Decision Making for Additive Manufacturing in Sustainable Defense Acquisition

20th Annual Acquisition Research Symposium

Naval Postgraduate School

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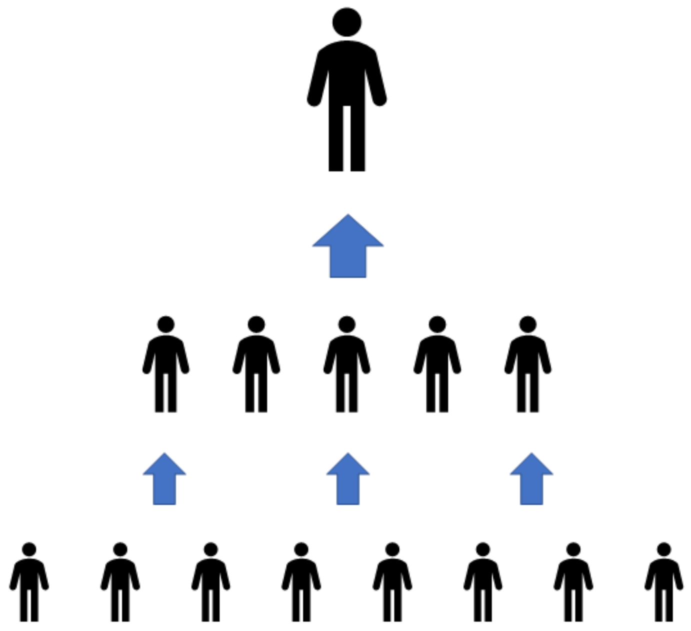
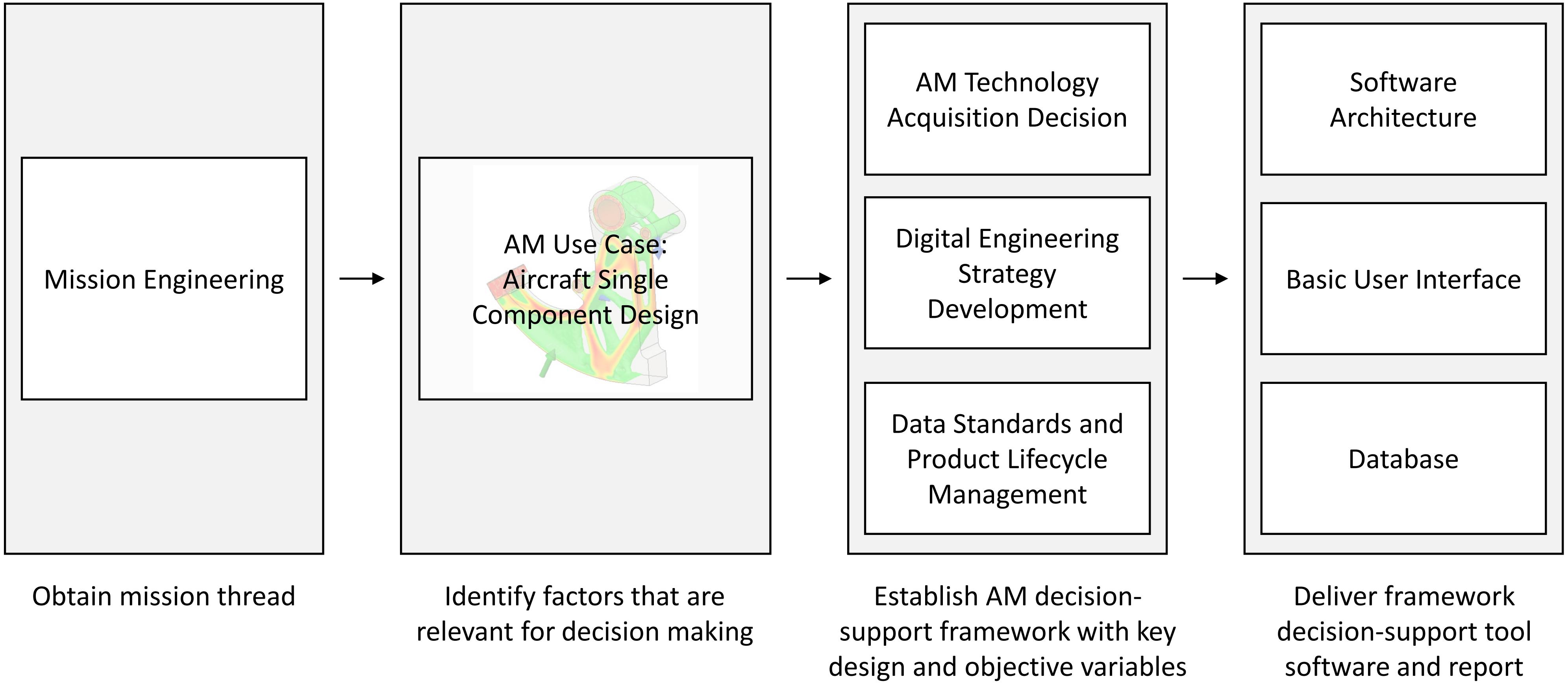
Research Question

- **Question**: Can we develop a framework to support the development of:
  - An Additive Manufacturing (AM) Supply Chain and Sustainment Strategy
  - A Digital Engineering (DE) strategy spanning the lifecycle
    - Digital engineering/design
    - Manufacturing
    - Supply chain
    - Maintenance
  - Initial focus is on data and framework surrounding AM
  - We compared the AM with traditional manufacturing (TM)



- Multiple levels of decision makers
- Strategic decisions:
  - Not necessarily technical expert
  - Attributes: Cost, quality, efficiency, etc.
- Technical levels:
  - Familiar with the more technical details of the decision
  - Attributes: Maintenance cost, machine tolerance, tensile strength, accuracy, etc.

Research Methodology



Use Case: Aircraft Single Component Design

- Scenario 1: Part Design Replication

  Original Design (TM) vs. Original Design (Various AMs)

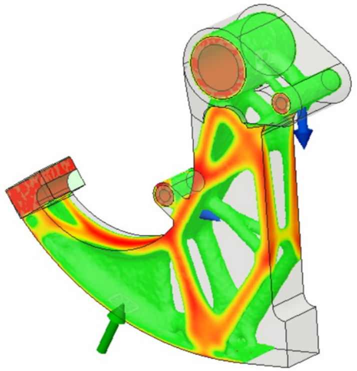
  - The company is comparing the utility of different manufacturing techniques to produce 100 replicates of the aileron bellcrank geometry using 6061 Aluminum.
  - The stakeholder is evaluating the effect of alternative manufacturing processes to replicate the same geometry and material as in the original design.

- Scenario 2: Part Design Improvement

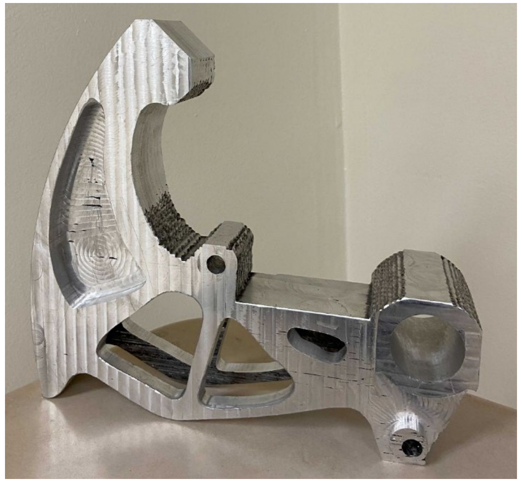
  Original Design (TM) vs. Topology Optimized Redesign (Various AMs)

  - The company is comparing the utility of different manufacturing techniques to produce 100 redesigned bellcranks, which have been optimized for light-weighting.
  - The stakeholder is evaluating the effect of a change in part geometry by additive manufacturing while the material (Aluminum 6061) is held constant.

Original Design



Light-weighting Analysis

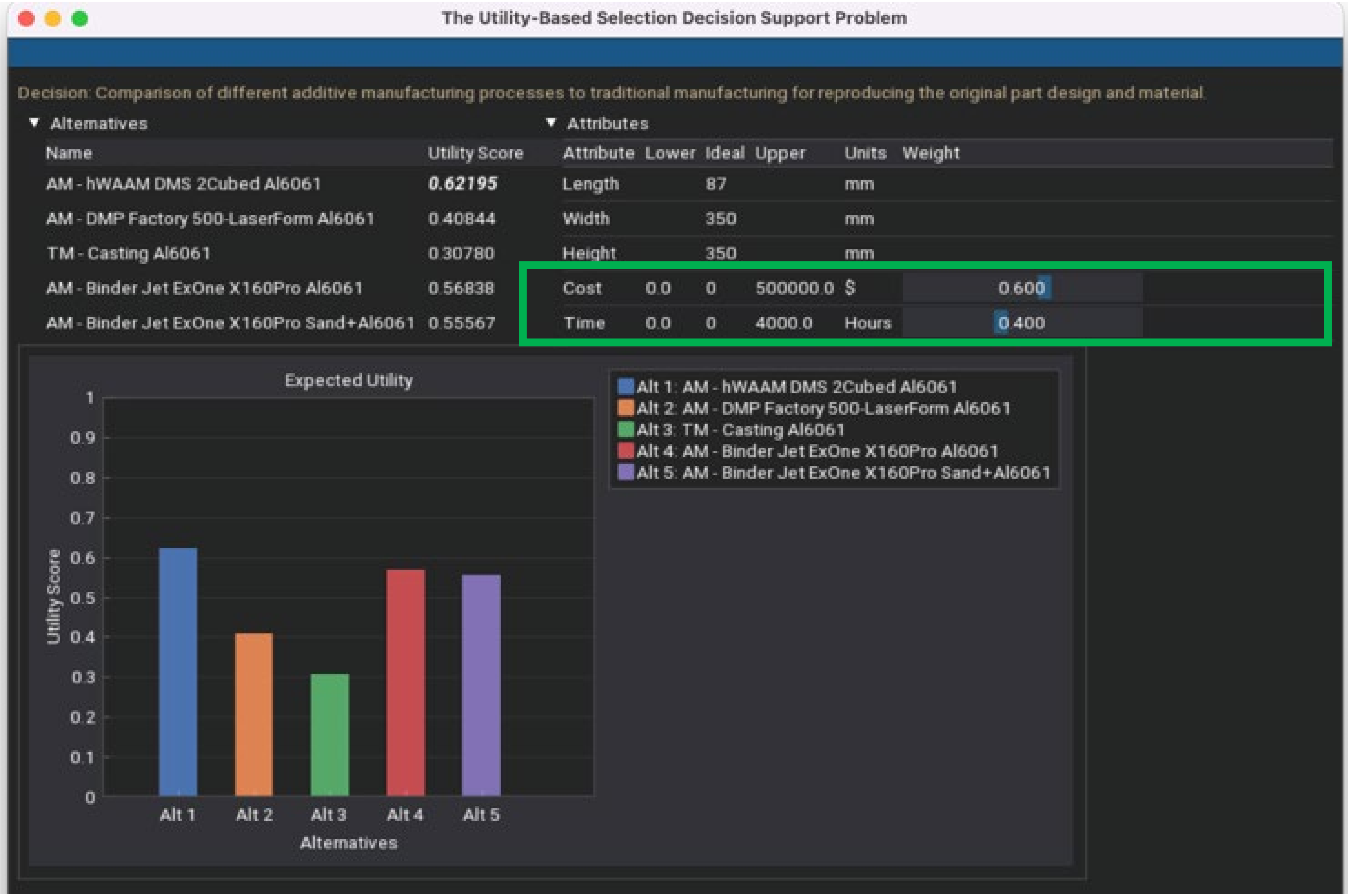


Topology Optimized Aileron Bellcrank

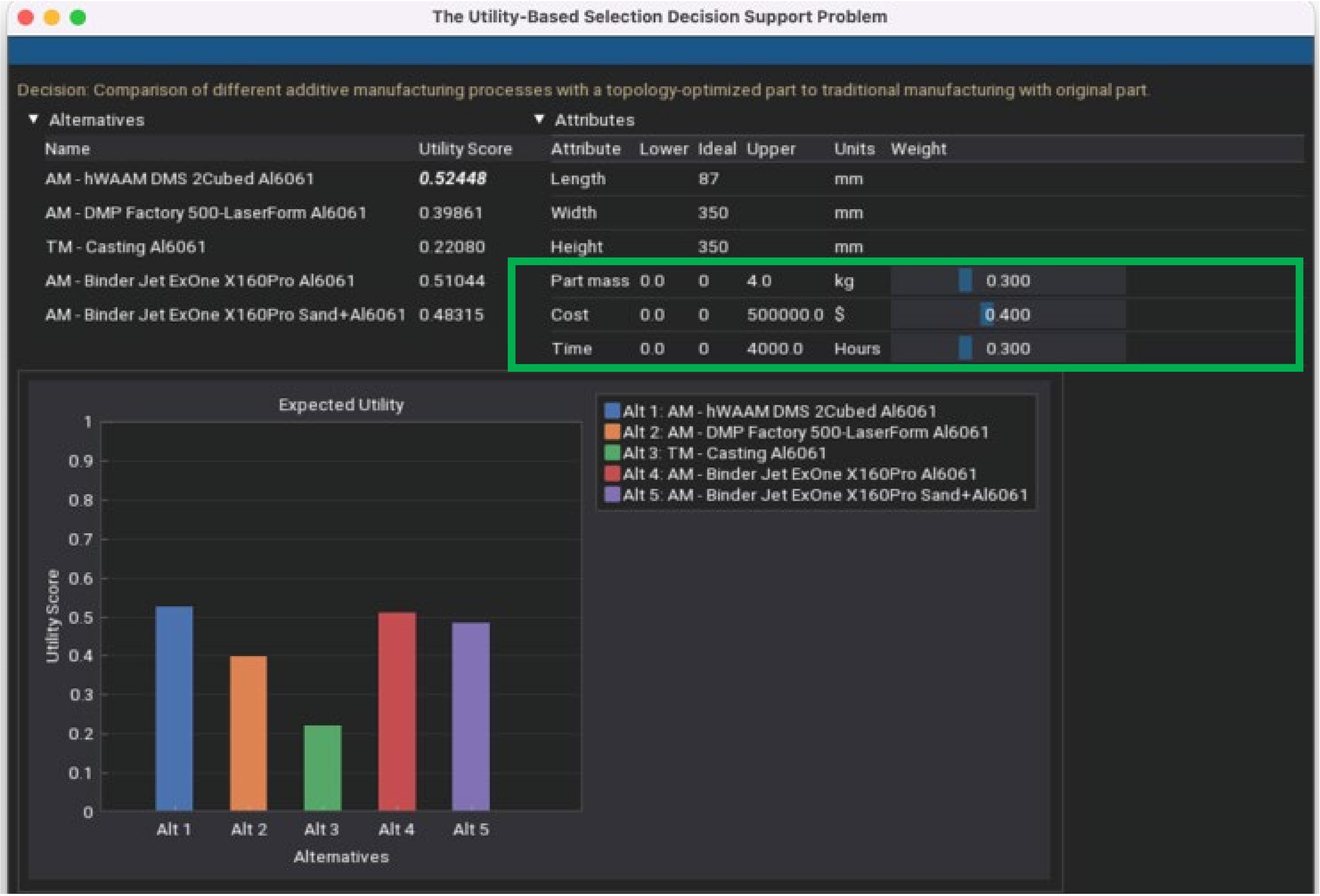
(Additive manufactured and post-processed)

Demo

Results: Scenario 1: Part Design Replication



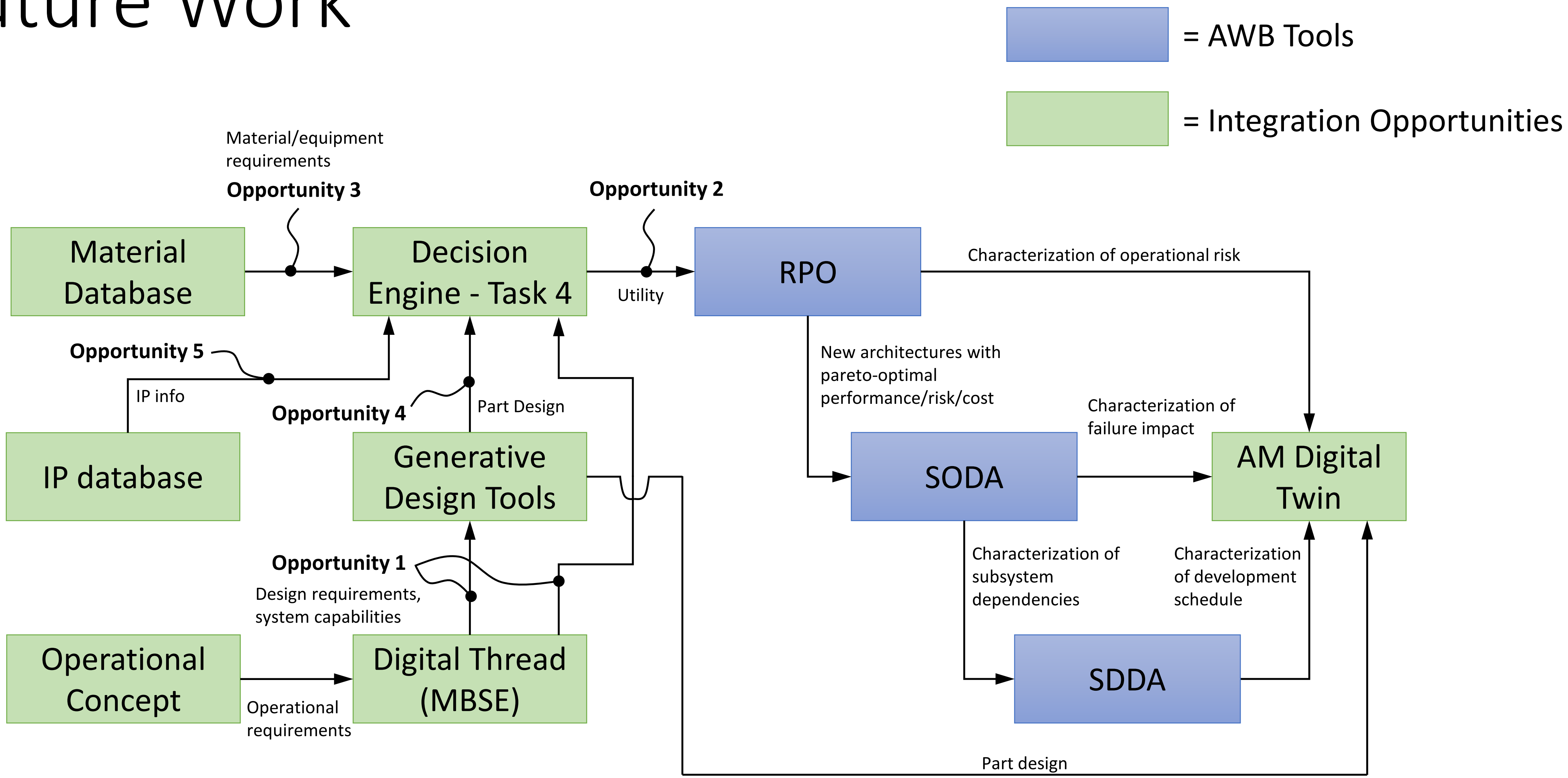
Results: Scenario 2: Part Design Improvement



Conclusions

- The research focused on the data and framework surrounding the opportunity to exploit additive manufacturing as a systems engineering problem.
- The discussion started with a description and conceptual background on the decision support tool.
  - We discussed the use case that consists of the design and manufacturing of an aircraft component, an aileron bellcrank.
- To further understand use case, we identified the critical decision and analysis variables and created a framework to understand how these variables impact each other.
  - We transferred the above framework into an algorithmic view of these variables to make an optimized decision regarding where and how additive manufacturing can have the most impact.
- We developed an interactive decision support tool (i.e., the decision engine) so that the decision makers can use the quantitative data to make a proper decision on additive manufacturing.

Future Work


= AWB Tools
= Integration Opportunities
Material/equipment requirements
Opportunity 3
Opportunity 2
Material Database
Decision Engine - Task 4
RPO
Characterization of operational risk
Utility
Opportunity 5
IP info
Opportunity 4
Part Design
New architectures with pareto-optimal performance/risk/cost
Characterization of failure impact
IP database
Generative Design Tools
SODA
AM Digital Twin
Opportunity 1
Design requirements, system capabilities
Characterization of subsystem dependencies
Characterization of development schedule
Operational Concept
Digital Thread (MBSE)
SDDA
Operational requirements
Part design

Thank you