



Speakers:


1. Adam Green, ATA Engineering Inc.
2. Eric Timmer, Rescale
3. Chris Ostoich, ATA Engineering Inc.


Driving Innovation with STAR-CCM+, HEEDS, and the Rescale Cloud

Date:

3/28/2019

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 ata-engineering

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 @ATAEngineering

Agenda

Driving Innovation with STAR-CCM+, HEEDS, and the Rescale Cloud

1. ATA Engineering
2. Rescale Cloud Computing
3. STAR-CCM+ / HEEDS process
4. Q & A

Who We Are

We are an employee-owned small business with a full-time staff of around 150, more than 125 of whom are degreed engineers









14
Registered
Professional
Engineers

15
Average
years of
experience

What We Do

ATA Engineering's high-value engineering services help solve the most challenging product design challenges

	Aerospace		Robotics & Controls		Themed Entertainment
Defense		Industrial & Mining Equipment		Consumer Products	

ATA Engineering - Timeline

➤ A Legacy of Engineering Excellence:

1975



SDRC was an early pioneer of CAE tools starting in 1967.

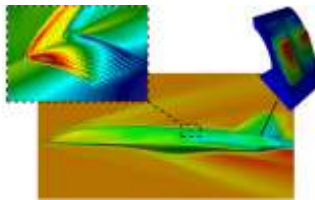
After a series of acquisitions, SDRC was purchased by Siemens and their I-DEAS software was integrated with Unigraphics into the well known NX product line.



2000

ATA Engineering was formed in April 2000 after a management buyout from SRDC of the Advanced Test and Analysis Division.

Given this shared corporate heritage, ATA maintains its strong relationship with Siemens today



2002



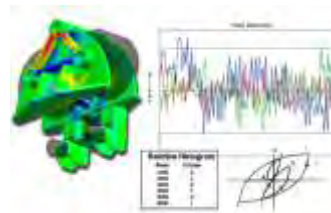
ATA opens Eastern regional Office (ERO) in Herndon VA



2005
ATA opens LA office in the heart of the Southern California Aerospace Industry

2007

2007
ATA opens Denver office and labels it RMO: Rocky Mountain Office

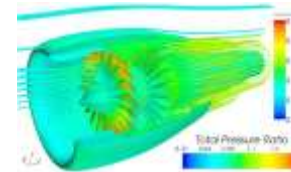


2009



2009
ATA opens Huntsville Office to service South Eastern Aerospace clients

ATA becomes a full VAR for Siemens selling NX, Femap and Nastran



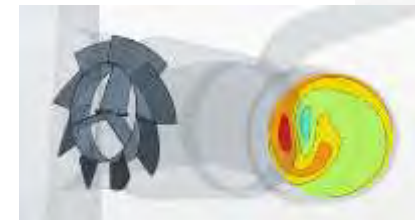
2010

2018



2018
ATA extends Siemens VAR relationship to include Sales and Support for STAR-CCM+ & HEEDS

ATA opens Berkeley, California Office



ATA is an Employee Owned Small Business

Employee ownership benefits you because our owners:



- take your project personally
- are empowered to make decisions
- love their jobs
- are efficiency minded
- recognize the direct link between your satisfaction and their success
- strive for customer delight

Reference: ATA experience and Sue Butler, Founder/Board Chair and Amanda DeVito, VP of Engagement, Butler/Till Media + Communications, *May I Speak to the Owner*, the ESOP Report, July 2016

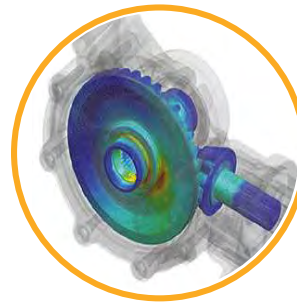
Our Services

We provide our customers with complete, integrated solutions



Design

From initial concept development to detailed structural design



Analysis

Comprehensive structural, fluid, acoustic, and thermal analysis services

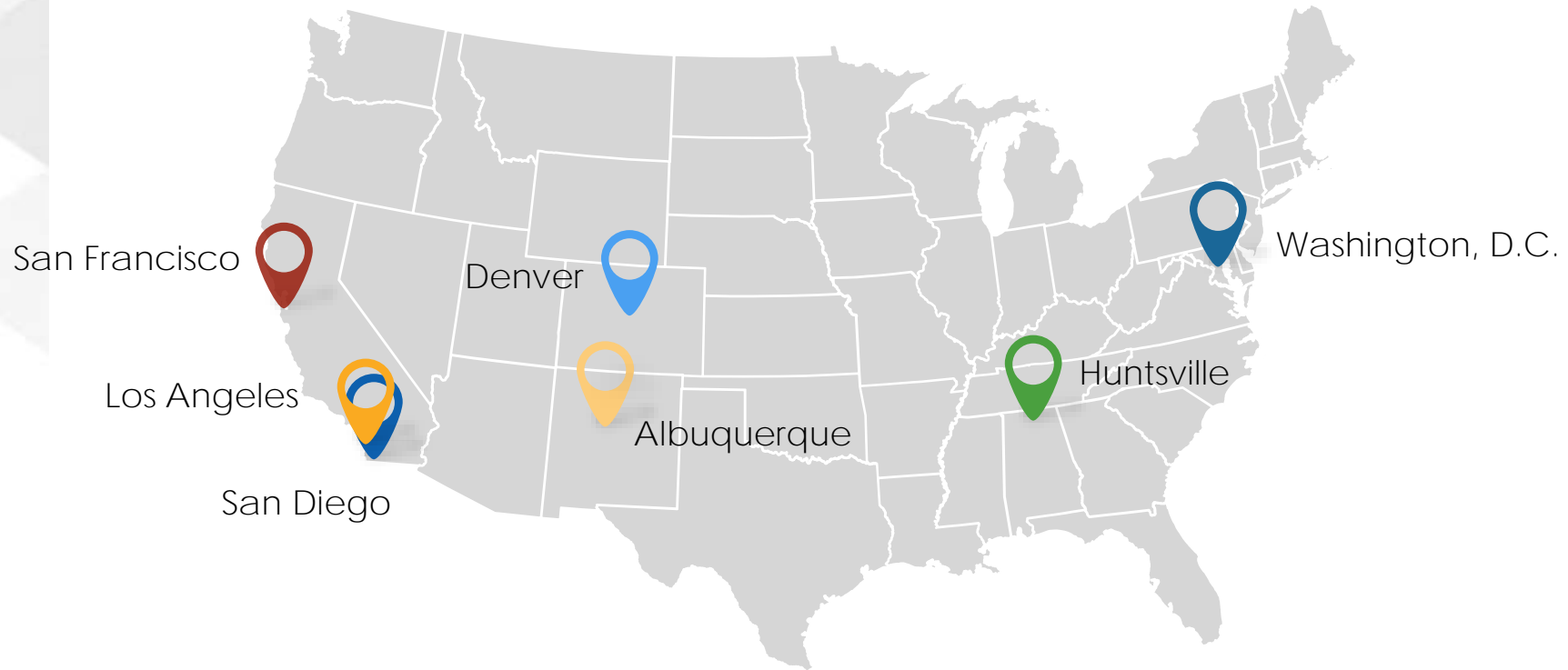


Test

Industry-leading structural test services for extreme loading environments

Our Offices

Our 7 nationwide locations provide local full-service capabilities and personal support to our customers



Our Software Services

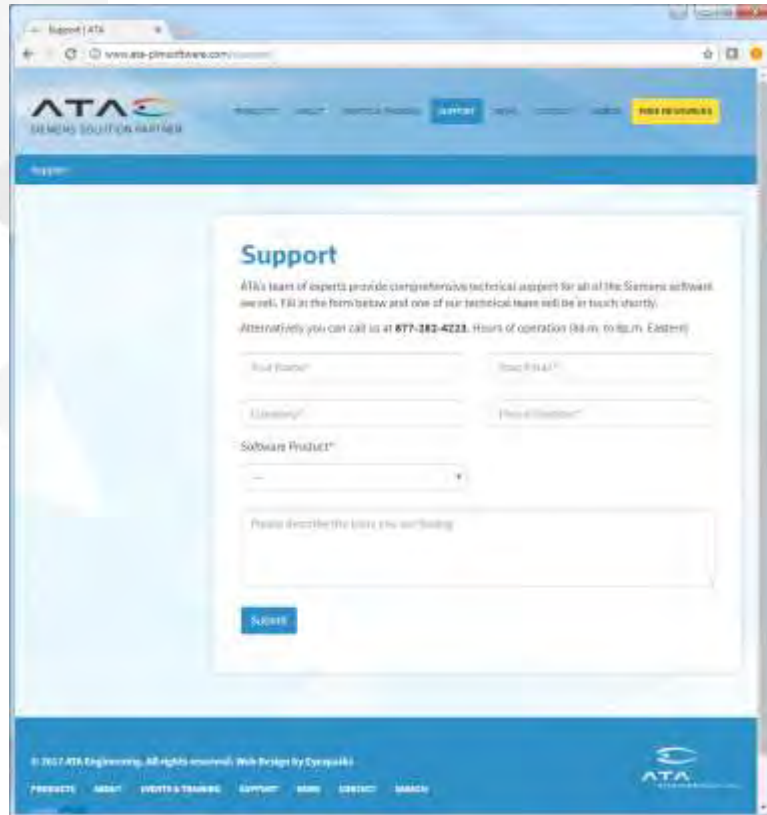
ATA is a value-added reseller for Siemens PLM Software

- Siemens product lines we support include
 - STAR-CCM+
 - HEEDs
 - AMESIM
 - Femap
 - Simcenter Nastran
 - Simcenter 3D
 - NX CAD & CAM
 - Teamcenter
 - Solid Edge
- Contact the hotline at 877-ATA-4CAE or <http://ata-plmsoftware.com/support>
- Developer of the official NX Nastran training materials
- Preferred North American provider of NX Nastran training



Our Online Resources

www.ata-plmsoftware.com

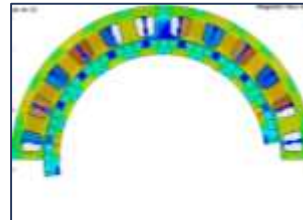
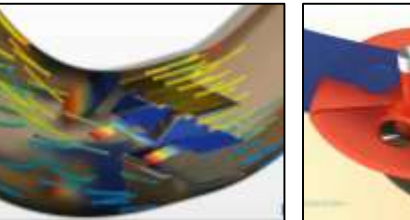
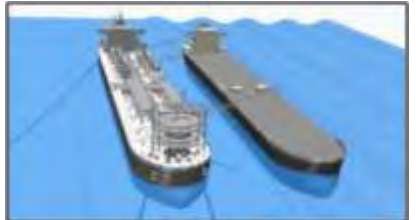
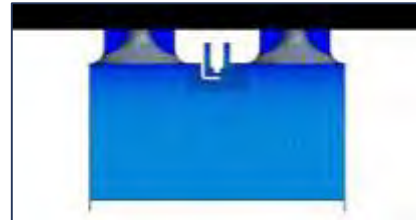
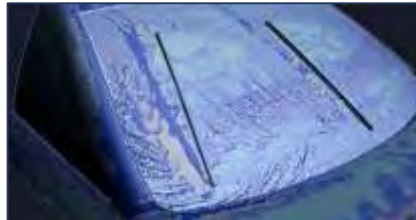
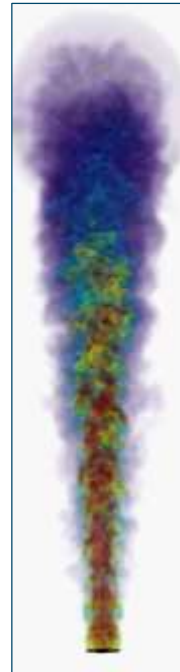


An integrated multiphysics solution for the digital product

STAR-CCM+

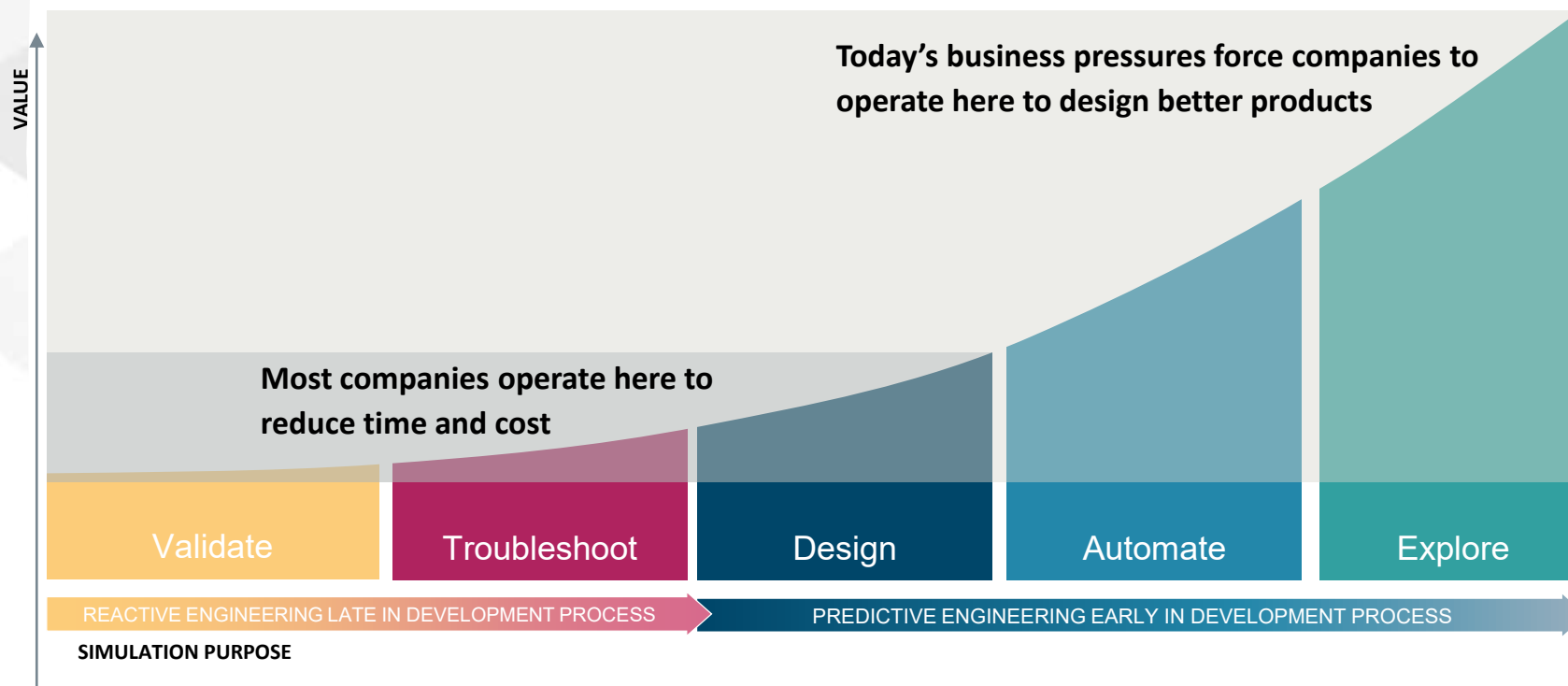
Realism with multiphysics

- Fluid dynamics
- Multiphase flows
- Reacting flows
- Solid mechanics
- Particle flows
- Rheology
- Electrochemistry
- Electromagnetics
- Aero-acoustics
- Fluid-structure interaction
- Conjugate heat transfer



STAR-CCM+: An integrated multiphysics solution for the digital product

Innovation with built-in design exploration



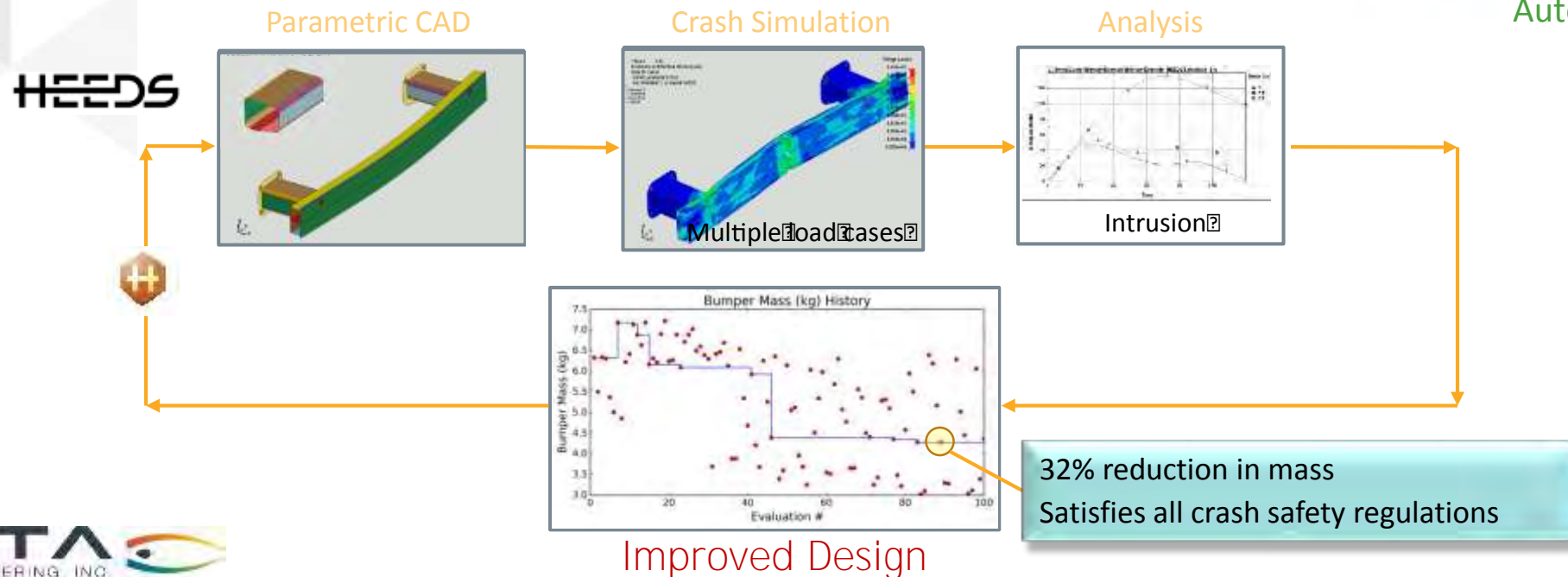
HEEDS: Discover Better Designs, Faster

Design Space Exploration

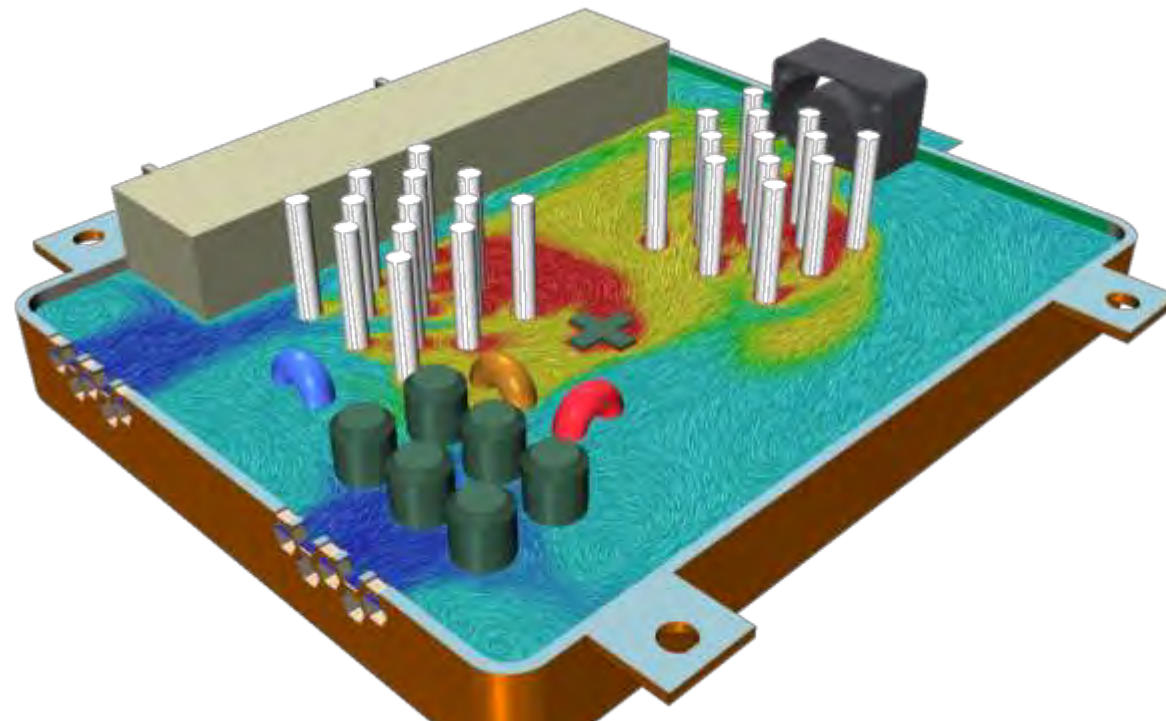
- Process Automation (Automate building of virtual prototype)
- Distributed Execution (Accelerate testing of virtual prototype)
- Efficient Search (Look for better design alternatives)
- Insight & Discovery (Ensure reliable product performance)



Automotive Bumper

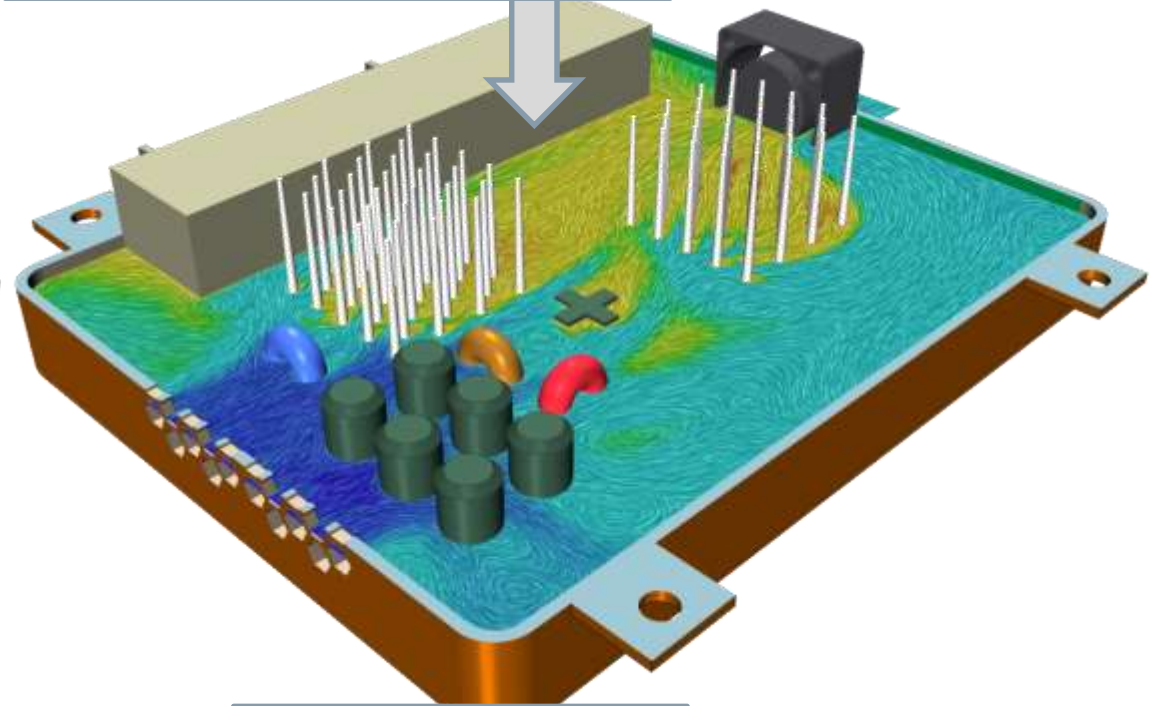


Driving Innovation Through Design Exploration



Baseline Design

51% reduction in mass
25% cooling improvement



Improved Design

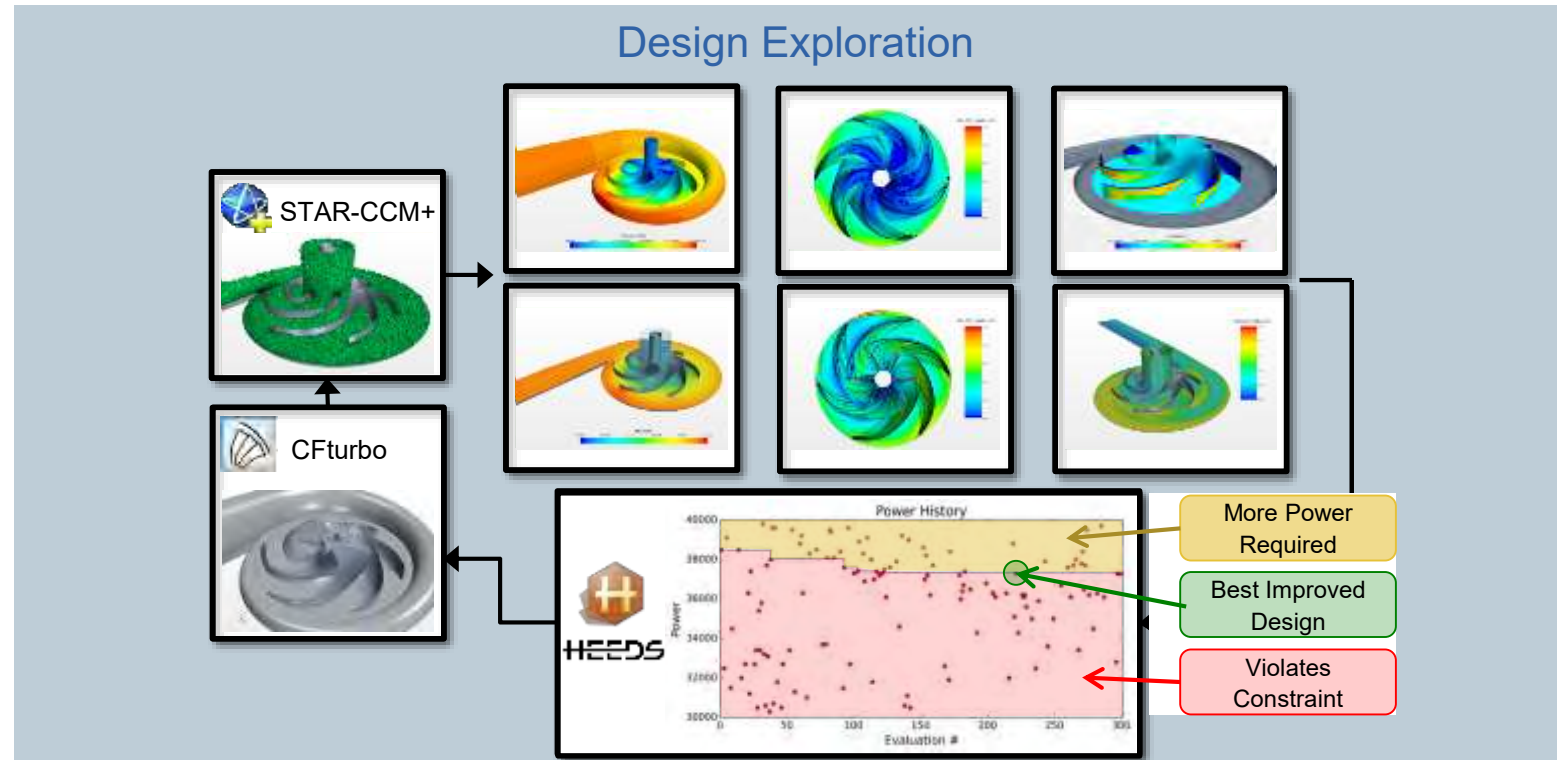
Streamlining the Design Exploration Process

Customer case study: Designing more efficient centrifugal pumps

SIEMENS
Ingenuity for life



- Efficiently and automatically explored 300 design alternatives
- Searched broad design space globally and locally
- Identified families of designs that delivered better performance than initial baseline design

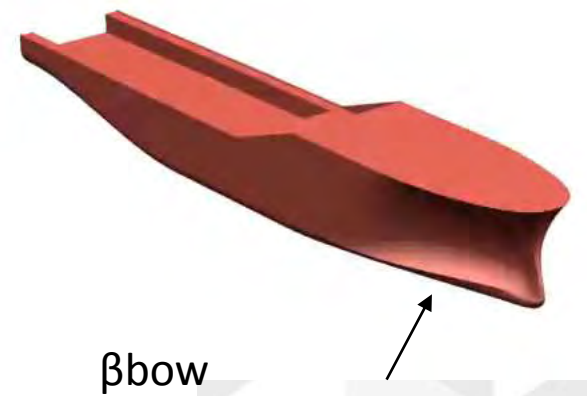
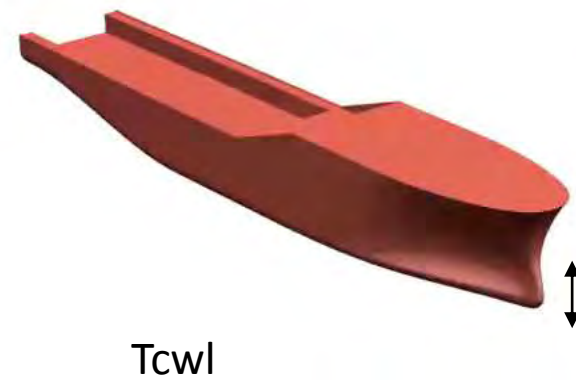
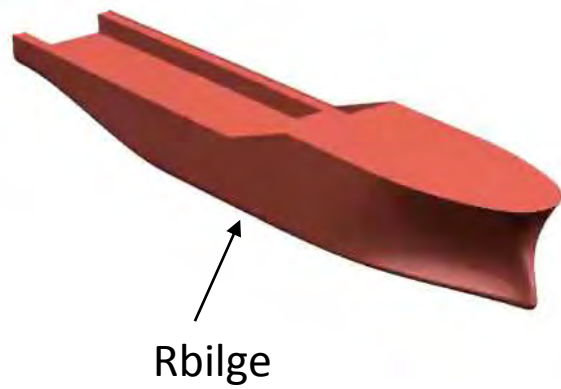
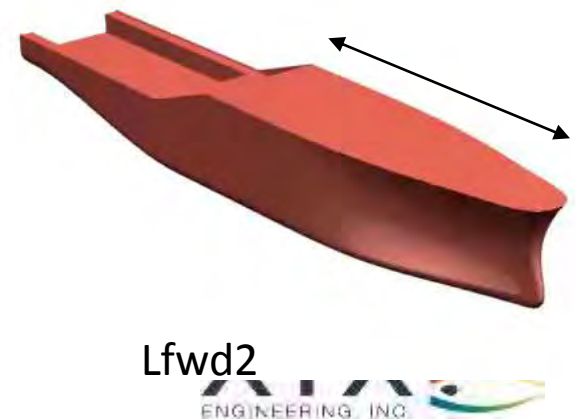
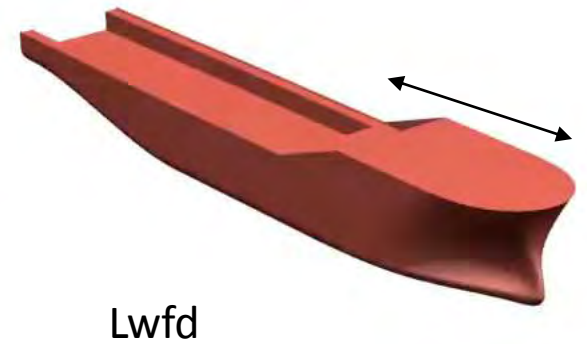
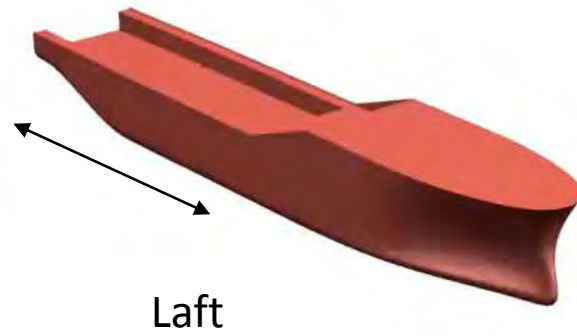
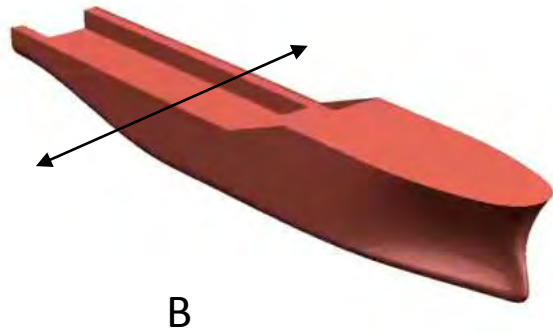
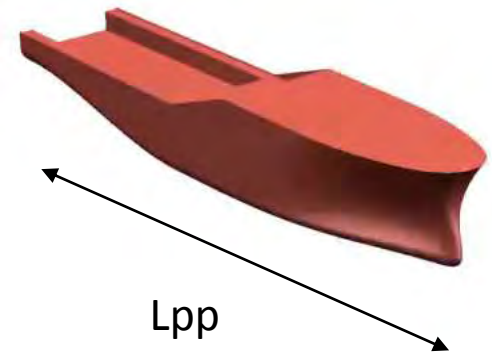


"I can now obtain better pump designs faster by spending more time on engineering decision-making, and less time on model setup & data transfer."

– Ed Bennett, VP of Fluids Engineering

Design approach setup

Parametric CAD



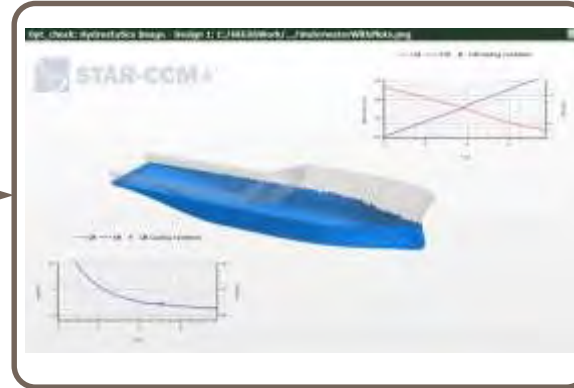
Design Space Exploration

Efficient Design Exploration

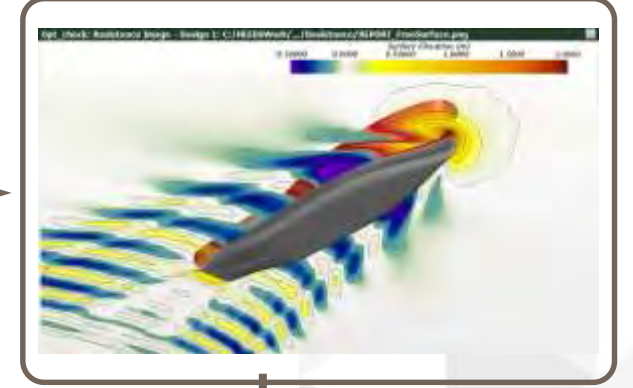
Update Ship Geometry



Calculate Steel Weight



Calculate Hydrostatics & Resistance



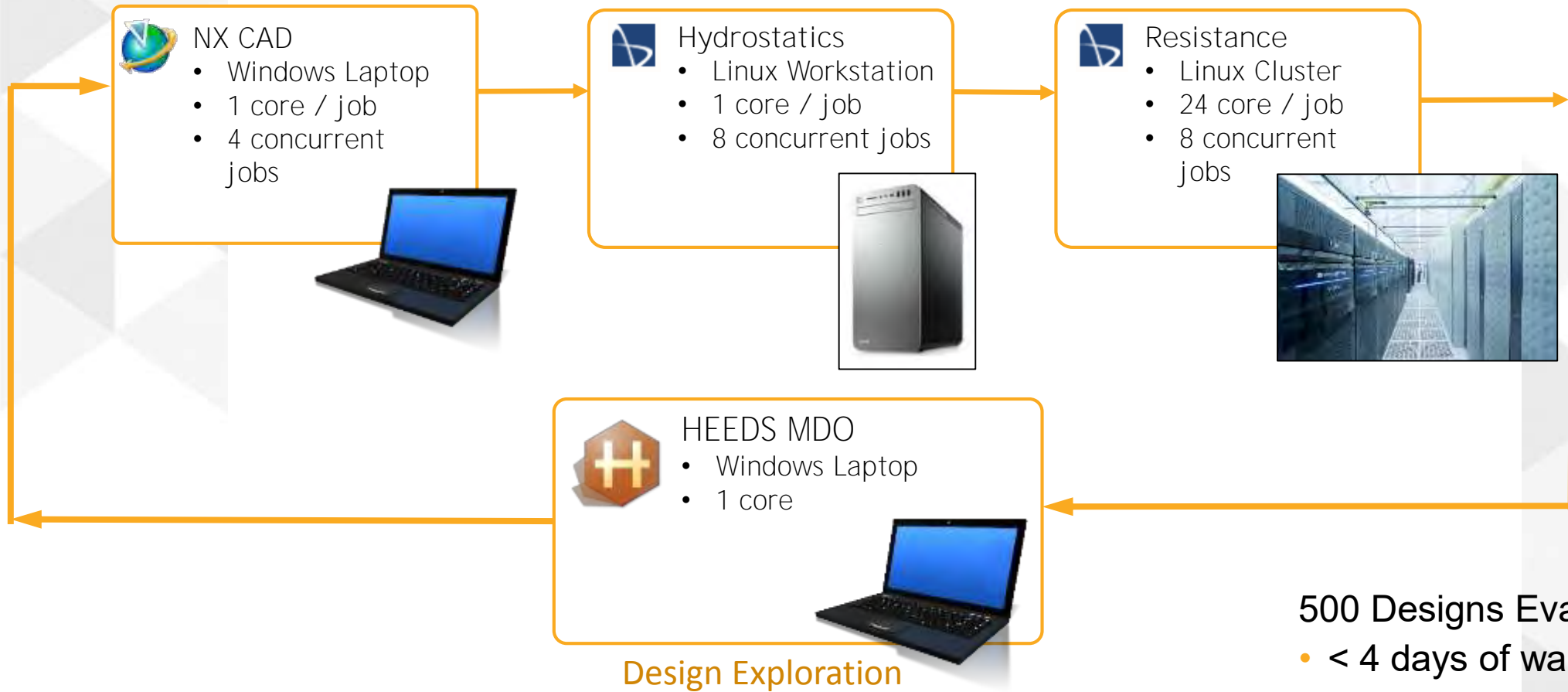
Directed Modification

HEEDS' intelligent search method

- SHERPA Search Framework



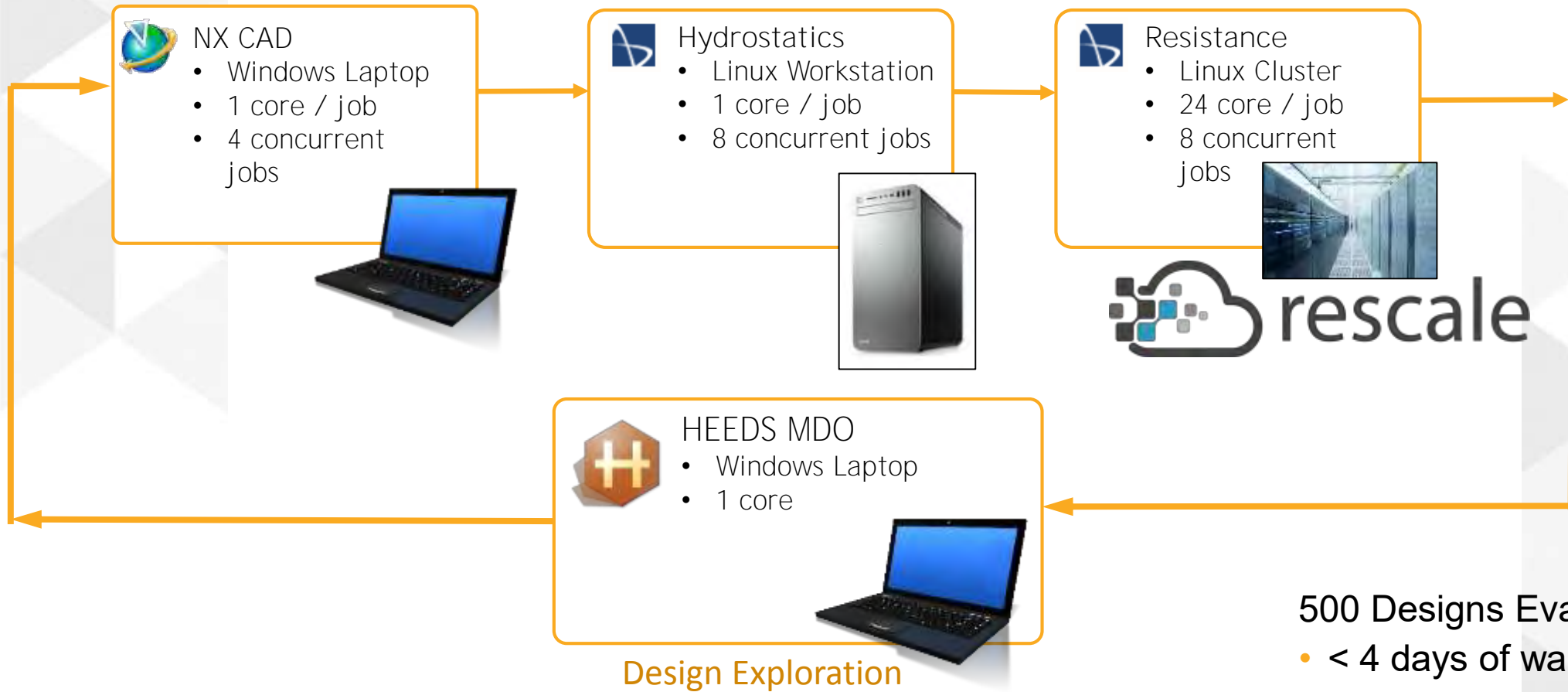
Design Space Exploration Scalable Computation



500 Designs Evaluated

- < 4 days of wall time
- ~2 hours per design

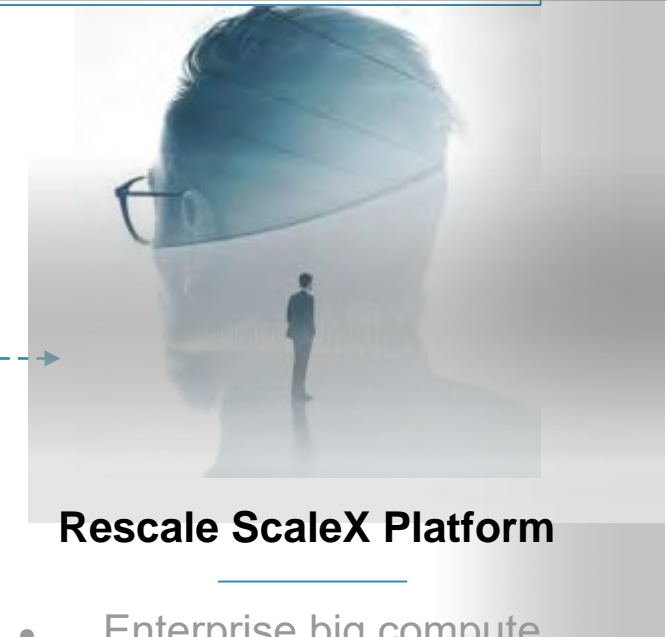
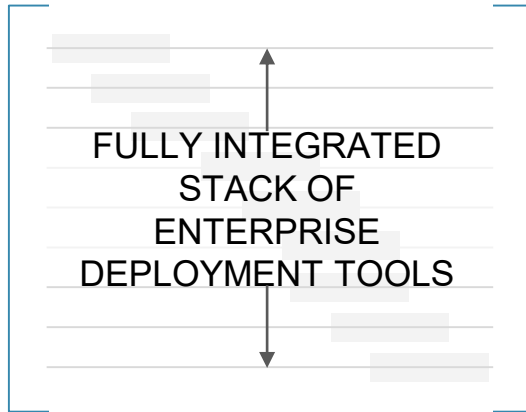
Design Space Exploration Scalable Computation



500 Designs Evaluated

- < 4 days of wall time
- ~2 hours per design

The Rescale HPC Platform experience



Rescale ScaleX Platform

- Enterprise big compute
- Innovation acceleration
- User-first platform
- Security and admin controls







Sending High-Fidelity Multi-Disciplinary Optimization to the Cloud for Transonic Vehicle Design


Date:


March 28, 2019

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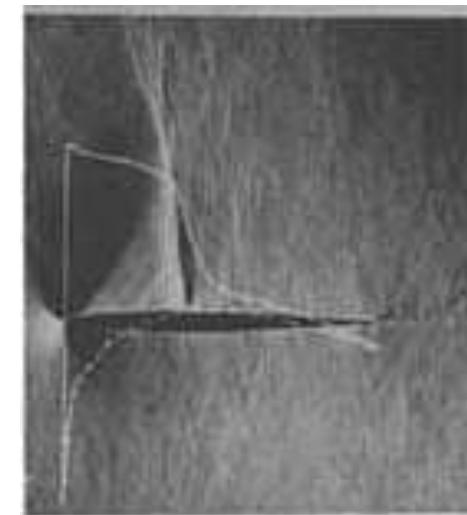
 www.ata-e.com

 [ata-engineering](https://www.linkedin.com/company/ata-engineering)

 [@ATAEngineering](https://twitter.com/ATAEngineering)

Transonic Flight Development

- Large drag increase near speed of sound
 - Significant difficulty accelerating past Mach 1
- Schlieren images showed standing shocks on wings leading to wave drag
- Significant breakthrough – Whitcomb Area Rule
 - Cross-sectional area to have smooth streamwise variation
 - Fuselage to narrow in vicinity of wings
 - “Coke Bottle” shape
- Area rule a product of decades-long study due to difficulties with transonic experimentation and understanding!



NACA 64A006 Airfoil in Mach 0.79 flow
(Beker, J. "The High-Speed Frontier")

Case Study: Convair F-102A

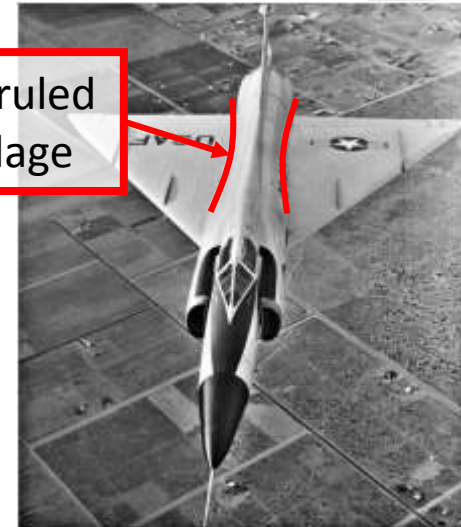
- In 1951, Convair began development on YF-102
- Although powered by Pratt and Whitney J-57 turbojet (US's most powerful engine), YF-102 couldn't break sound barrier
- Area-ruled fuselage allowed aircraft to easily push past the speed of sound to Mach 1.24 resulting in production of F-102A
- Can HEEDS + STAR-CCM+ predict this result in a few days?

Straight-sided fuselage



Convair YF-102 59-1785 with the original fuselage, photographed 21 December 1954 (NASA)

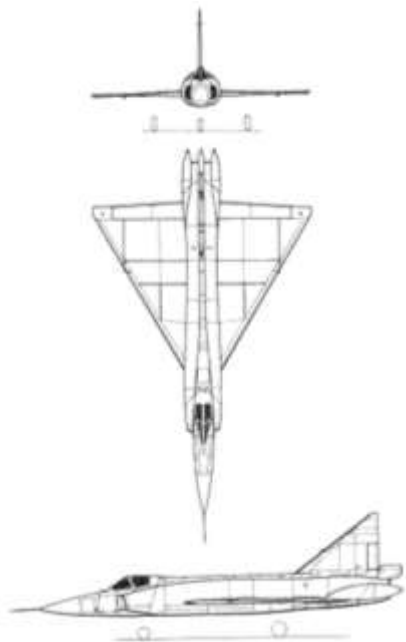
Area-ruled fuselage



Convair F-102A-90-02 Delta Dagger, 57-0828. The "waspy waist" area-ruled fuselage is very noticeable. (U.S. Air Force)

Baseline “YF-102” Model

- Simplified YF-102 model created in STAR-CCM+ CAD tool
- Fuselage parametrized by 5 equally-spaced mid-body radii
- Delta wing lofted between two NACA 0004-64 airfoils

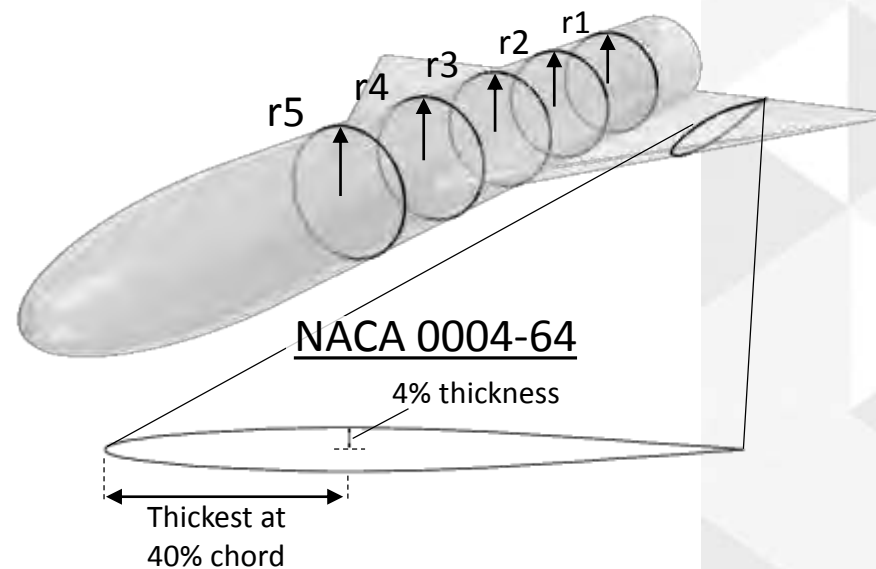


F-102A Drawings

(<http://www.aerospaceweb.org/>)



STAR-CCM+ Model



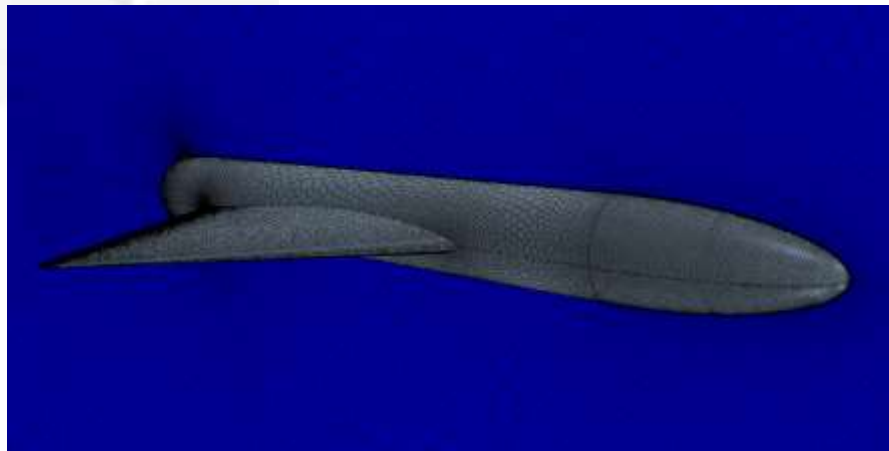
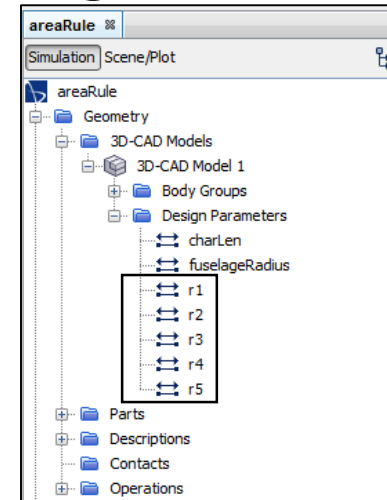
NACA 0004-64

4% thickness

Thickest at
40% chord

STAR-CCM+ Seamlessly Remeshes Flow Domain After Geometry Change

- Radii defined as exposed parameters
 - External CAD package can also be used
- STAR-CCM+ robustly remeshes after parametric geometry changes

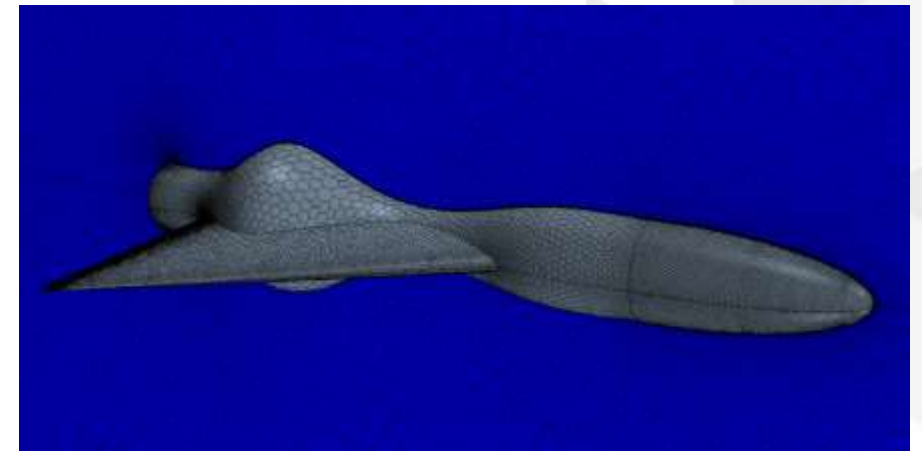


$r2 = 1.08 \text{ m} \rightarrow 2.0$

$r4 = 1.08 \text{ m} \rightarrow 0.7$



Auto-remesh after
geometry modification

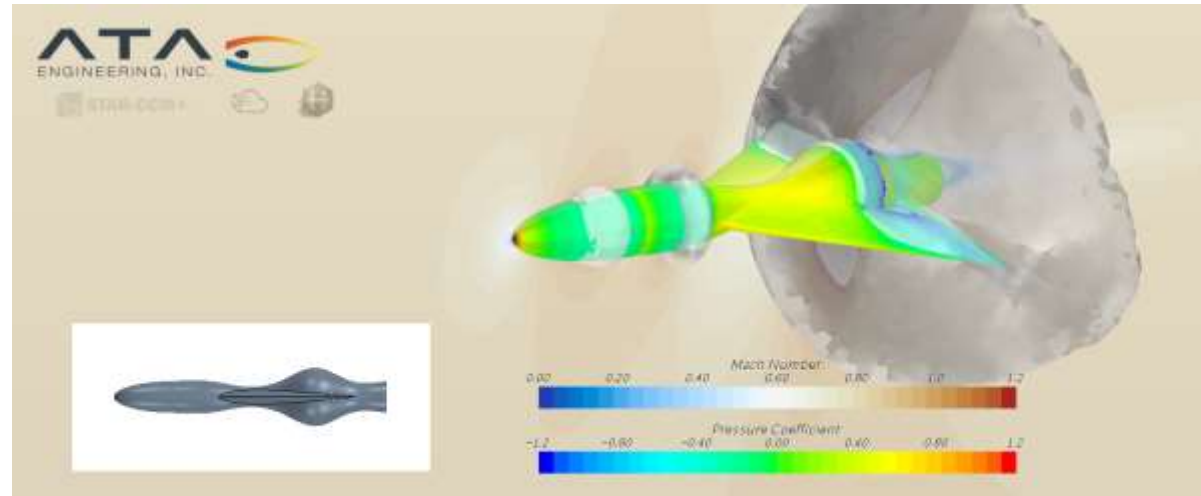


STAR-CCM+ Guides User Through Simulation Setup

➤ User guided through model setup

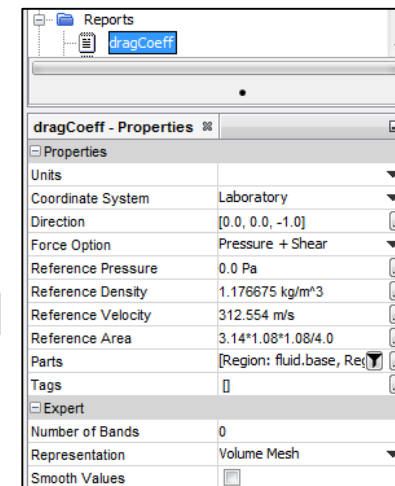


➤ Powerful and intuitive post-processing capabilities



➤ Easily create reports to interrogate solution for engineering quantities

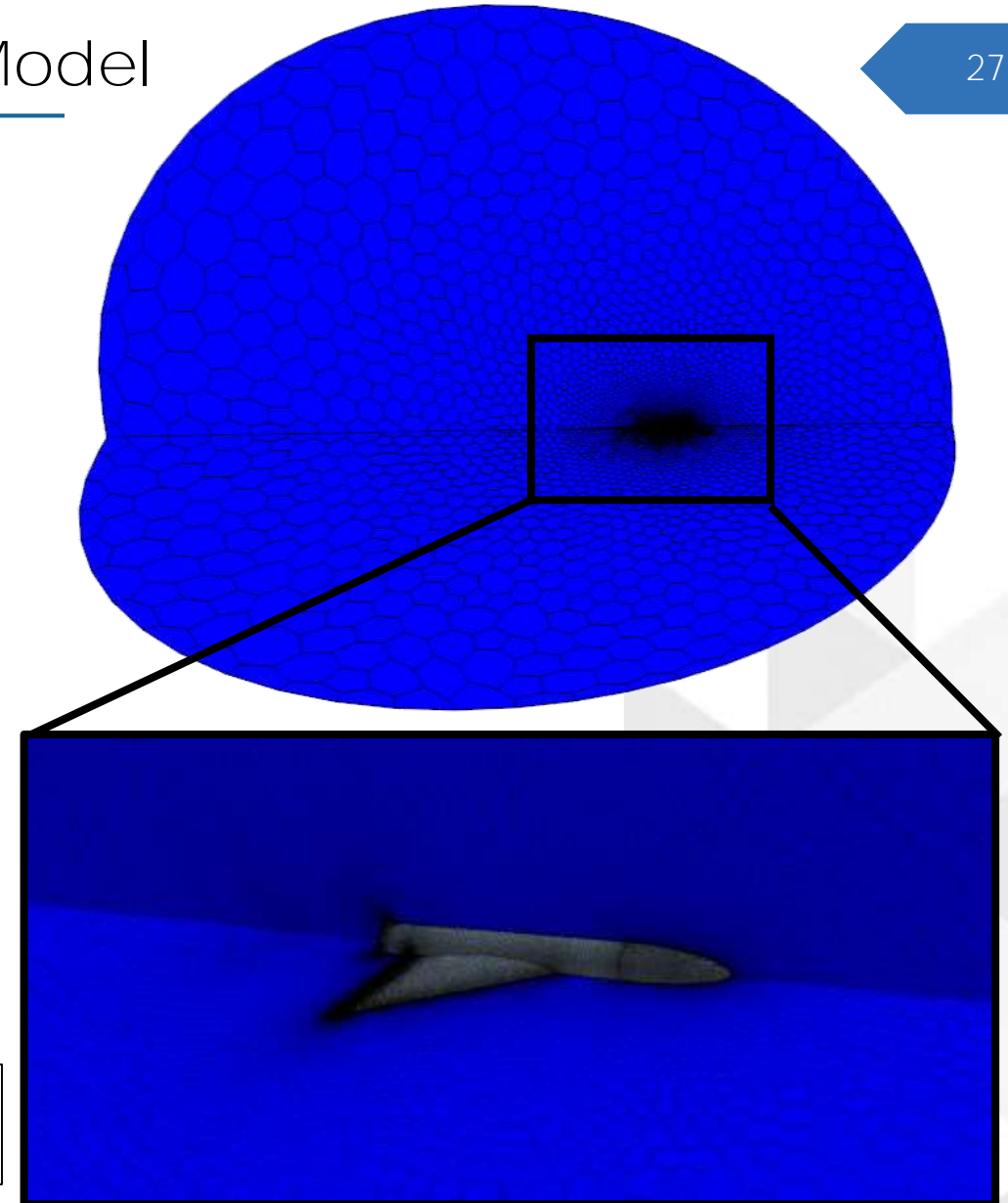
➤ Drag coefficient created to use as response variable in HEEDS



Computational Model

- Physics
 - Three Dimensional
 - Steady
 - Ideal Gas (Air)
 - Coupled Implicit Steady Solver
 - RANS with Menter SST Closure Model
- Boundaries
 - No-slip on vehicle surface
 - Symmetry planes intersect at vehicle axis
 - Mach 0.9 freestream at 300 K and 1 ATM
- Mesh
 - 408460 polyhedral and prism cells
- Solver Details
 - CFL=20
 - Grid sequencing initialization, expert driver, and continuity convergence accelerator used
 - Stopping criteria set to 1000 iterations, 30 min. on 8 cores

Modest-sized model used for demonstration case but approach can be scaled up to realistic problems

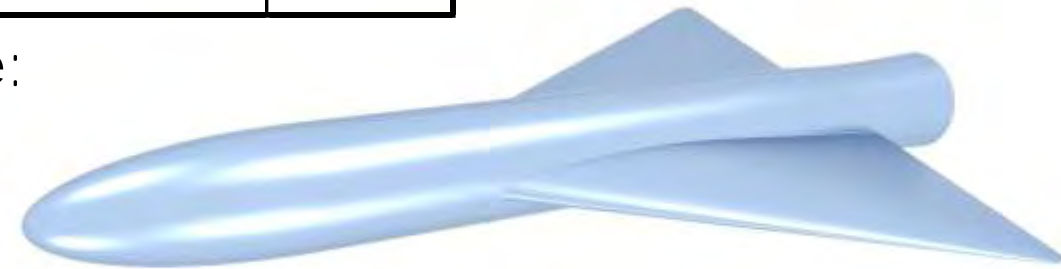


HEEDS Optimization

- HEEDS SHERPA design space exploration intelligently searches radii ranges to determine minimum drag configuration

Parameters	Range		Resolution	Response	
	Minimum	Maximum		Variable	Objective
r1	0.5 m	2 m	101	$C_D = \frac{Drag}{1/2 \rho_{\infty} U_{\infty}^2 A}$	Minimize
r2	0.5 m	2 m	101		
r3	0.5 m	2 m	101		
r4	0.5 m	2 m	101		
r5	0.5 m	2 m	101		

- Exhaustive search of this design space:
101⁵=10.5 billion simulations
- SHERPA finds improved design after
150 evaluations



HEEDS Setup is Easy with STAR-CCM+ Analysis Portal

Process Specified:

- STAR-CCM+ is only analysis portal in the process
- More analyses can be added to the process. Ex. CAD, FEA

Files: Input and output files are the same in this analysis, model and results held in .sim file

STAR-CCM+ instructed to use 8 cores and clear the solution and remesh when run

Licensing Options:

- Use Power Tokens
- Use Serial and HPCs
- Use Power Sessions
- Use Power Pre
- Use Power on Demand

Key:

Run Options:

Cores per job: 8

- Clear solution history
- Clear solution fields
- Mesh
- Remove invalid cells
- Run

Initial steps to run: 0

For each design:

- Export Scene (.sce) files
- Save modified SIM model
- Save modified CAD client
- Use single STAR-CCM+ server

HEEDS automatically detects geometry parameters for ease of variable setup

Variable Name	Type	Min	Baseline	Max	Resolution
r1	Continuous	0.5	1.08	2	10E
r2	Continuous	0.5	1.08	2	10E
r3	Continuous	0.5	1.08	2	10E
r4	Continuous	0.5	1.08	2	10E
r5	Continuous	0.5	1.08	2	10E

dragCoeff report used for response variable

- Drag coefficient report used for response variable
- Optimization algorithm directed to minimize the drag coefficient

Python-based API Creates Seamless Interface to Rescale Cloud-Based HPC

- Rescale resource configuration selected from within HEEDS
- STAR-CCM+ runs performed on rescale cluster
 - In this case an environment variable was defined to point to our company's local license server
 - Power On Demand can be used in lieu of traditional STAR-CCM+ license

Analysis name: F102STAR_Run
 Portal: STAR-CCM+ (input and output)

Execution | Files | STAR-CCM+ Portal | Dependencies | View

Compute resource: ATA_Rescale | Resource pre-allocation: Requested

Execution command: %HEEDS_STARCCM_CMD%
 Command options: %CMD_OPTIONS% %INPUTFILE% -batch updateSTARCCMModel.java
 Num. designs to execute simultaneously: 1

Analysis Resource Allocation

Allocate resources for this analysis

Share the allocation with other analyses using the same compute resource
 Create a unique allocation just for this analysis

Rescale Allocation Options

Software used: cd_adapco_star_ccm | 13.06.011

Execution command: starccm+ -power -batch run -load <input-file> ✓

Project Id: [none]

Cluster:

Existing cluster:

Create a new cluster:

Temporary Persistent

Core type: Onyx

Instant On-demand

Number of cores: 8

Core type: Onyx
 Processor: Intel Xeon E5-2666 v3 (Haswell)
 Speed: 2.9
 Available memory: 3300
 Num nodes: 1
 Num cores: 8
 Price / core: 0.12 per hour
 Price: 0.96* per hour

* The total cost will depend on the number of designs run in the study.

Estimated time: 15 minutes
 Additional time: 15 minutes

Run in: Ana
 Run condition: Alwa
 Finished condition: See

Recommended Workflow for Cloud Computing

Reduce the risk of wasting cloud computing allocations by troubleshooting in local sandbox.

1. Develop coarse, low-fidelity model that can run quickly on local machine
 - Allows you to run a few HEEDS evaluations locally to troubleshoot
 - Current example: Inviscid, coarse mesh
2. Create refined, high-fidelity model locally
 - Current example: Viscosity, turbulence model, resolved boundary layers
3. Plug high-fidelity model into already proven HEEDS project
 - Use cloud computing resource to optimize high-fidelity model

Rescale ScaleX Platform

Running Jobs Monitored through Rescale Portal

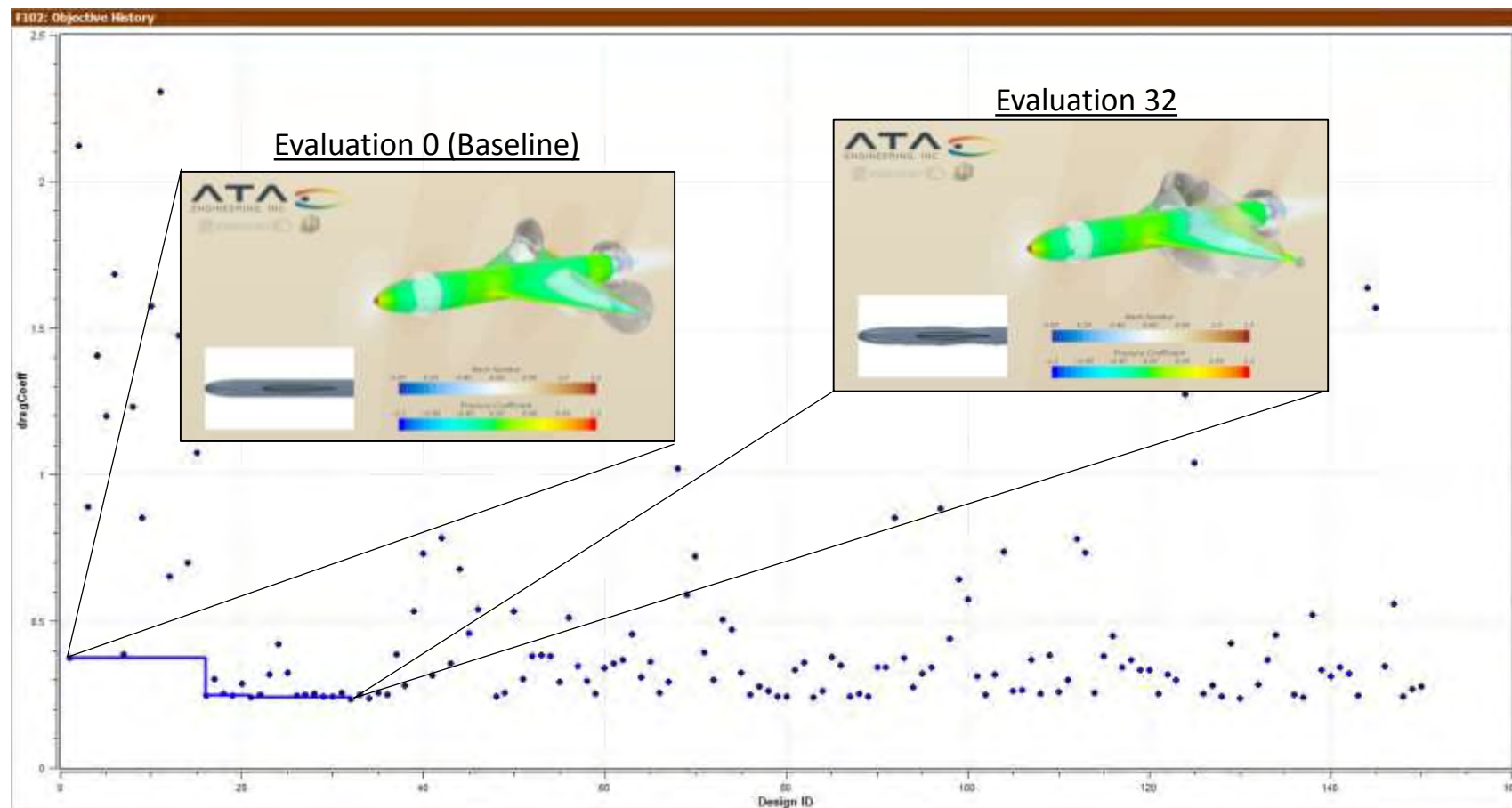
The screenshot displays the Rescale ScaleX Platform interface. At the top, there is a navigation bar with options: '+ New Job', 'Jobs', 'Clusters', 'Desktops', 'Files', 'Transfers', 'Help', and a user profile 'chris.ostolech@ata-e.com'. Below the navigation bar, the cluster name 'NONE.31.1.1' is shown, along with a 'Cluster - Started (16 hours 45 minutes)' status bar. The main area is divided into two sections: 'Live Tailing' and 'SSH'. The 'Live Tailing' section features a file list on the left and a terminal window on the right. The file list includes: 'Executa_NONE_irtAnalysis.cmd', 'P_in_F102STAR_Run_areaRule.aim', 'P_out_F102STAR_Run_areaRule.sim', 'RescaleUploadFileToExe.py', 'areaRule.sim', 'process_output.log', and 'updateSTARCCMModel.java'. The terminal window shows the following output:

```
[2019-03-27T17:54:02Z]:
[2019-03-27T17:54:02Z]: Expert Driver: Corrections Control update. Please wait ...
[2019-03-27T17:54:02Z]: Done.
[2019-03-27T17:54:02Z]: -----
[2019-03-27T17:54:02Z]:
[2019-03-27T17:54:02Z]: Continuity convergence accelerator (CCA) iteration update ... done.
[2019-03-27T17:54:02Z]: Turbulent viscosity limited on 3183 cells in Region
[2019-03-27T17:54:02Z]: Iteration Continuity x-momentum y-momentum z-momentum Energy TKE SQR dragcoeff
[2019-03-27T17:54:02Z]: 401 2.77906e-02 4.758769e-02 4.667341e-02 3.575726e-02 2.484776e-02 3.234004e-00 7.913377e-09 4.249215e-01
[2019-03-27T17:54:05Z]: Continuity Convergence Accelerator (CCA) iteration update ... done.
[2019-03-27T17:54:05Z]: Turbulent viscosity limited on 3183 cells in Region
[2019-03-27T17:54:05Z]: 402 1.827501e-02 4.697237e-02 4.627982e-02 3.500691e-02 2.589738e-02 1.687186e-00 6.276755e-09 4.248243e-01
[2019-03-27T17:54:08Z]: Continuity Convergence Accelerator (CCA) iteration update ... done.
[2019-03-27T17:54:08Z]: Turbulent viscosity limited on 3183 cells in Region
[2019-03-27T17:54:08Z]: 403 2.788346e-02 4.707492e-02 4.968182e-02 3.945474e-02 2.476898e-02 2.691438e-00 5.789755e-09 4.246522e-01
[2019-03-27T17:54:11Z]: Continuity convergence accelerator (CCA) iteration update ... done.
[2019-03-27T17:54:11Z]: Turbulent viscosity limited on 3183 cells in Region
[2019-03-27T17:54:11Z]: 404 2.778954e-02 4.688922e-02 4.673459e-02 3.538428e-02 2.4641E-02 2.715400e-00 5.59626e-09 4.244726e-01
```

The 'SSH' section at the bottom shows a 'New SSH Session' form with fields for 'Server IP' and 'Role'. A 'Need Help?' button is visible in the bottom right corner.

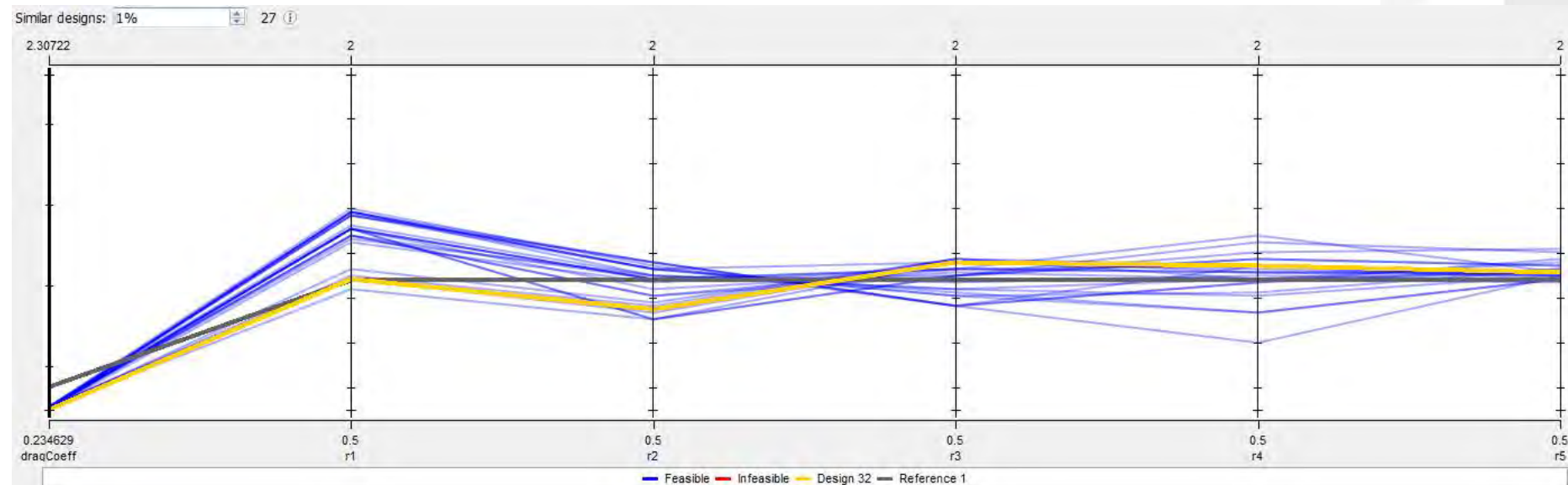
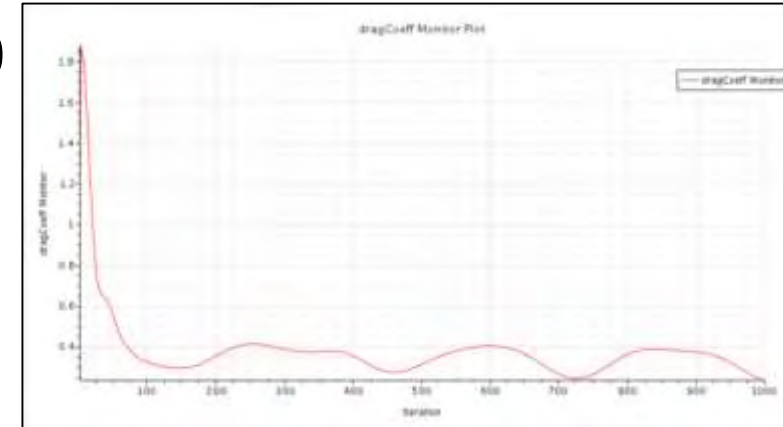
HEEDS Design Optimization

- HEEDS SHERPA explores design space to drive towards objective
- Evaluation 32 (out of 150) found to have the lowest drag coefficient
- Improved fuselage results in 38% reduction in drag



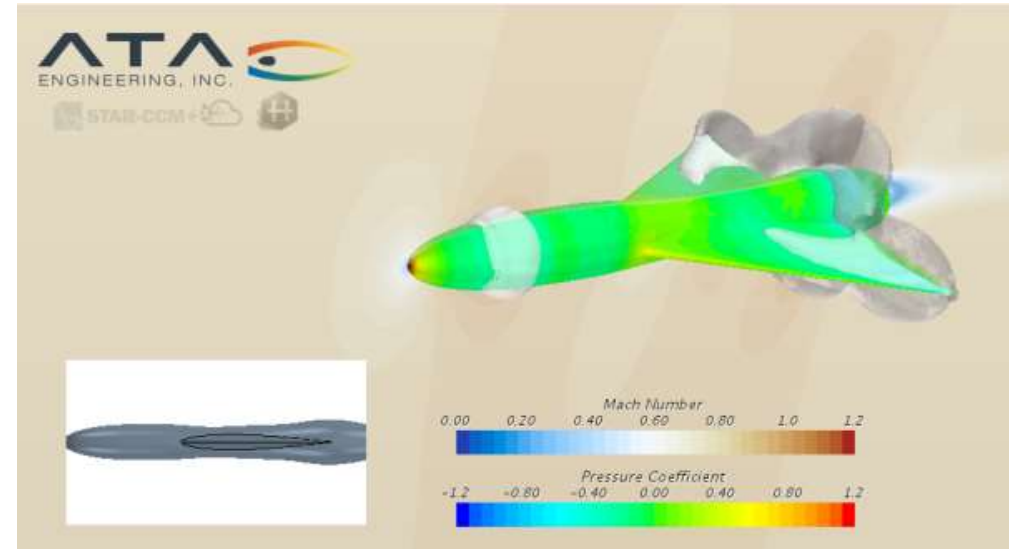
HEEDS Analysis Interrogation Tools

- Evaluation 32 had the lowest C_D at step 1000
 - However, it wasn't converged
- HEEDS provides powerful post-processing tools to filter out top performers and determine right solution for you
 - 27 designs are within 1% performance of evaluation 32

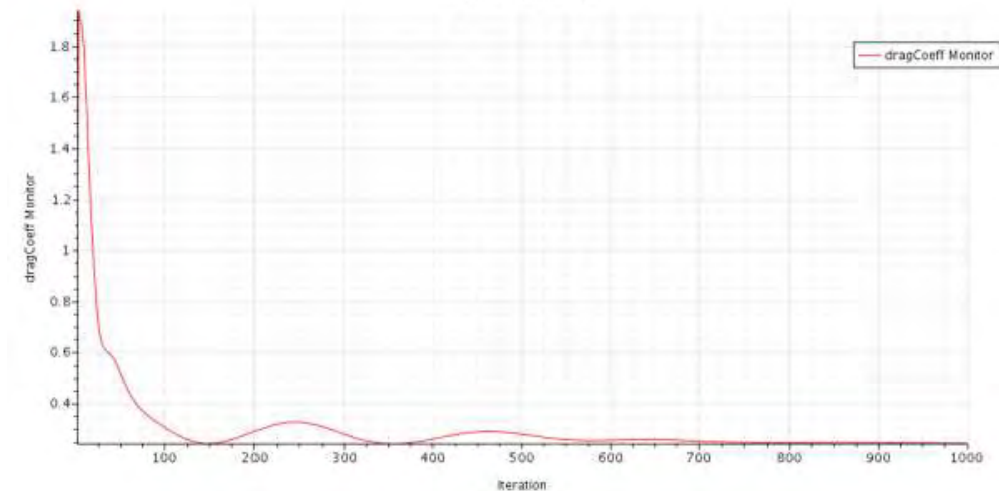


Alternate Improved Design

- Using HEEDS post-processing tools, evaluation 79 determined to be a successful design variant
- C_D converged at end of STAR-CCM+ analysis
- 35% reduction in C_D from baseline design



dragCoeff Monitor Plot



Scalability

- Small demonstration case took 799 CPU-hours to improve design 35% over 150 evaluations in 4 days with minimal analyst setup
- Using Rescale resource “Onyx” costs \$0.12/CPU-hr
- Hardware cost to improve design on Rescale resources was \$95.83
 - Not including cost of STAR-CCM+ licensing
- Assuming perfect scaling, a similar 20 million cell study would cost \$4700 on 400 cores.
- The cost of a 400-core cluster would be ~\$200,000
 - Assumptions
 - Room available with sufficient cooling and clean and reliable power
 - Existing network with safe, reliable, and fast storage (many TB)
 - Racks exist to hold HPC hardware
 - A dedicated staff member would be needed to maintain the system and infrastructure

- Needed to design an aircraft fuselage with a lower drag coefficient in transonic flight
- Used HEEDS Design Space Exploration software with STAR-CCM+ flow solver utilizing Rescale cloud-based HPC resources to find a better design
- The virtually hands-off method produced a design with a 35% reduction in drag coefficient
- HEEDS produced an improved aircraft design based on high-fidelity STAR-CCM+ predictions and minimal analyst effort utilizing affordable Rescale cloud-based HPC resources

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