Development of a Manufacturability Assessment Methodology and Metric

Manufacturability **A**ssessment
Knowledge-Based **E**valuation

MAKE

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ERDC

Mission Context
Resilience
Lifecycle Cost
Tradespace

ISER

Big Data
Manufacturability
Reliability
Affordability

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Outline

- Intro and Background
- Methodology
- Case Study Overview
- Benefits to Customer

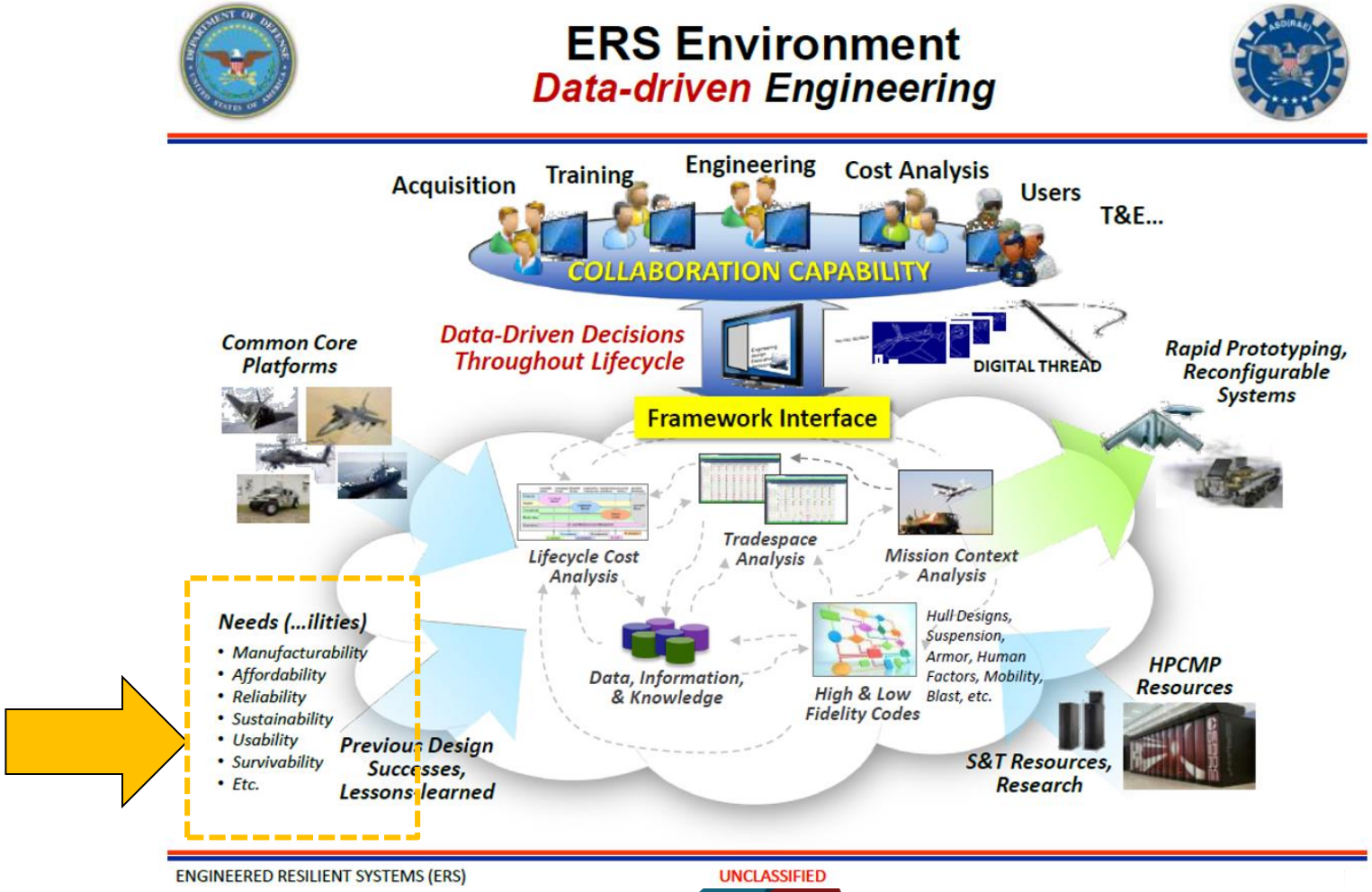
Project Team "Working Group"

- Research team with **180 combined years** of industry experience.
- **Areas of Experience:**

Aerospace
Automotive
- all-terrain vehicles
- consumer road vehicles
- military vehicles

Consumer & Personal Care Products
Healthcare
Electronics
Electronic Test Equipment
Elevators
Industrial Parts
Logistics
Medical Devices
Musical Instruments
Networks
Office Furniture
Plant Equipment
Quality Assurance
Residential Appliances
Shipbuilding
Transportation
Utility

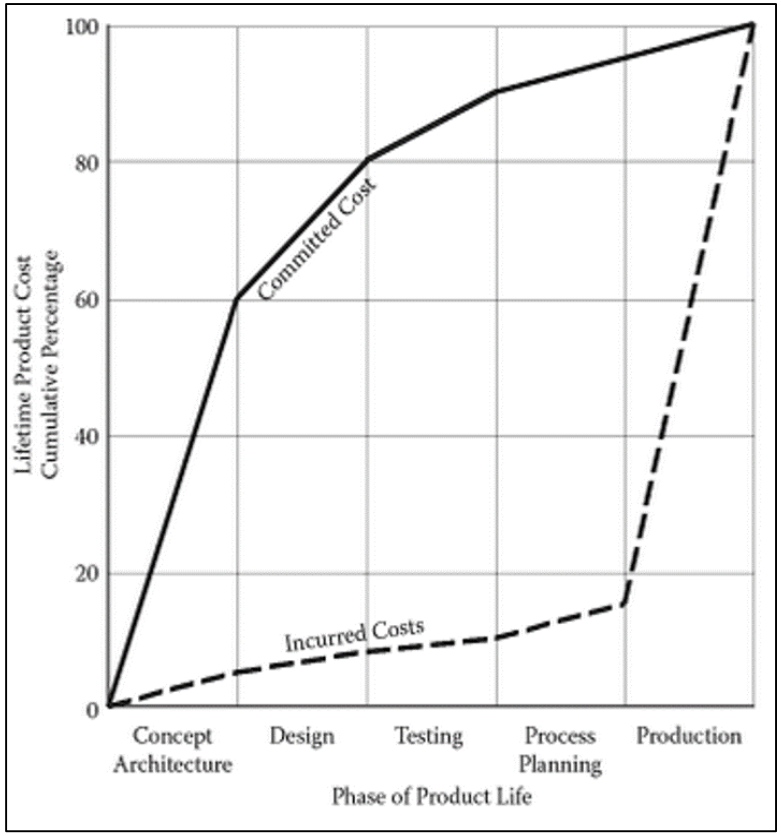
Connecting to the ERS Tradespace



What is MAKE?

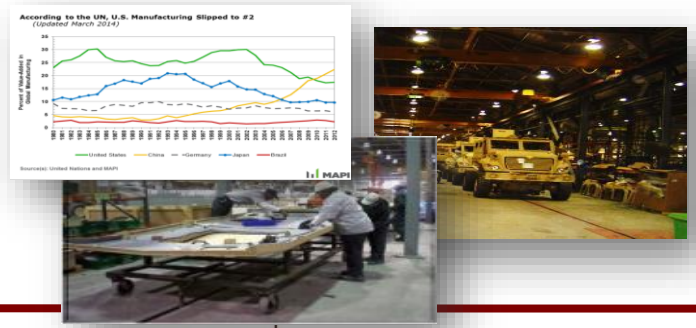
- **Manufacturability** – ease in which a component or product can be manufactured.
- **Assessment** – detailed review of how the design impacts manufacturing.
- **Knowledge-Based** – judgment based assessment by subject matter experts (SMEs).
- **Evaluation** – identification of cost drivers and prescriptive measures to improve manufacturability.

What is the need for MAKE?



Product Cost vs. Phase of Product Life, D.M. Anderson 2014

- **Improvements in cost, design, and manufacturability of the product**
- **Risk mitigation**
- **Reduction in time-to-market**
- **Provide mechanism for trade off analysis**



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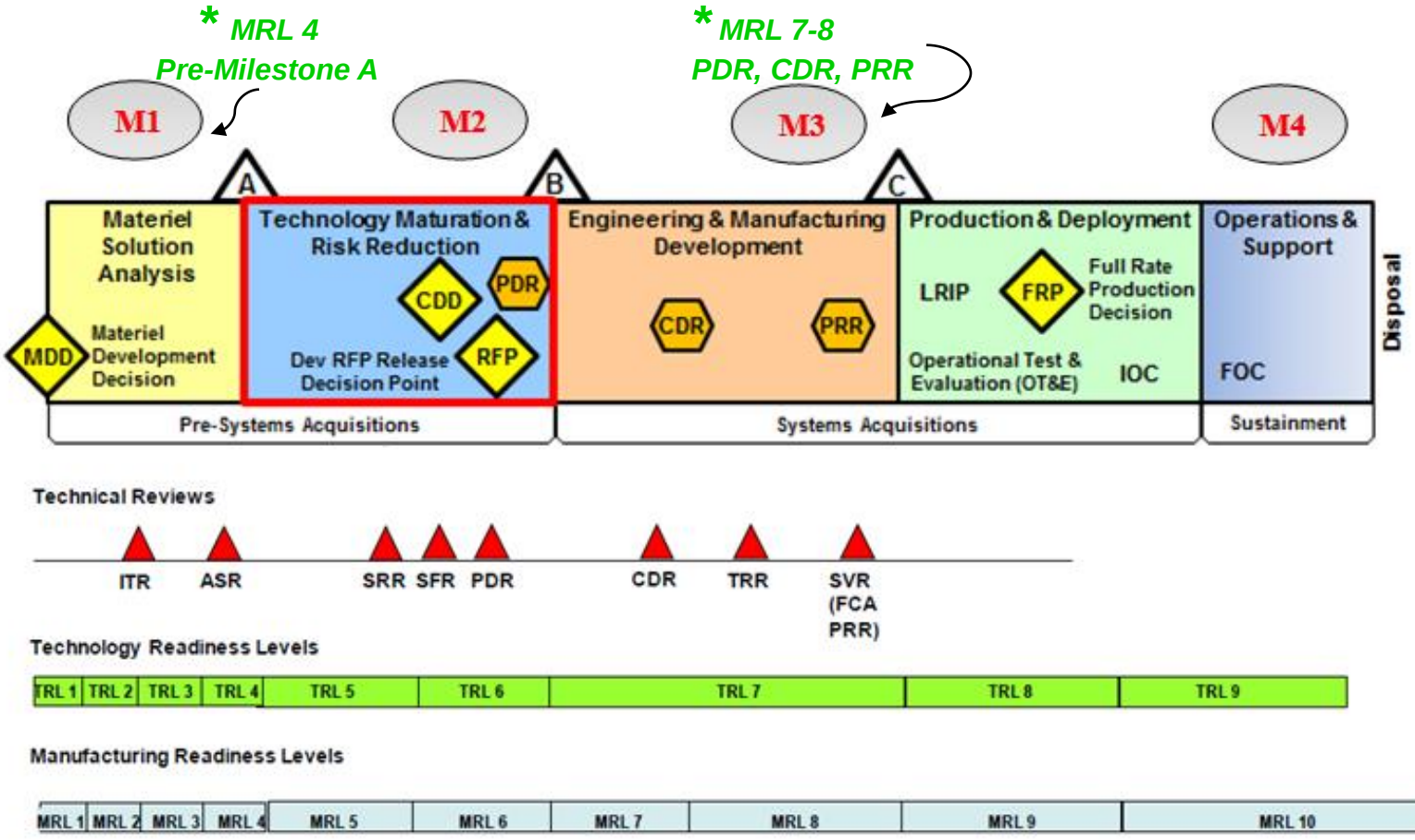
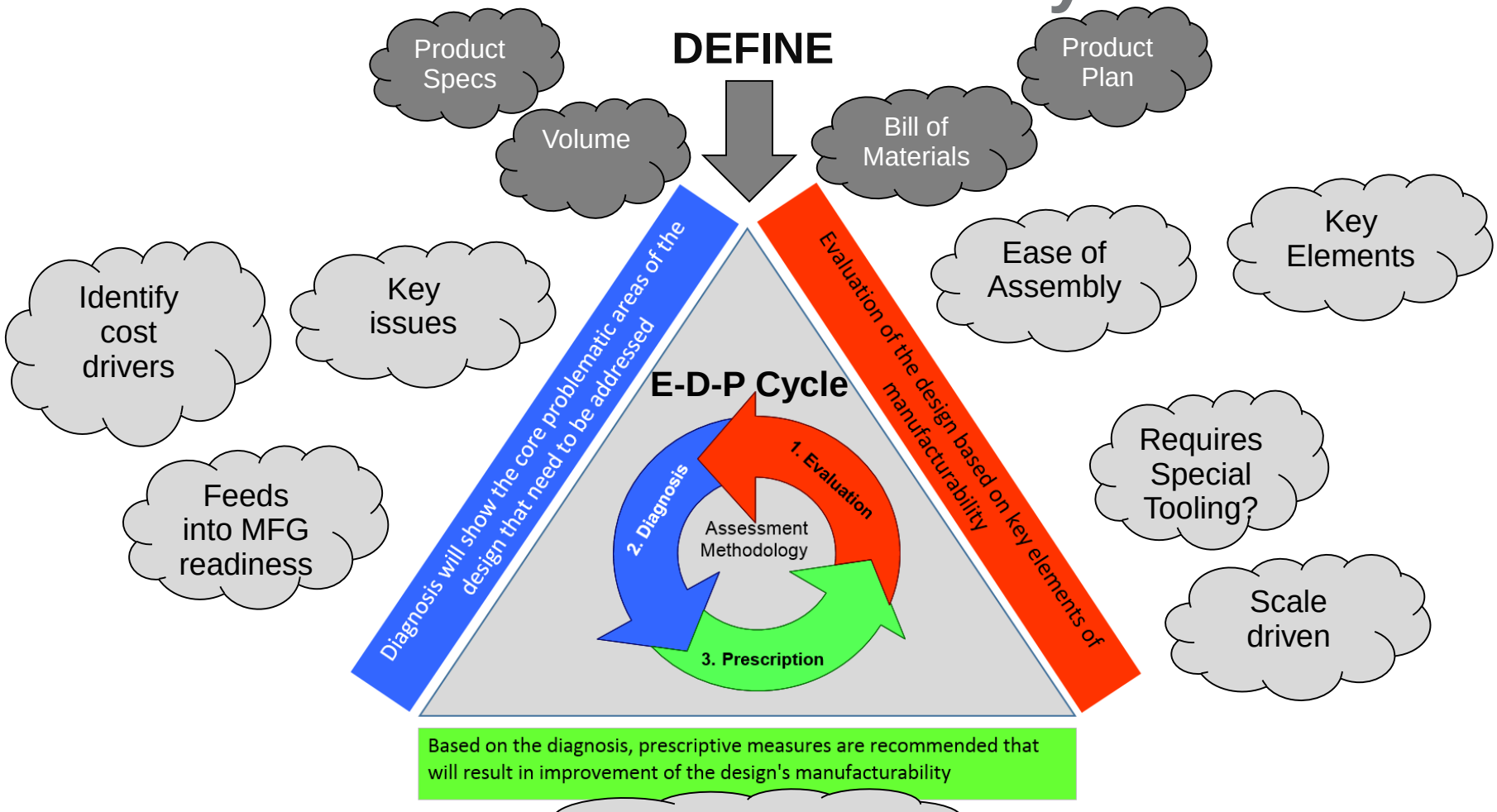
"Potential" Metrics During the Product Life Cycle

(ref: Defense Acquisition Life Cycle Chart (DoD Directive 5000.02, 2015)



Framework for Manufacturability Assessment



Judgment Based Assessment

- **Proper execution of the MAKE assessment requires input by subject matter experts (SME) pertaining to the aspects of manufacturing specified in the matrix in relation to a particular engineering designed product.**

- **A SME is a person who is generally recognized as an authority in a particular field by peers/ colleagues who are also knowledgeable in that field.**

A SME's Role

INPUTS

Evaluate:

- Bill of Materials
- Experience/Body of Knowledge
- Design Data and Characteristics

Diagnosis:

- Best Practices
- Body of Knowledge

Prescription:

- Best Practices
- Body of Knowledge

OUTPUTS

Evaluate:

- What are the critical aspects of the design?

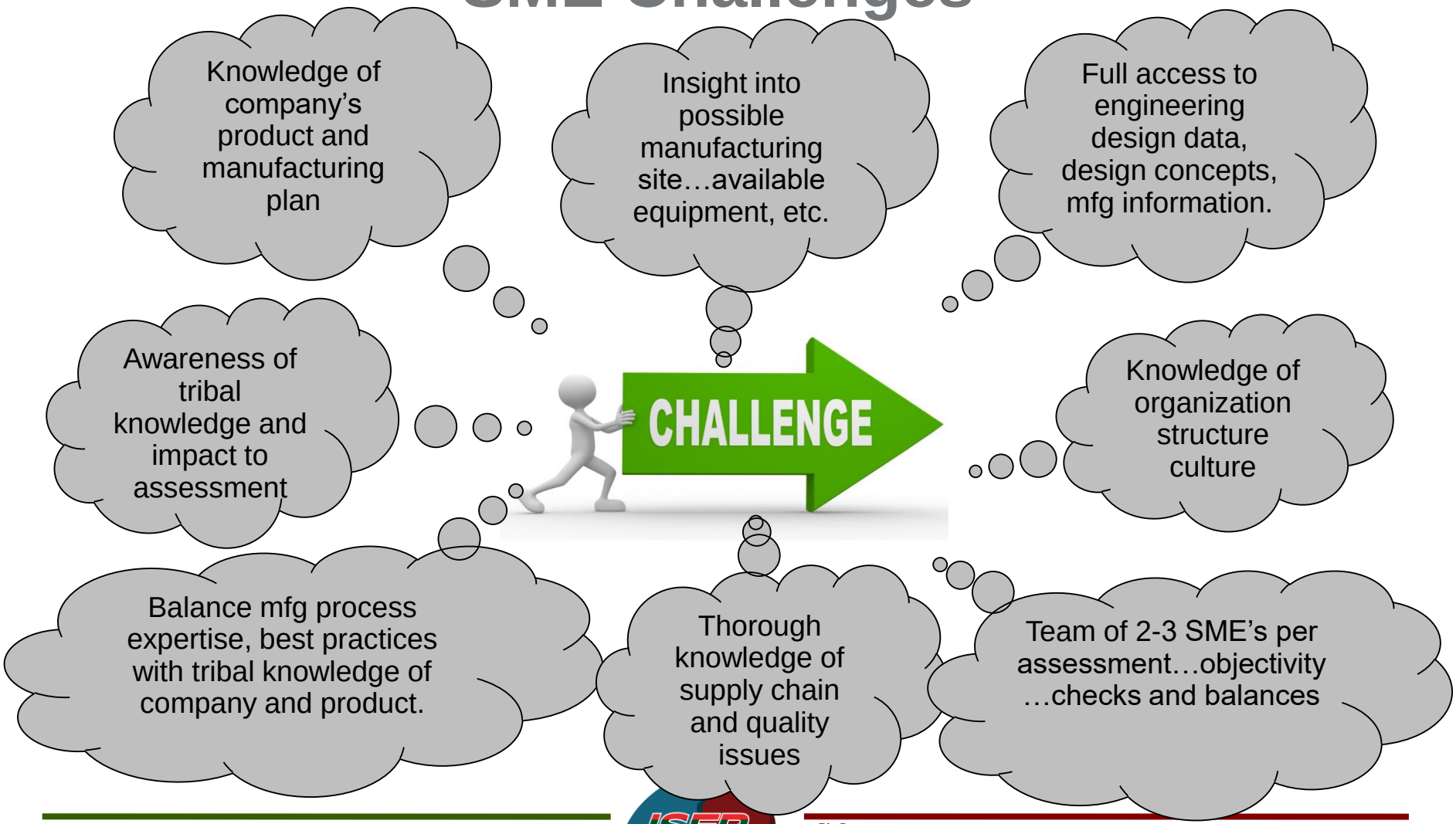
Diagnosis:

- How do the critical aspects of design interact with the aspects of manufacturing?

Prescription:

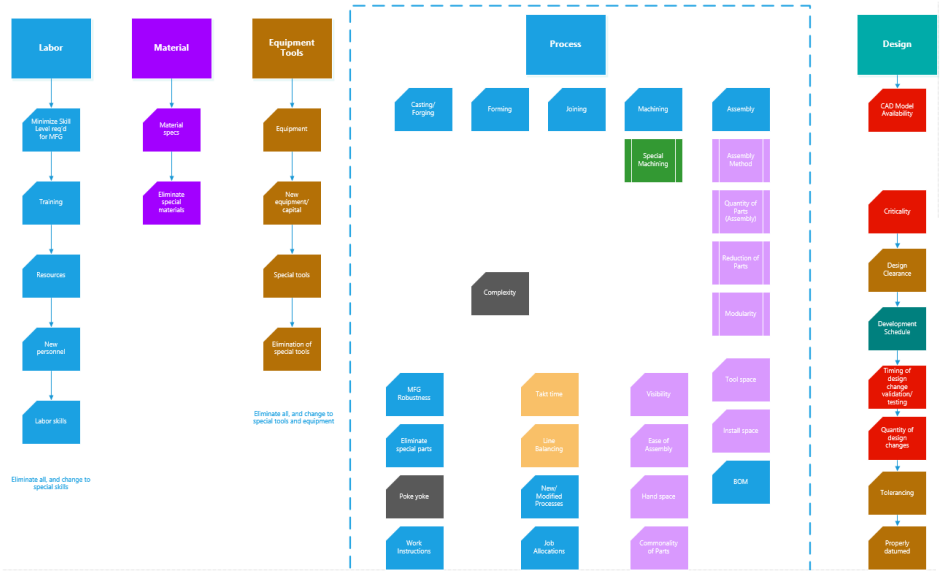
- What are the recommendations to improve manufacturability?

SME Challenges

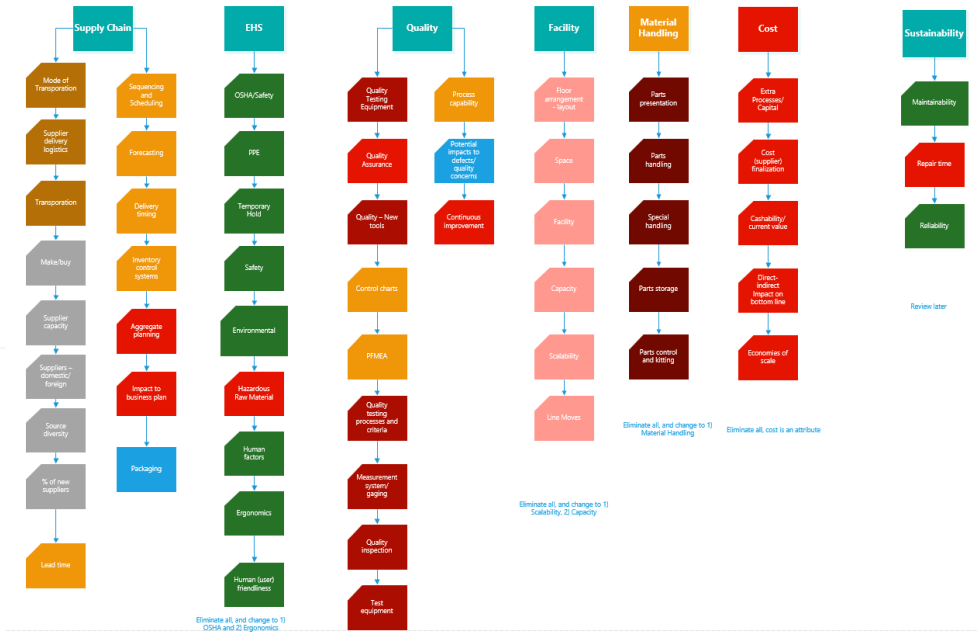


Affinity Diagram Exercise

- **Grouped ideas were translated into the following:**



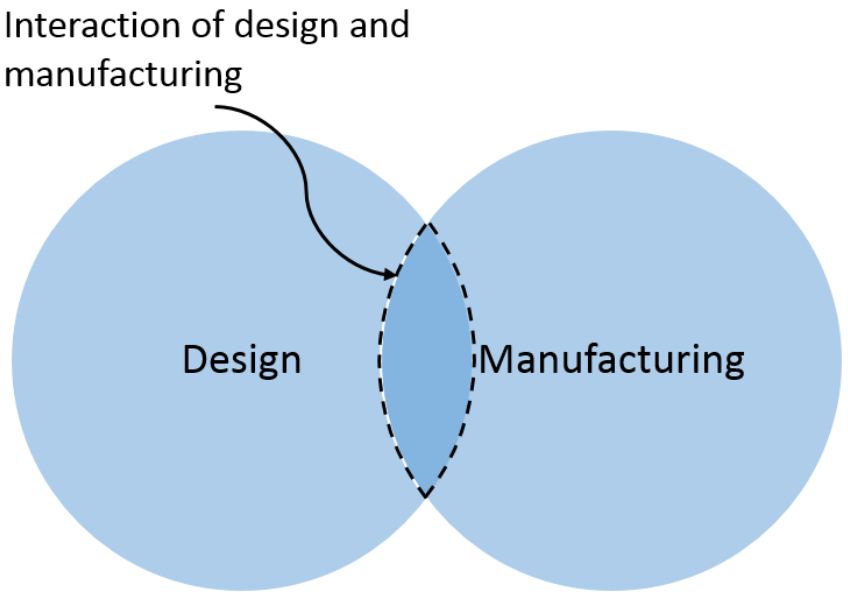
91 elements



Observed interactions/overlap between the elements and the grouped categories

Development of Key Elements

- The assessor's intent would be to ***understand the impact of characteristics of the "design" on particular areas of "manufacturing"?***



Evaluation Phase

- **Manufacturability Interaction Matrix**
  - ► Understand "impact of the design" on "particular aspects of manufacturing"
  - ► Original matrix was 15 x 9 but was reduced after 1st case study due to overlap of the aspects of design and manufacturing
  - ► Shows the interactions (X) between the "aspects of design" and the "aspects of manufacturing".

Aspect of Design / Aspects of Mfg (AM)	Material	Product and Manufacturing Information (PMI)	Part Geometry
Process	X	X	X
Process Capability	X	X	X
Supply Chain	X	X	X
Equipment/Tools	X	X	X
Facility	X	X	X
Labor	X	X	X
Quality	X	X	X
EHS	X	X	X
Ergonomics	X	X	X
Capacity and Scalability	X	X	X
Maintainability	X	X	X

Evaluation – Rating Scales

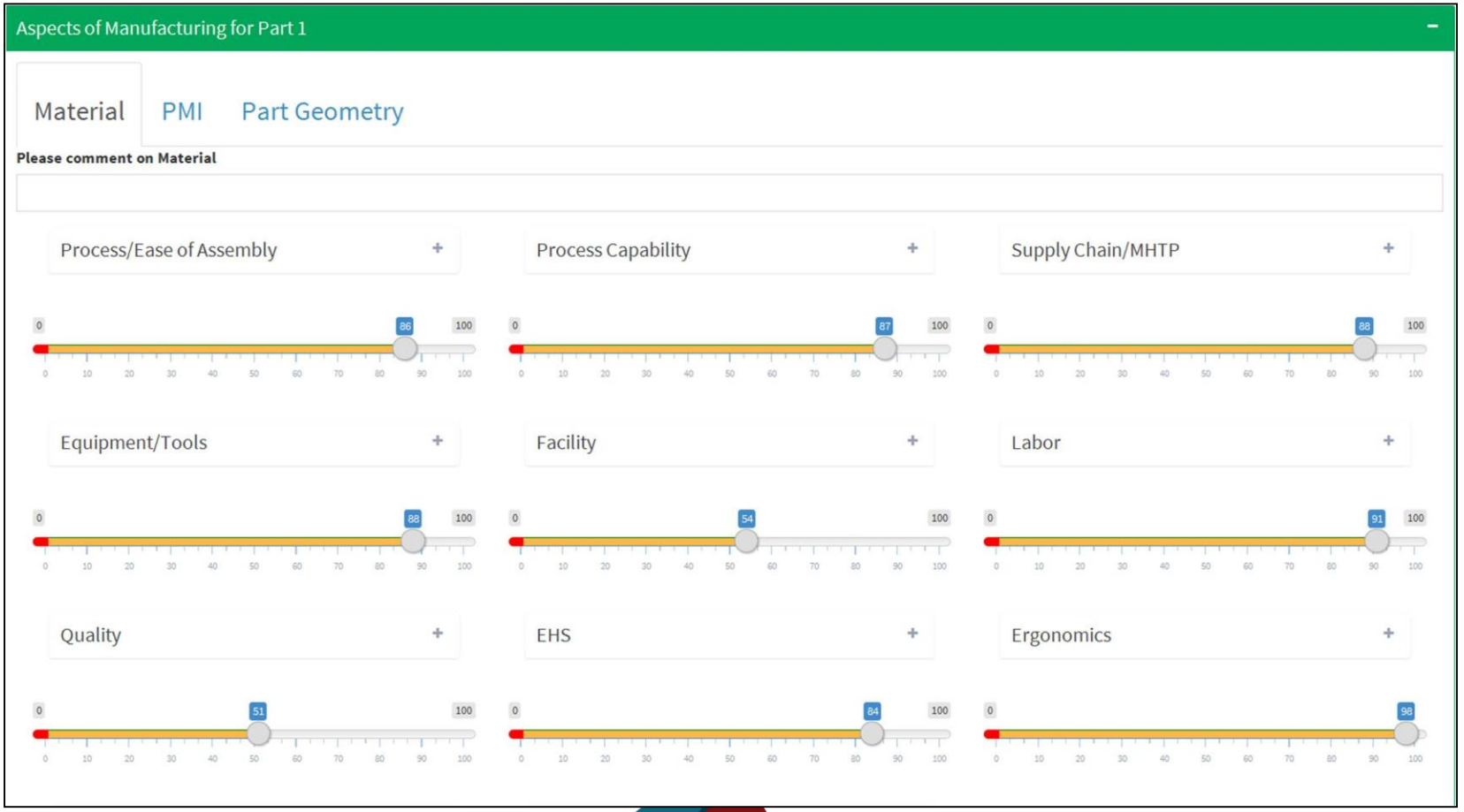
- **SME Rating system* (1 – 100) based on the following criteria:**

Color	Rating	Description
Red	1 - **60**	High concern significant issues, **stop and evaluate**
Yellow	**61 - 85**	Medium concern, some issues (additional build time, extra resources, and special tooling, etc. may be required), **proceed with caution**
Green	86 - 100	Low concern, very few issues, **proceed**

** Based on prior work with a large defense contractor – needs to be further validated with subsequent research*

Evaluation Phase

MAKE Tool



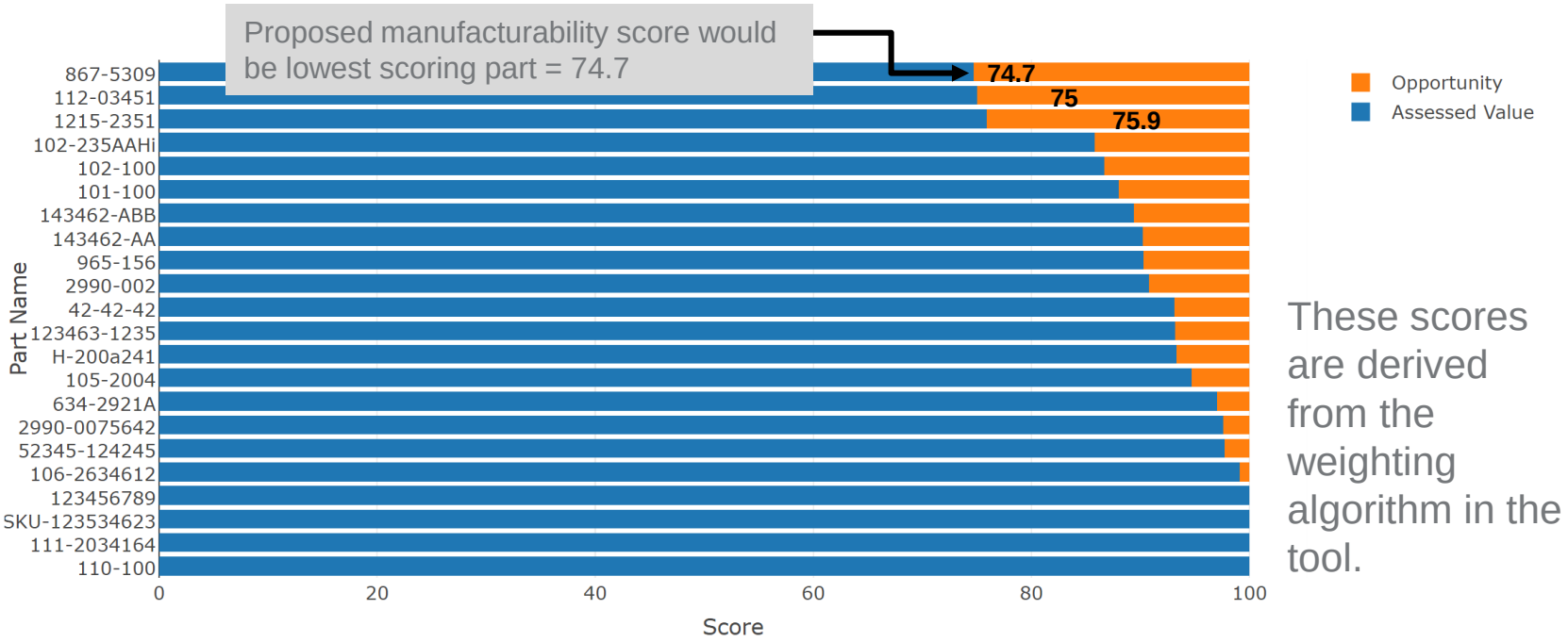
Diagnosis Phase

Understand cost drivers and areas of risk.

High Concern
0

Moderate Concern
3

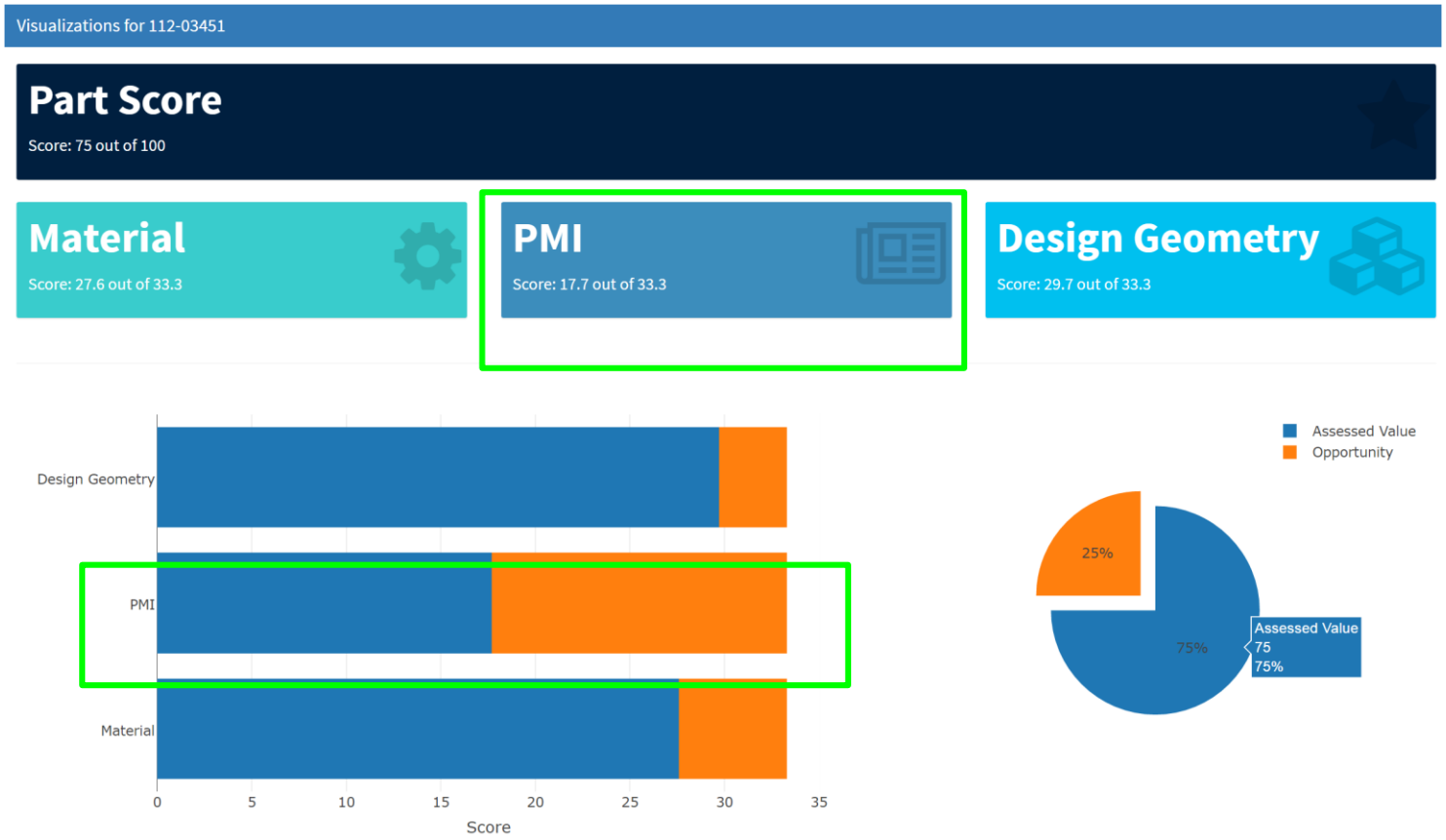
Low Concern
19



These scores are derived from the weighting algorithm in the tool.

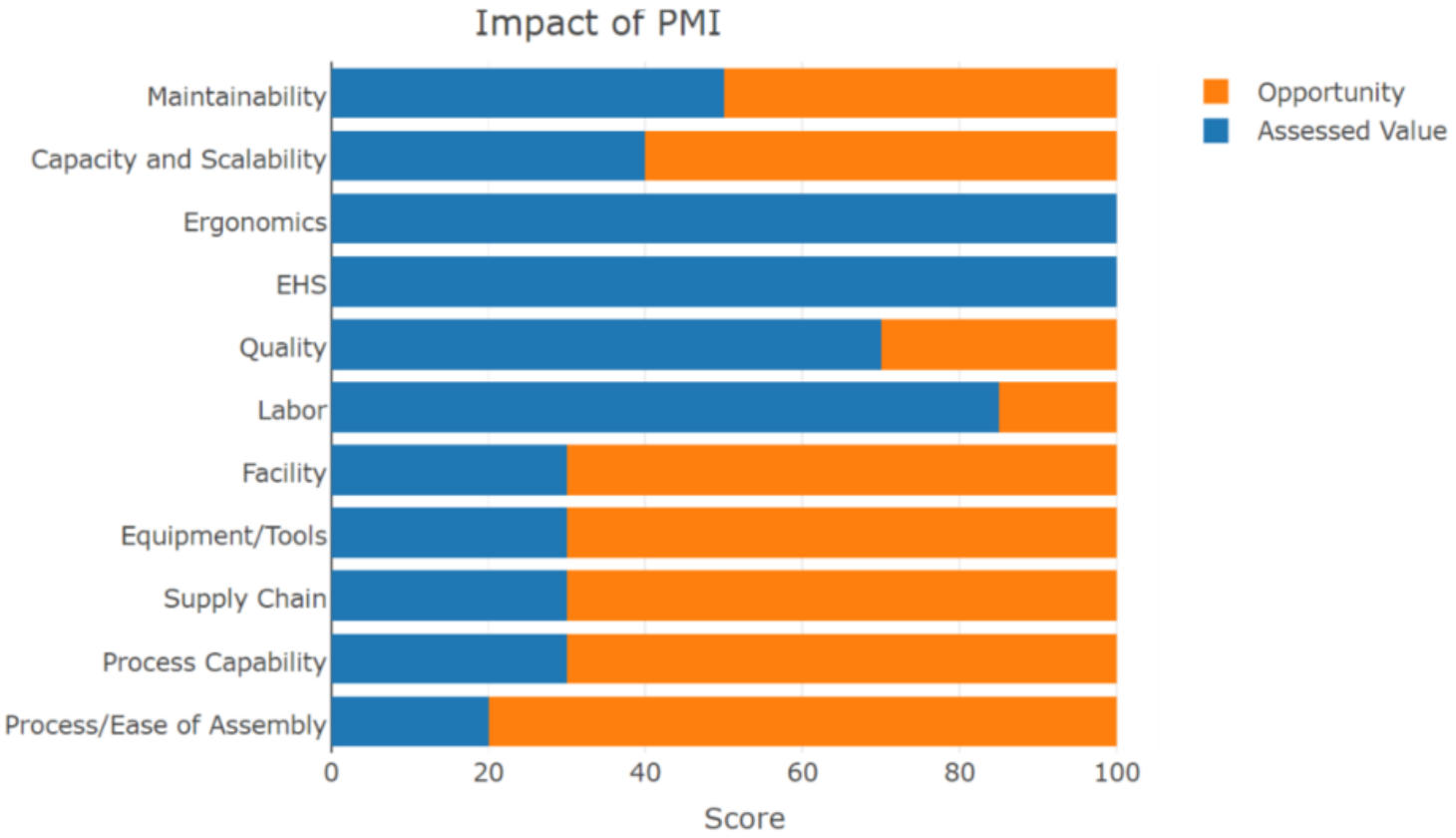
Diagnosis Phase

Investigate into specific part #s with lower scores ultimately pursuing root causes.



Diagnosis Phase

Dive deeper into PMI to understand the impact of the design on particular aspects of manufacturing.



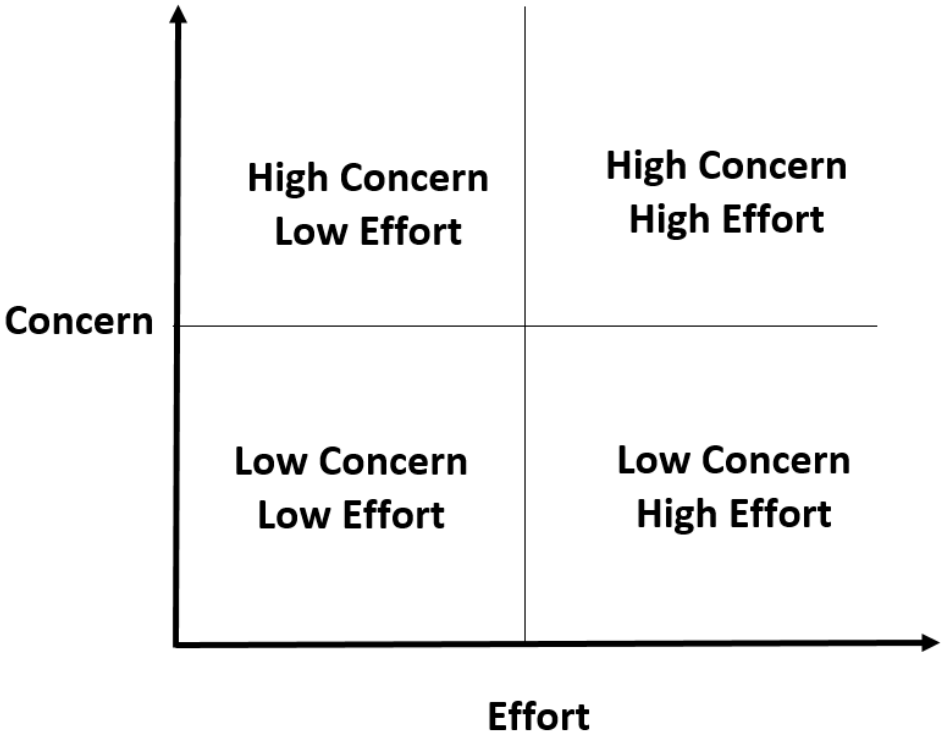
Prescriptive Phase

Example of a typical recommendation

Concern	Recommendation
Standardization of fasteners	- Various different fasteners used within the assembly requiring the operator to use multiple types of tools. Evaluate the fasteners and standardize across the assembly
Use of a socket that touches the resistor. 	1) Adhere to design for manufacturability guidelines – design must account for tooling needed for manufacturing and assembly process. 2) If design cannot be changed to accommodate tooling, specify tools in mfg that accommodate the design concern. In this case, use thin walled sockets or specify the use sockets with protective coating.

Prescriptive Phase

- Recommendations to improve the manufacturability scores
- Qualify these based on effort and risk to the company



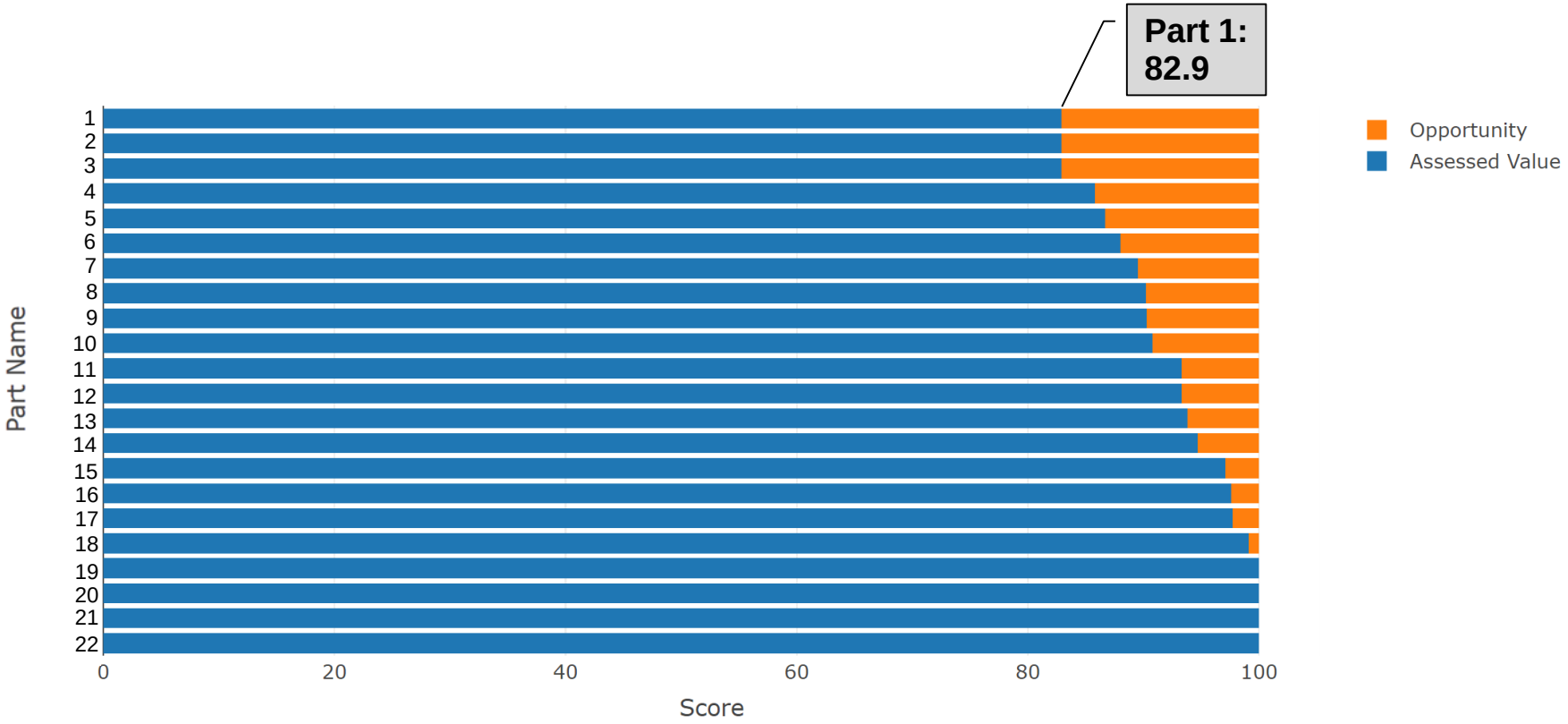
Case Study

- R&D company (contractor to DoD) preparing to enter low-rate production stage of product manufacturing
- Focus of the team was to review CAD drawings and physical prototype to provide client with a manufacturability assessment of the product
- Long term strategy for increased production rate and/or transition to commercial manufacturing
- Study conducted by SME's from the MAKE team.

Evaluation

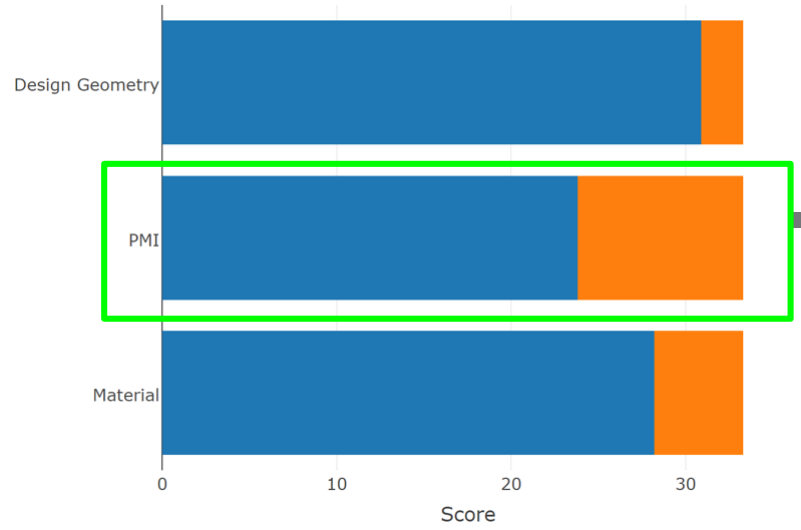
- **Two products were evaluated: Product A (main product), and Product B (accessory to Product A)**
- **A total of 32 parts included in the assessment**
- **Consisted of injection molded parts, fabricated metal parts, MIL-SPEC hardware and connectors, wiring harnesses, circuit boards with modules**

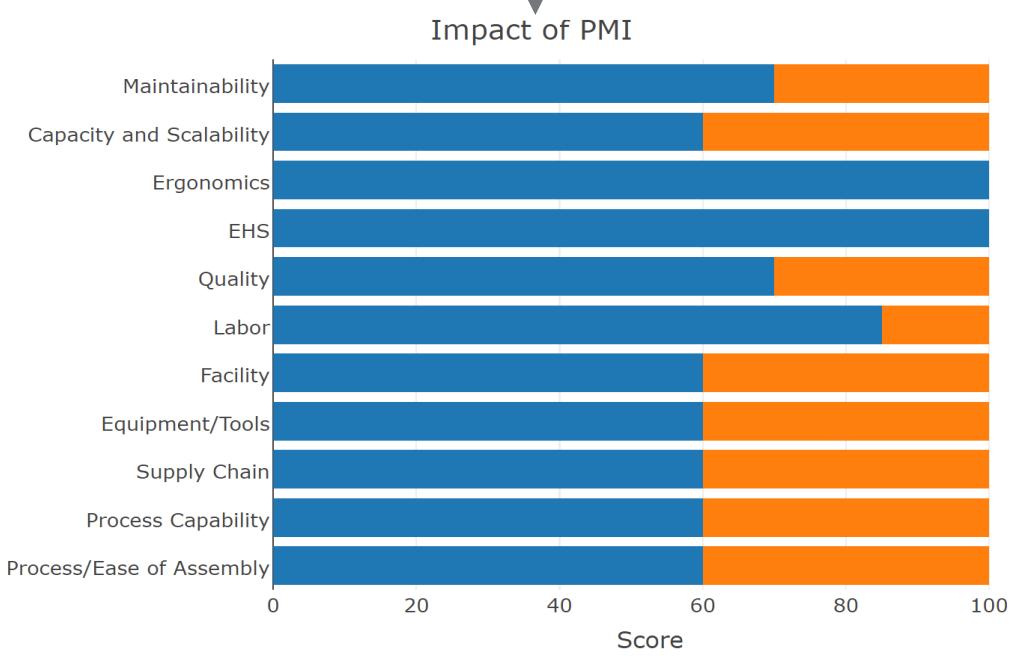
Diagnosis – Product A*



*only Product A will be discussed in this presentation

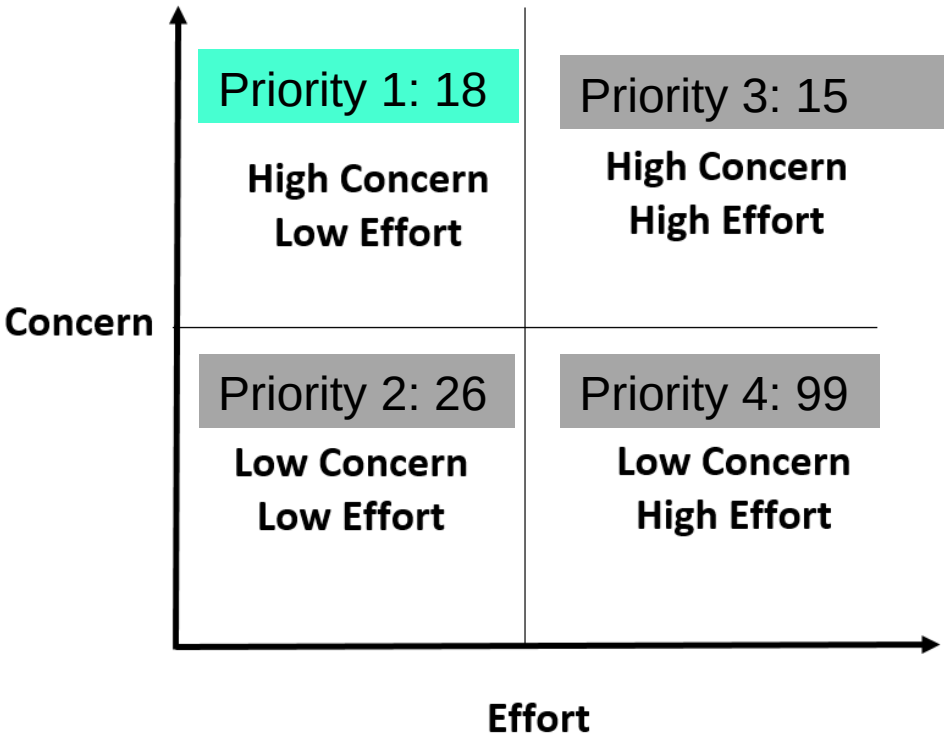
Diagnosis – Product A
Part 1 deep dive





Prescription Phase – Product A

- Recommendation matrix (included in final **client package)** addresses 158 concerns
- **SME team evaluated the effort associated with each recommendation.**
- Prioritization of the recommendations was provided.



Recommendation Summary

Product	Score	# of concerns	# of recommendations	Agreement*
A	74.7	158	80	67%
B	82.9	69	49	66%

* Based on feedback from case study client as results were presented. This information will be verified/updated after additional review of the assessment details by the client.

Benefits of Structured Manufacturing Assessments Throughout the Product Lifecycle

- **Better determination and mitigation of risks**
- **More consideration of manufacturing issues earlier in the design phase and throughout the design review process**
- **Reduction of costs throughout the product lifecycle**
- **Better decision making (mfg processes, suppliers, etc.)**
- **More considered Make/Buy Supply Chain Decisions**
- **More concise determination of TRL & MRL Status**
- **Provides approach for producibility analysis in support of AS6500**
- **Enhanced resilience of product**

Acknowledgements

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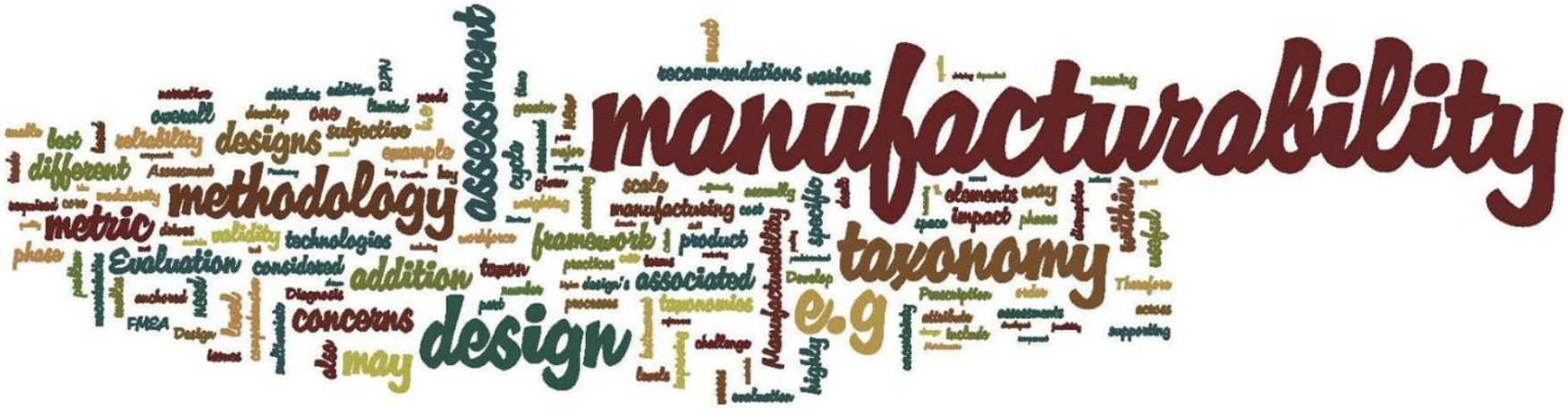
- **This research is also partially supported by Mississippi State University, the Center for Advanced Vehicular Systems Extension, and the Institute for Systems Engineering Research.**



Thank you!!