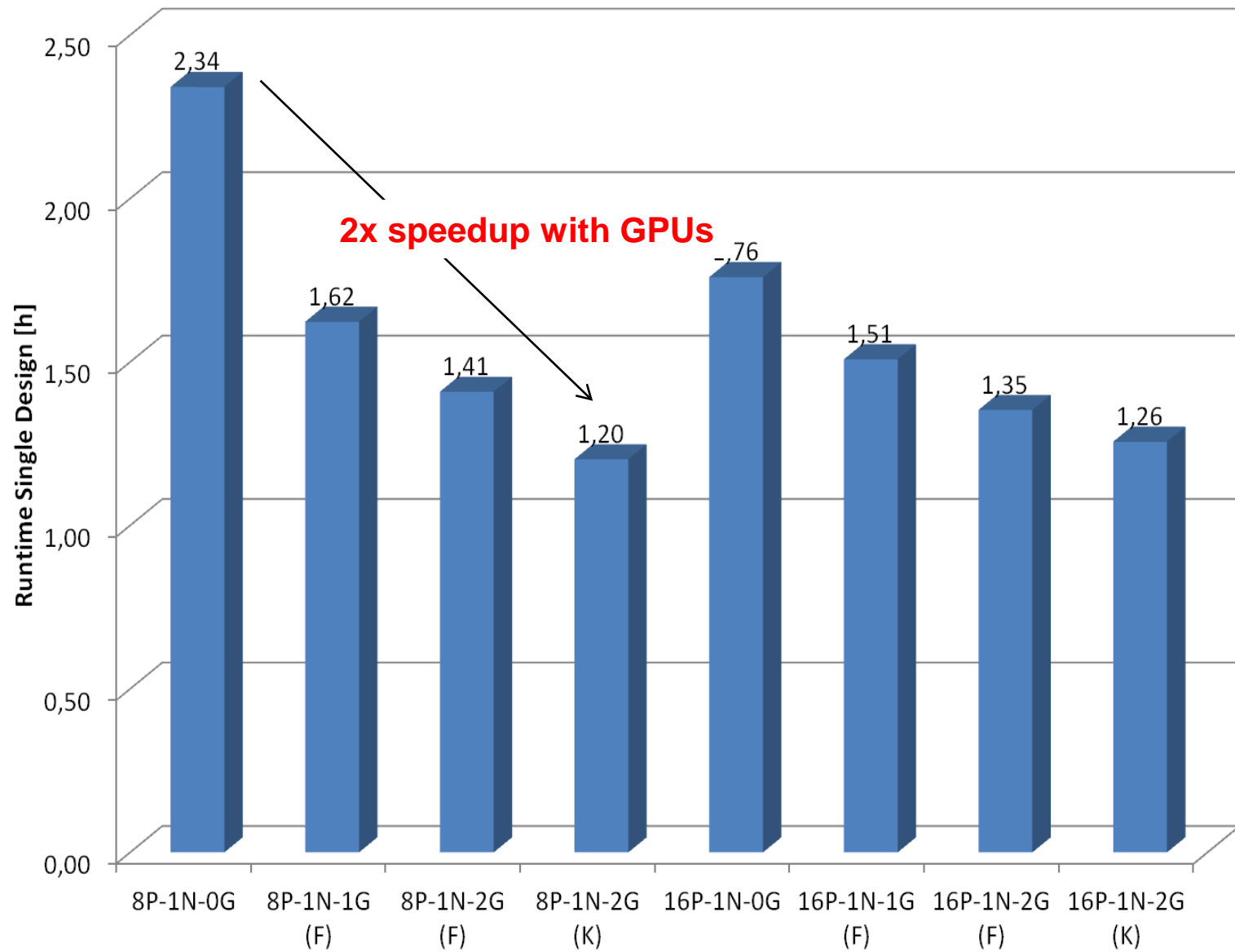


Beam in Bending:

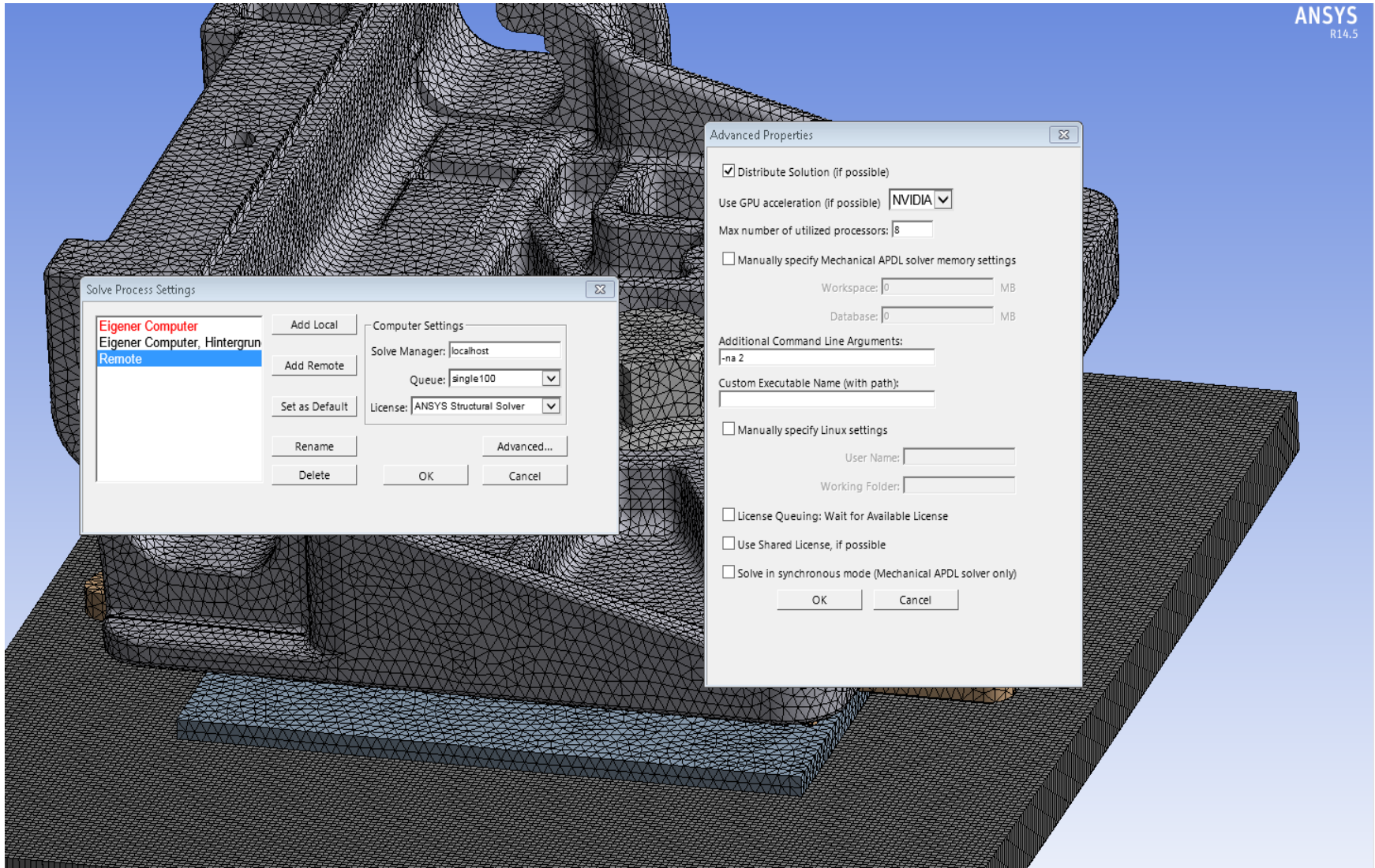
1 body, no contacts,
4.0 MDOF, 88 TFLOP / iteration
Sensitivity study,
No Geometry Updates



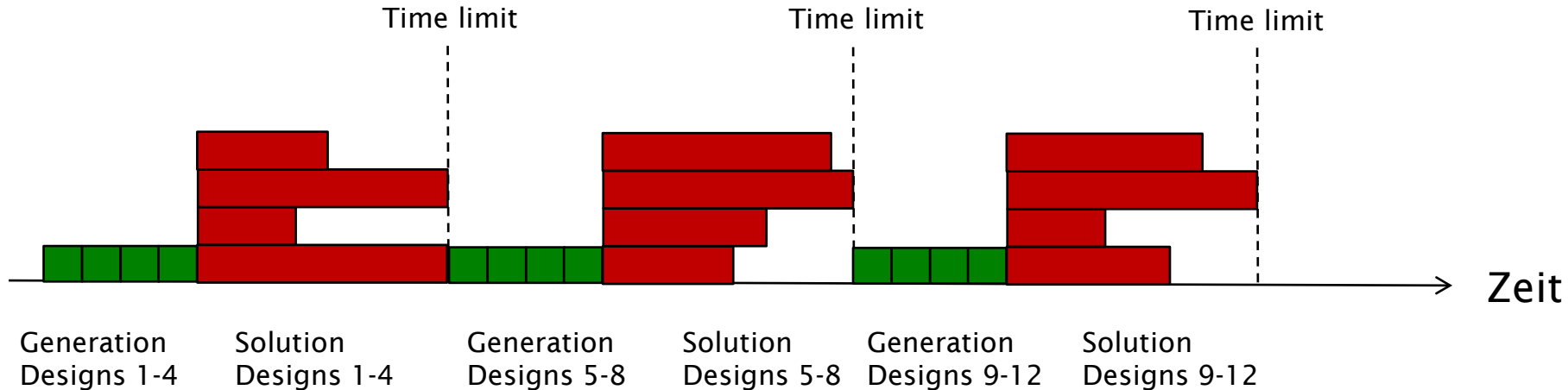
Power Window Actuator, Single Design



Note: For a single solution, GPU are controlled via Advanced Properties



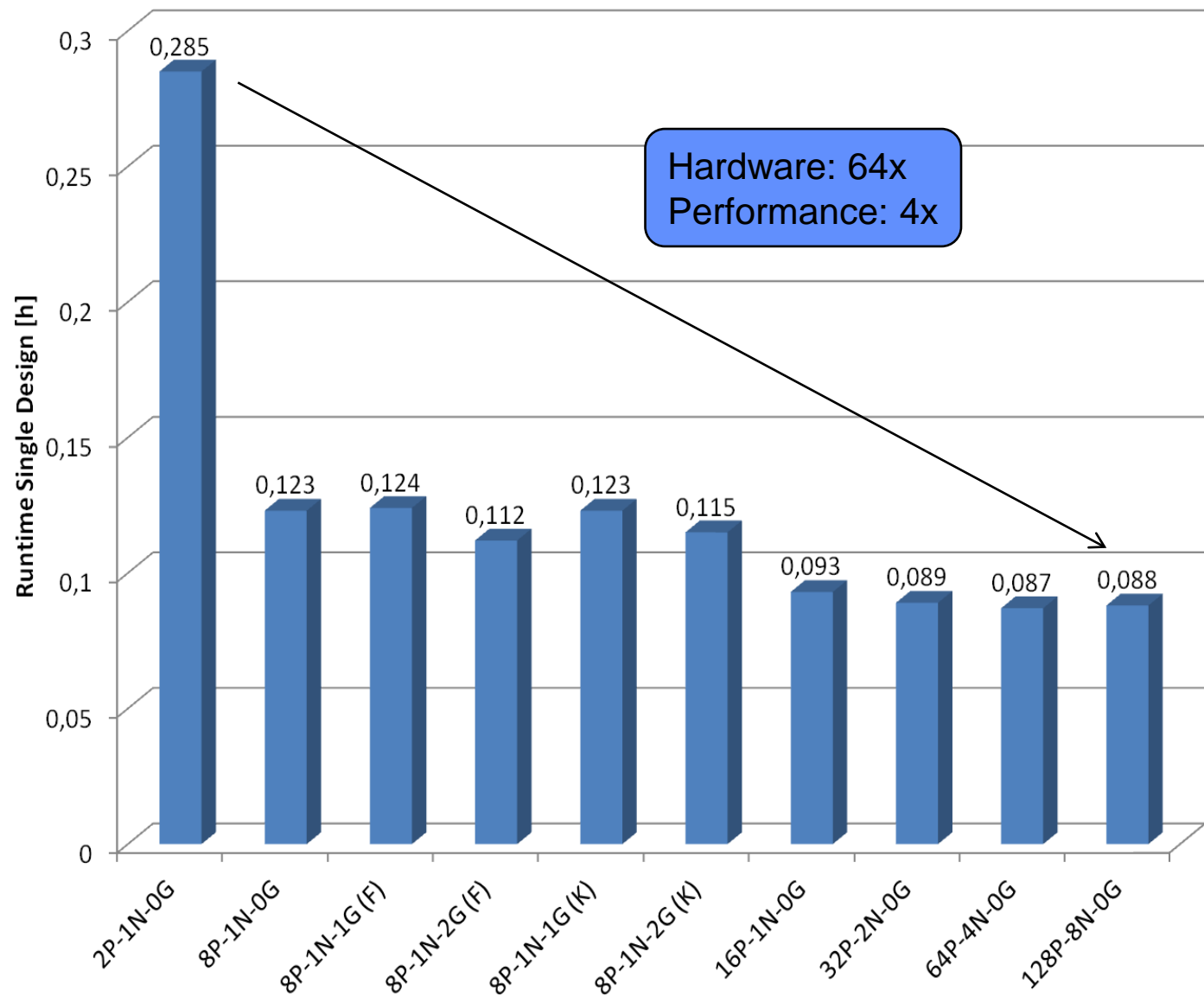
Power Window Actuator, Sensitivity Analysis



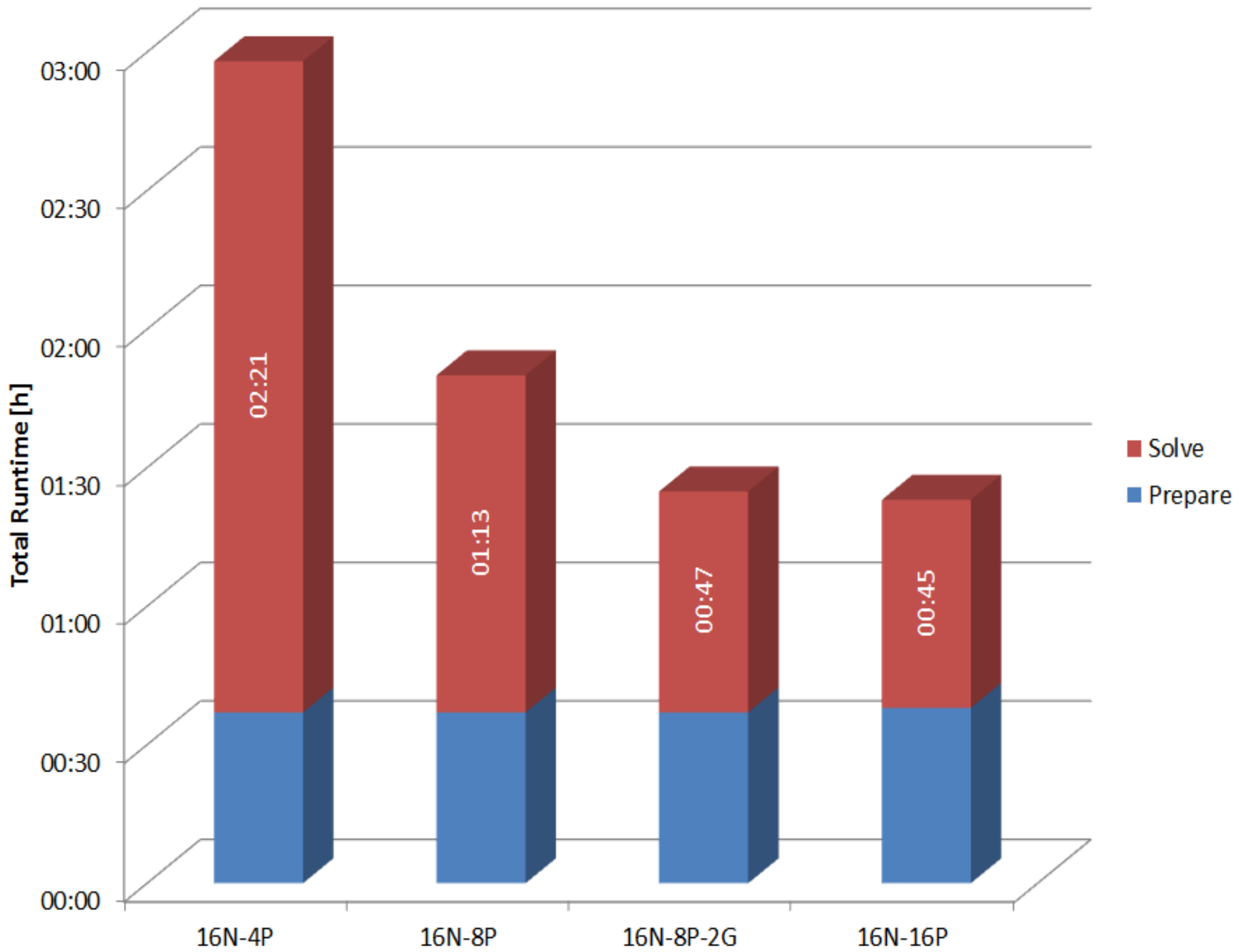
Running 4 design points on 4 compute nodes simultaneously:

- Designs are created sequentially in batches
- A new set of design points is sent to RSM for processing only after the previous set is completed
- Since we had at least one non-converging design in each set, the runtime is completely controlled by the (user defined) time limit

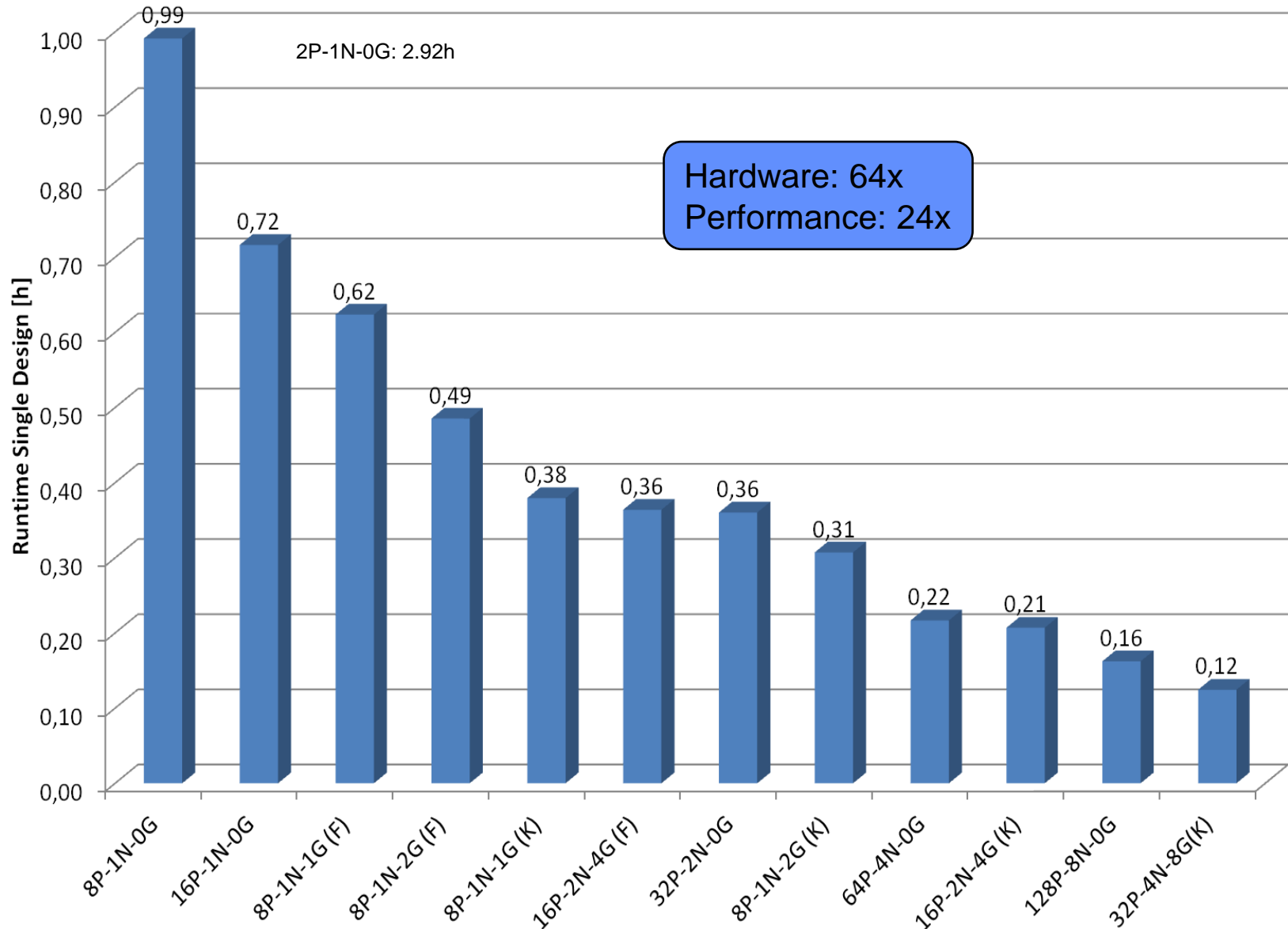
Mountain Bike Frame: Single Design



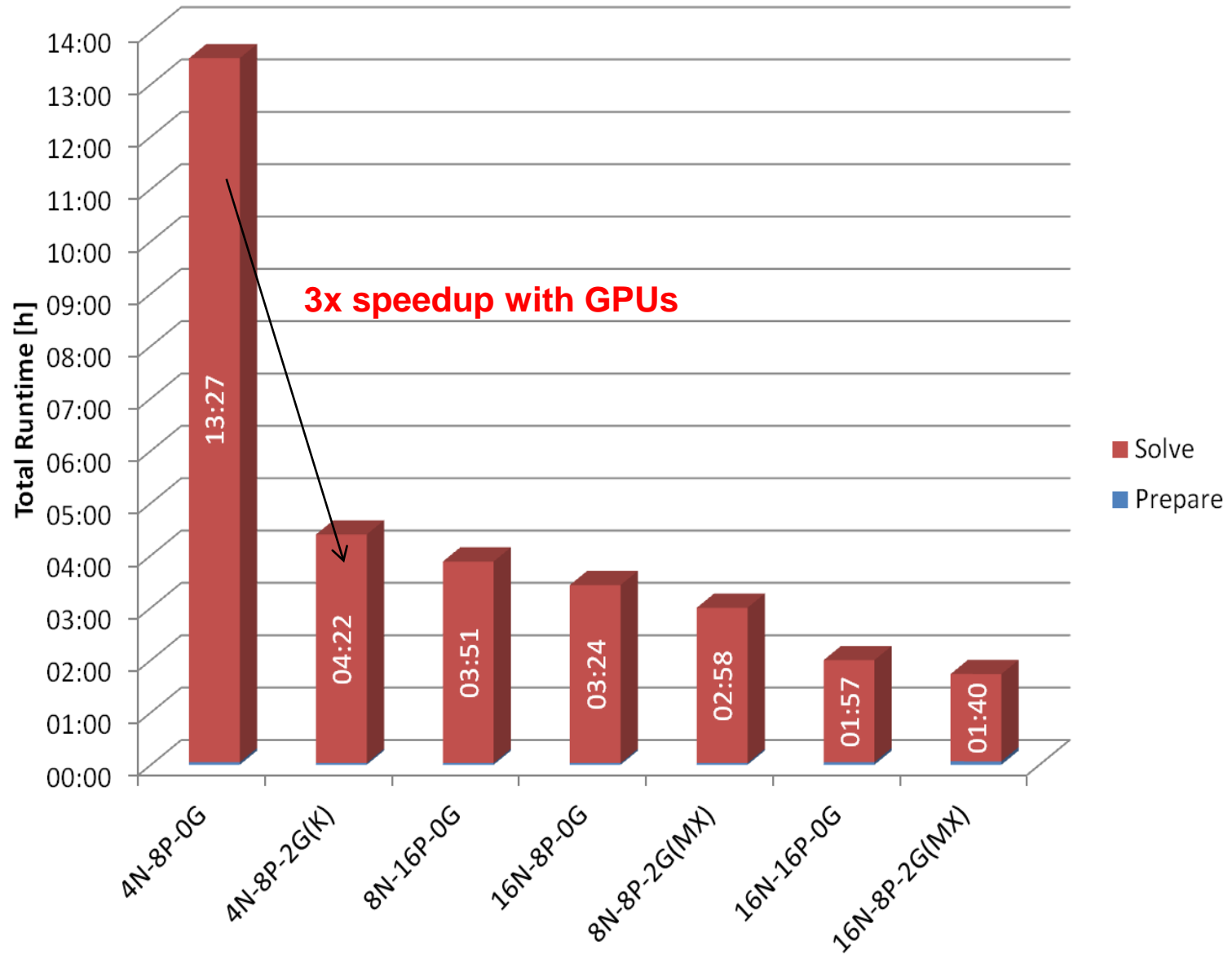
Mountain Bike Frame: Sensitivity Analysis 64 Designs



Beam in Bending: Single Design



Beam in Bending: Sensitivity Analysis 48 Designs



Summary:

- **The Power Window Actuator case suffers from instability of the model. Chances are good to achieve speedups when going parallel or using GPUs.**
- **The Mountain Bike Frame is too small (TFLOP / iteration) to benefit from going parallel. The total runtime is dominated from the preparation stage, not by the solution.**
- **The Beam in Bending is a synthetic case that demonstrates what is possible when the times for preparation are negligible and there is a lot of number crunching to do.**

Lessons learned I

- HPC Parametric Pack licenses can only be used when the designs are submitted via the Design Point table
- Geometry updates have to be done upfront/sequentially, because DesignModeler is not supported by HPC Parametric Pack Licenses
- You have to know your model very well to avoid bad designs
- Efficiency of HPC / GPUs is case dependent
- Running many design simultaneously will most likely help, unless the case is dominated by geometry preparation
- GPUs are not supported by R14.5 when running jobs via ,update all design points'. We had to modify the Python Scripts directly to add the command for using GPUs (-acc nvidia -na 2)

Outlook

- **ANSYS Release 15 is just around the corner (Dec. 2013)**
- **optiSLang 4.1 was released on Nov. 18**
- **optiSLang 4.1 and ANSYS 15 should enable updating the Design Point Table ,on the fly‘**

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