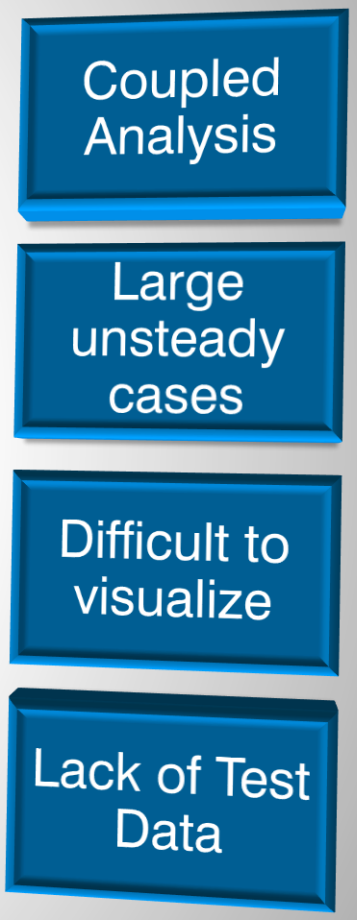
LEVERAGING DATA SCIENCE AND UNCERTAINTY QUANTIFICATION FOR PROPULSION APPLICATIONS

Steve M. Legensky, President and CTO

Propulsion Applications Challenge Analysis

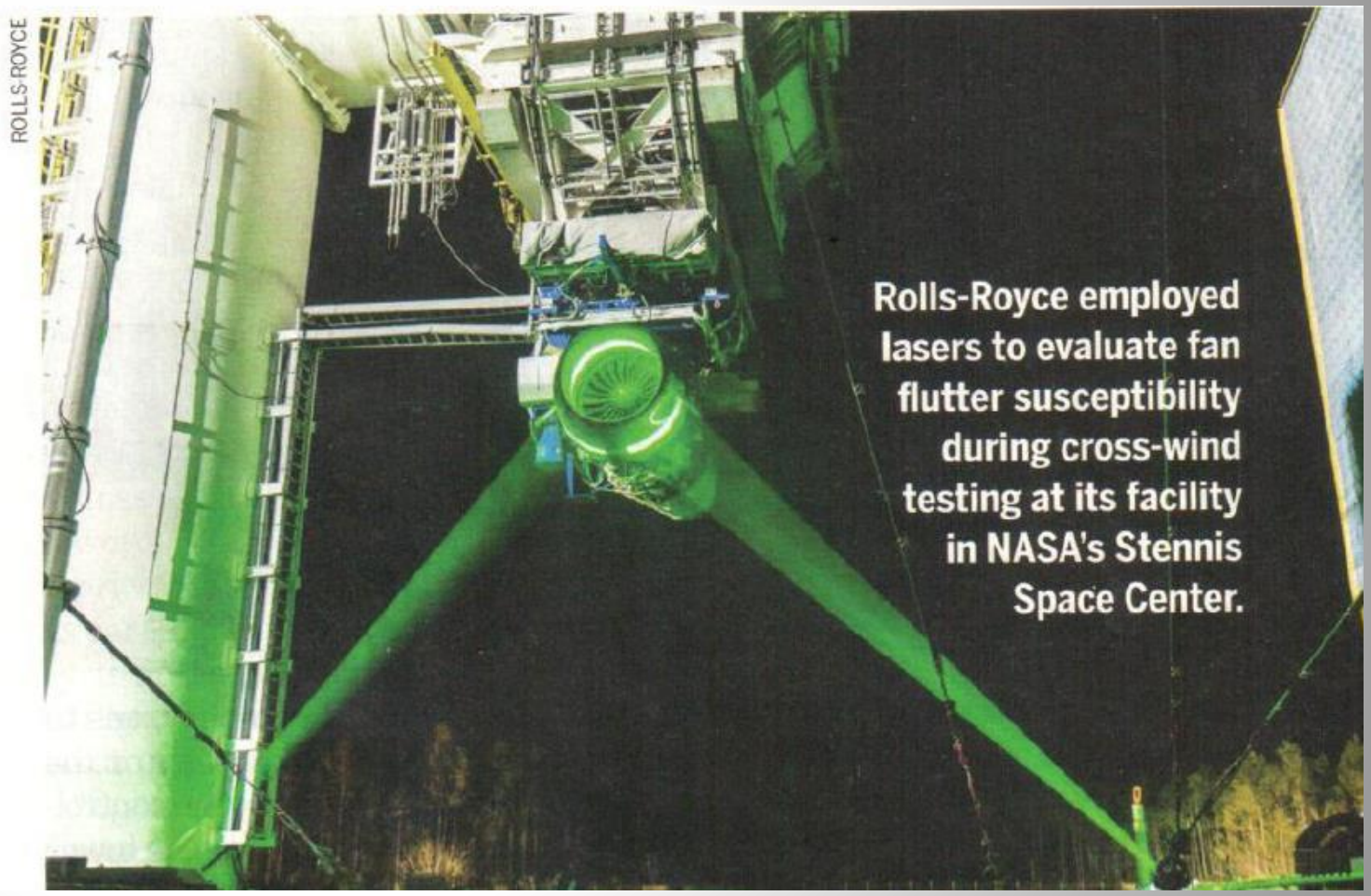
- Turbomachinery
  - Hot vs. cold geometry
  - As-built shapes vs. design
  - Fan noise, combustion coupling are unsteady
- Turbo or Scram Combustion
  - Inherently unsteady, multi-scale
- Rocket propulsion
  - Hot vs. cold geometry in turbopumps



Real-world Boundary Conditions are not Simple

- CFD analysis depends on accurate boundary conditions
- In-place, cross wind time varying measure-ment is difficult and expensive

From: Aviation Week and Space Technology, November 11-24/2019



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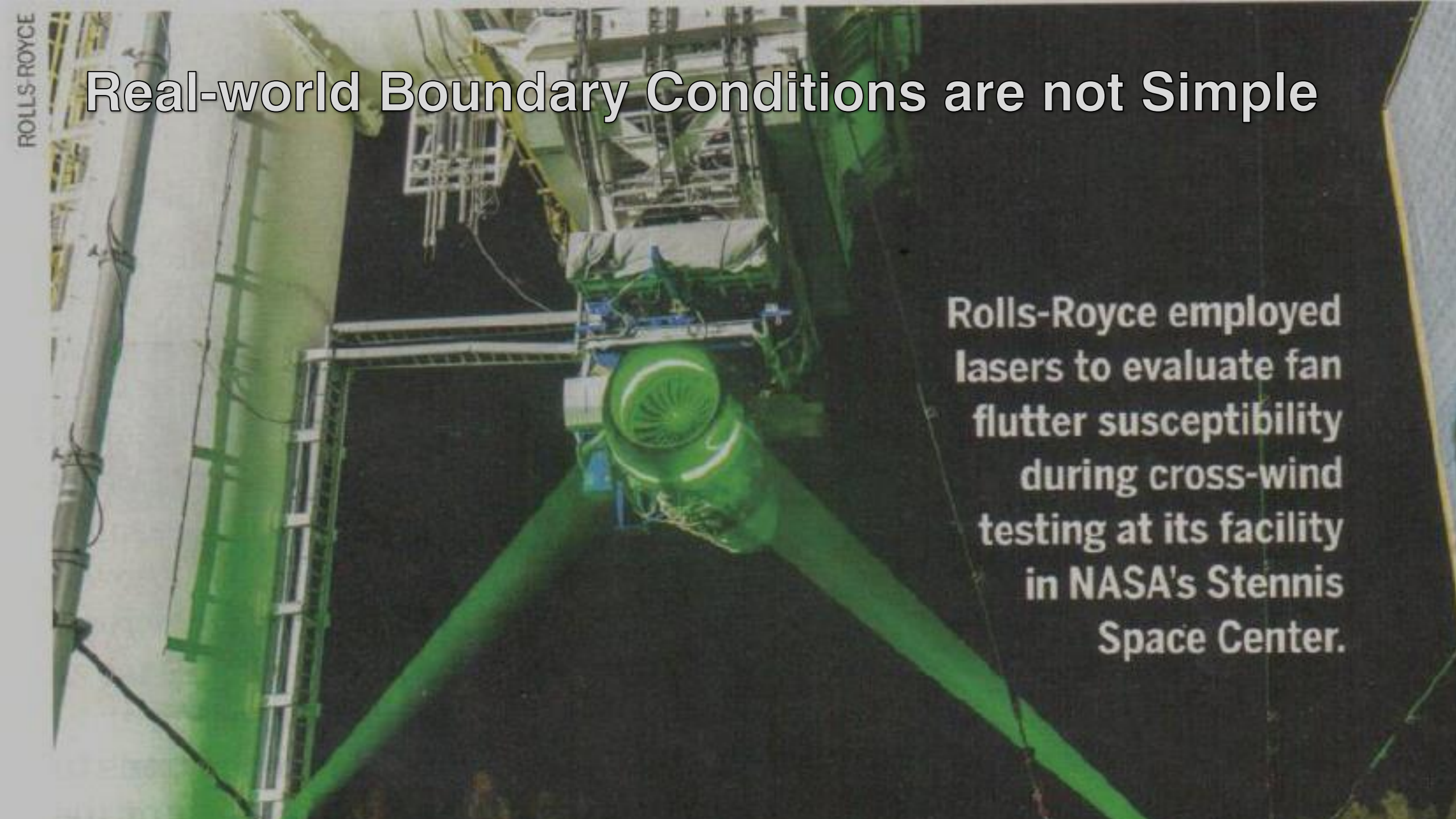
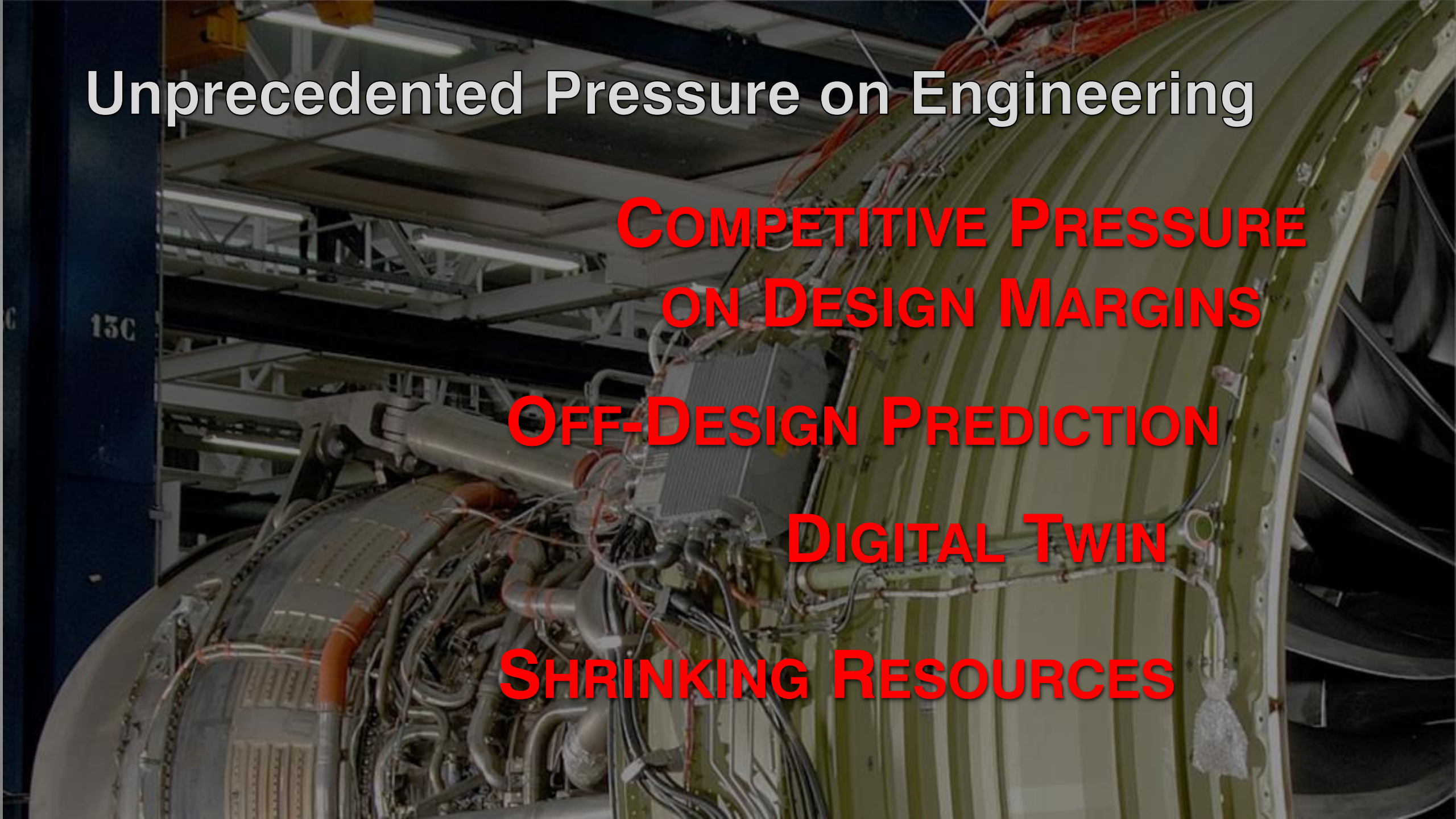


Unprecedented Economic Pressure

- Competition is squeezing the margins of weight, strength, efficiency and service life
- Demand for more reliable prediction, even off-design
- Digital Twins driving assimilation of measurement and simulation
- The pandemic is forcing limited staff to do more with less



Unprecedented Pressure on Engineering

Competitive Pressure on Design Margins

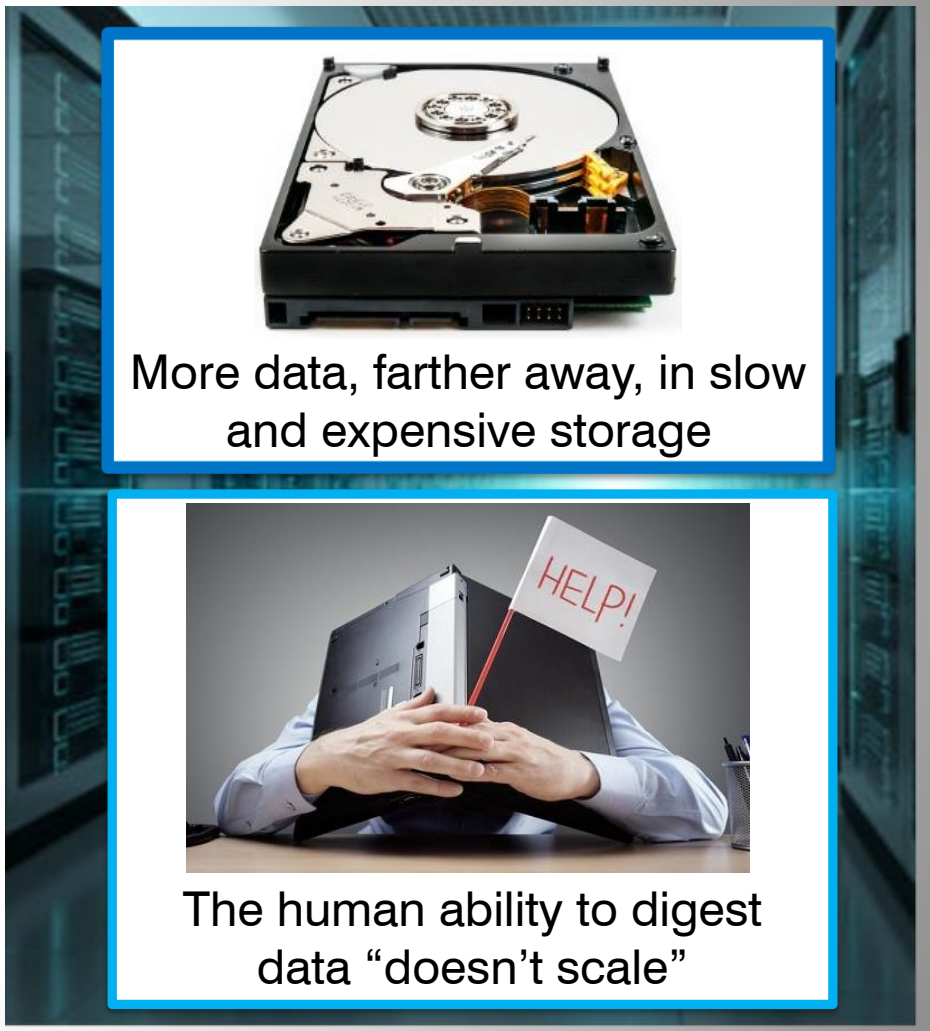
Off-Design Prediction

Digital Twin

Shrinking Resources

Simply Doing “More of the Same”?

- Unsteady CFD is more ‘accurate’ but runs are huge in time & space
- Uncertainty quantification & optimization require many runs
- HPC resources can be physically or logically distant
- Results from engineering simulation and experiments/tests are trapped in huge files - Information overload!

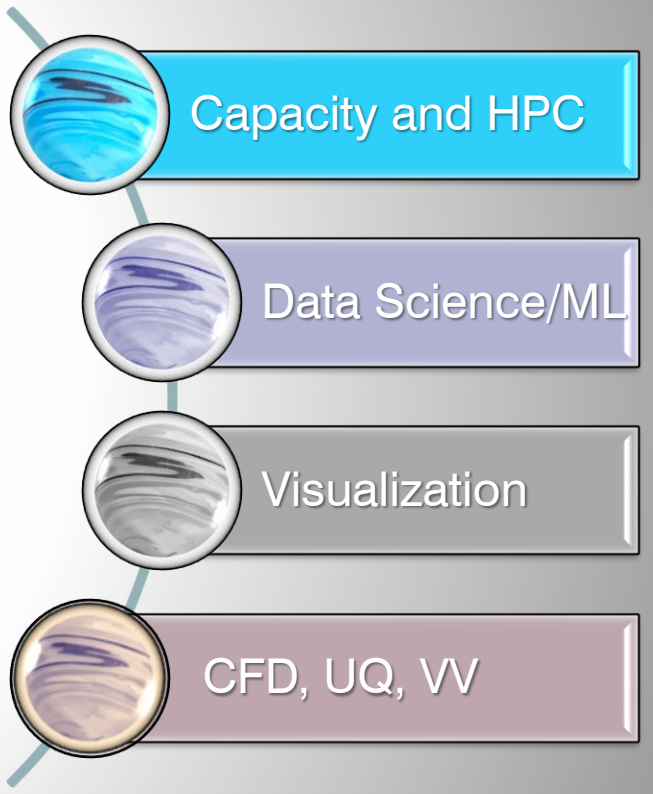


More data, farther away, in slow and expensive storage

The human ability to digest data “doesn’t scale”

Meeting Expectations Requires Innovation

- We work at the Frontier of Data Science, Capacity & Visualization
- We ask and answer BIG questions:
  - How can we gain more insight and easily archive more knowledge from massive amounts of data?
  - How much faster can we verify performance with every design change?
  - What is needed to achieve performance certification through simulation alone?

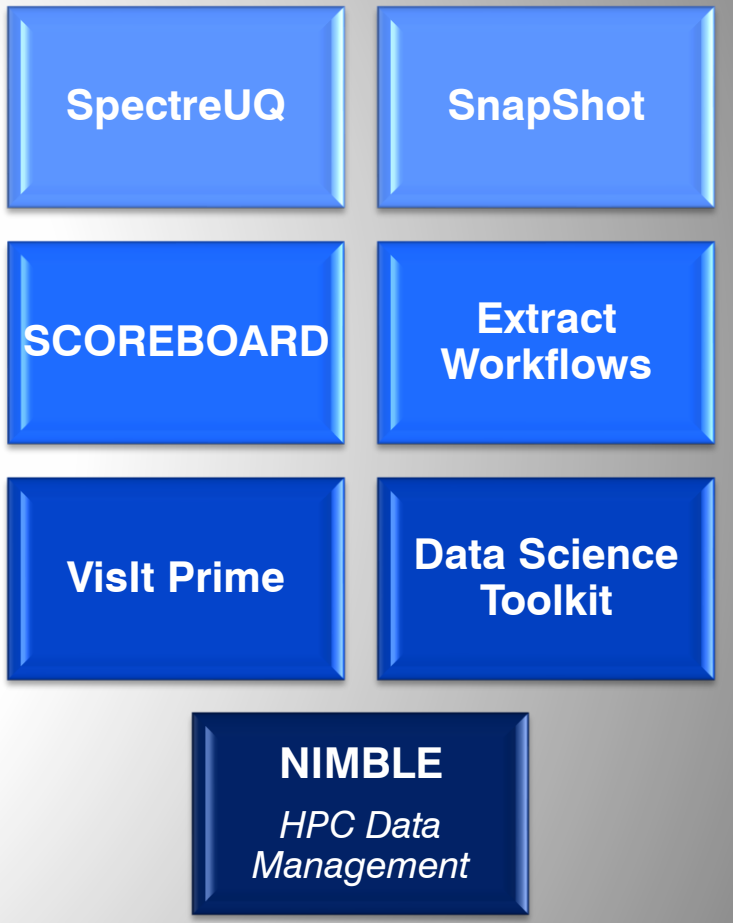


Our Vision: A Dynamic Transformation

- Reduce Risk by Incorporating VV and UQ
  - Today's CFD Typically has Many Compromises
  - VV and UQ tools need to be accessible to all engineers
- Compress HPC-scale Engineering Workflows
  - Get data from solvers and tests more efficiently
  - Trade-off time, space and precision as needed
- Accelerate Understanding & Communication
  - Data Science and Machine Learning
- Cost-effective, open software tools with flexible licensing & expert support

Our Tools: Advanced Software, Domain Experts

- Reduce Risk by Incorporating VV and UQ
  - SpectreUQ™ – The UQ wizard built on DAKOTA
  - SnapShot™ – Ingest massive data, compare, report
- Compress HPC-scale Engineering Workflows
  - SCOREBOARD – easy-to-integrate *in situ*/*in transit*
  - Open extract architecture - FV XDB, vtk, CSV, more
- Accelerate Understanding & Communication
  - Enhanced, DOE VisIt – super scalable, high order support
  - DMD, POD, FFT analysis – easy, fast, robust



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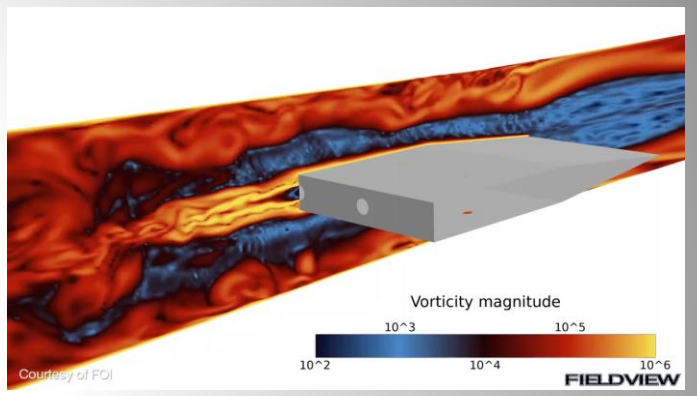
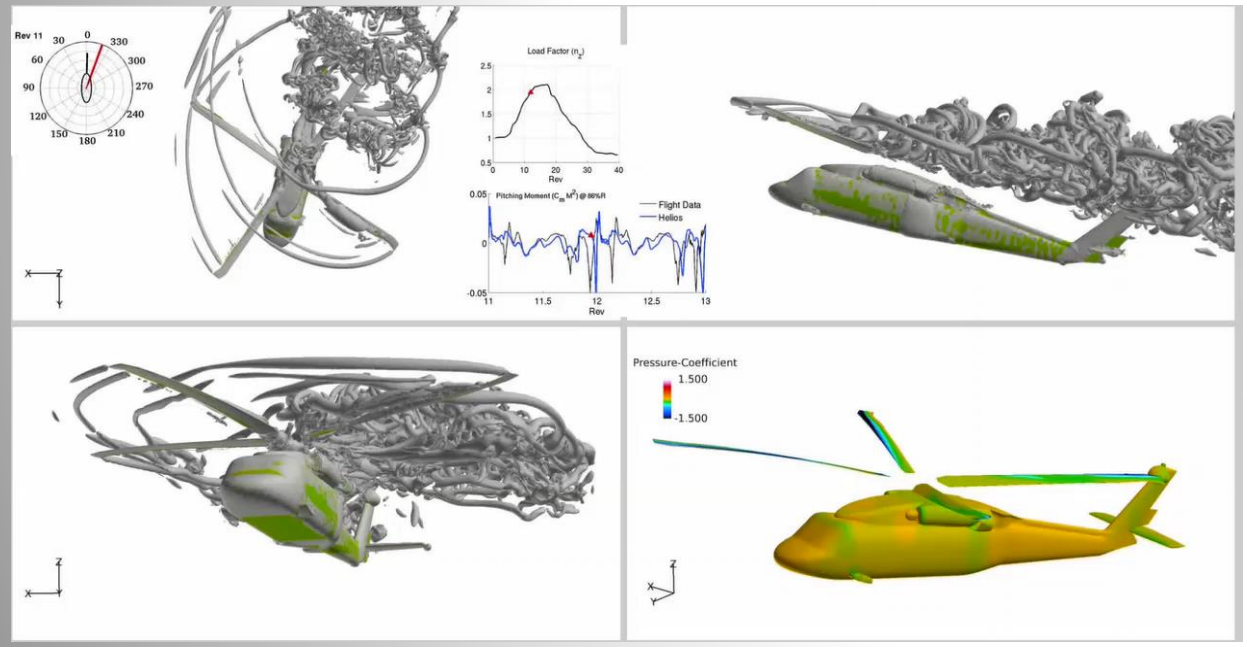
Choose Solutions from Intelligent Light

*Our team & technology are built on **27 years** of experience and inspiration serving the CFD community via FieldView & Applied R&D*





- Cost-effective software tools with flexible licensing & expert support
- We partner with FV CFD, Inc.
- We’re the ’35 year old startup’ here to support you!

Getting Started with Our Products

- ✓ Contact Intelligent Light for a web-based briefing
- ✓ Define a pilot project which has value to your organization
- ✓ Our engineers work the pilot project with you, ensuring success
- ✓ Explore subscription options that are right-sized for your needs

info@ilight.com
www.ilight.com

THANK YOU ON BEHALF OF OUR TEAM!

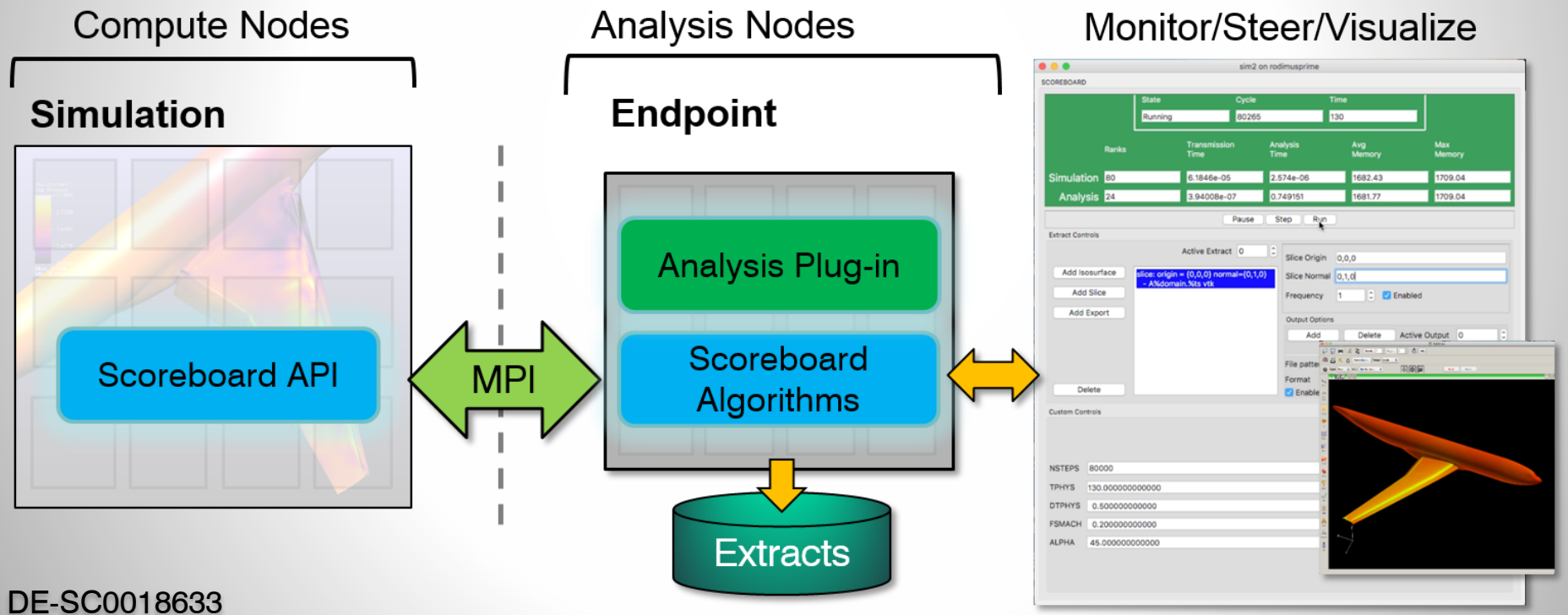
Questions?

info@ilight.com
www.ilight.com

SUPPLEMENTAL

Extracting, Analyzing, Storing: SCOREBOARD

- The ‘next generation’ of *in situ*
- Easy to integrate, open, flexible
- Low Solver Memory, CPU Impact
- Separate Analysis Cores, Nodes



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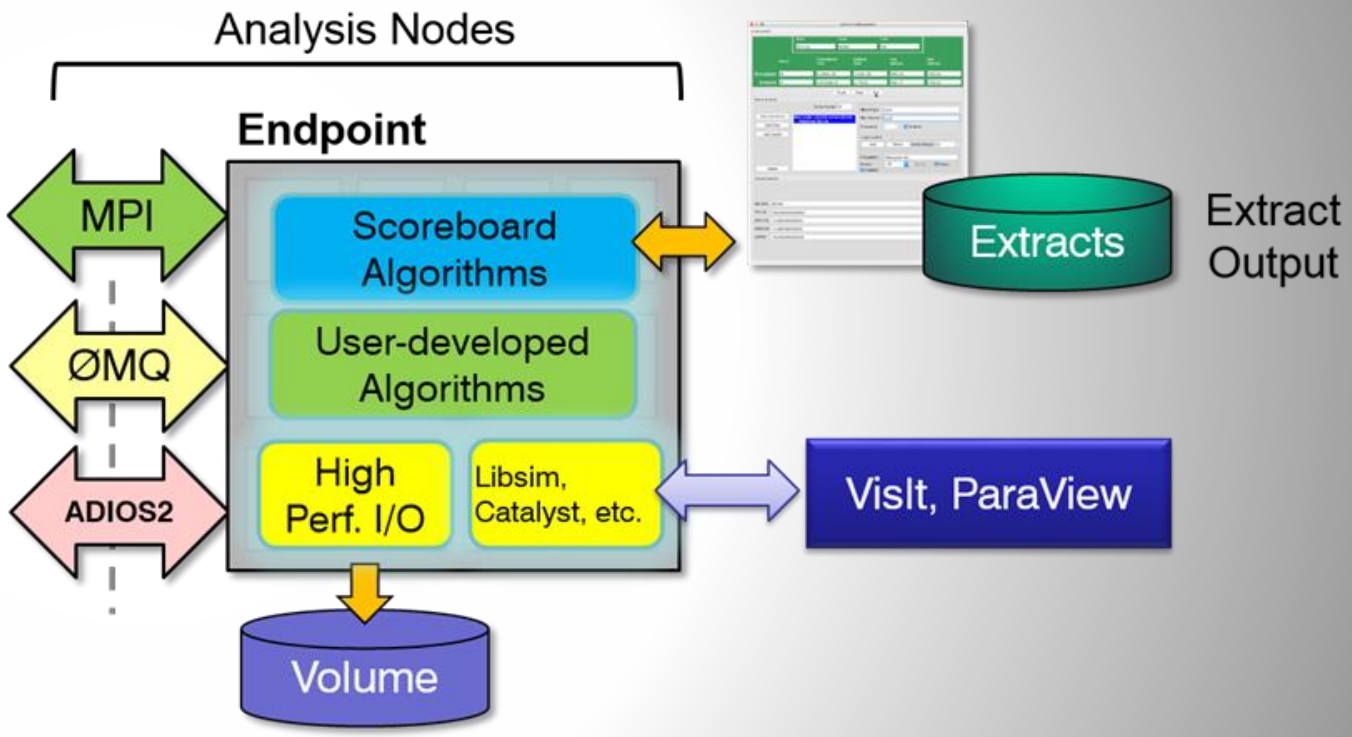
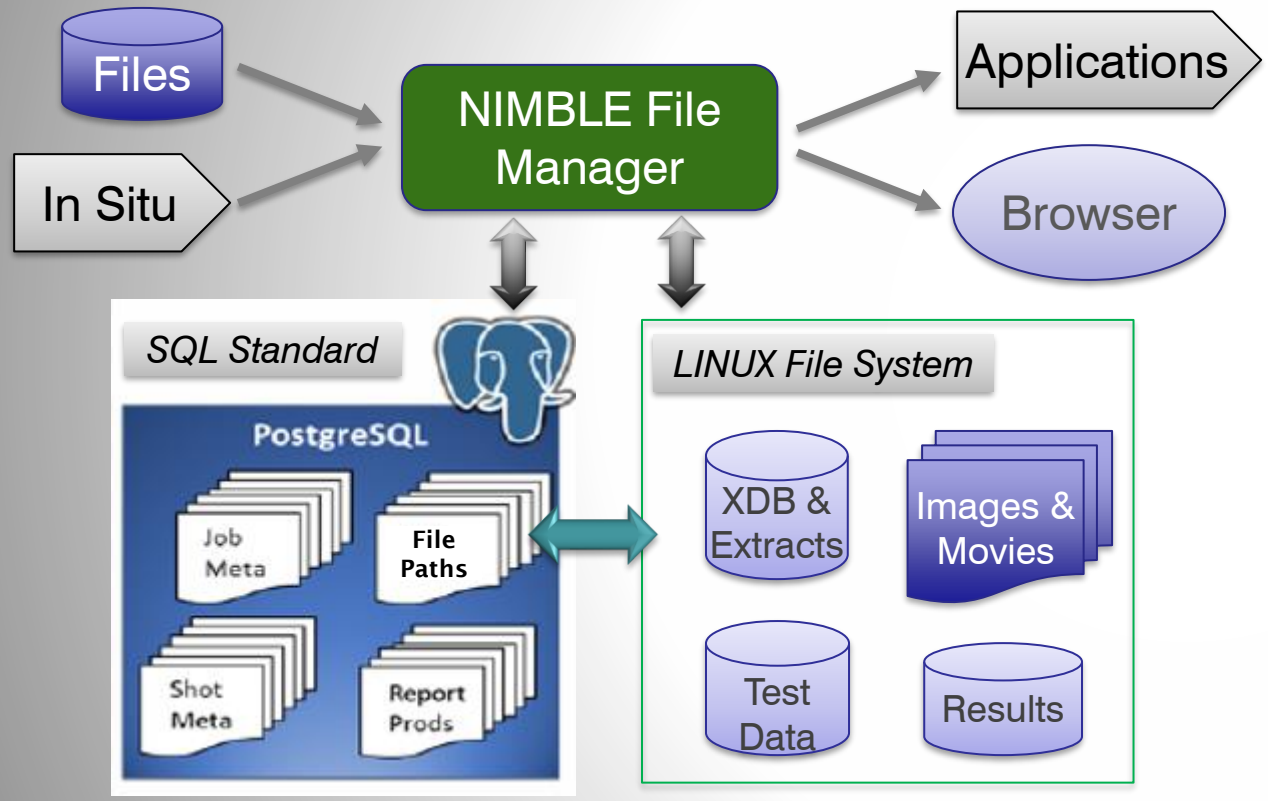
SCOREBOARD ENDPOINT(S)

- Efficient visualization and extract production
- Live *in situ* and steering with minimal solver impact
- High-performance parallel I/O via ADIOS2
- Plug-in architecture for your algorithms
- Open, standards-based architecture means low risk



NIMBLE: Data Management for CFD & Experiments



- Organize simulation and test data for maximum benefit
- Open, standards-based architecture means low risk
- NIMBLE Python plug-in is easily integrated into your workflow
- Each user's data is secured in a LINUX file system