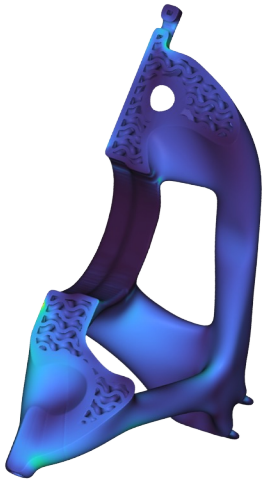
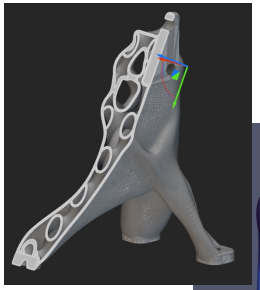
Leveraging Design, Process, and Physical Data in Simulation-First Workflows



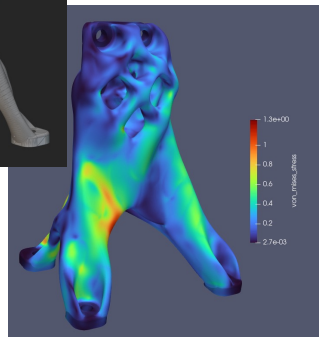
Vadim Shapiro
Intact Solutions

Intact Solutions

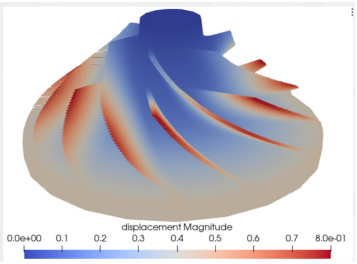
Plug and play simulation examples: fully automated, no preprocessing, solver of choice

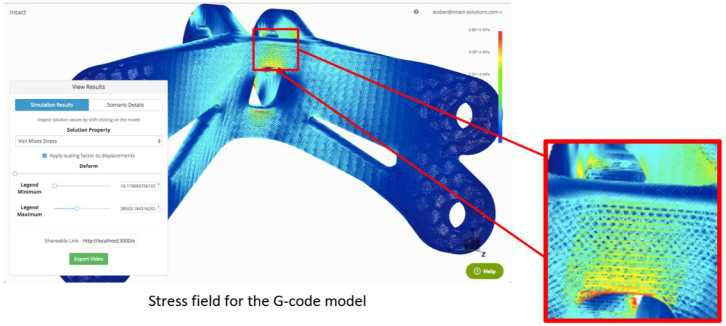


Meshfree analysis of NASA bracket



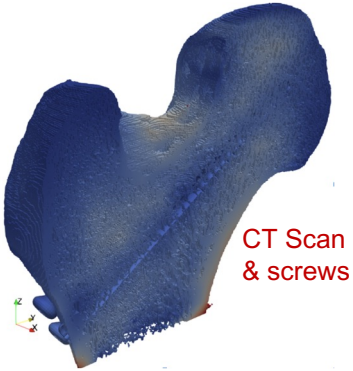
… or from slice data and measured material zones





Stress field for the G-code model

Performance analysis from G-code and measure material props



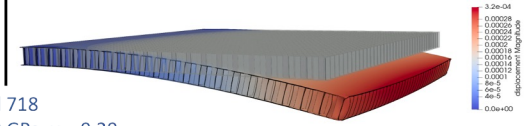
CT Scan (FGM) & screws

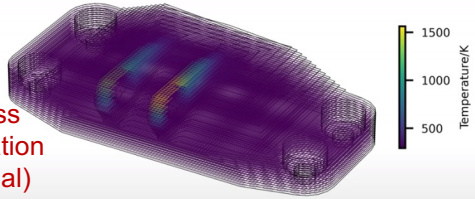
Titanium (Ti64)
E = 115 GPa, v = 0.34

Linear gradation

Inconel 718
E = 190 GPa, v = 0.29

FG honecomb sandwich structure

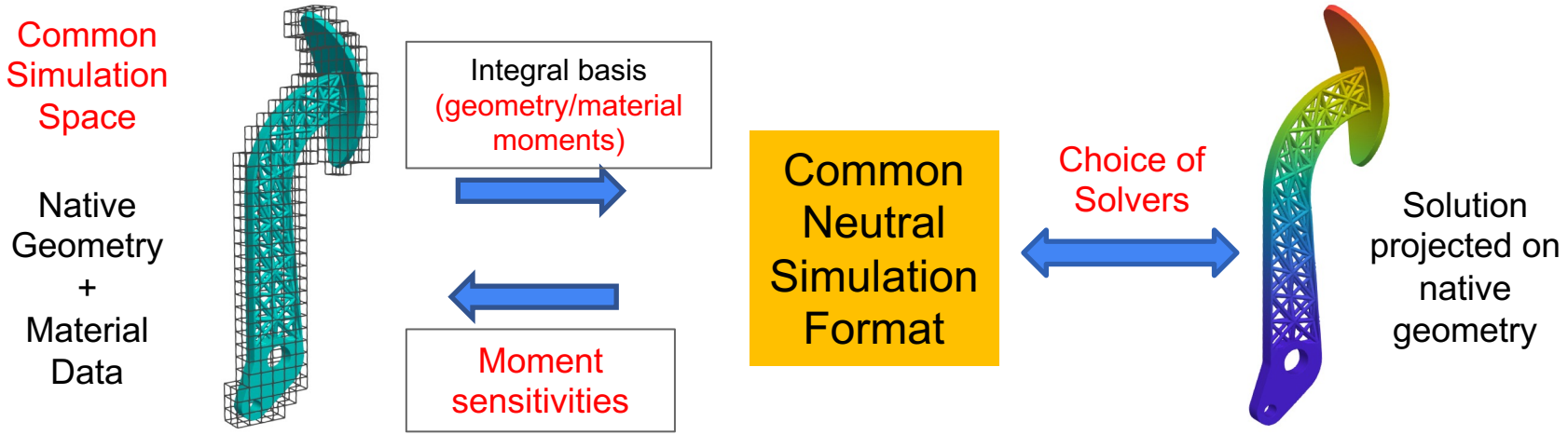




Process simulation (thermal)

Comprehensive Solution to Simulation Interoperabilty Problem

Plug-and-play: any Geometry, any Material, any Solver



- **Standard semantics based on rigorous principles**
- **Native models and data**
- **No manual preprocessing, simplification, or meshing**
- **Full automation**
- **Native design/optimization space**
- **Huge productivity gains!**

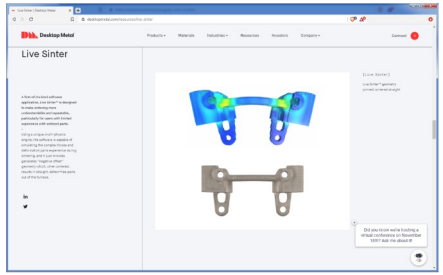
Intact Solutions

Intact Solutions

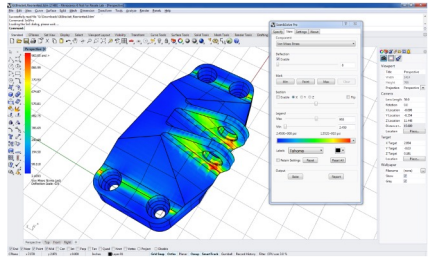
Spinoff from UW-Madison (offices in Madison and Berkeley)

- **Component simulation technology (Plug-and-Play)**
  - Intact.Simulation
  - Intact.Generative
  - Intact.Additive
- **Advanced R&D projects & Partnerships**
  - DARPA (TRADES, Plug and Play Simulation)
  - NIST (AM Part Performance Qualification, AM Process Simulation)
  - NASA (thermal control systems, tow-steered composites)
  - Multiple industrial collaboration and partnerships
- **Examples of the products that embed our simulation technology**
  - Live Parts and Live Sinter from Desktop Metal
  - Scan and Solve (SnS) For Rhino
  - Intact.Design for simulation of Onshape assemblies
  - Intact.Simulation with Grasshopper (in Beta)

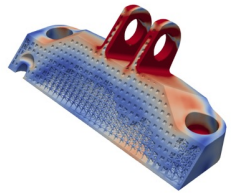
Live Sinter

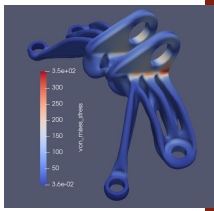


SnS for Rhino

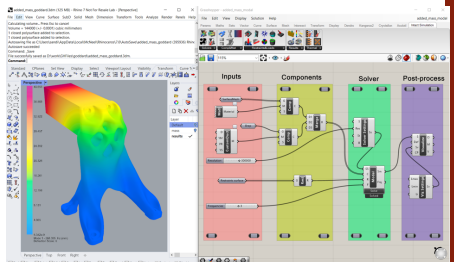


Intact.Generative





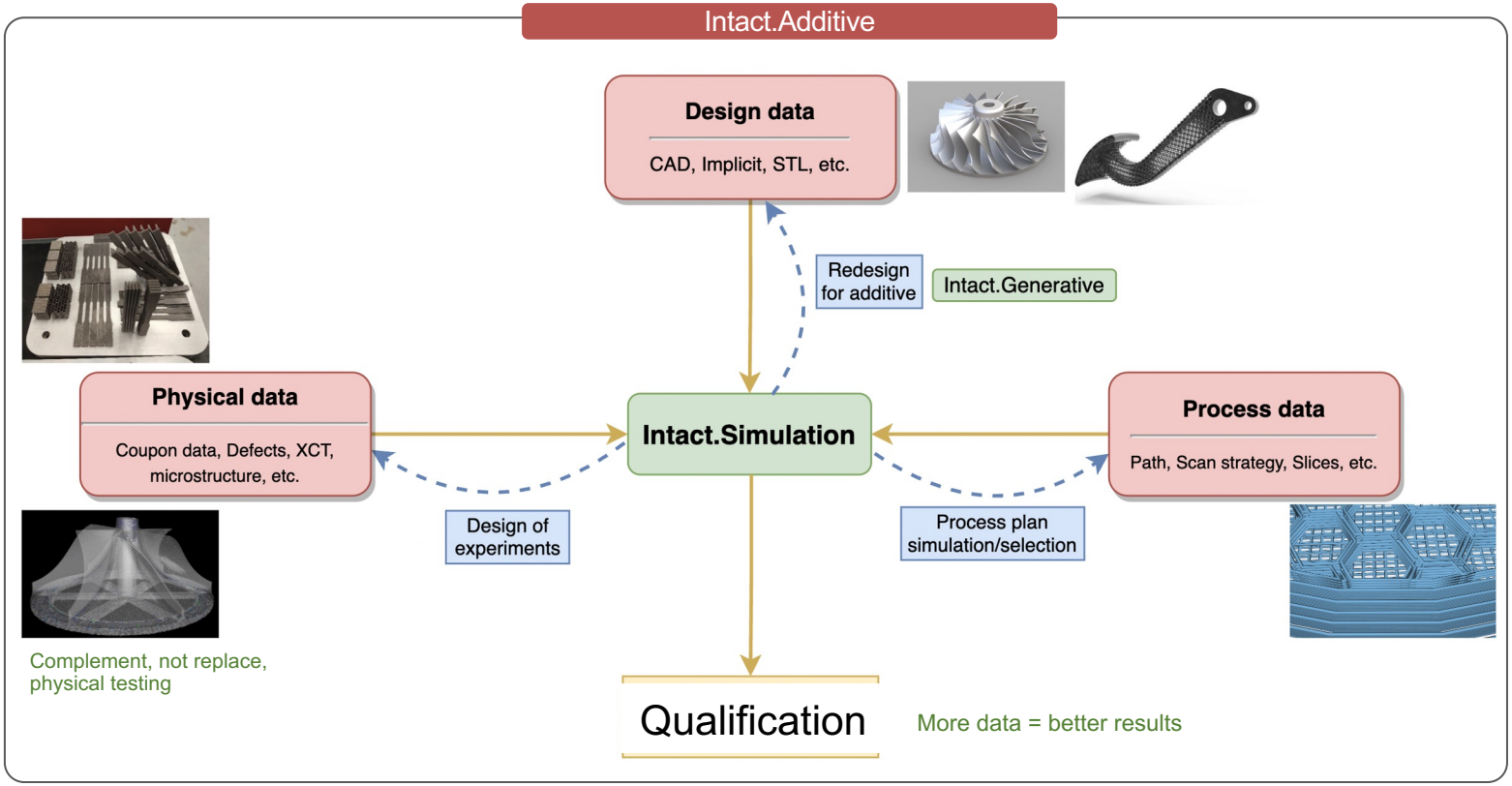
Intact.Simulation



Intact.Additive

● High complexity ● Heterogeneous data ● Complex workflows

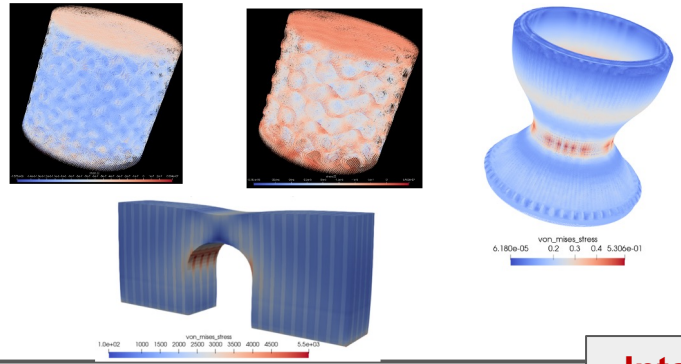
✓ Application- and process-specific
✓ Combine experiments and simulation



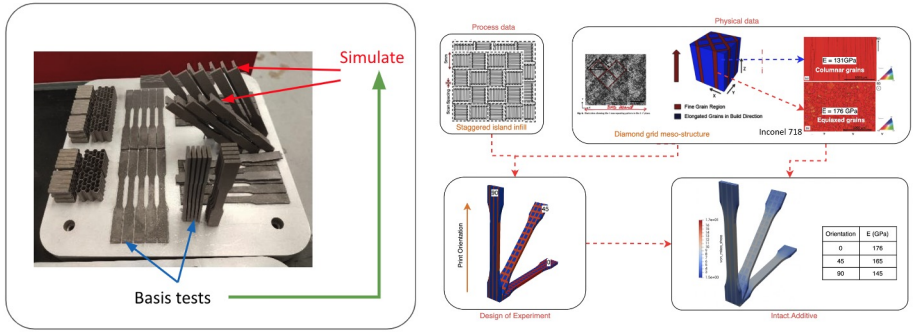
Intact.Additive Examples (emerging tech)

• High complexity • Heterogeneous data • Complex workflows that are Application Specific

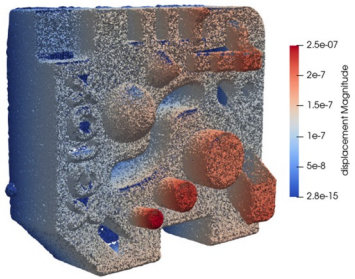
Process Plan Selection



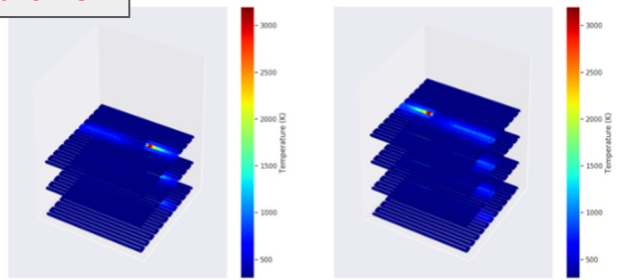
Material Characterization



Intact.Additive



As-manufactured (CT Scan) Validation



Process Simulation (thermal)

Pain points (technical) – with emerging solutions!

For OEM and SME

- Diversity data / models / simulation tools
  - Interoperability
  - Trust
  - Validation
- Availability and cost of simulation-based qualification tools
  - As designed, As planned, As Built
  - Material characterization
  - Process
- Complexity (application and process dependent)
  - Modeling
  - Data (experimental and simulation)
  - Computational
  - ➢ Separation of concerns (e.g. design vs analysis)
  - ➢ Localization (in space & time)
  - ➢ Multiple scales

Non-technical challenges … … require solving technical challenges

For OEM and SME

- Standardization is a double-edge sword
  - Focus on semantics, NOT formats
  - Standardize What, NOT how
- Accessibility to data challenges
  - Competitive advantage
  - IP (what vs how)
  - Security
  - Liability
- Hardware/Physical vs Software bias
  - Software is still a necessary evil

"The wonderful thing about standards is that there are so many of them to choose from."

— **Grace Murray Hopper**

Opportunities – are we asking the right questions?

For OEM and SME

Meltpool prediction from simulated thermal history via ML

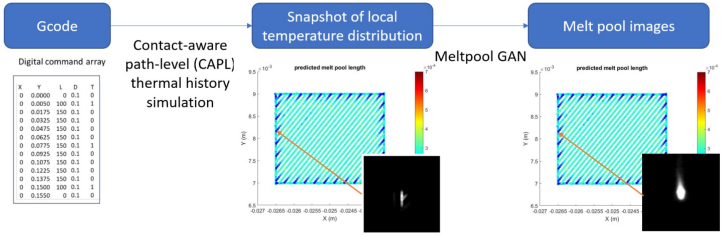
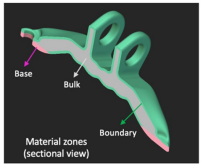


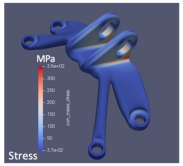
Figure 2. MeltpoolGAN predicting the melt pool shapes based on CAPL thermal history.

- Data and model fusion (modality, fidelity, scale)
  - Modeled + measured
  - Simulated + measured
  - Modeled + simulated + measured

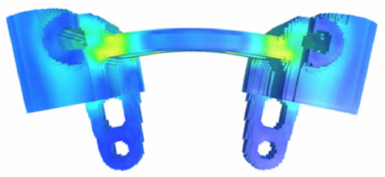
- Heterogeneity as design freedom
  - Mechanical properties
  - Physical properties (deformations, stresses)

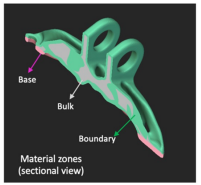


The as-built part has heterogeneity that was not accounted for during design

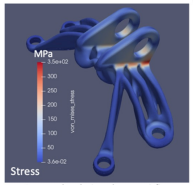


To overcome heterogeneity, users over design, resulting in heavy inefficient parts to satisfy safety factor requirements

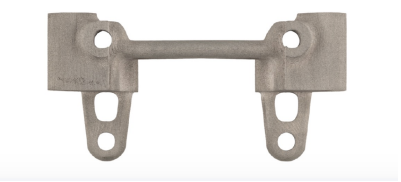




Our method accounts for and (leverages!) heterogeneity



As a results, designed part satisfies safety factors *and* are significantly lighter



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Intact.Simulation can leverage your data!

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