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

Speakers:

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

Date:

3/28/2019

13290 Evening Creek Drive S, Suite 250, San Diego CA 92128

(858) 480-2000

www.ata-e.com

ata-engineering

@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

13290 Evening Creek Drive S, Suite 250, San Diego CA 92128

(858) 480-2000

www.ata-e.com

ata-engineering

@ATAEngineering

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

ATA ENGINEERING, INC.

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, INC.

ATA Engineering - Timeline

➢ A Legacy of Engineering Excellence:

1975 2000 2002 2007 2009 2010 2018

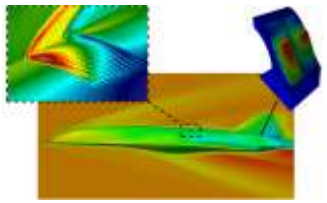
SDRC was an early pioneer of CAE tools starting in 1967.

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.

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

ATA opens Eastern regional Office (ERO) in Herndon VA



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

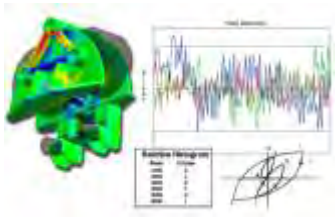
2007
ATA opens Denver office and labels it RMO: Rocky Mountain Office

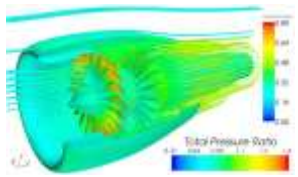
2009
ATA opens Huntsville Office to service South Eastern Aerospace clients

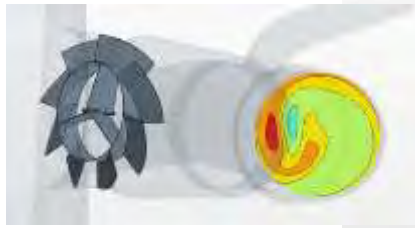
ATA becomes a full VAR for Siemens selling NX, Femap and Nastran

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:

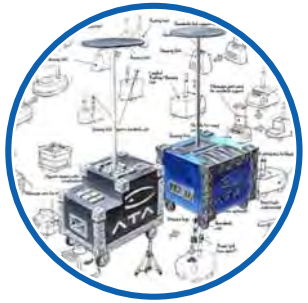
- take your project personally
- are empowered to make decisions
- love their jobs
- are efficiency minded
- recognize the direct link between your satisfaction and their success
- strive for customer delight

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

ATA ENGINEERING, INC.

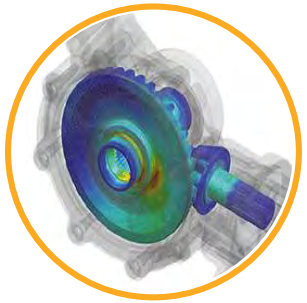
Our Services

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

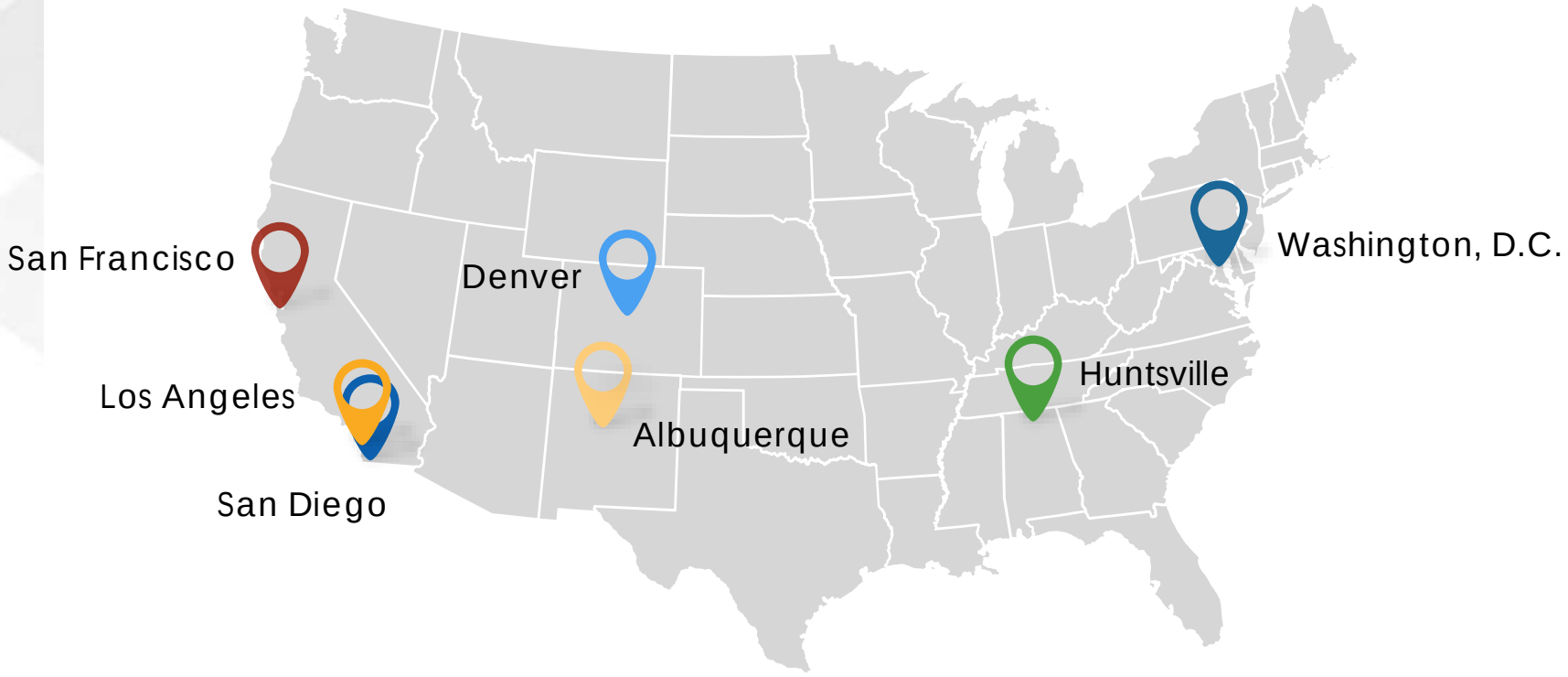
Test

Industry-leading structural test services for extreme loading environments

ATA ENGINEERING, INC.

Our Offices

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



ATA ENGINEERING, INC.

Our Software Services

ATA is a value-added reseller for Siemens PLM Software

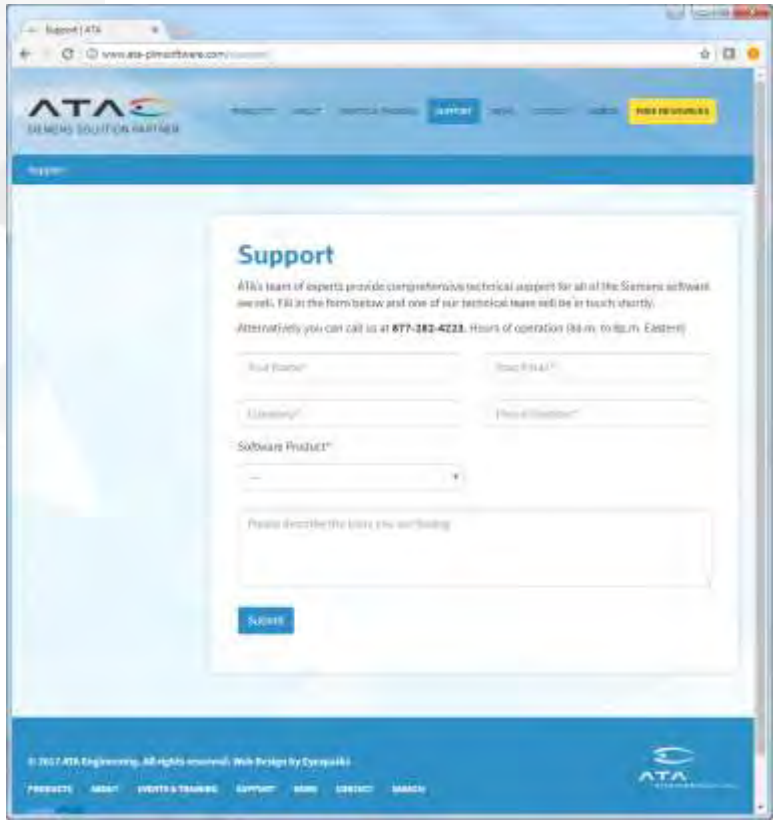
- Siemens product lines we support include
  - STAR-CCM+
  - HEEDs
  - AMESIM
  - Femap
  - Simcenter Nastran
  - Simcenter 3D
  - NX CAD & CAM
  - Teamcenter
  - Solid Edge
- Contact the hotline at 877-ATA-4CAE or http://ata-plmsoftware.com/support
- Developer of the official NX Nastran training materials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

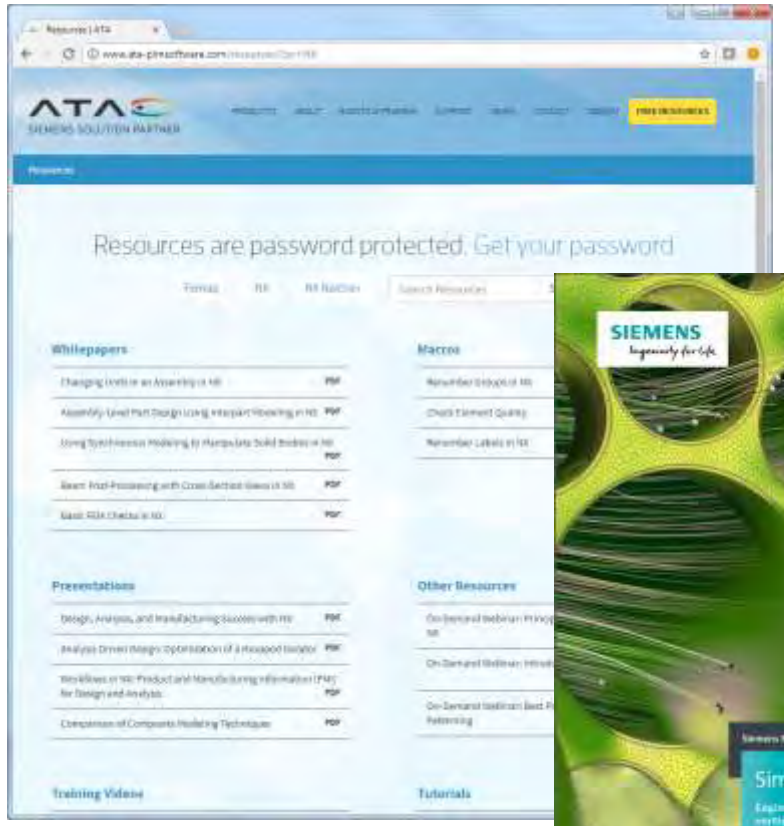
ATA ENGINEERING, INC.

SIEMENS

Our Online Resources

www.ata-plmsoftware.com





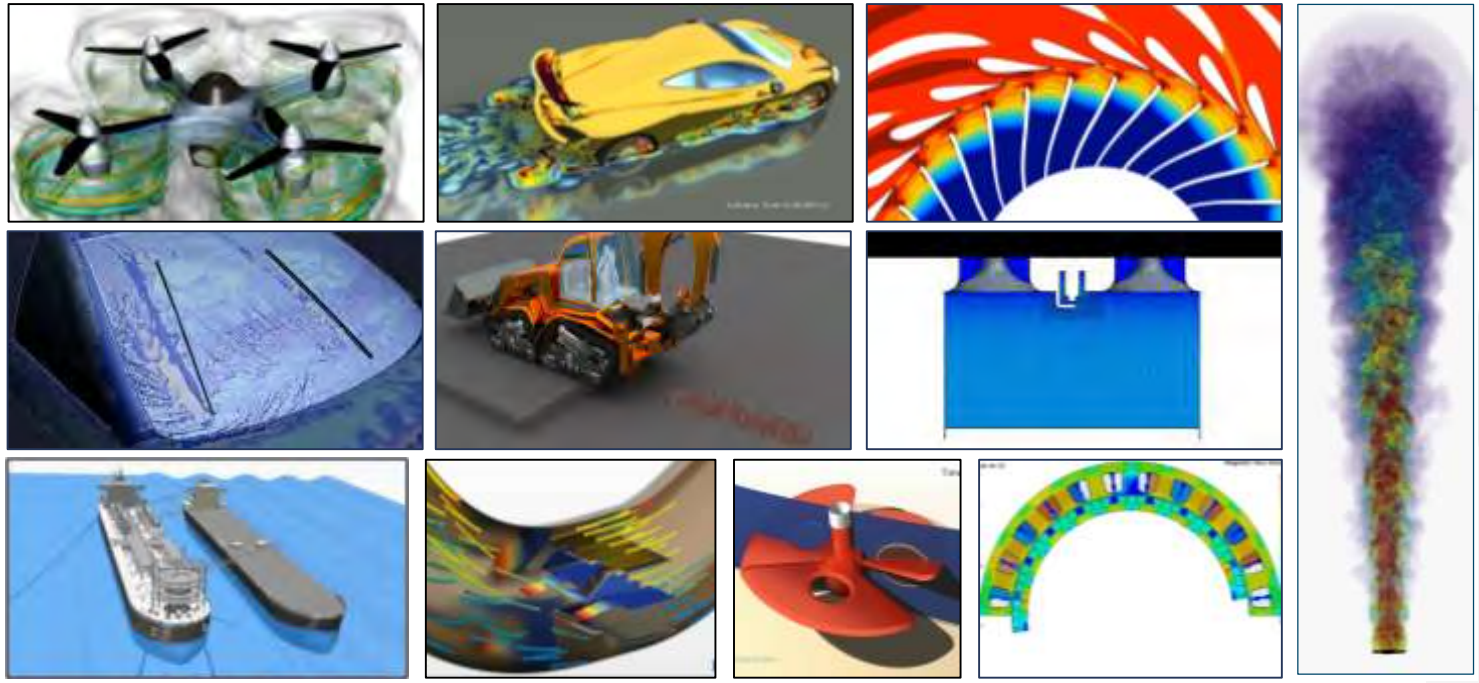
ATA ENGINEERING, INC.

An integrated multiphysics solution for the digital product

STAR-CCM+

Realism with multiphysics

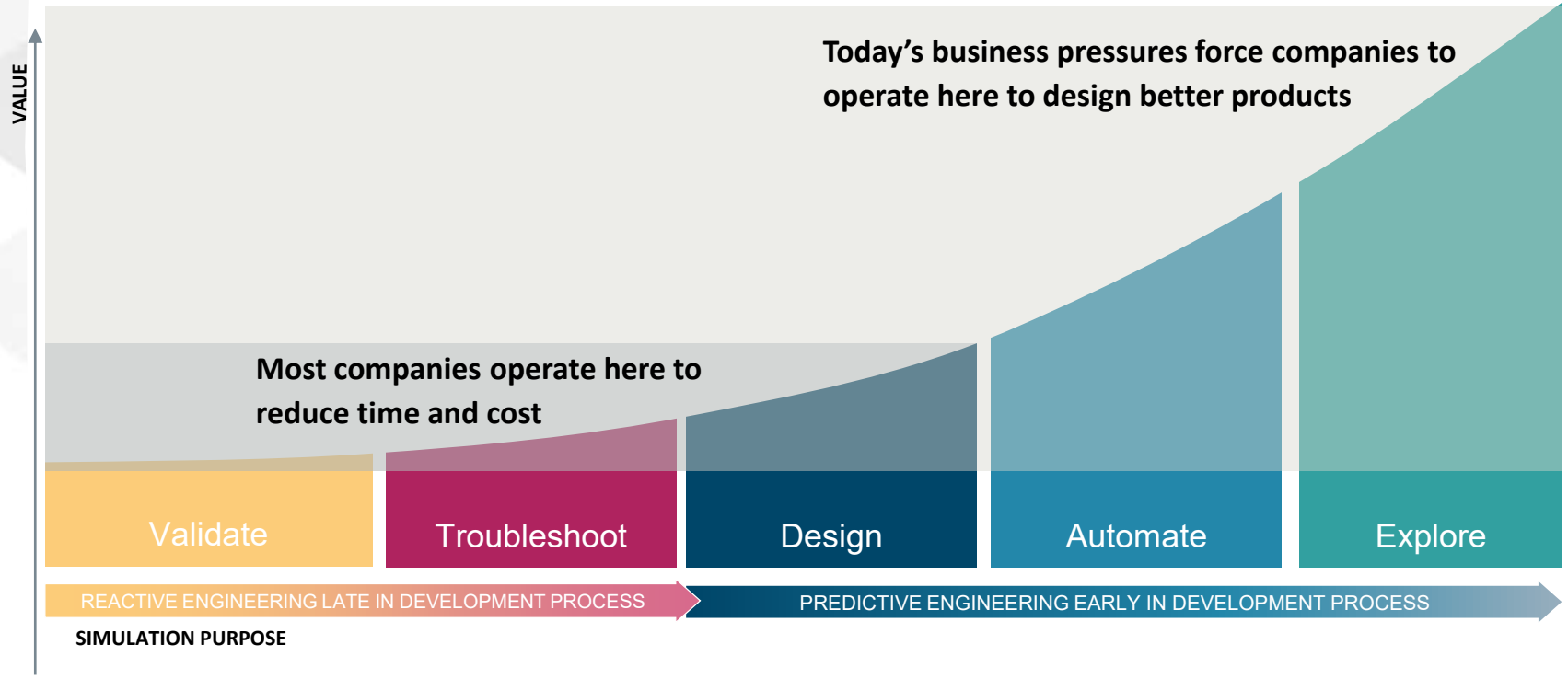
- Fluid dynamics
- Multiphase flows
- Reacting flows
- Solid mechanics
- Particle flows
- Rheology
- Electrochemistry
- Electromagnetics
- Aero-acoustics
- Fluid-structure interaction
- Conjugate heat transfer



ATA ENGINEERING, INC.

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

Innovation with built-in design exploration



ATA ENGINEERING, INC.

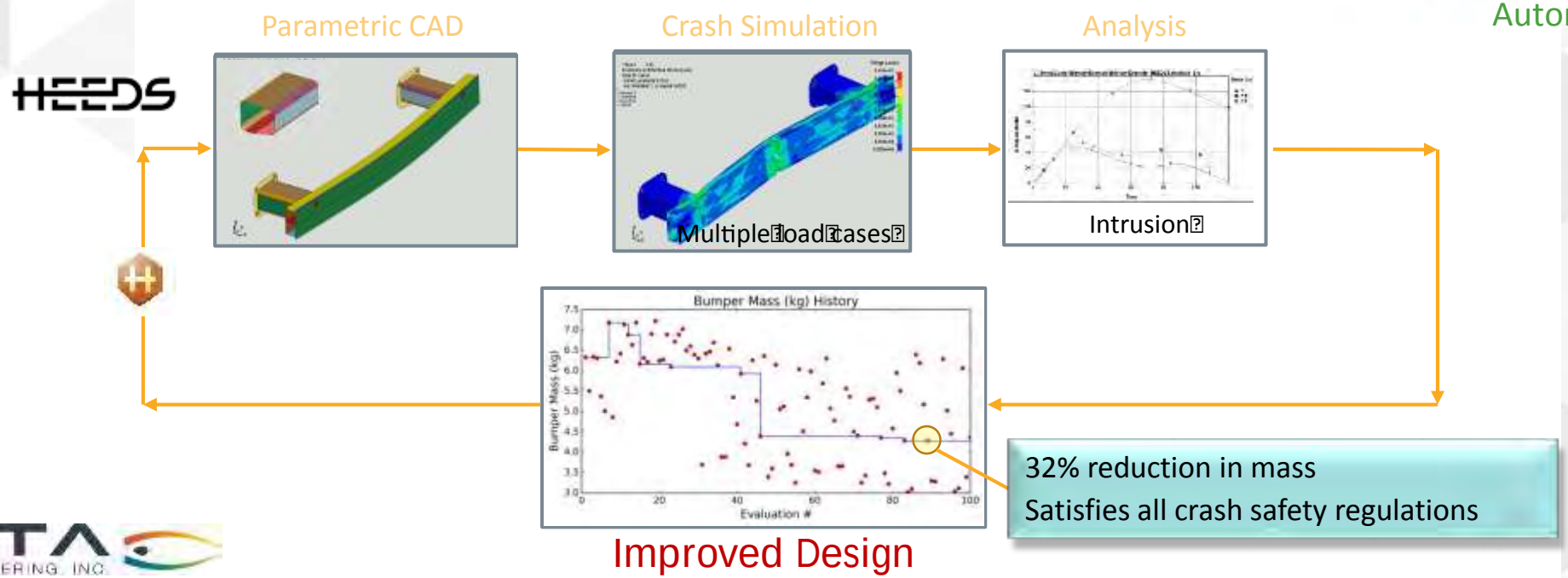
HEEDS: Discover Better Designs, Faster

SIEMENS
Ingenuity for life

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)

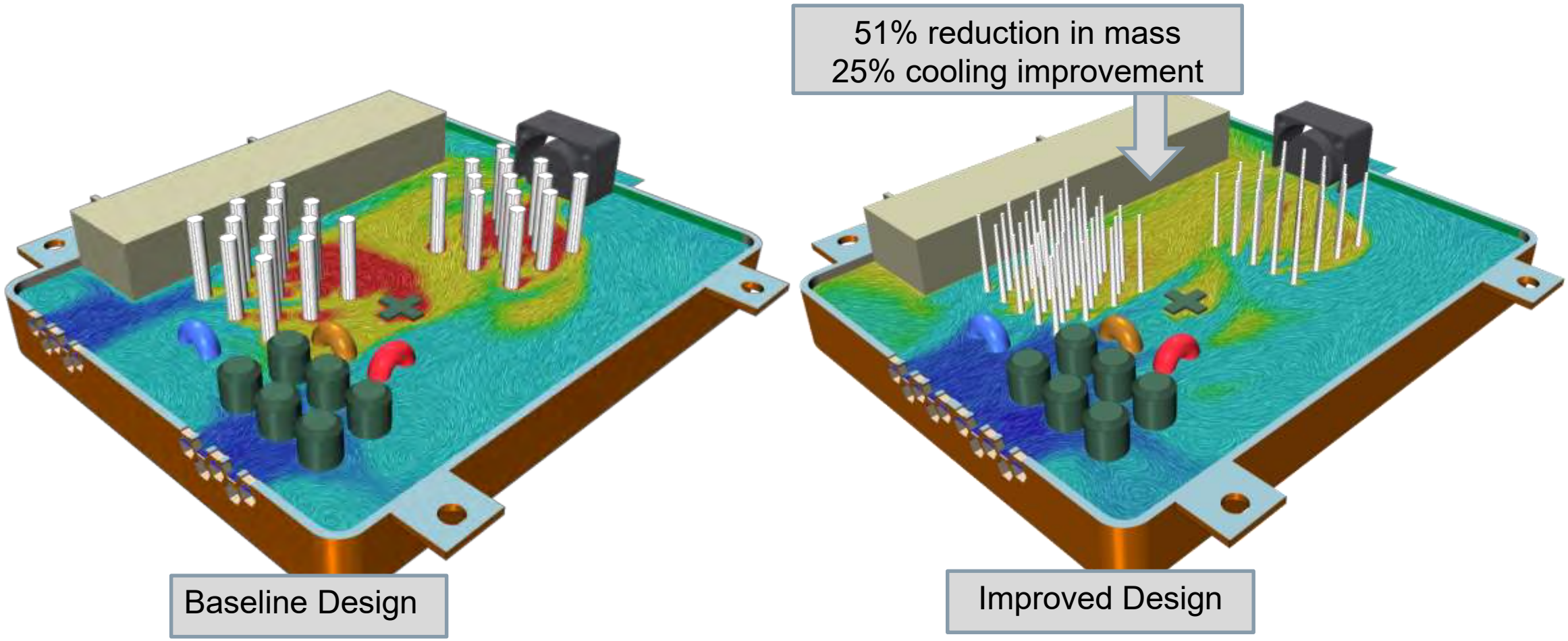
Automotive Bumper



ATA ENGINEERING, INC.

Driving Innovation Through Design Exploration

SIEMENS
Ingenuity for life

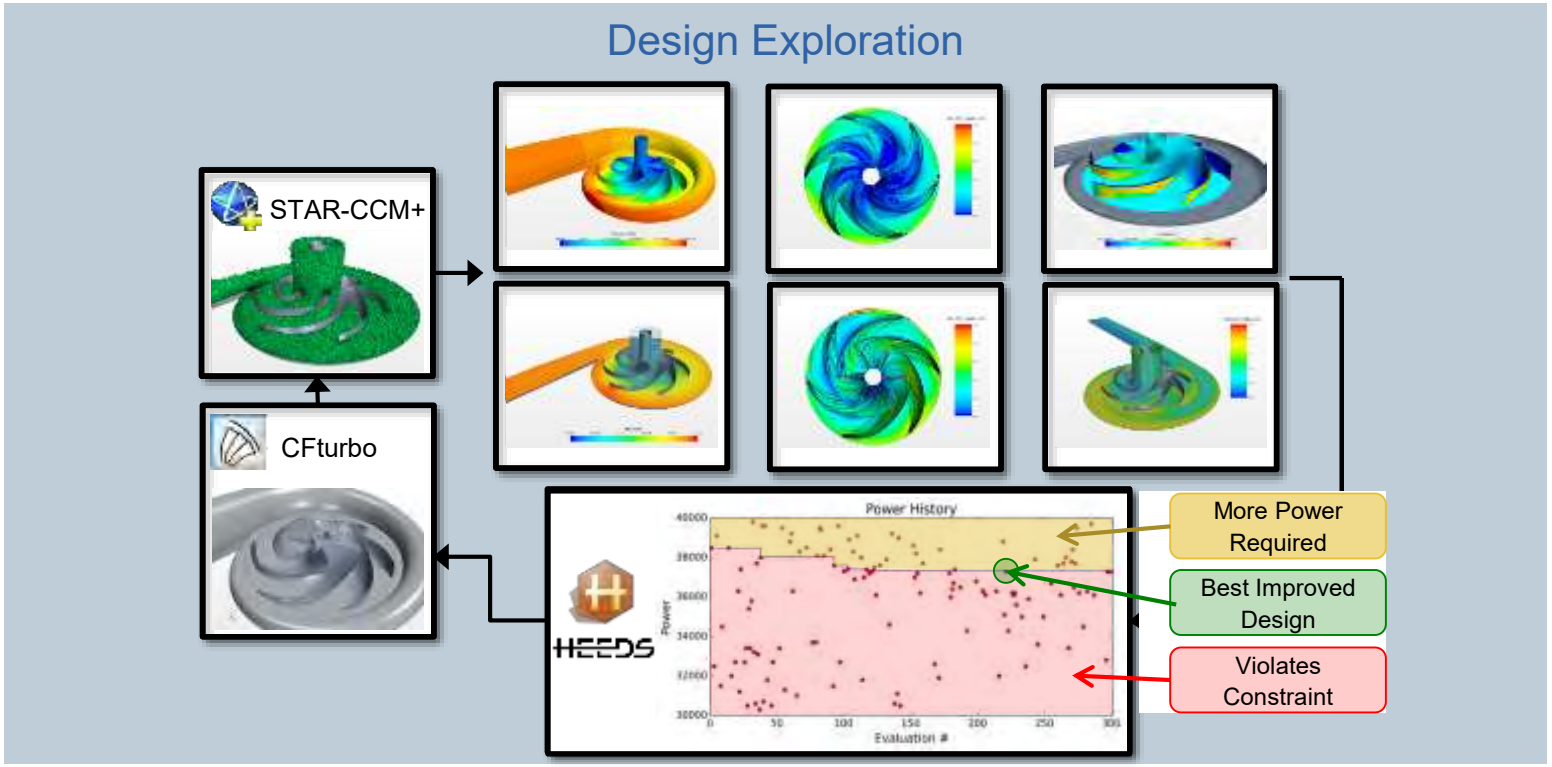


Streamlining the Design Exploration Process

Customer case study: Designing more efficient centrifugal pumps

SIEMENS
Ingenuity for life

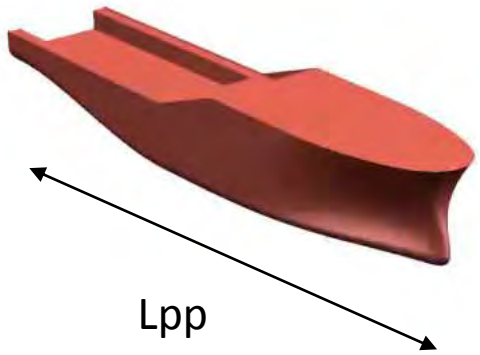
- Efficiently and automatically explored 300 design alternatives
- Searched broad design space globally and locally
- Identified families of designs that delivered better performance than initial baseline design

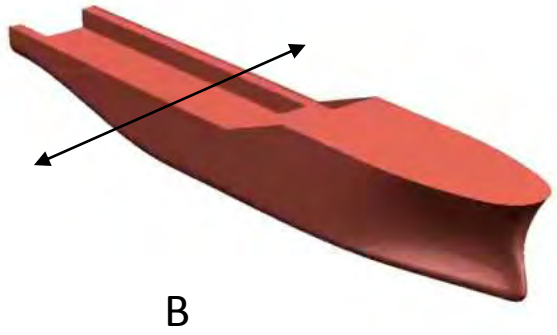


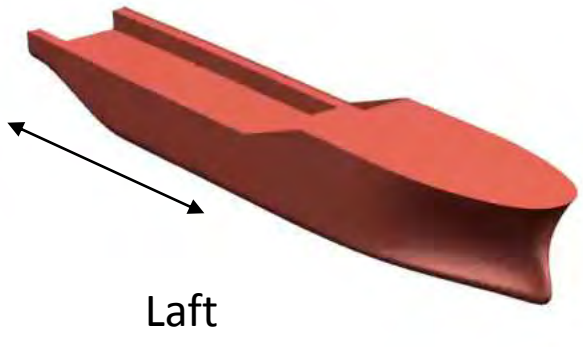
"I can now obtain better pump designs faster by spending more time on engineering decision-making, and less time on model setup & data transfer."

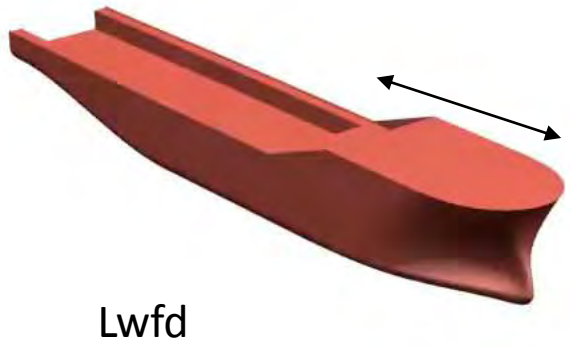
– Ed Bennett, VP of Fluids Engineering

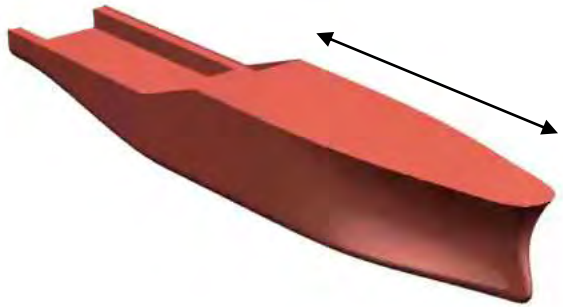
Design approach setup
Parametric CAD

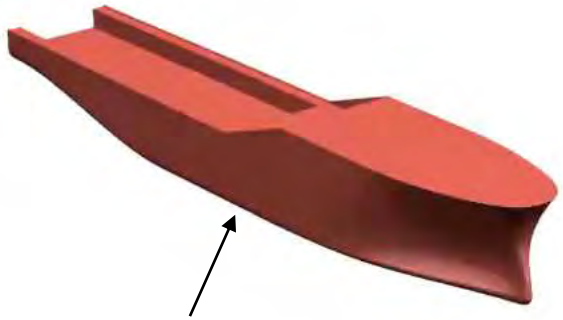


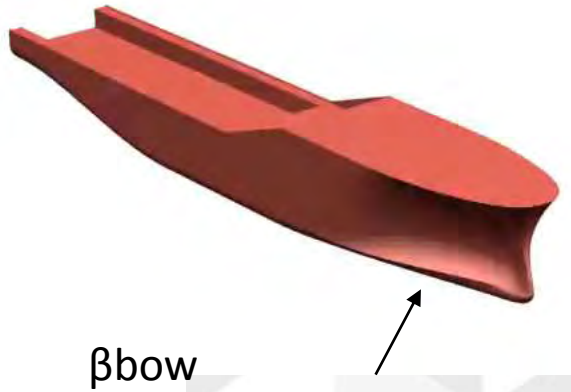












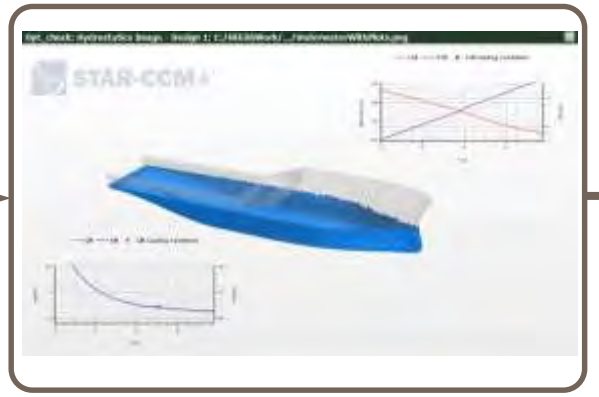
Design Space Exploration

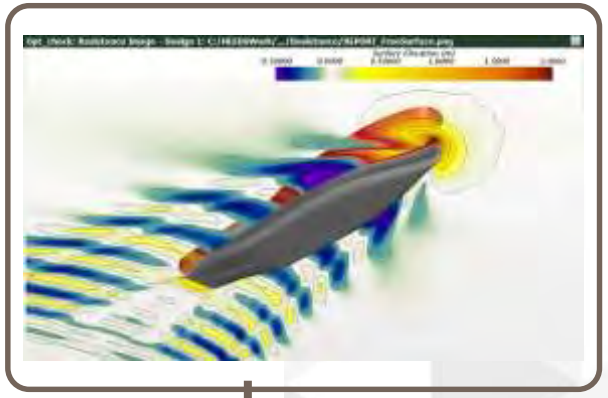
Efficient Design Exploration

Update Ship Geometry

Calculate Steel Weight

Calculate Hydrostatics & Resistance





Directed Modification

HEEDS' intelligent search method

- **SHERPA Search Framework**

Design Space Exploration
Scalable Computation

NX CAD
- Windows Laptop
- 1 core / job
- 4 concurrent jobs

Hydrostatics
- Linux Workstation
- 1 core / job
- 8 concurrent jobs

Resistance
- Linux Cluster
- 24 core / job
- 8 concurrent jobs

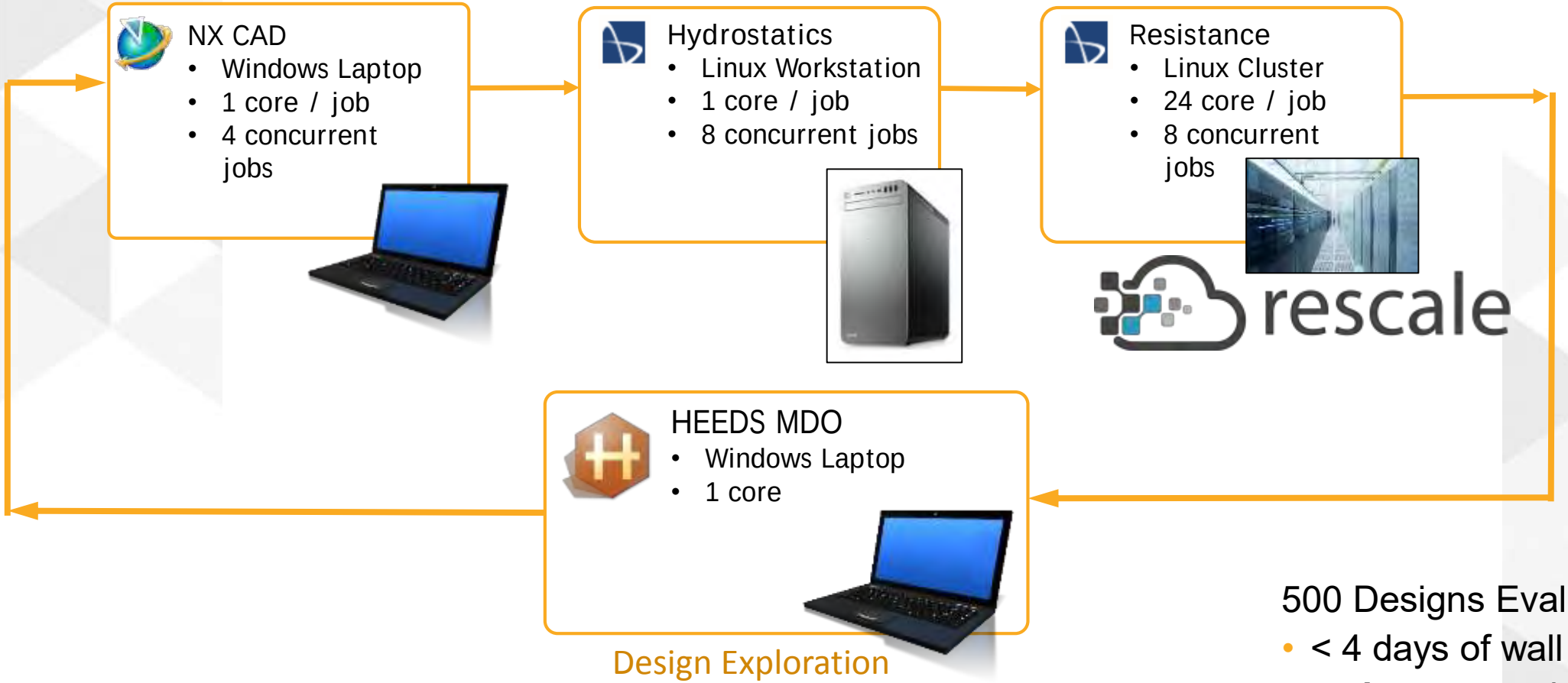
HEEDS MDO
- Windows Laptop
- 1 core

Design Exploration

500 Designs Evaluated
- < 4 days of wall time
- **~2 hours** per design

ATA ENGINEERING, INC.

Design Space Exploration
Scalable Computation

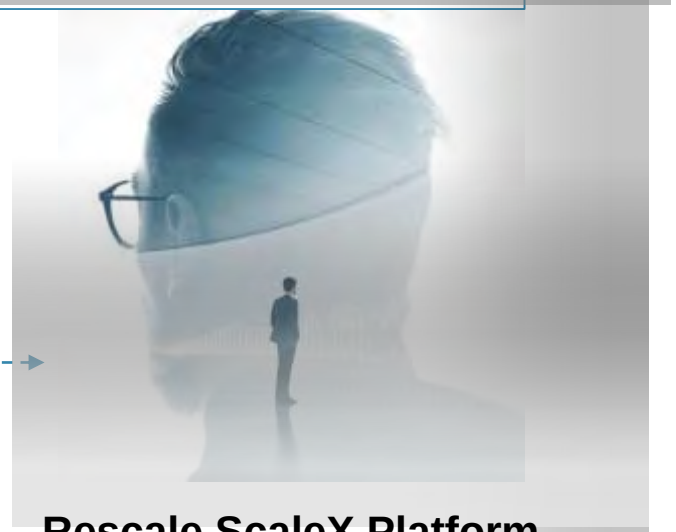


500 Designs Evaluated
- < 4 days of wall time
- **~2 hours** per design

ATA ENGINEERING, INC.

The Rescale HPC Platform experience

FULLY INTEGRATED STACK OF ENTERPRISE DEPLOYMENT TOOLS



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

13290 Evening Creek Drive S, Suite 250, San Diego CA 92128

(858) 480-2000

www.ata-e.com

ata-engineering

@ATAEngineering

Transonic Flight Development

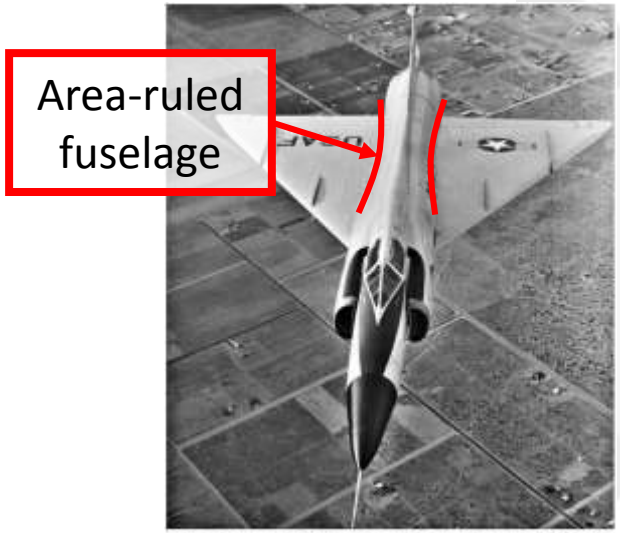
- Large drag increase near speed of sound
  - Significant difficulty accelerating past Mach 1
- Schlieren images showed standing shocks on wings leading to wave drag
- Significant breakthrough – Whitcomb Area Rule
  - Cross-sectional area to have smooth streamwise variation
  - Fuselage to narrow in 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?

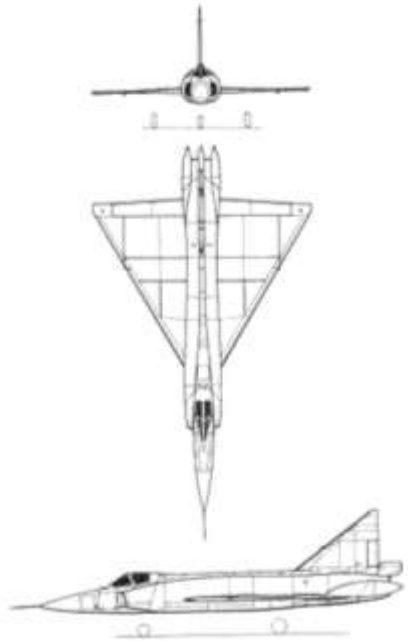
Convair YF-102 53-1785 with the original fuselage, photographed 31 December 1954. (NASA)



A Convair F-102A-80-CO Delta Dagger, 57-0809. The "Coke bottle" area-ruled fuselage is very noticeable. (U.S. Air Force)

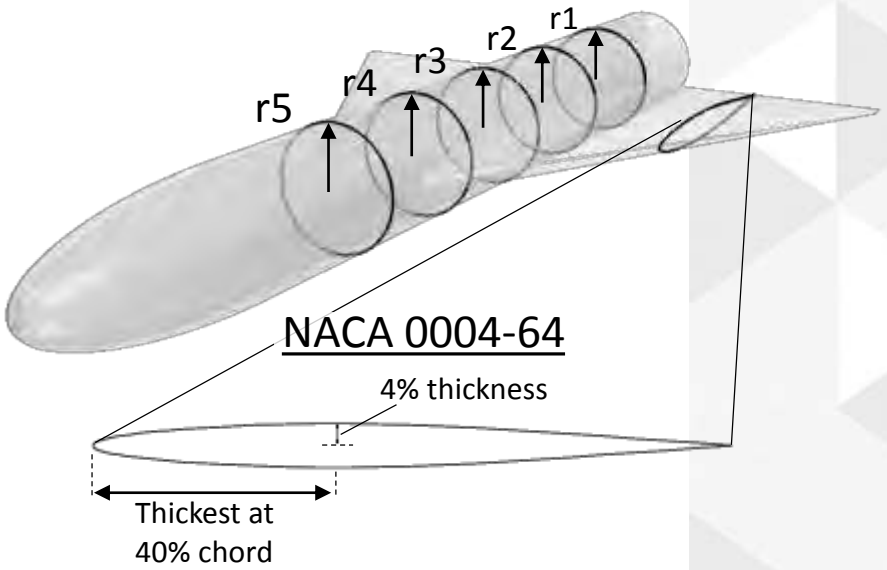
Baseline "YF-102" Model

- 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



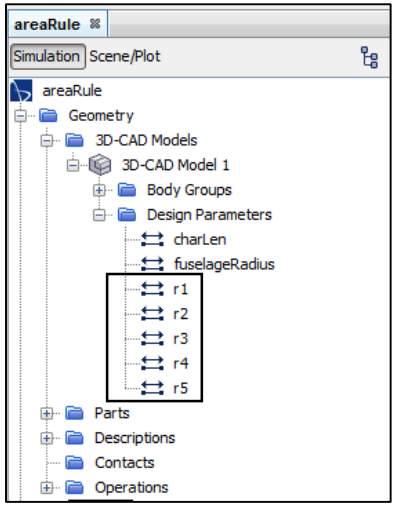
F-102A Drawings
(http://www.aerospaceweb.org/)

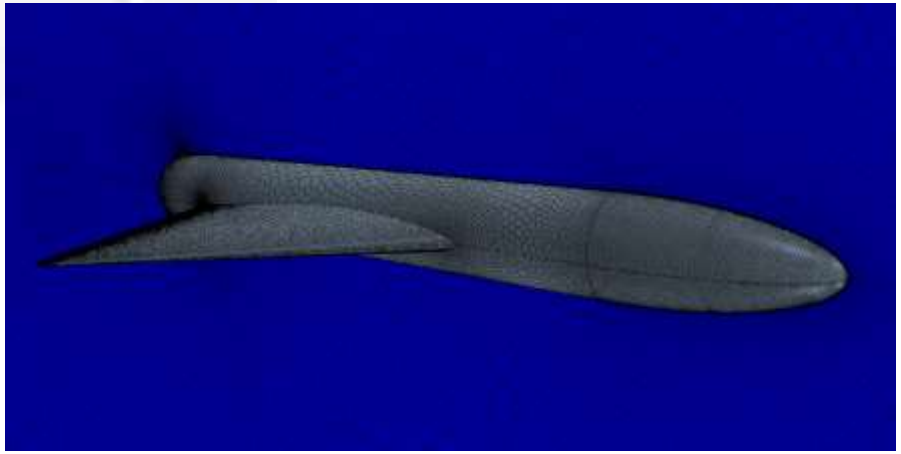
STAR-CCM+ Model



STAR-CCM+ Seamlessly Remeshes Flow Domain After Geometry Change

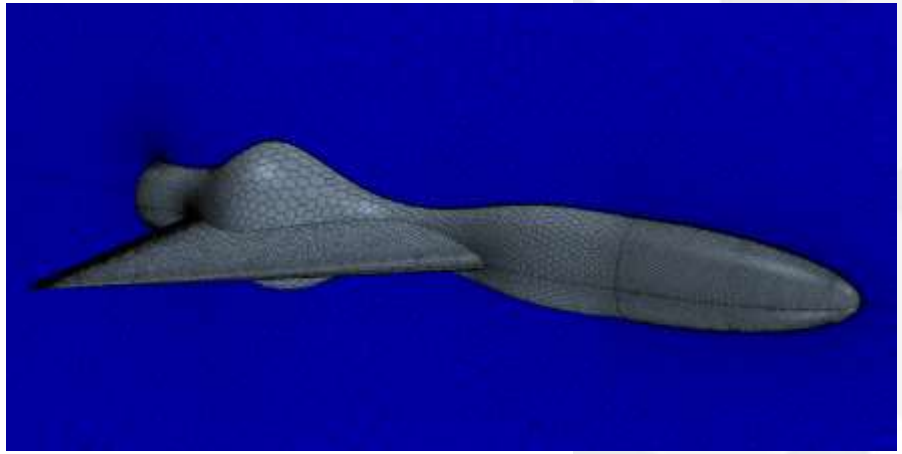
- Radii defined as exposed parameters
  - External CAD package can also be used
- STAR-CCM+ robustly remeshes after parametric geometry changes





r2 = 1.08 m → 2.0
r4 = 1.08 m → 0.7

Auto-remesh after geometry modification

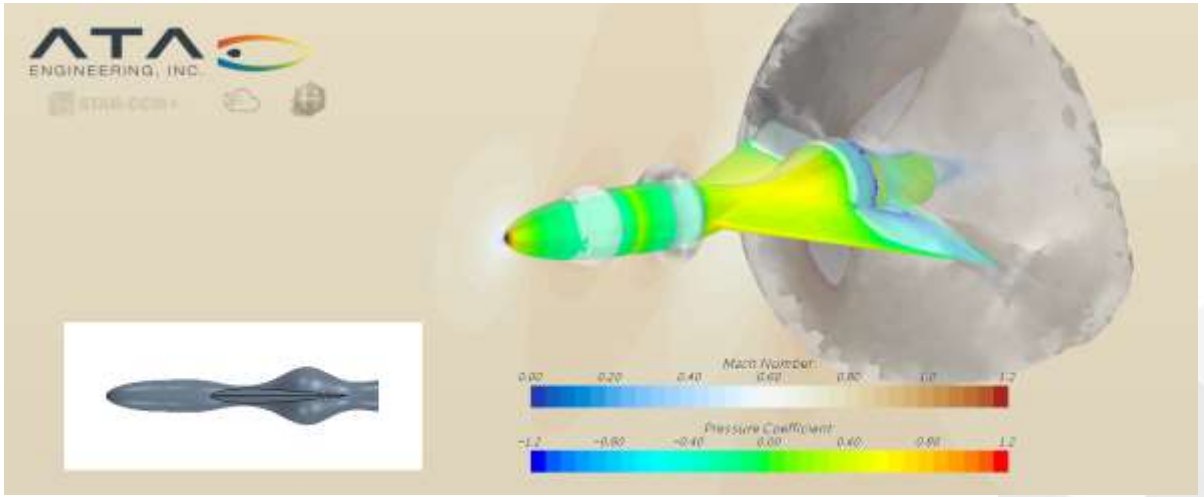


ATA ENGINEERING, INC

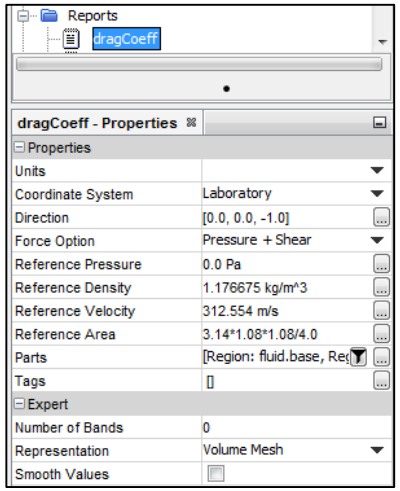
STAR-CCM+ Guides User Through Simulation Setup

- 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

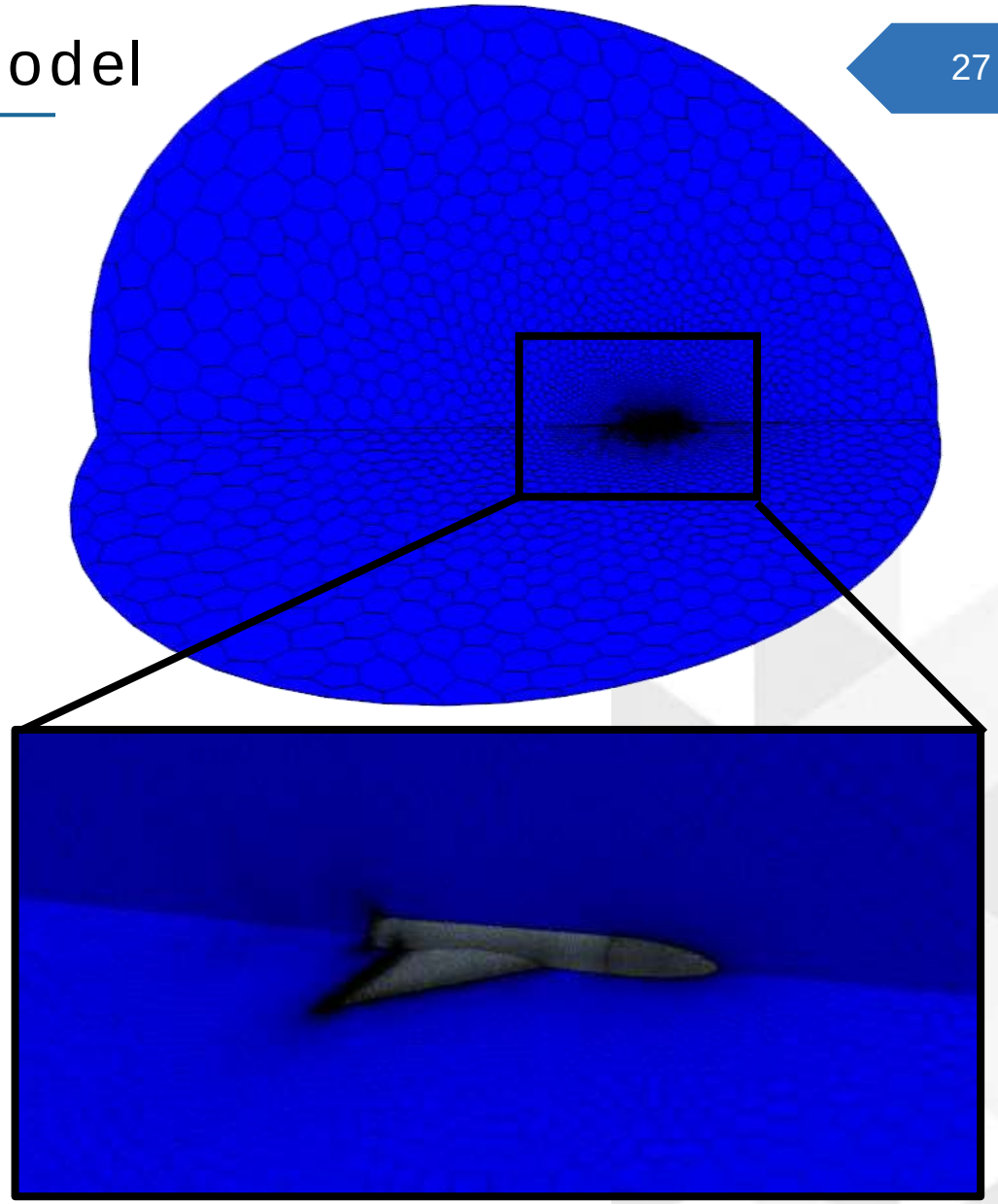


ATA ENGINEERING, INC

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



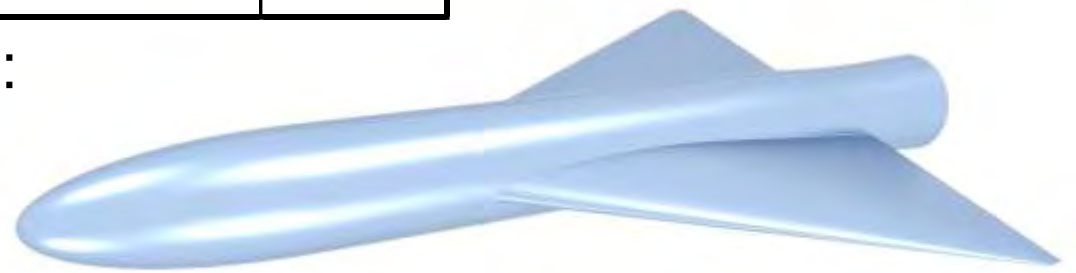
HEEDS Optimization

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

Parameters	Range		Resolution
	Minimum	Maximum	
r1	0.5 m	2 m	101
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

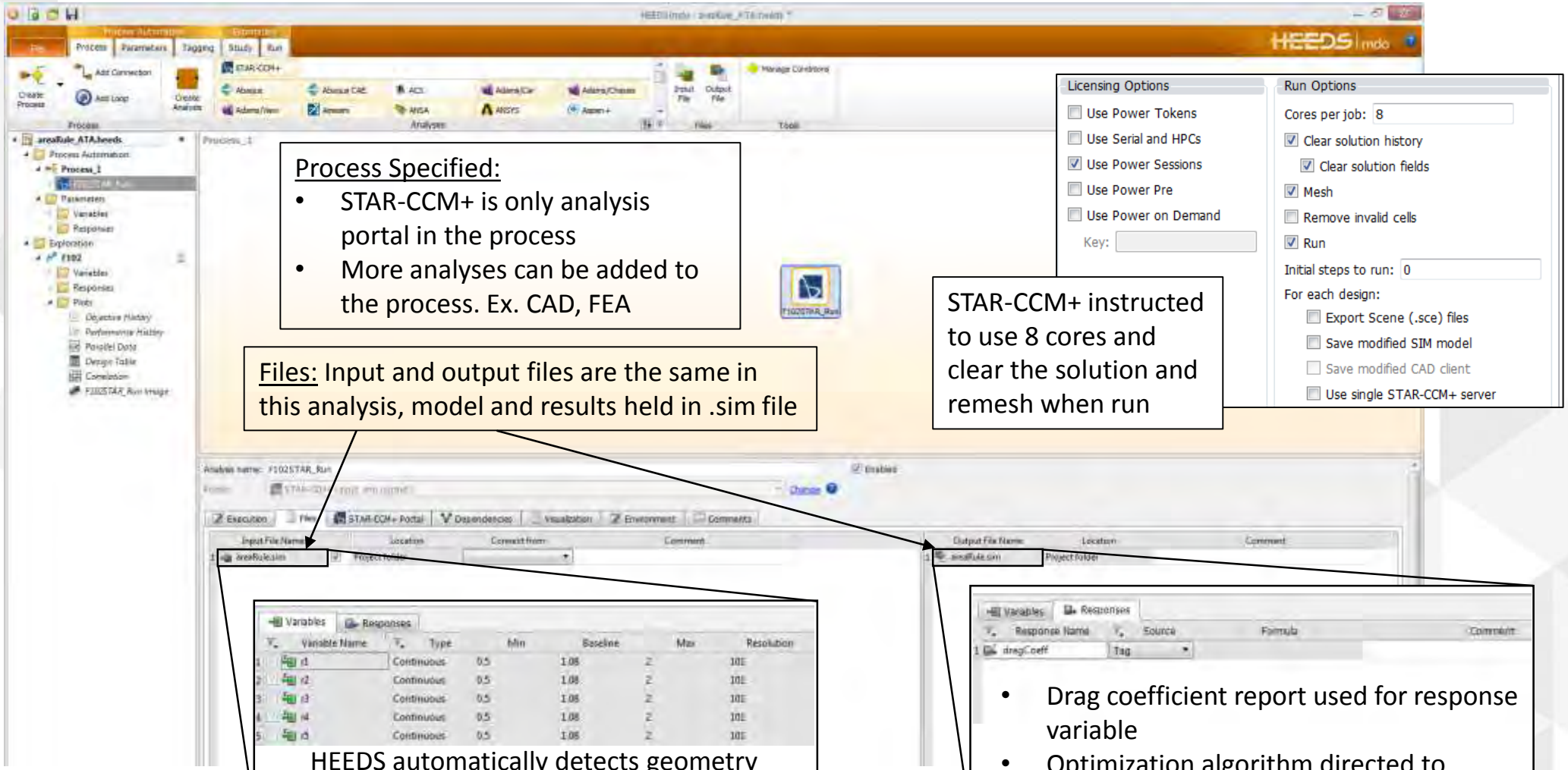
Response	
Variable	Objective
$C_D = \frac{Drag}{1/2\,\rho_\infty U_\infty^2 A}$	Minimize

- Exhaustive search of this design space: 101^5=10.5 billion simulations
- SHERPA finds improved design after 150 evaluations



ATA ENGINEERING, INC

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

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

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

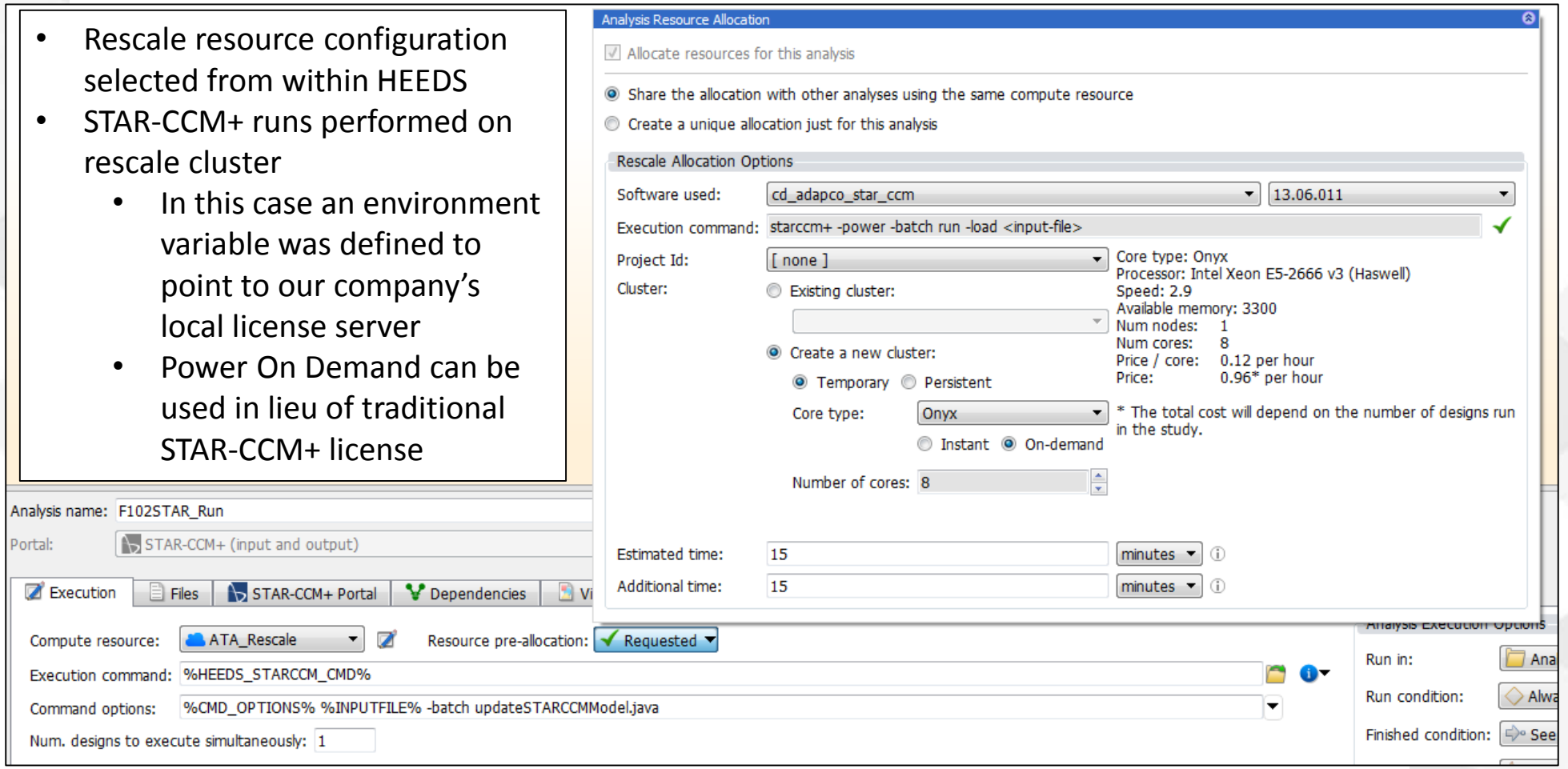
HEEDS automatically detects geometry parameters for ease of variable setup

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

ATA ENGINEERING, INC

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



ATA ENGINEERING, INC

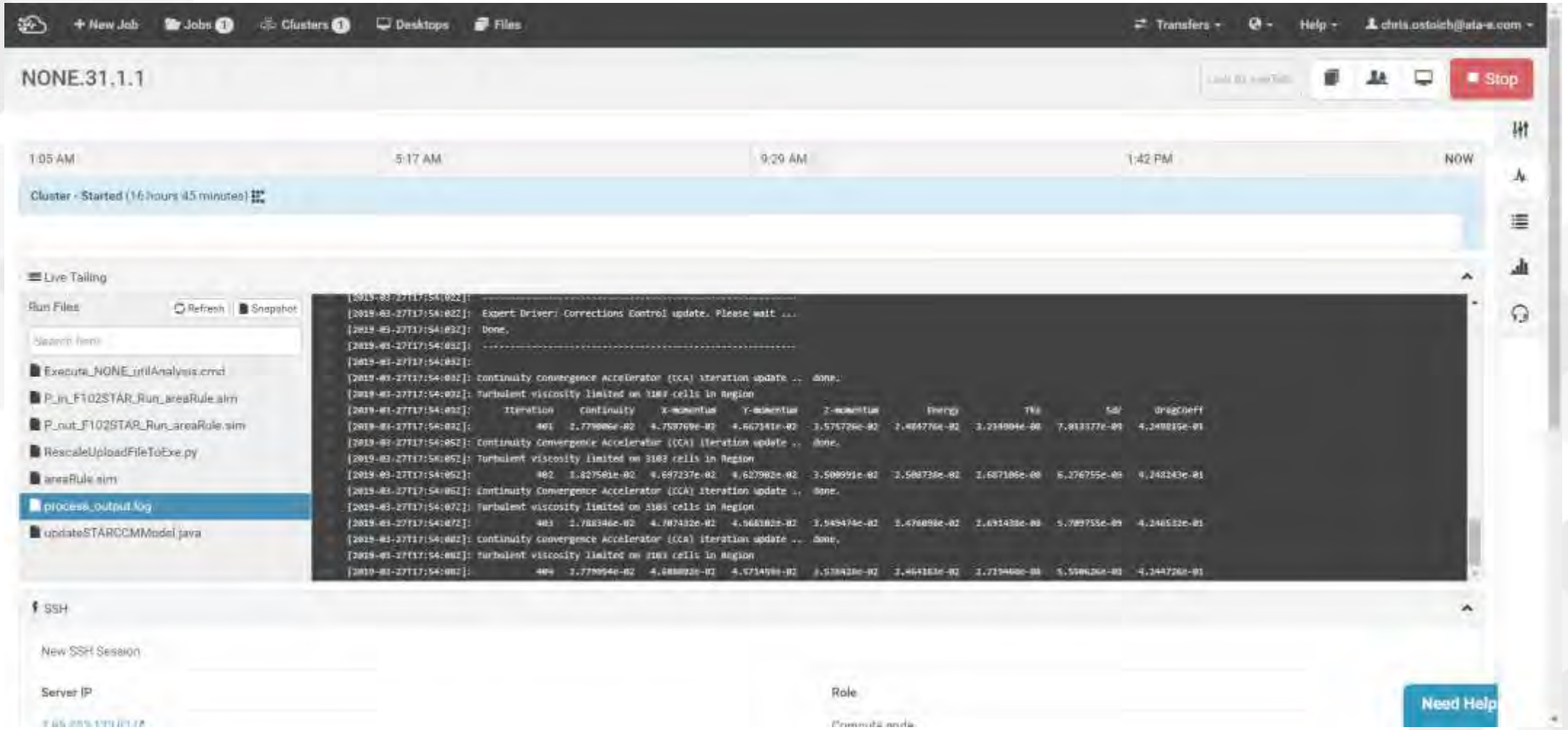
Recommended Workflow for Cloud Computing

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

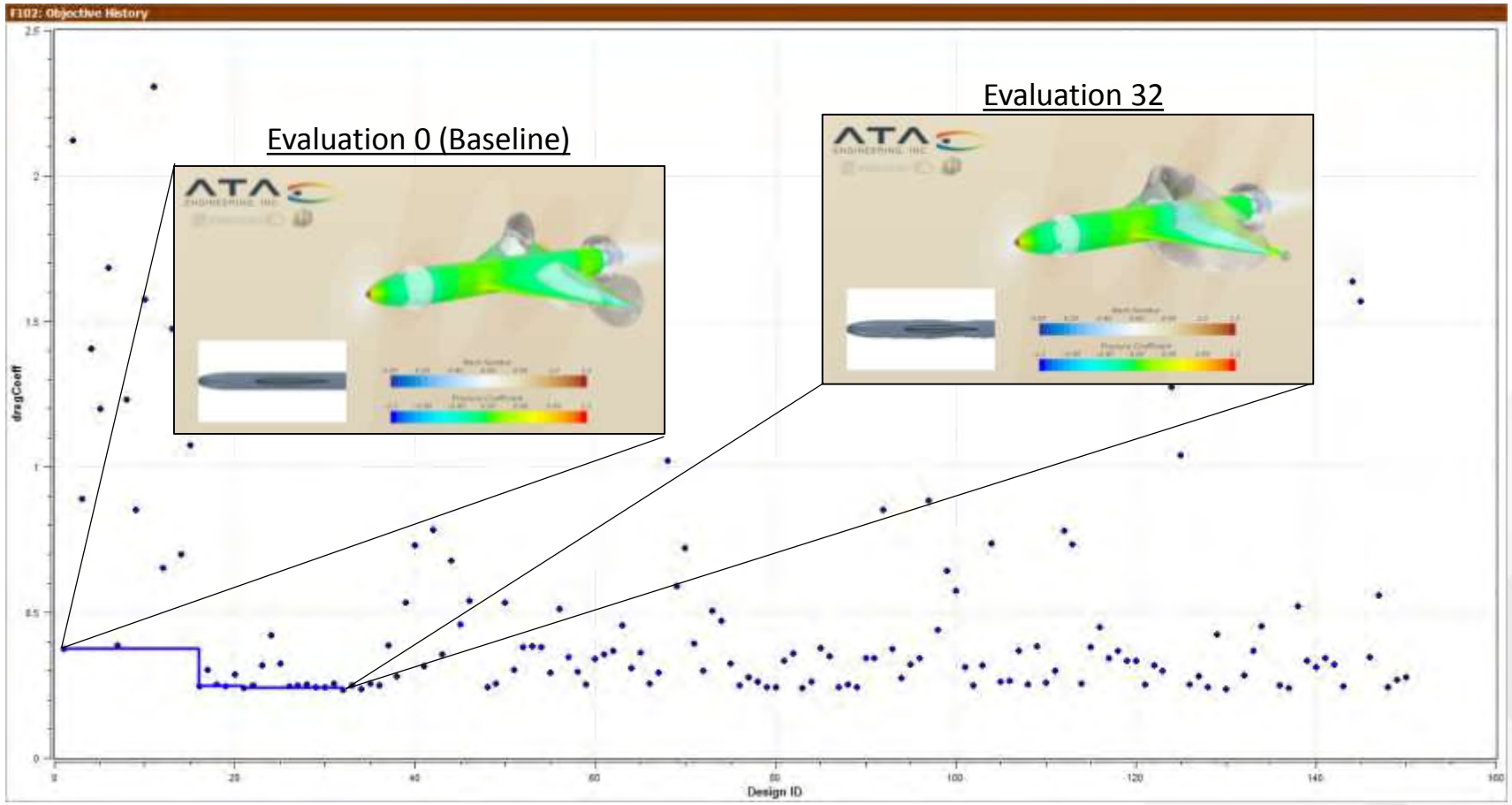
Running Jobs Monitored through Rescale Portal



ATA ENGINEERING, INC

HEEDS Design Optimization

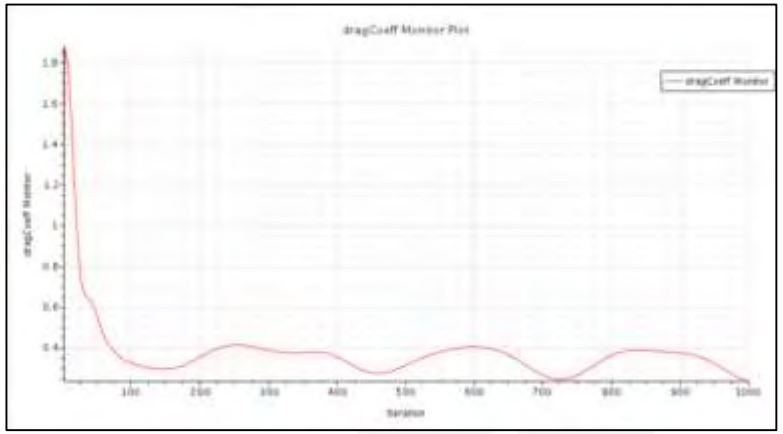
- HEEDS SHERPA explores design space to drive towards objective
- Evaluation 32 (out of 150) found to have the lowest drag coefficient
- Improved fuselage results in 38% reduction in drag



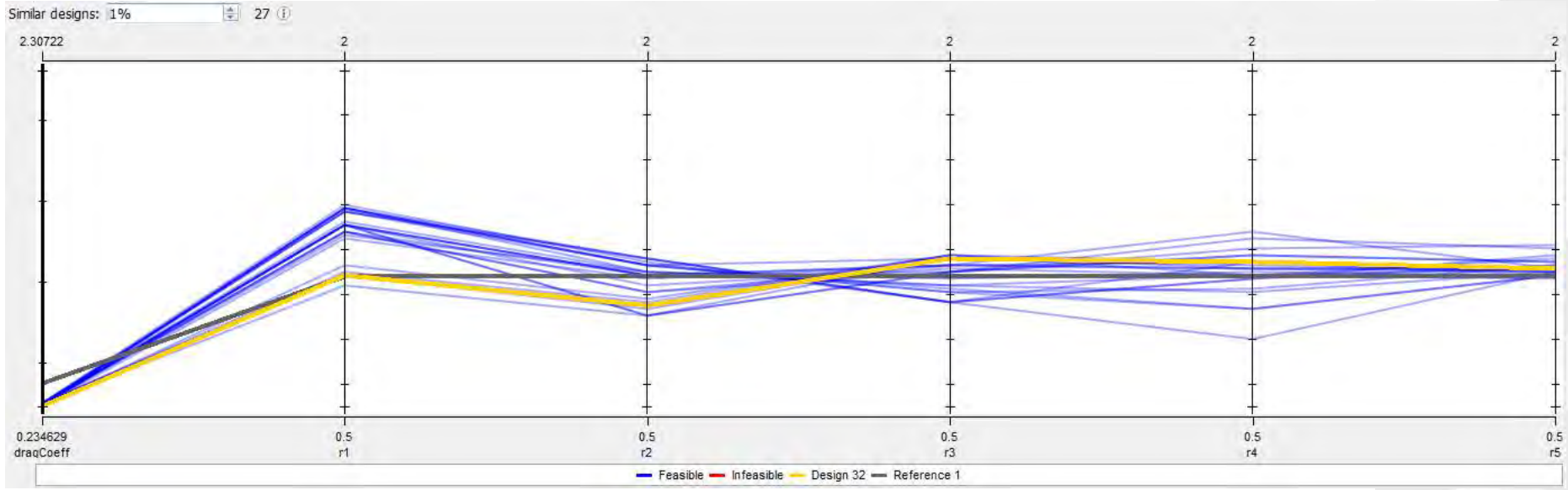
ATA ENGINEERING, INC

HEEDS Analysis Interrogation Tools

- Evaluation 32 had the lowest C_D at step 1000
  - However, it wasn't converged



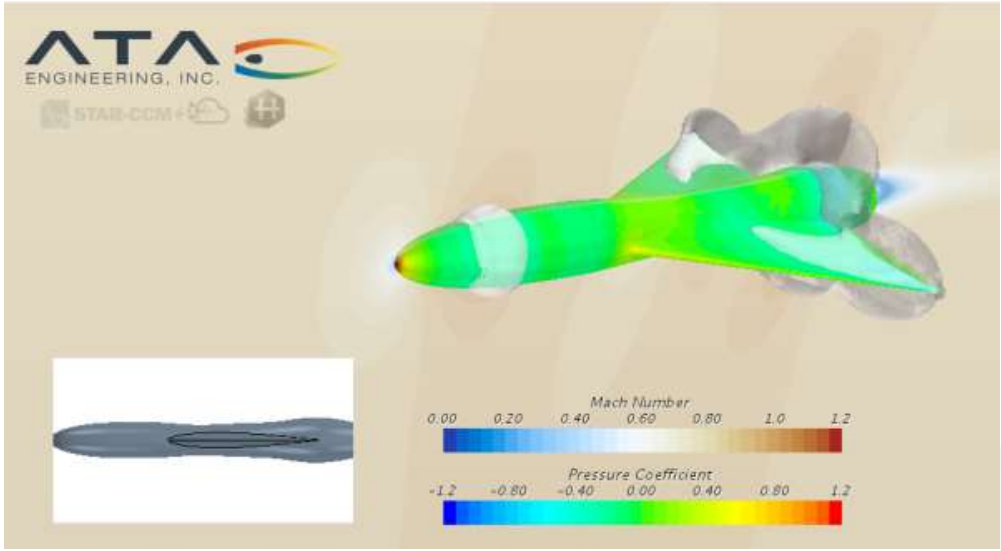
- HEEDS provides powerful post-processing tools to filter out top performers and determine right solution for you
  - 27 designs are within 1% performance of evaluation 32

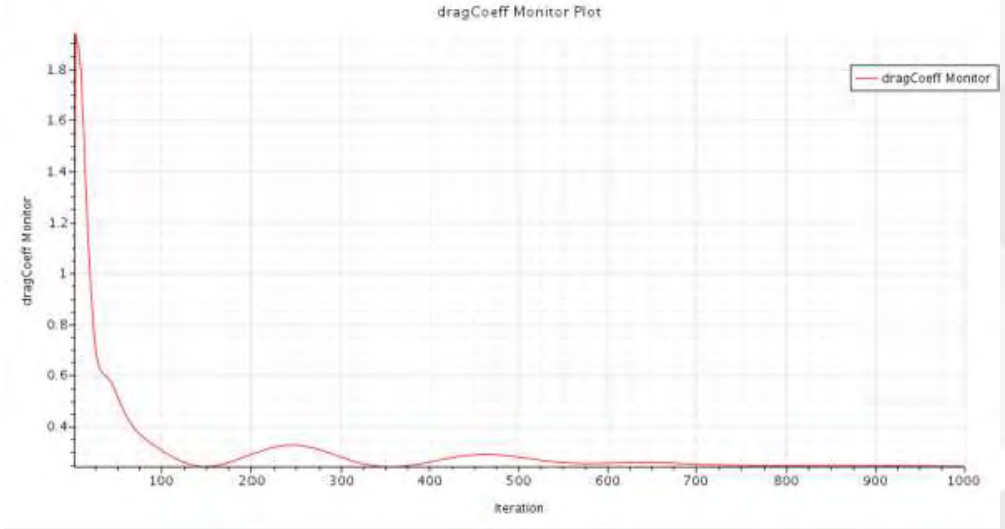


ATA ENGINEERING, INC

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





ATA ENGINEERING, INC

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

Summary

- 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

Contact Us

13290 Evening Creek Drive
Suite 250, San Diego, CA 92128

(858) 480-2000

sales@ata-e.com

www.ata-e.com
www.ata-plmsoftware.com

@ATAEngineering

ata-engineering

ATA ENGINEERING, INC