MISSISSIPPI STATE UNIVERSITY™
CENTER FOR ADVANCED
VEHICULAR SYSTEMS EXTENSION

Manufacturability Assessment Knowledge-Based Evaluation

MAKE

MRL Working Group Meeting - July, 26, 2016

Tonya McCall, Larry Dalton, and JR Burt

ERDC

Mission Context
Resilience
Lifecycle Cost
Tradespace

ISER

Big Data
Manufacturability
Reliability
Affordability

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ENGINEERED RESILIENT SYSTEMS
DEPARTMENT OF DEFENSE

"ERS buys down acquisition risk"

Dr. Jeff Holland, ERDC Director & ERS COI Lead

ERS-NDIA Briefing, March 24-26, 2015

ERS "Manufacturability" Module

Larry Dalton, Module Lead – Larry.G.Dalton@usace.army.mil, (601) 634-2847

Purpose

To understand various aspects of designs manufacturability by developing an assessment methodology targeted for use assessing system designs for the DoD lifecycle acquisition process. This methodology will assist design teams with assessing and improving the manufacturability of a product design.

Products/Capability to be Delivered

ERS Manufacturability Module

- **Manufacturability Metrics –** The manufacturability metric(s) that assess the difficulty to manufacture products . The metric(s will consider the technology readiness level (TRL) as well as the manufacturing readiness level (MRL) to rate the product on a scale determined by subject matter experts
- **Updated ERS manufacturability Roadmap -** phases, products, and efforts of the development process to synchronize with ERS tradespace module/tool development efforts
- **Development of the manufacturability assessment methodology -** provide descriptions of anchoring factors for quantitative and qualitative metrics to include scalability, risk, etc.
- **Submit and publish a research conference paper as well as a conference presentation (e.g. IEEE, MORSS, NDIA, etc.) -** papers to communities of interest to gain user/community feedback and advertising ERS capabilities
- **Collaboration with and feedback from DMDI Institute (DMDII), Additive Manufacturing Engineering (AME), and Model Based Engineering (MBE) –** to leverage community expertise for metric development and review as well as module exposure
- **Verified Manufacturability Module for ERS demos & presentations –** Manufacturability module for use by ERS for usability studies, verification, and inclusion in the ERS tool set

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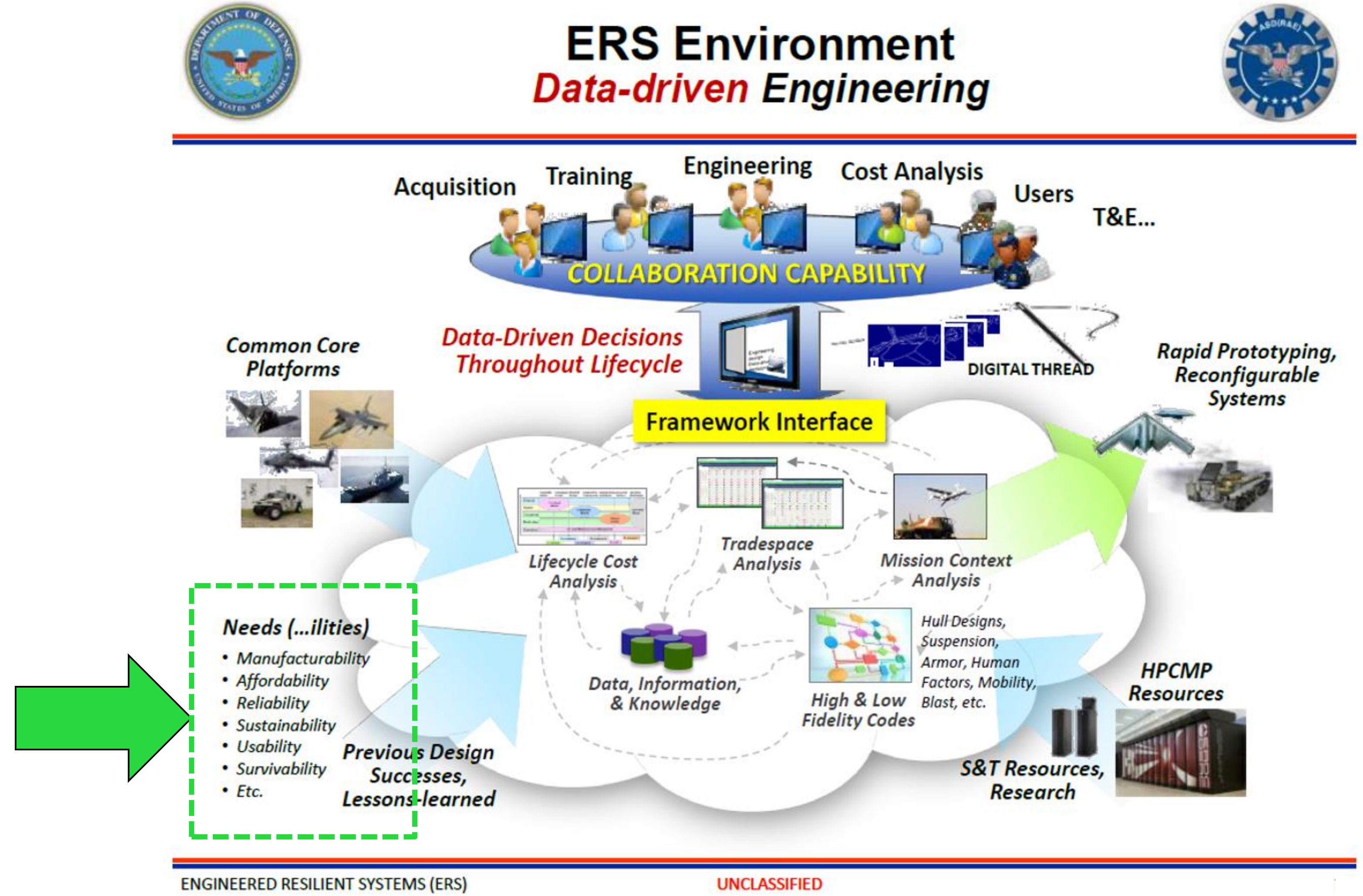
What is the need for MAKE?



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Collaboration Effort

ERDC
Engineer Research and Development Center

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MRAP, Navistar Maxx Pro, West Point, MS Production Facility, over 6,000 vehicles produced, 2007 - 2009.

Project Team "Working Group"

- **A Diverse Research Team with over 180 combined years of industry experience (Reps from CAVS-E, ISER, ERDC, and Outside Consultants).**
- **Areas of Experience:** **Functional Areas:**

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

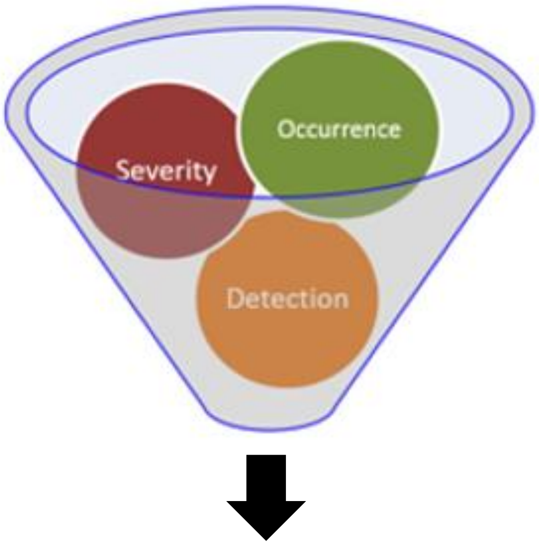
Functional Areas:

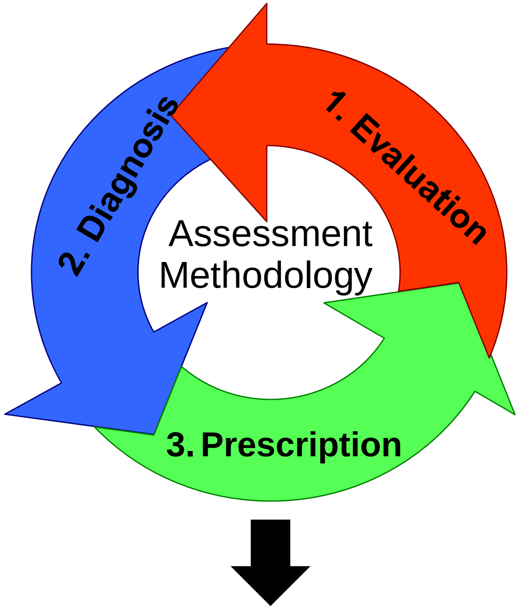
Product Design
Mfg. Process Engineering
Quality Engineering
Mathematics
Computer Science
Systems Engineering

Original MAKE Concept

Originally thought of as having similarities to FMEA

- Unit-less metric
- Continuous improvement cycle

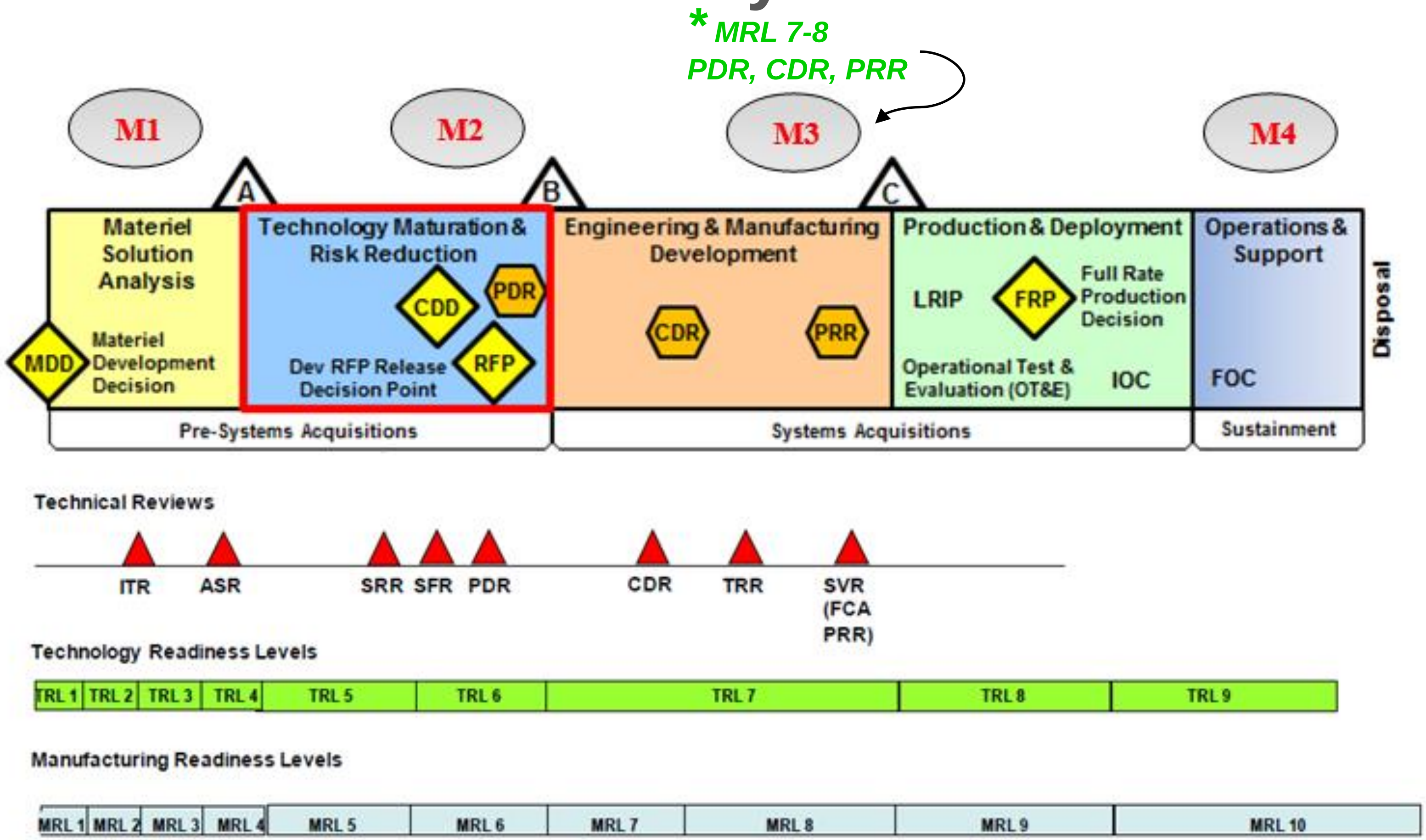




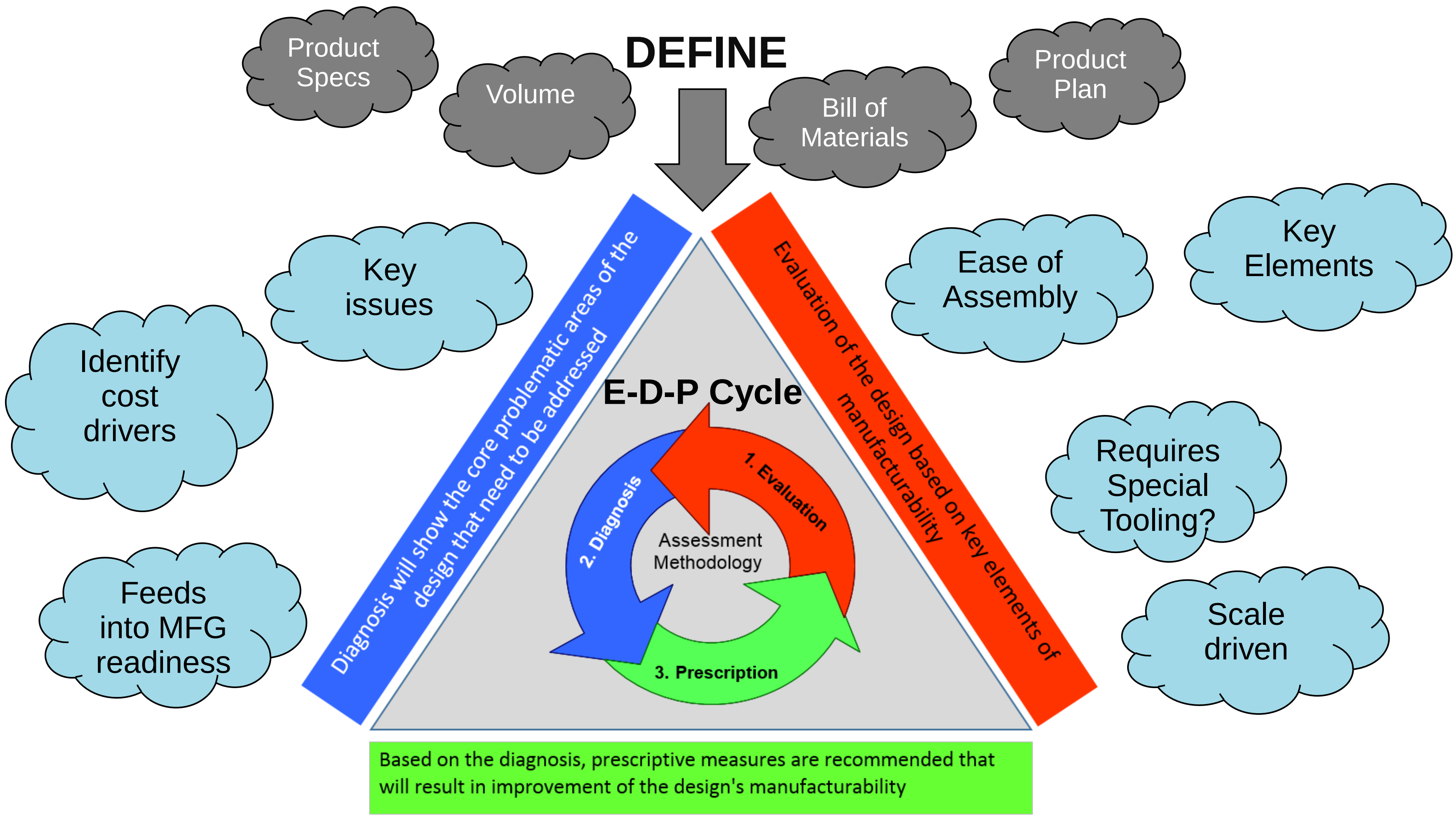
RPN = Sev x Occ x Det

Manufacturability Metric

Four "Potential" Metrics Throughout the Product Life Cycle



Framework for the Manufacturability Assessment

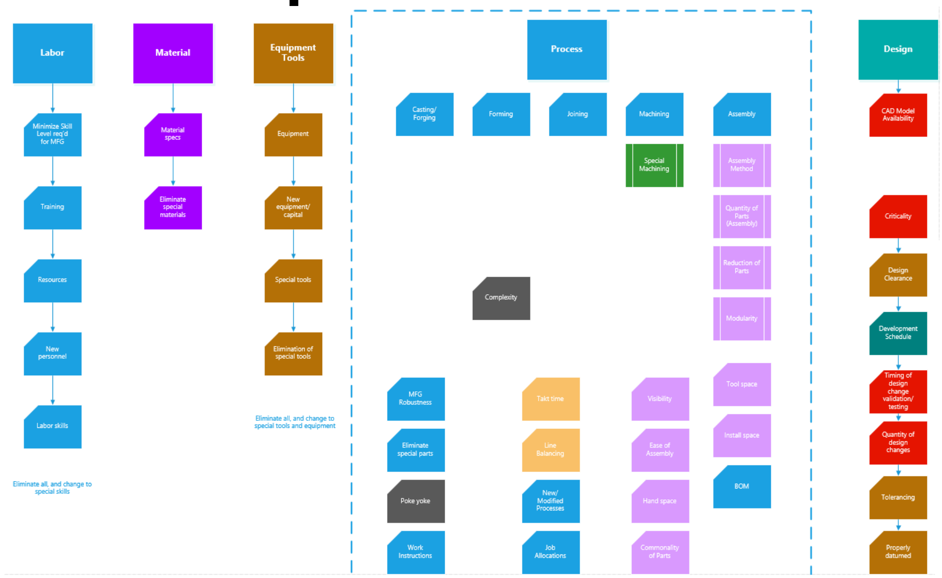


Development of Key Elements

- **What is “Manufacturability”?**
  - Describes the relative ease with which a product or component can be manufactured.
  - The inherent difficulty of manufacturing a product to design specifications has both direct and indirect cost implications.
  - Major criteria such as process costs, time to produce, production volumes, supply chain issues and product quality collectively determine manufacturability,
- **As the team generally discussed the key components of manufacturability, a brainstorming activity was performed to identify the specific elements that impact it.**

Affinity Diagram Exercise

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

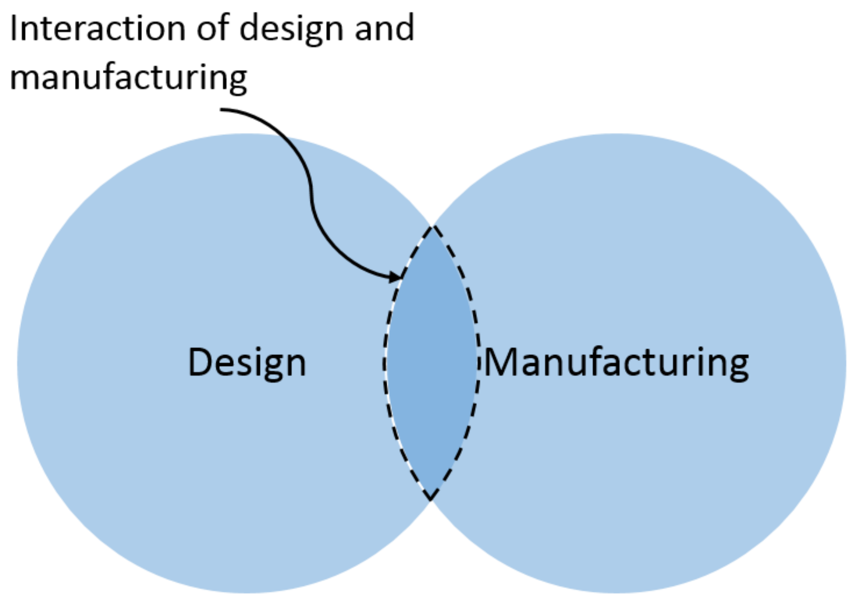


91 elements

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"?***



Manufacturability Interaction Matrix

- 15 x 9 matrix showing the **interactions** (**X**) between the "aspects of design" and the "aspects of manufacturing".
- What is the impact of the "aspects of design" on the "aspects of manufacturing"? Ex. What is the impact of "ease of assembly" on the "process"?

Aspect of Design / Aspect of Mfg	Design	Material	Product Dimensioning	Special Tools	Part Geometry	Special Skills	Ease of Assembly	Reliability	Process Capability	Capacity and Scalability	Ergonomics	Material Handling, Transporting, and Packaging	Strategic Sourcing	Quality testing and equipment	Maintainability
Process	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Supply Chain	X	X			X	X				X	X	X		X	X
Equipment/Tools	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Facility	X			X	X					X	X	X	X	X	X
Labor	X						X		X	X	X	X	X		
Quality	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Cost	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EHS	X	X		X	X	X	X			X		X	X	X	
Sustainability	X	X		X	X		X				X			X	

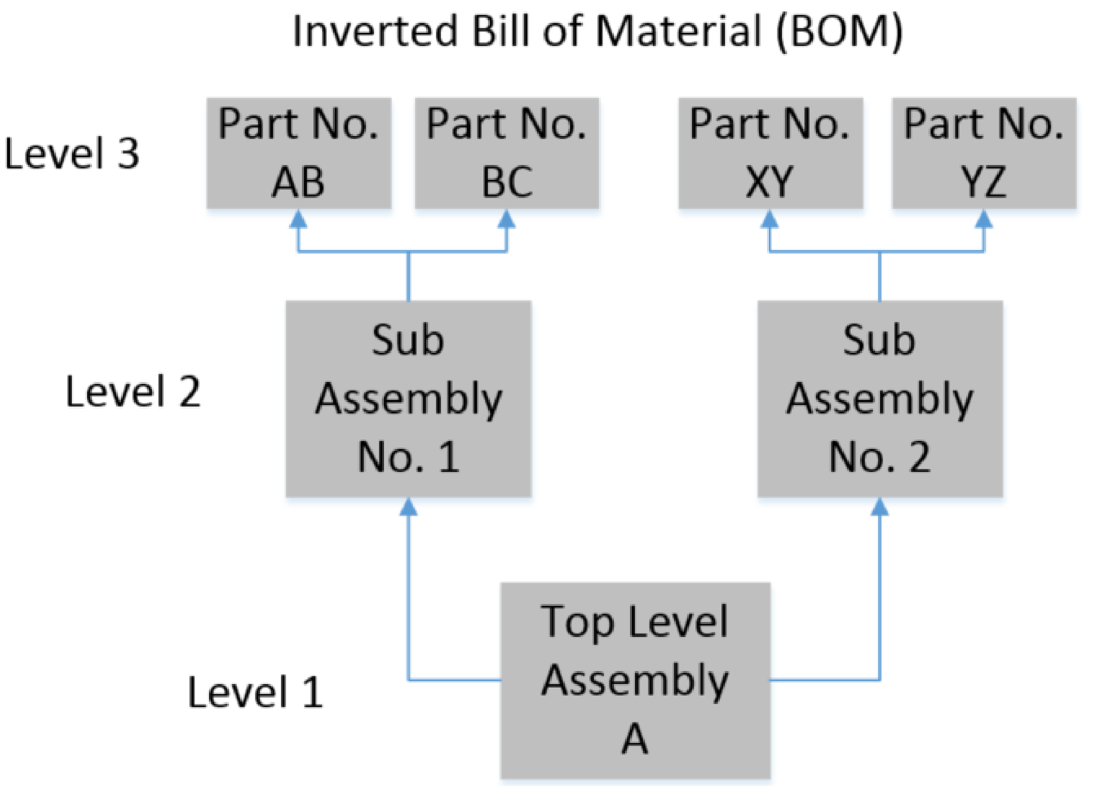
Evaluation Phase

- **Version 2.0 Manufacturability Interaction Matrix**
  - Understand impact of the design on particular aspects of manufacturing
  - Example "What is the impact of material on the manufacturing process?"

Aspects of Mfg (AM) \ Aspect of Design	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

Structured Evaluation

- In the inverted BOM, evaluation of lowest level part number(s) will occur first.
- Once all parts at lowest level evaluated, assembly level will be evaluated.



Assessment will be based on an Inverted BOM approach.

Evaluation – Rating Scales

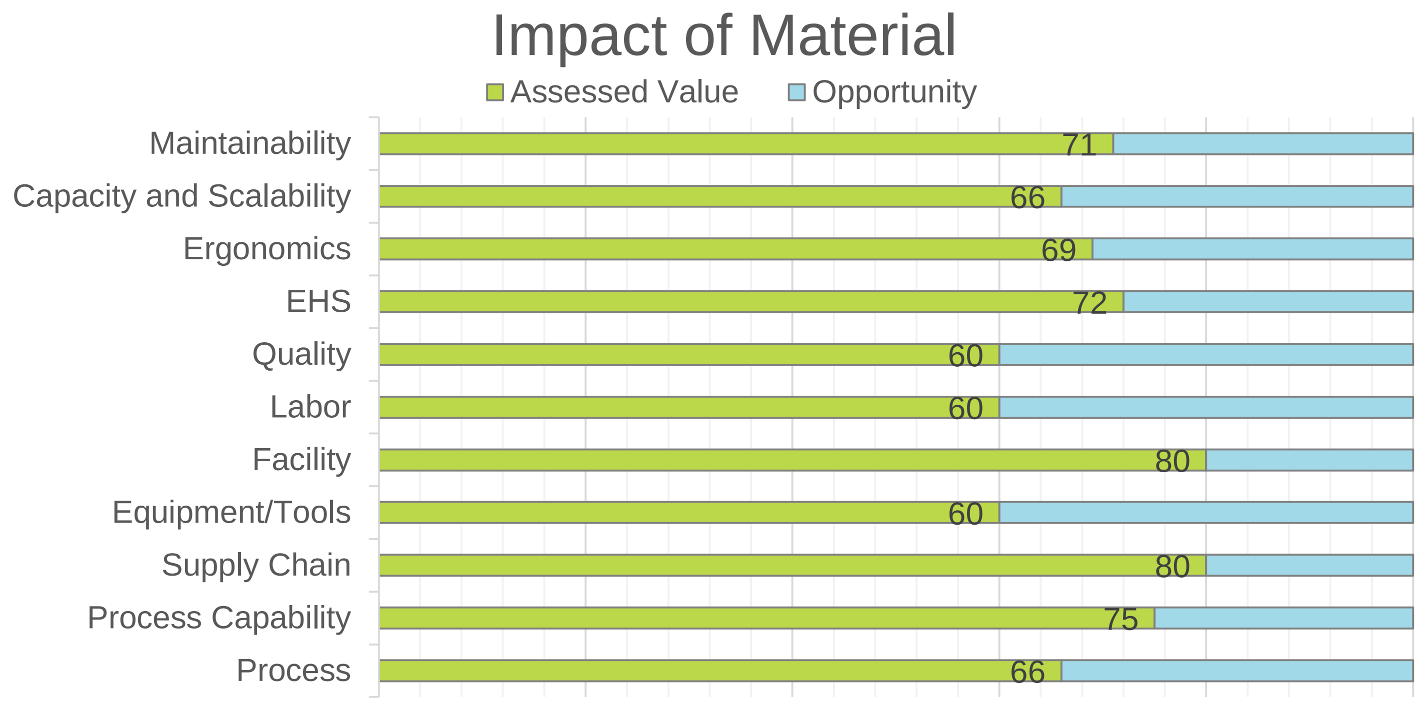
- **Rating system* based on the following criteria:**

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

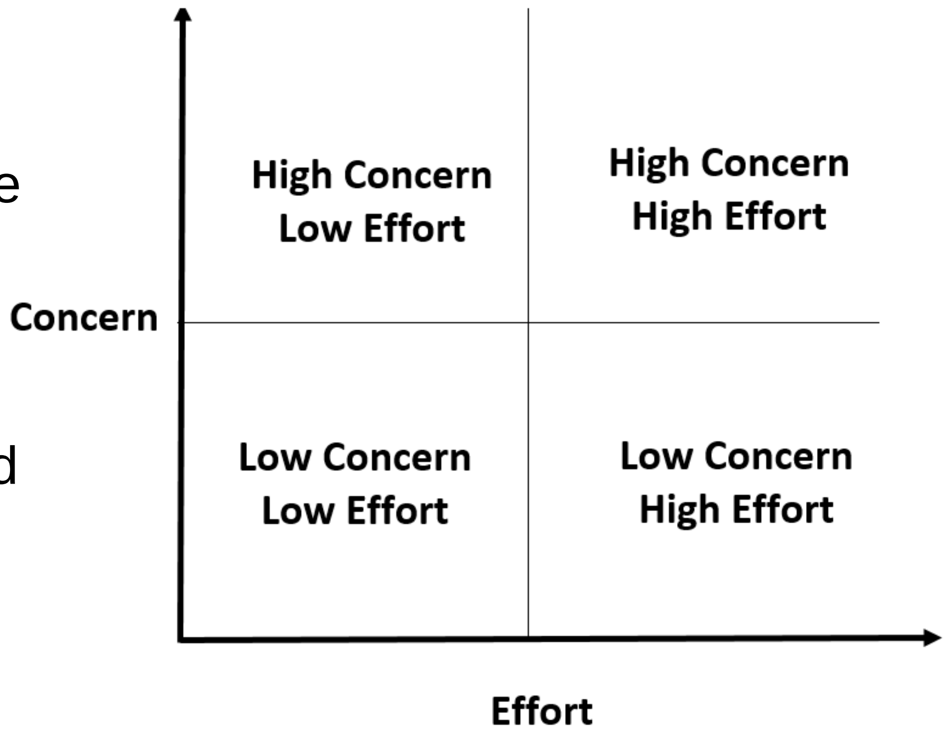
Diagnosis Phase

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



Prescription Phase of Study

- Utilize a taxonomy of best practices.
- SME input is provided to mitigate risk & facilitate improvement in the manufacturability scores.
- Communicate the SME proffered recommendations based on the assessed effort and risk to the operation.



Case Study Evaluation Progression

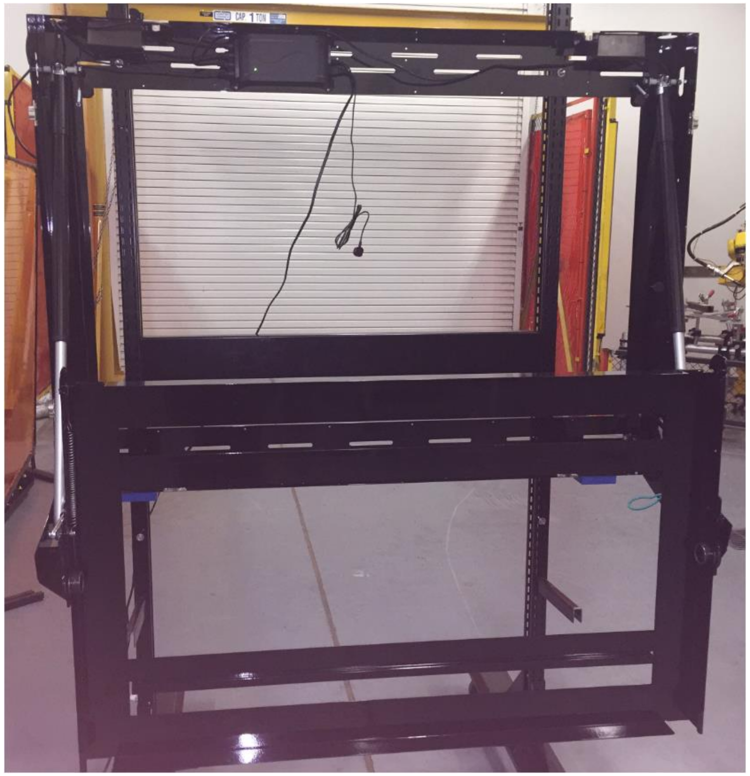
1. Perform a pre-assessment based on conceptual design
2. Review of product design (drawings, CAD models)
3. Review current prototype manufacturing processes
4. Perform assessment based on physical prototype(s)

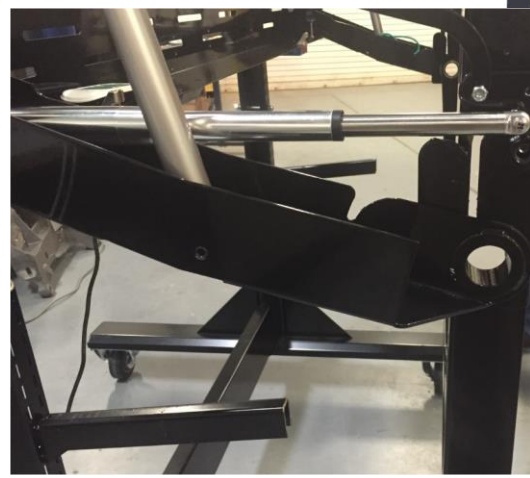
MRL 4 - 8

Milestones A - C

1st Case Study

- **RTVM - Rotatable TV Mount**



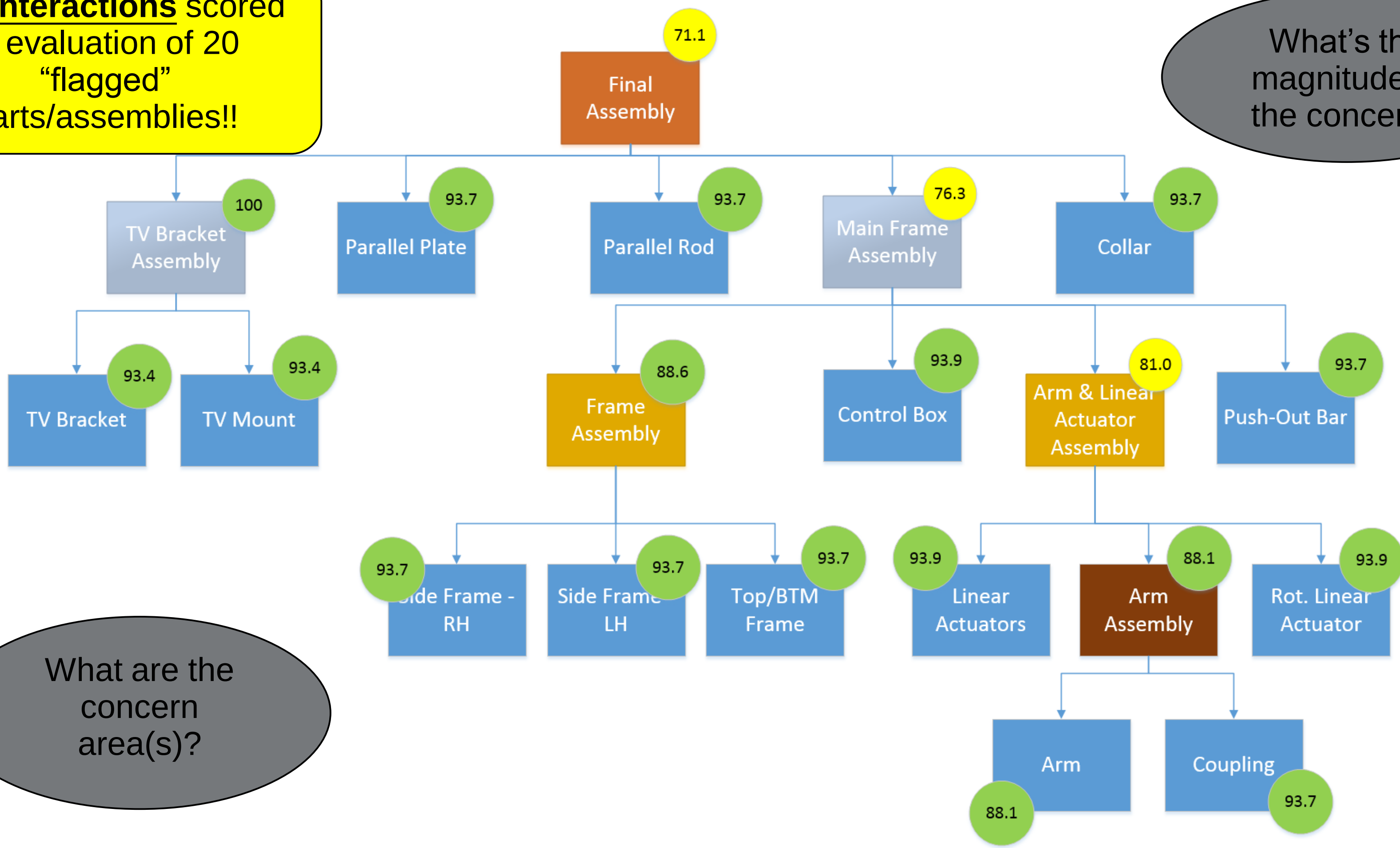


Components: Sheet Metal, Electrical/Electronic, Electro-Mechanical actuators, Springs, Fasteners, etc.

Evaluation of Design

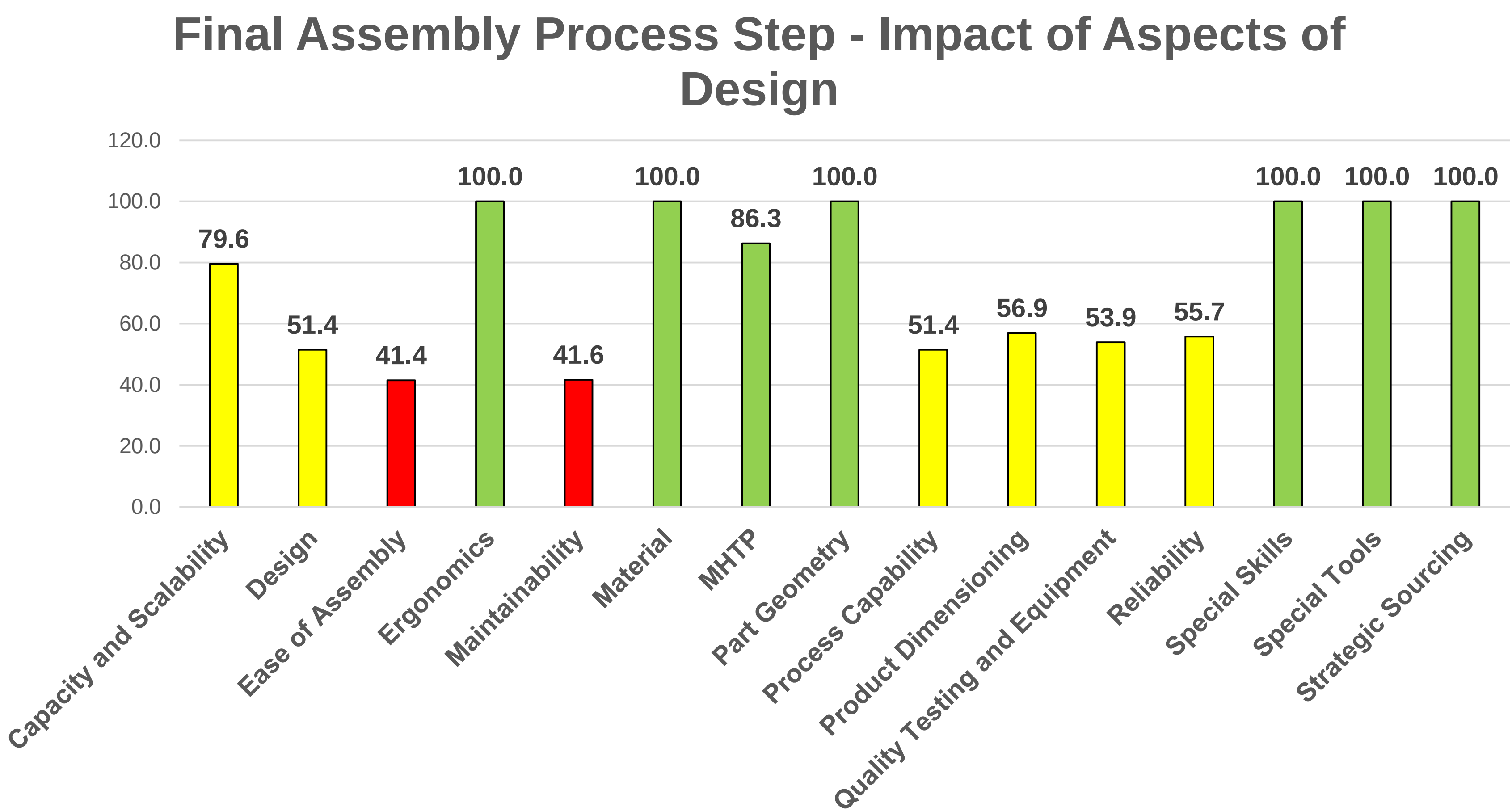
300 **interactions** scored in evaluation of 20 "flagged" parts/assemblies!!

What's the magnitude of the concern?



What are the concern area(s)?

Diagnosis: Concern areas within Mfg



Prescriptive: Concerns & Recommendations

Element	Score	Concern	Recommendation
Product Dimensioning	44.6	1) Disagreement between drawing tolerance and quality capability. 2) Block tolerance high – three decimal places = +/-.015. Unnecessary tight tolerances are costly. Drawing dimensioned to three decimal places which is beyond Leonard's capability. 3) Dimension not specified on the assembly drawing 4) Perpendicularity call-out (squareness) not shown for quality verification purposes.	1) Dimensions should reflect two decimal point specifications to reflect Leonards' quality capability of +/-.031". 2) Update frame assembly drawing with dimensional and geometric specifications. 3) Need to confirm decision that this will be a welded assembly (as built for prototype) instead of bolted. Once decision is confirmed, remove bolt holes and add notes for welding (weld locations, weld fixturing, bead size, and weld finishing, etc.)
Quality Testing and Equipment	63.0	Tight drawing tolerance (as drawn). Does not match manufacturing capability or quality measurement capability. Need to be able to measure and confirm squareness of the finished assembly.	Update all drawings to show +/-0.031" tolerance for all two decimal point dimensions. Ensure there is quality check (measure and confirm) for squareness of the frame assembly.
Capacity and Scalability	69.7	Volume greater than 100/month would cause issues 1) Increase labor force would be required 2) Additional equipment, fixtures, jigs, etc. would be needed to support the increased volume (ex. Laser, turret punch)	1) Discuss with future assembly house (Leonard) on capability for future expansion(2018 and beyond = volume >100/month) 2) Manufacturing set up would be more batch queue, so focus needs to be on part storage capacity. 3) Review finished goods inventory and order shipment policy.

"Live" MAKE Demo

Mr. J.R. Burt


manufacturability
methodology
assessment
taxonomy
design
metric
framework
e.g
designs
Evaluation
addition
concerns
different
associated
may

Questions