



Alliance for the Development of
ADDITIVE PROCESSING
Technologies

Systematic Development of Framework for Validation and Performance Quantification of Additively Manufactured (AM) Replacement Parts for Structural Steel Applications

***Thomas G. Gallmeyer*¹; Jinesh Dahal¹; Aaron P. Stebner¹;
Ravi Thyagarajan²; Juan Mirando Santiago³; Adam Pilchak⁴;
Jacob Nuechterlein⁵**

¹Colorado School of Mines

²US Army TARDEC, MI

³Army Field Support Battalion Ft. Carson, CO

⁴Air Force Research Laboratory, OH

⁵Elementum 3D, CO

DRIVING ADDITIVE
MANUFACTURING INTO THE FUTURE



Replacement parts can be difficult to source.

Many components have convoluted procurement/repair path.

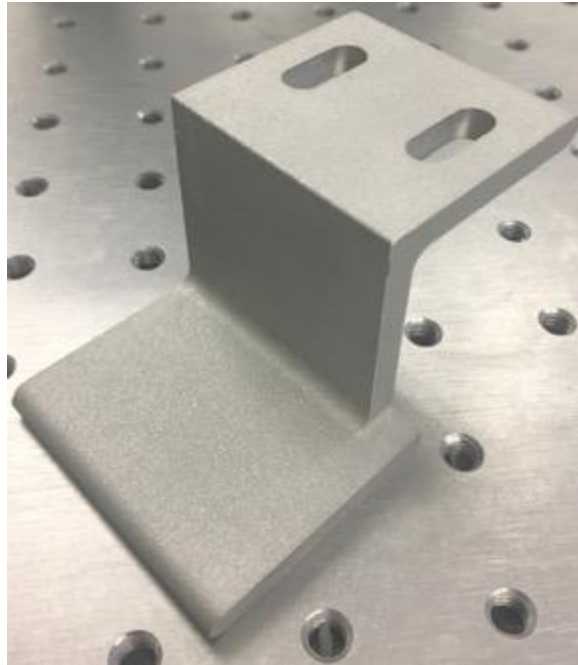


Lead times = weeks to years



AM offers alternative to lengthy lead times.

Parts can be sourced in hours instead of weeks/years.



What if part has never been produced by AM before?

Uncertainty with manufacturing new part.

→ Part not originally designed for AM

-Multiple, iterative design/build cycles

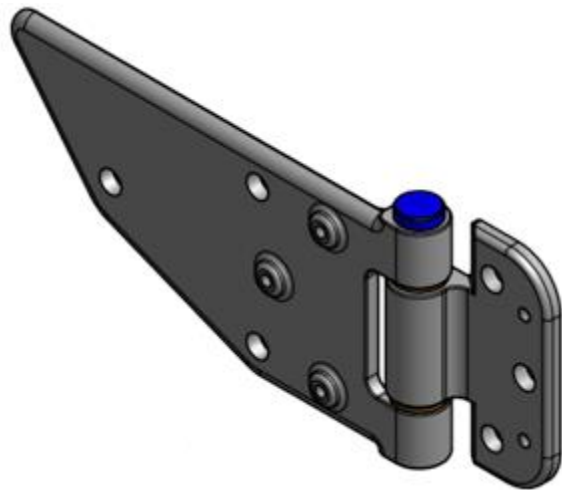
-Lengthy qualification process

→ both require time and money

****Use preexisting data for new quality specs.****

Accelerated Design/Qualification of Vehicle Hinge Assembly

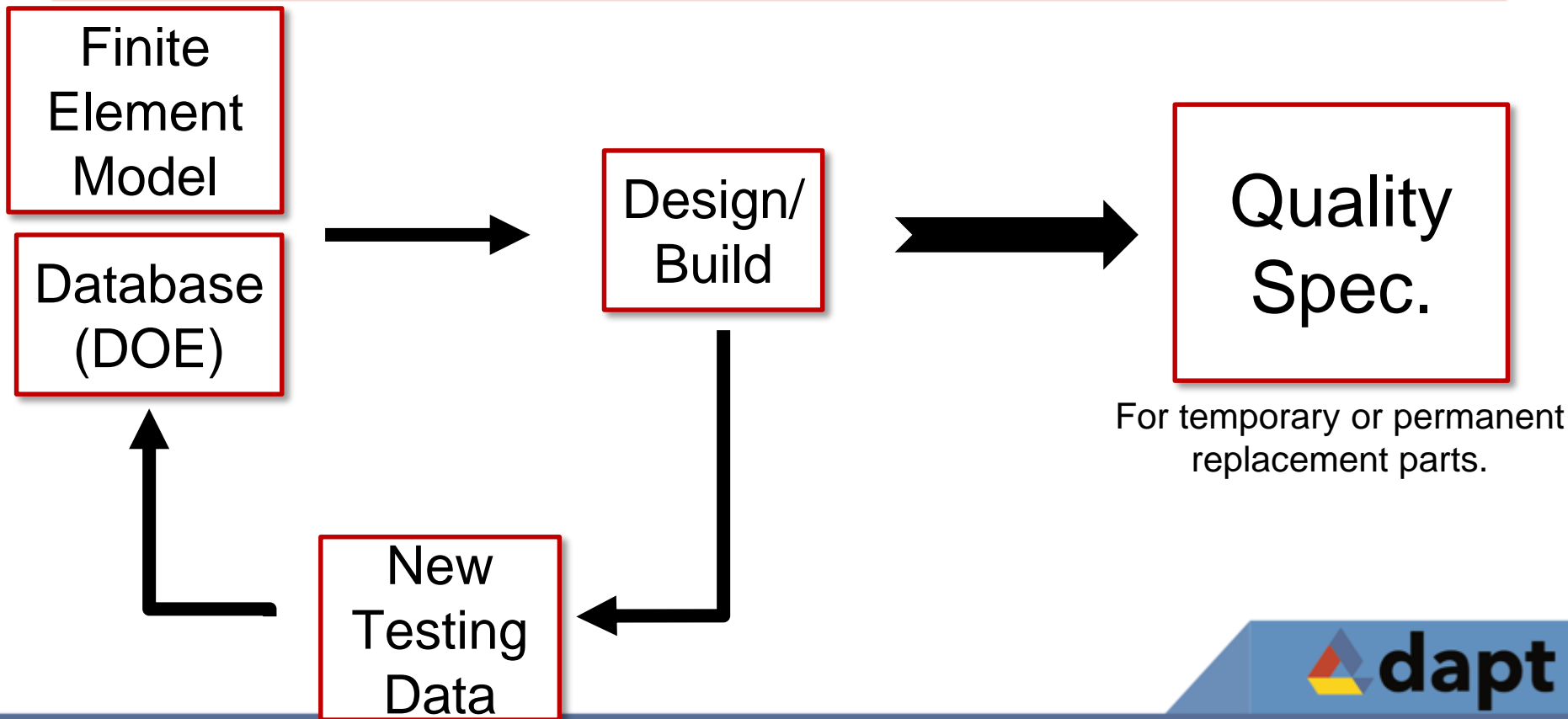




The part chosen is a door hinge assembly from the featured MRAP/Maxxpro (left).



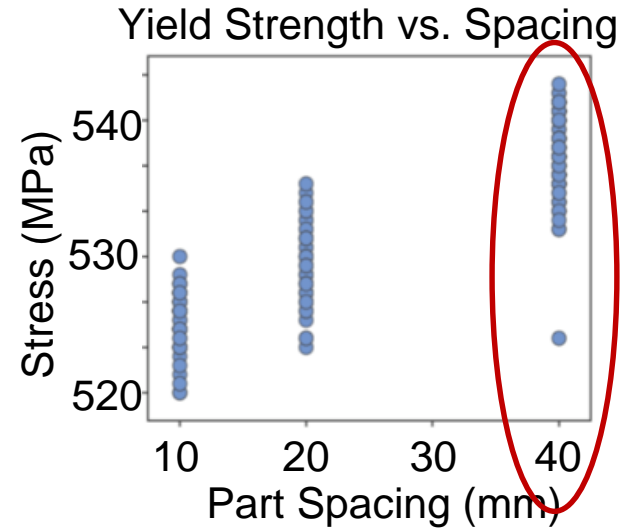
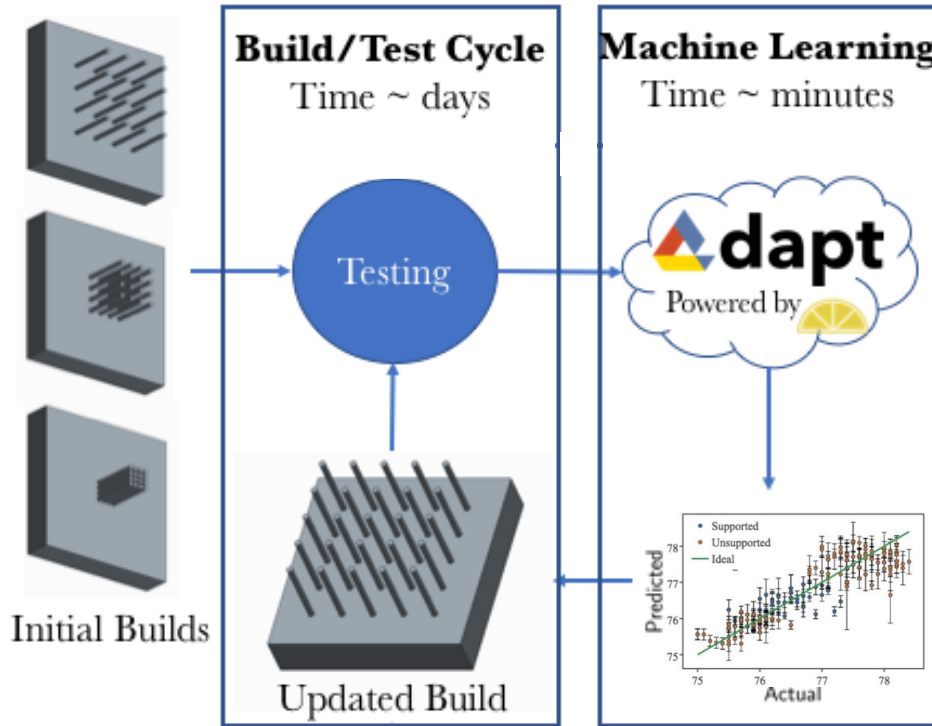
Overview of data-driven approach



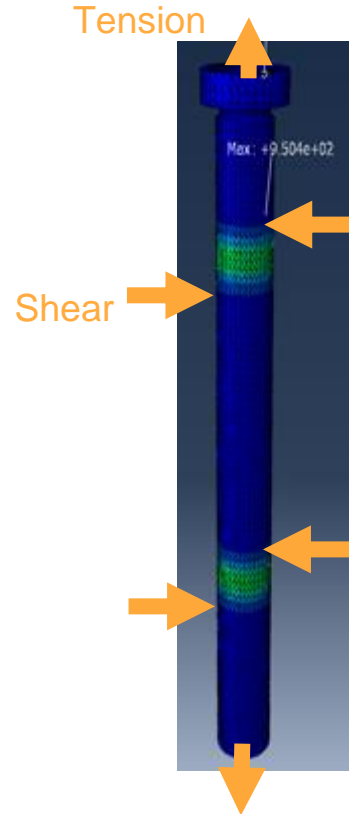
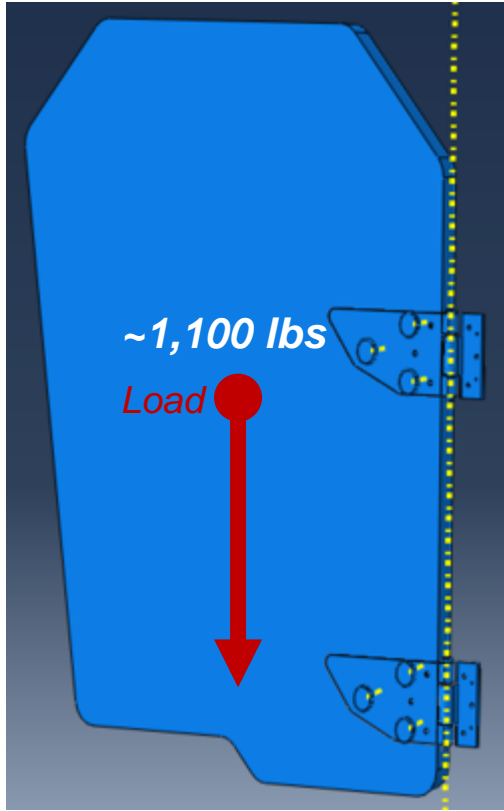
For temporary or permanent replacement parts.



Data-driven approach can reduce time for qualification.



FEA done to identify maximum stress states for assembly.



Abaqus FEA model shows:

- *Critical stress state is combined tension-shear in hinge pin.*
- *von Mises stress ~950 MPa.*

Part Specifications: Processing – Quenched and Tempered to 890 MPa minimum

Overview of build plates manufactured

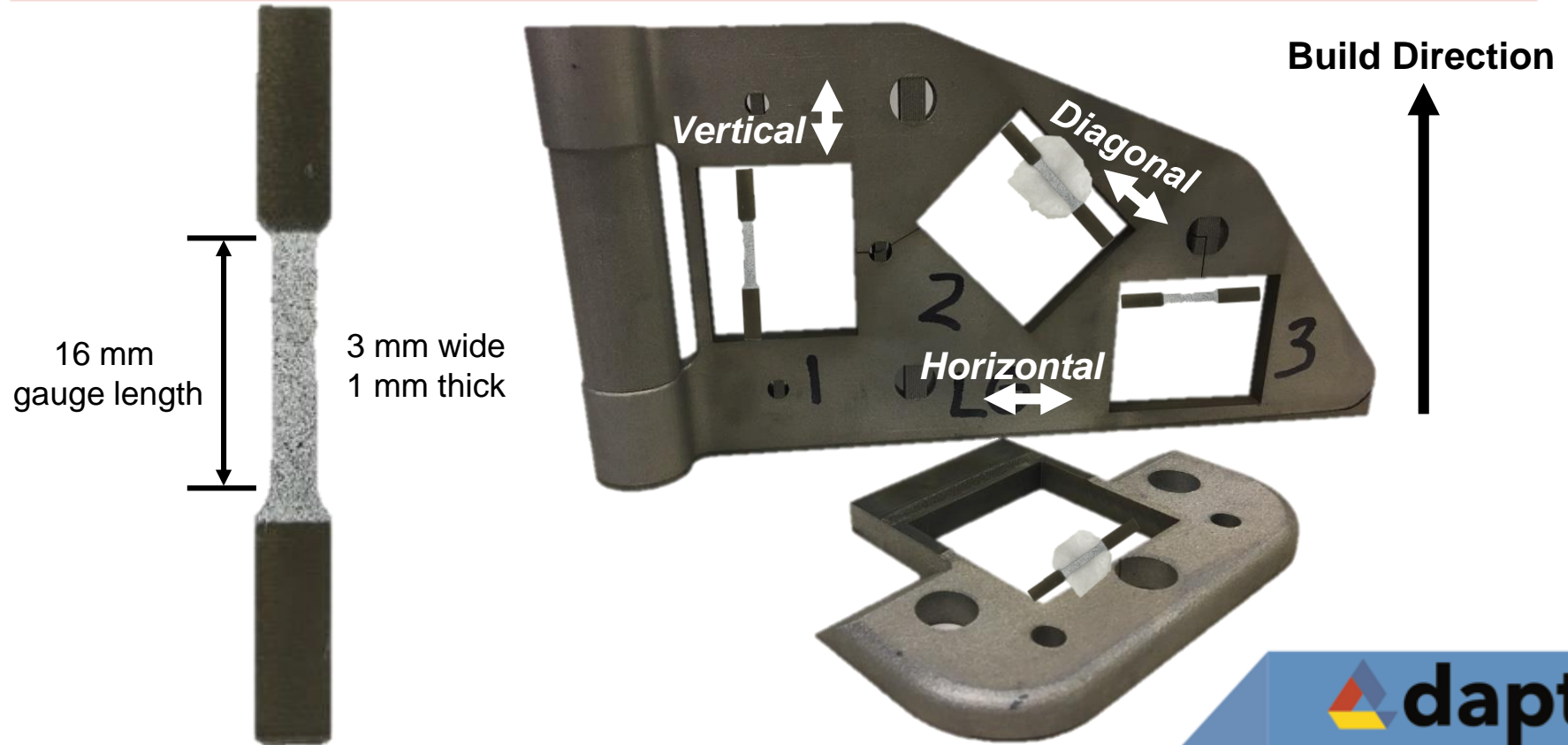


Alloy selected for this project was 17-4 PH stainless steel.

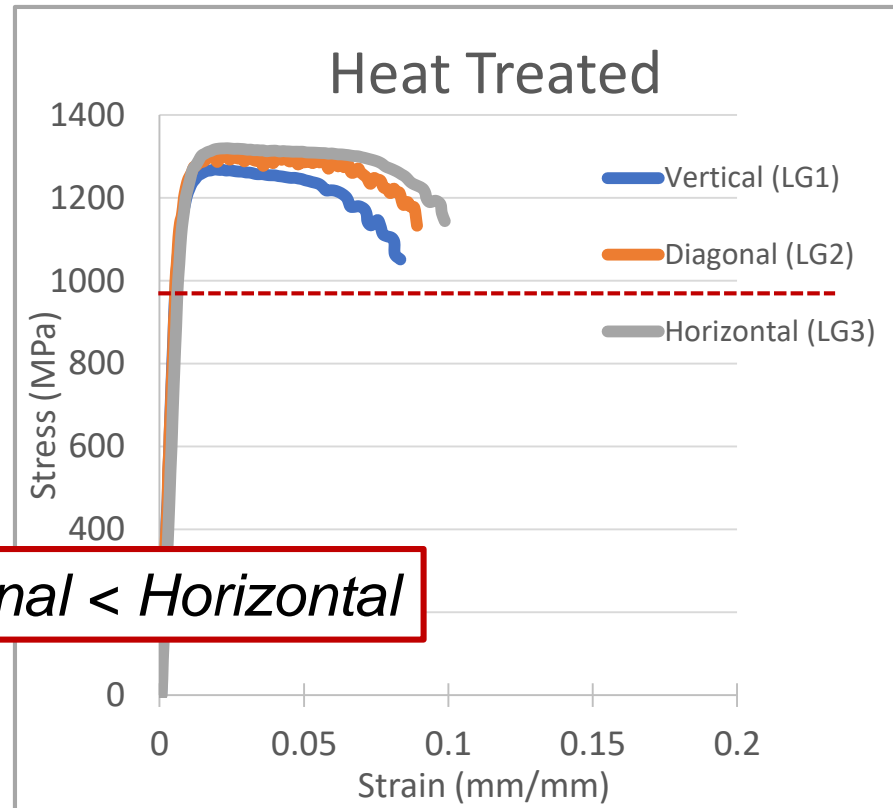
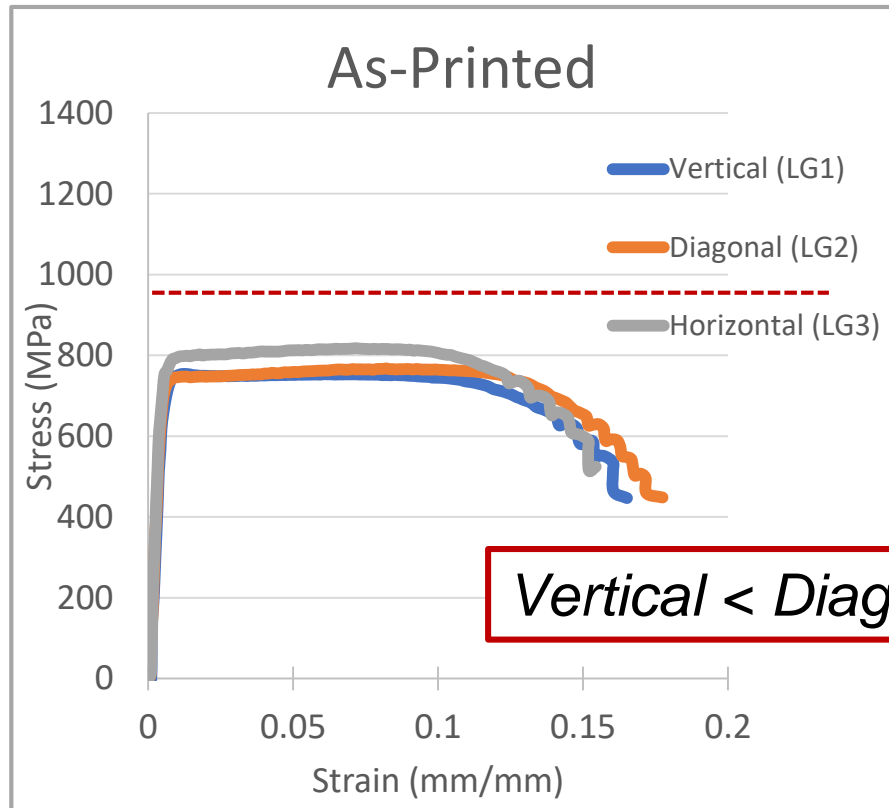
ELEMENTUM



Static Monotonic Failure



Slight orientation dependence with build direction.



Vertical < Diagonal < Horizontal

Tension Torsion-Torsion Fatigue Testing

-Static 280 MPa axial stress, alt. 280 MPa torsional stress @ 2 Hz cycle rate

-1,000,000 cycles “run out” criterion

*→ Simulate opening/closing door 50 times/day
= ~55 years of use before “run out”*

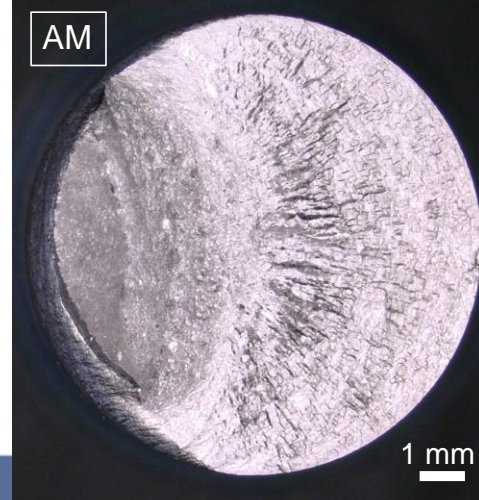
Preliminary results:

Legacy: ~470,000-1,000,000 = ~26-55 years

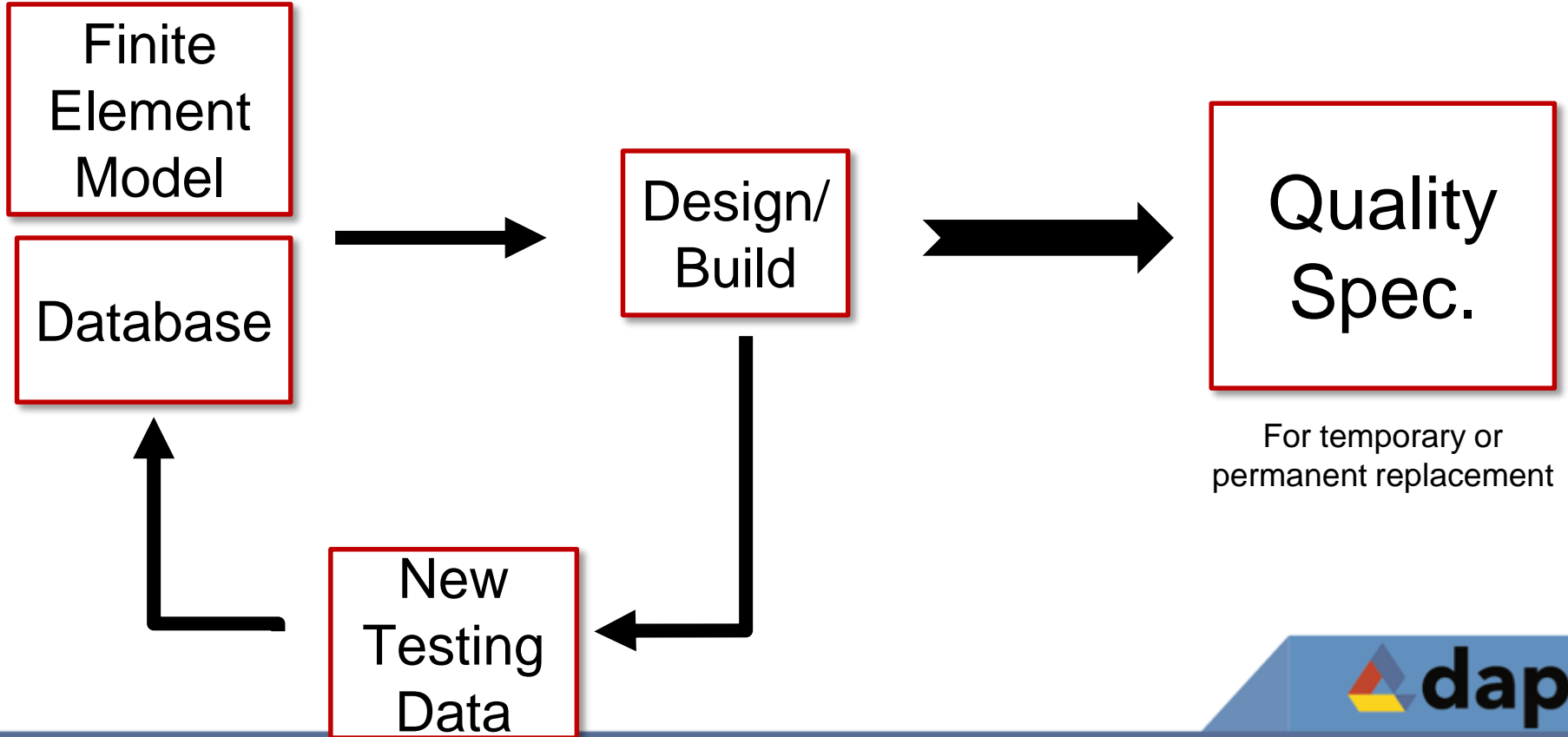
AM: ~75,000-120,000 = ~4-7 years

AM HT: ~40,000-50,000 = ~2-3 years

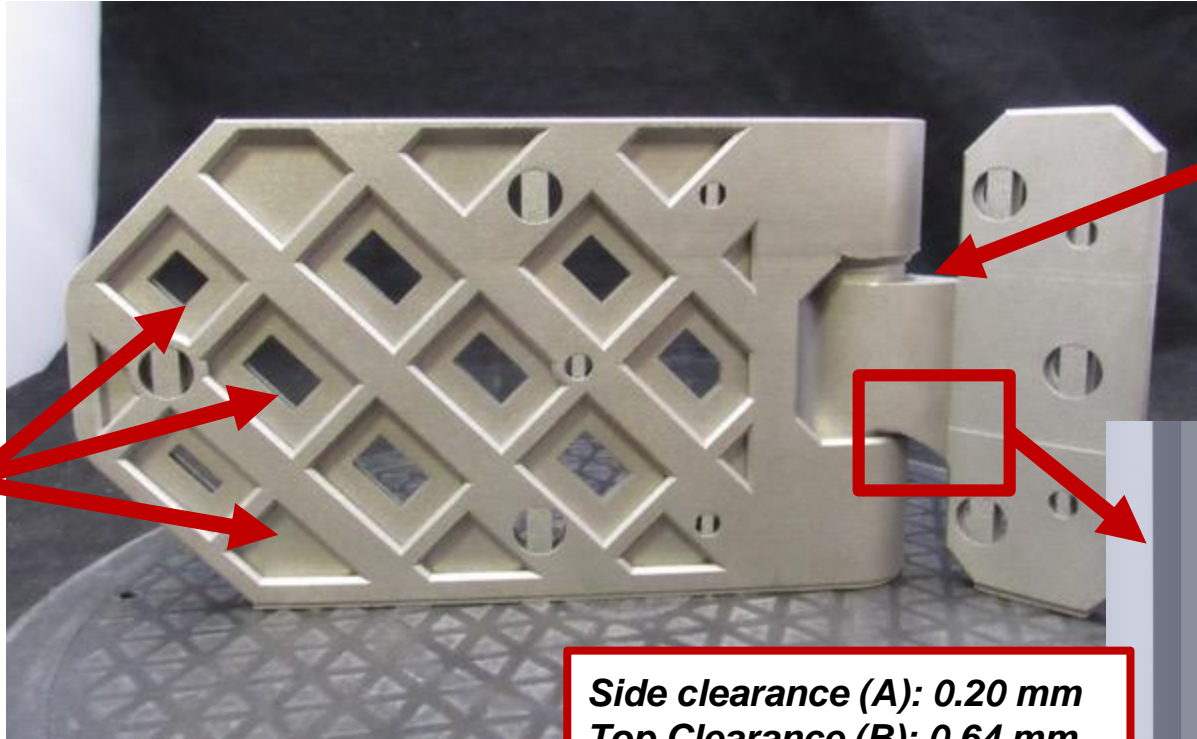
AM parts can be used as satisfactory replacements for significant durations



Data-driven model will accelerate future part design.



Redesigned existing hinge for additive manufacturing.

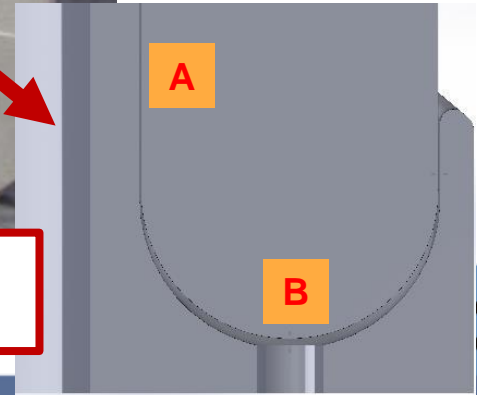


*Hinge assembly
printed as single
piece*

**Same interfaces
as original part**

*Reduces part
weight and
thermal stress
from printing*

**Side clearance (A): 0.20 mm
Top Clearance (B): 0.64 mm**



Data-Driven model will accelerate future part design.

- Machine learning model applied to learn process-property relationship.*
- New parts capable of being produced on first attempt.*
- Way to qualify parts not originally designed for AM.*
- Ability to redesign parts in the field for new service requirements.*

Acknowledgements

Stebner Research Group:

Dr. Aaron Stebner

Dr. Branden Kappes

Jinesh Dahal

Bryan Marsh

Funding

US Army TARDEC

Special Thanks:

Elementum 3D

Navistar Defense

DISCLAIMER:

Reference herein to any specific commercial company, product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the Department of the Army (DoA). The opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or the DoA, and shall not be used for advertising or product endorsement purposes.

NAVISTAR[®]
DEFENSE

ELEMENTUM


 **dapt**

Thank you!
Questions?