Field of 3Dreams
Implementation of Additive Manufacturing in the Shipyard

NSRP All Panel Meeting March 24, 2021

GENERAL DYNAMICS
NASSCO

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NSRP
NATIONAL SHIPBUILDING RESEARCH PROGRAM
Taking Shipbuilding and Repair to the Next Level
Proudly Celebrating 50 Years of Innovation

Agenda

- Presenter & Background
- Theme -Objective
- Industry AM
- Collaboration GD 3D Printing Team & NSRP
- Project Execution (DMAIC TOOLS)
  - Current State and wastes
  - New Tech selection and new process development
  - Future State
  - Traditional V AM examples
  - Savings: Cost and Cycle Time Compares
- Take-Aways
- Maturity
- Questions?

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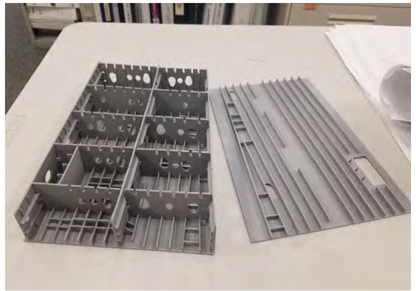
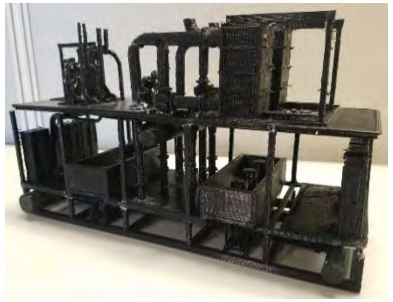
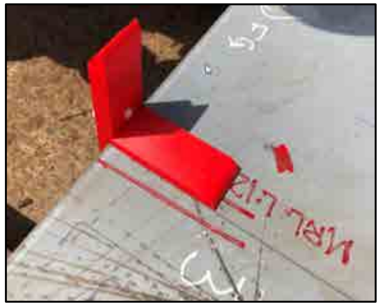
Theme- Objective

- Introduce Additive Manufacturing (AM) technology into the shipyard and engineering processes.
- Lay down a standard entry level process to adopt AM technology that significantly reduces labor, material costs, and cycle time in the following areas of focus
  - Design prototypes
  - Small jigs and fixtures
  - Metrology and maintenance spares.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Why Not Ships Parts?

- NASSCO and Industry Process constraints
- Require qualification and approval by Regulatory Bodies such as ABS and Navy
- Risk of part failure of load bearing parts in ships service
- Conflict with traditional industry process , steel construction, welding, blasting and paint
- Ship environment, with regard to corrosion, temperature, fatigue over time
- The interface connections were unproven bonding, friction fitting, or mechanical fitting, the only likely integration methods with existing ships parts.
- Secondary challenges, with regard to Navy parts, which are traditional copy and paste designs
- Finally Ship parts are REALLY BIG!

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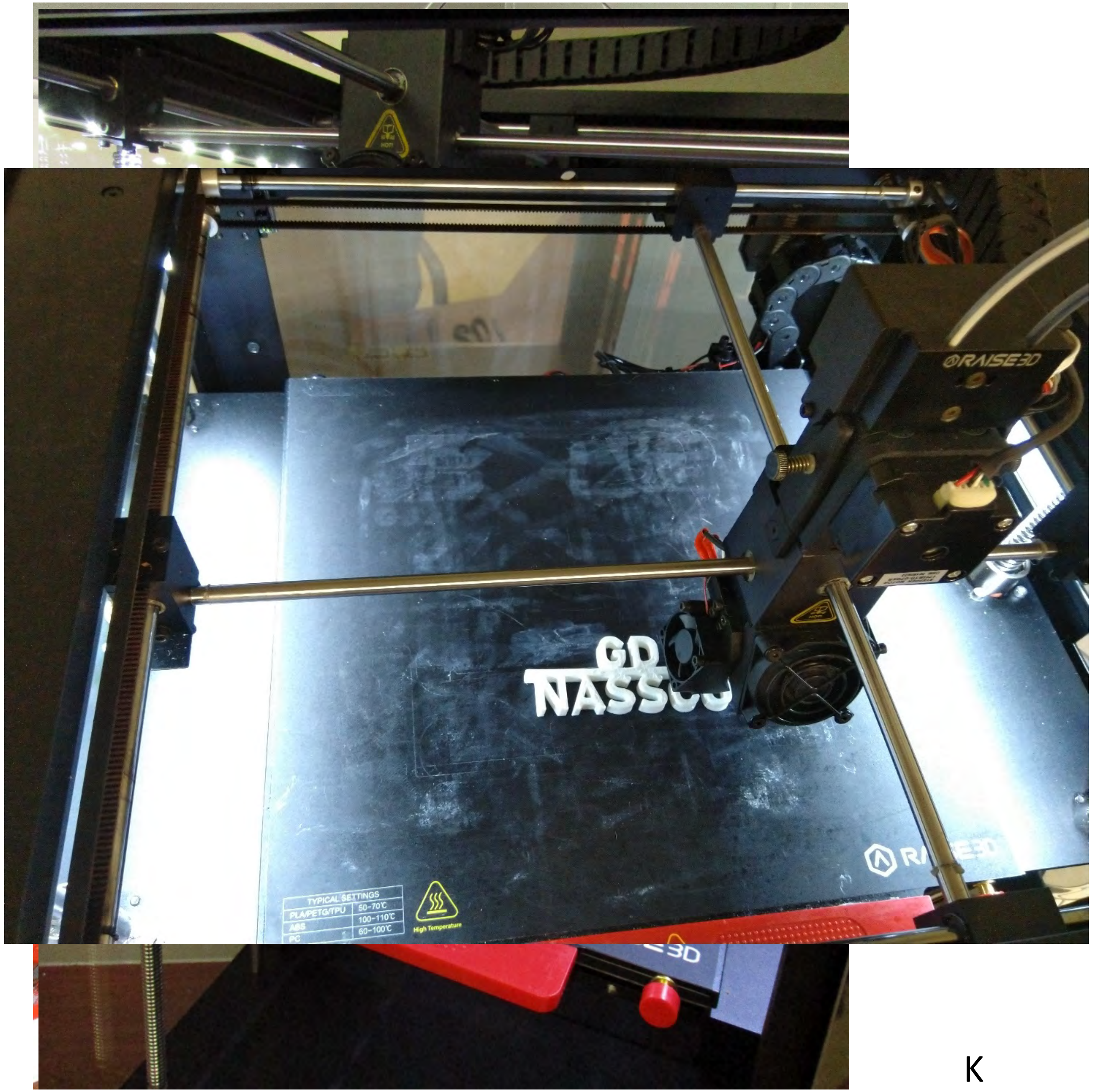
Background AM

- Additive manufacturing (AM) popularly known as 3D printing, is a technique that builds objects layer by layer from a CAD model design using materials such as polymers, metals and composites.

- This technology has been available since the late 80’s.



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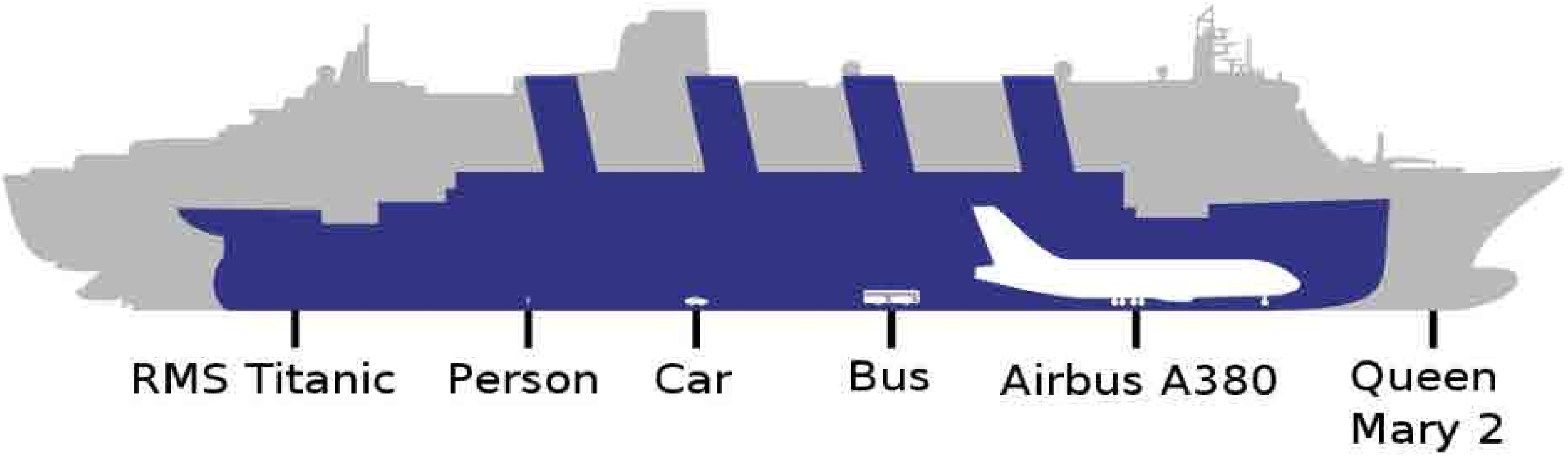
Background AM cont.

- AM offers great possibilities to accelerate design innovation, compress supply chains, reduce material and energy usage, waste and reduce cost.
- Shipyards in general have been slow to adopt the technology.
  - This is due mainly to part volume, size, material, environment and regulatory approval



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Collaboration

- NASSCO has been a member of the GD 3D Printing Team since its introduction in 2014
  - NASSCO
  - Electric Boat
  - Bath Iron Works
  - Gulfstream
  - Jet Aviation
  - European Land Sys.
  - Land Systems
  - Mission Systems
  - Information Tech.

Team Charter
Share 3D-printing knowledge and lessons-learned among GD business units
Share successes to inspire new ideas, and failures to prevent repeats
Share equipment capacity to maximize use of resources
Discuss challenges and work toward common solutions
Partner on research and development efforts, where applicable
Influence corporate strategy by defining what is possible

- This Project in part was funded by the National Shipbuilding and Research Program (NSRP)
  - Selected as a panel project in 2020
  - Outcome of sharing how AM could be adopted across the USA shipbuilding community in the chosen area of focus.

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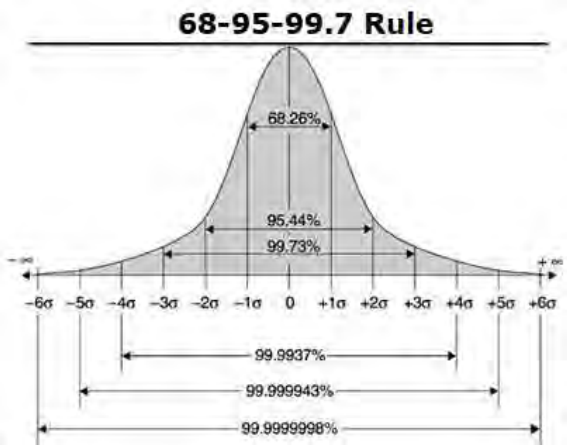
Project Approach Lean Tools: DMAIC

- **DMAIC** *(an acronym for Define, Measure, Analyze, Improve and Control)* refers to a data-driven improvement cycle used for improving, optimizing and stabilizing business processes and designs.

- The DMAIC improvement cycle is the core tool used to drive **Six Sigma** projects. However, DMAIC is not exclusive to Six Sigma and *can be used as the framework for other improvement applications..*



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Define Phase

- Problem Statement (condensed)
  - The design and procurement of small jigs/ tools/ fixtures/ prototypes/ templates/ mock ups and maintenance part substitutions using traditional methods is costly and turnaround times from order to receipt were excessive.
- Objective Statement (condensed)
  - The goal is to develop a clear methodology and a proven process that incorporates in-house additive manufacturing capability to develop cost effective and timely solutions in the target areas where opportunities exist on current commercial and navy contracts.
- Scope Boundaries (clarification)
  - Applicable additive solutions to be in plastic/polymer that satisfies customers
- Metrics
  - Labor hrs, material cost and cycle time
- **Depts Involved**
  - Metrology, Layout Department, Engineering and Weld Services,
- Timeframe
  - Year 2020

LEAN PROJECT STATEMENT

Project Title: Additive manufactured solutions in the shipyard for job aids, consumables and part prototypes	Project Number: Start: Feb 2020	End: Dec 2020
Champion: W Tschernkowitsch	Lean Specialist: S Murray	
Vice President: Bill Cuddy/Steve Davison	Department No.: 12	

PROBLEM STATEMENT

Expensive metrology tools and equipment are typically purchased externally from limited vendors with recurring costs. These consumables typically have a high cost per part and tend to have single-source suppliers with long lead times.
In the shipboard detail part of the design process, there is negligible prototyping done; typically drafted 2D drawings are created, which do not allow a more practical look and feel of the intended part design. Few parts that do turn into 3D prototypes tend to follow the same approach as normal part procurement and manufacturing processes with long lead times. This can stifle the creative design process and iterative approach to optimize designs.

OBJECTIVE STATEMENT (Specific, Measurable, Attainable, Relevant & Timely)

The goal is to develop a clear methodology and a proven process that incorporates in-house additive manufacturing capability to develop cost effective and timely solutions in the following target areas where opportunities exist on current commercial and navy contracts. We will target material savings in Weld Services, Metrology, Layout Department and Engineering.

1. We anticipate to utilize the additive manufacturing technology with these specific (and similar) parts and examples:
   a. Draft Mark templates for new hulls
   b. SHCM (special alignment points) check gages
   c. SHCM (special alignment points) layout gages
   d. Corner Jig SMR holder – Metrology
   e. Facility check jigs (rails all sizes) – Metrology
   f. Transfer pucks (consumables) – Metrology
   g. Corner / Edge pin nest for SMR – Metrology
   h. Weld and Bevel size check gages – Welding
   i. Koike Arm Bracket – Weld Repair
   j. Spacer parts for suitcase wire feeder
   k. Koike track running wheel – Weld Repair
   l. Universal Template knobs/parts
   m. Weld machine exterior parts (obsolete)
   n. Plate shaping templates (Production)
   o. Prototypes and Mockups (Engineering)
   p. Various templates and jigs for Layout

There may be an opportunity in using additive manufacturing as temporary solutions to support Test and Trials activities and reduce wait times. The scope of this project does not include the use of additive material to replace original design ships parts that require certification and material testing or other approval procedures required by external customer.

PROJECT METRICS

- **Primary metric (Labor hours, Material Dollars, Cycle Time):**
- **Are there any consequential metrics?** We do not have an established process for additive manufacturing at NASSCO so we are creating a level of risk in the implementation. There is potential risk that some end use parts may require engineering calculation or analysis to prove acceptance

FINANCIAL OPPORTUNITIES

- **Labor Savings (initial estimate): TBD**
- **Material Savings (initial estimate):TBD**

SUPPORT DEPARTMENTS REQUIRED	TEAM MEMBERS	
1)Kelly Christiansen (Steel/Layout/AC)	4) Bernardo Vasquez (ENG)	7) Steve Ong (Layout)
2)Wesley Downes (Eng)	5) Mike Murphy (Weld Services)	8)
3)Marcelo Gamez (Eng)	6) Adan Rodriguez (A/C)	9)

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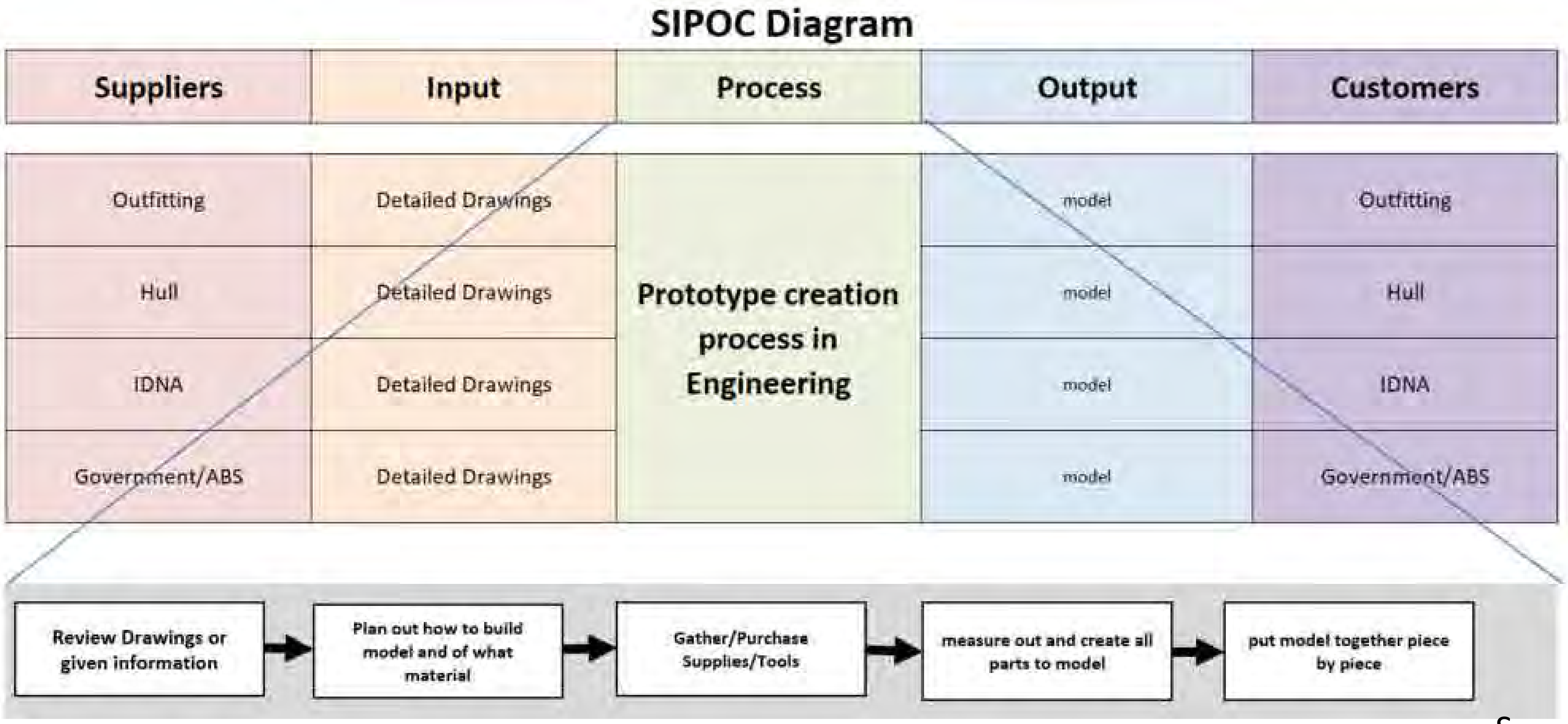
DMAIC: Define Phase

- Develop SIPOC (Engineering)
  - Process to create prototypes



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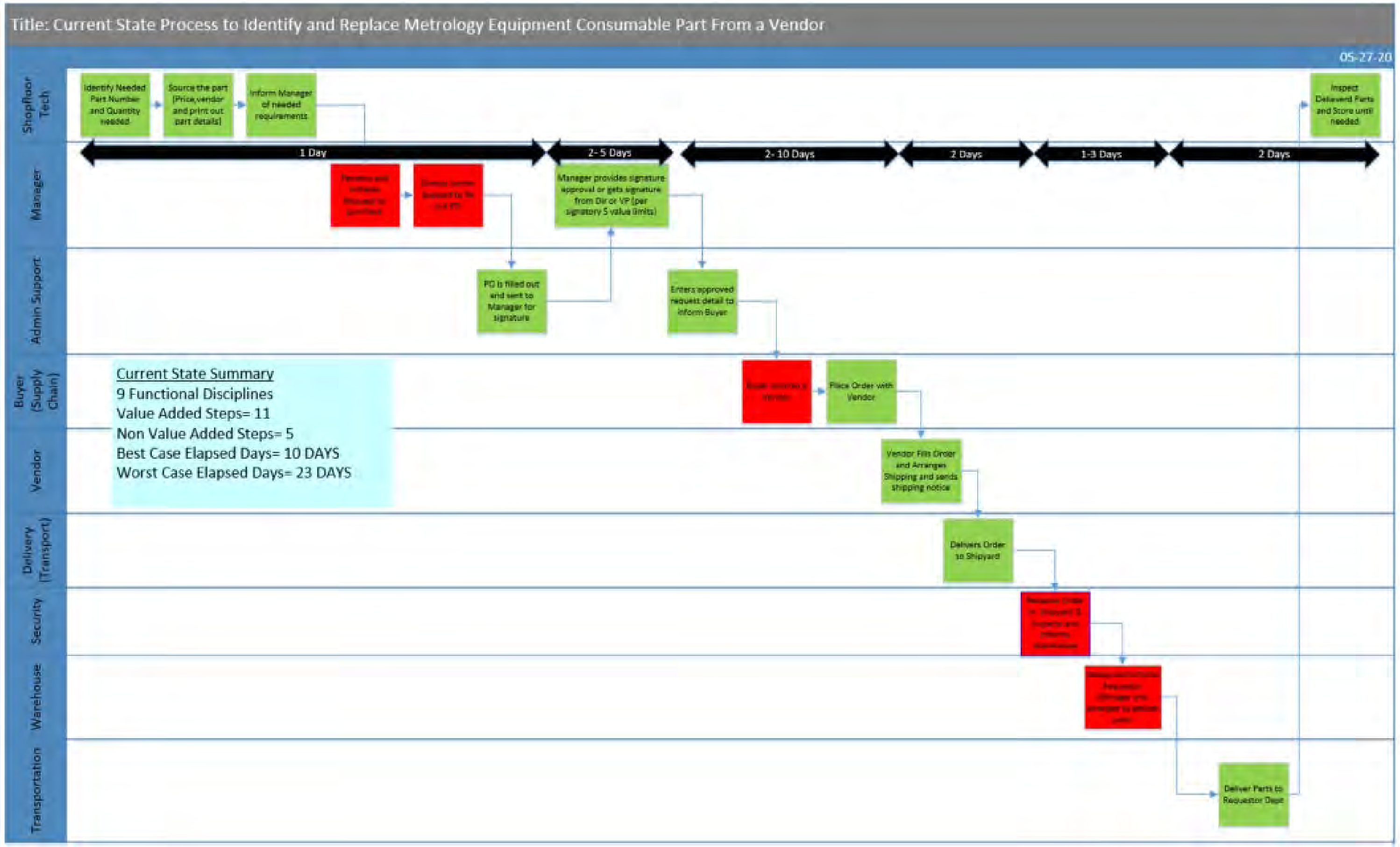
DMAIC: Measure Phase: Process to secure metrology and weld service spares (Shipyard) sim for prototypes (Engineering)

- Develop Current State Map (Shipyard and Engineering)
    - And Value Analysis

<u>Current State Summary</u>
9 Functional Disciplines
Value Added Steps= 11
Non Value Added Steps= 5
Best Case Elapsed Days= 10 DAYS
Worst Case Elapsed Days= 23 DAYS



- Value Added Activities
    - PO filled and approvals
    - Place order
    - Fill order
    - Delivery of parts
- Non Value Added Activities
    - Research
    - Inspection
    - Storage
    - Other administration

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DMAIC Measure Phase : Summary of the 3 Predominant Processes

- Summary: Elapsed Days, Functional Disciplines , VA/NVA Steps

Process	Range of Elapsed Days	Count of Functional Disciplines	Count of VA, NVA Steps
1. Source metrology spares from a vendor (1 and 3 Sim) (Shipyard and Engineering)	10-23	9	11,5
2. Source Prototypes/ Mock Ups (Engineering)	12-22	4	12,2
3. Source production support/marketing parts from a vendor (1 and 3 similar) (Engineering and Shipyard)	10-23	9	11,5

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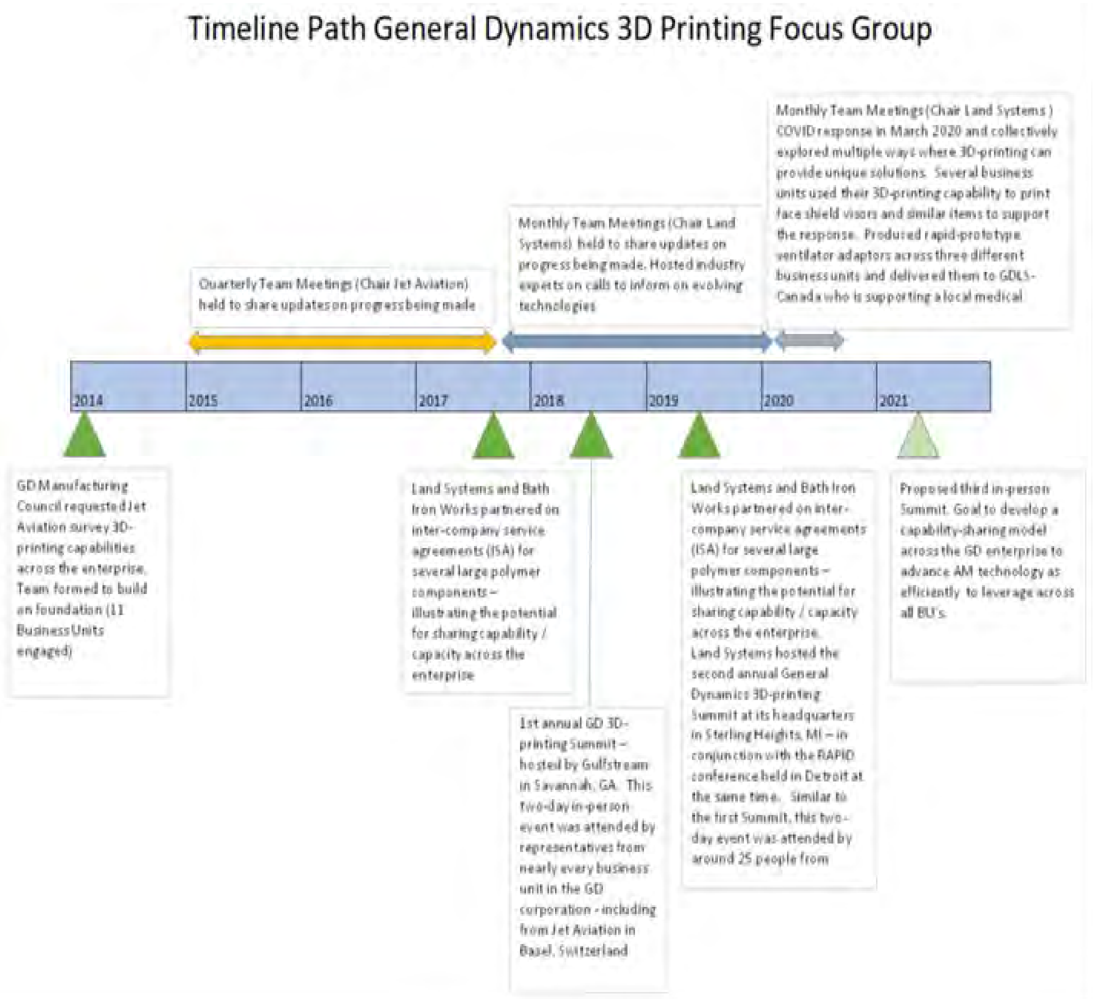
DMAIC Analyze Phase 3D Printing Group

- Role of the 3D Printing Group To give the eyes to the Enterprise to see
    - Cross BU (around 9 BU members 40+ participants on monthly calls)
  - NASSCO member since 2014 (Eng Reps Only)
    - 2017 Manufacturing Engineering and Operations joined with Engineering

- Benefits to NASSCO
  - Group collaboration (Accelerated Learning Curve)
    - Understanding of AM practical examples
    - Understanding of AM technologies
      - Available and affordable equipment
    - Expertise to draw from to provide direction, and get our "toe in the water"



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DMAIC Analyze Phase   AM Benefits

- Benefits of Additive (and Industry research)
  - **Reduces cost (shipyard and engineering)**
  - **Reduces the amount of steps in a process (shipyard and engineering)**
  - **Reduces the amount of steps in a prototyping or mock up process (functional / early engineering)**
  - **Reduces production delays when existing fixtures break (shipyard)**
  - **Reduces the amount of steps in a sourcing process (shipyard and engineering)**
  - Reduces the need for manual assembly
  - Reduces material waste
  - Reduces weight
  - **Reduces Lean Wastes (See later Reference 8 LEAN WASTES “DOWNTIME”) (shipyard and engineering)**
  - Reduces inventory (low volumes versus traditional minimum order sizes)
  - Reduces the amount of distinct parts
  - Reduces the range of materials required
  - **Reduction of Lead Times internally or externally (shipyard and engineering)**
  - **Flexibility to design solutions to meet customer needs (shipyard and engineering)**
  - **Flexibility to support “one off” solutions that suppliers did not offer a specific solution without long design cycles , minimum batches with hi-set up costs (shipyard and engineering)**

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DMAIC Analyze Phase Why Not Ships Parts

- NASSCO and Industry Process constraints
- Require qualification and approval by Regulatory Bodies such as ABS and Navy
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DMAIC Analyze Phase

- NASSCO Business Environment (Constraints) affecting AM technology integration
- Capital expenditure was limited, initial investment had to be very modest in AM
- Senior Management was not fully educated about the potential and capabilities of additive manufacturing ,hence tentative "buy-in" and not a longer term investment plan yet considered
- There weren't too many implemented additive solutions in the Marine Industry to tout as meaningful examples with cost savings data or proven business benefits that could motivate rapid change
- Non-existent R&D capability in the shipyard, this was going to be the Team's second or third job by a handful of enthusiastic Team members who were interested in the potential and could provide a meaningful case to propose to Management to get equipment funding
- NASSCO In house engineers had non-existent design development experience in 3D printing design, modeling and technology. Shipbuilding designs tend contract to contract to be a "copy and paste" preferred approach with reluctance to significantly change designs without a good deal hand wringing and significant investment in shipyard design resources.

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DMAIC Analyze Phase

- NASSCO Business Environment (Constraints) affecting AM technology integration
- The NASSCO shipyard facility due to a favorable year round climate is open air for the most part, which would preclude the use of large-scale 3D printing capabilities unless built into clean environment. CAP-Ex Investment was not prioritized which precluded the case for larger build volumes and potential for metal additive manufacture
- Risk averse mentality , typically we would adopt a crawl before walk before run philosophy on new technology
- MRP system tools are 40 years old , with considerable number of patches to make them run and interface with other business tools

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Analyze Phase

- NASSCO Business Environment (Constraints) affecting AM technology integration
- "Never the right time" to introduce part re-designs due to long initial Contract design lead times, following short design rollovers from Hull to Hull ,mixed with in-process manufacture of current Contracts and Hulls.
- Supply Chain buyers at NASSCO did not have Additive Manufacturing experience or confidence to changeover to nontraditional solutions to part procurement at short notice
- Reluctance to move away from traditional and familiar buyer/ supplier partnerships
- Existing Certification authorities ABS, NAVSEA. USCG had no real run time with AM to issue design rules, material certification, quality standards or testing requirements to the marine industry
- There wasn't a "3D Printing Playbook" to follow, which added to risk concerns and conservative investment upfront

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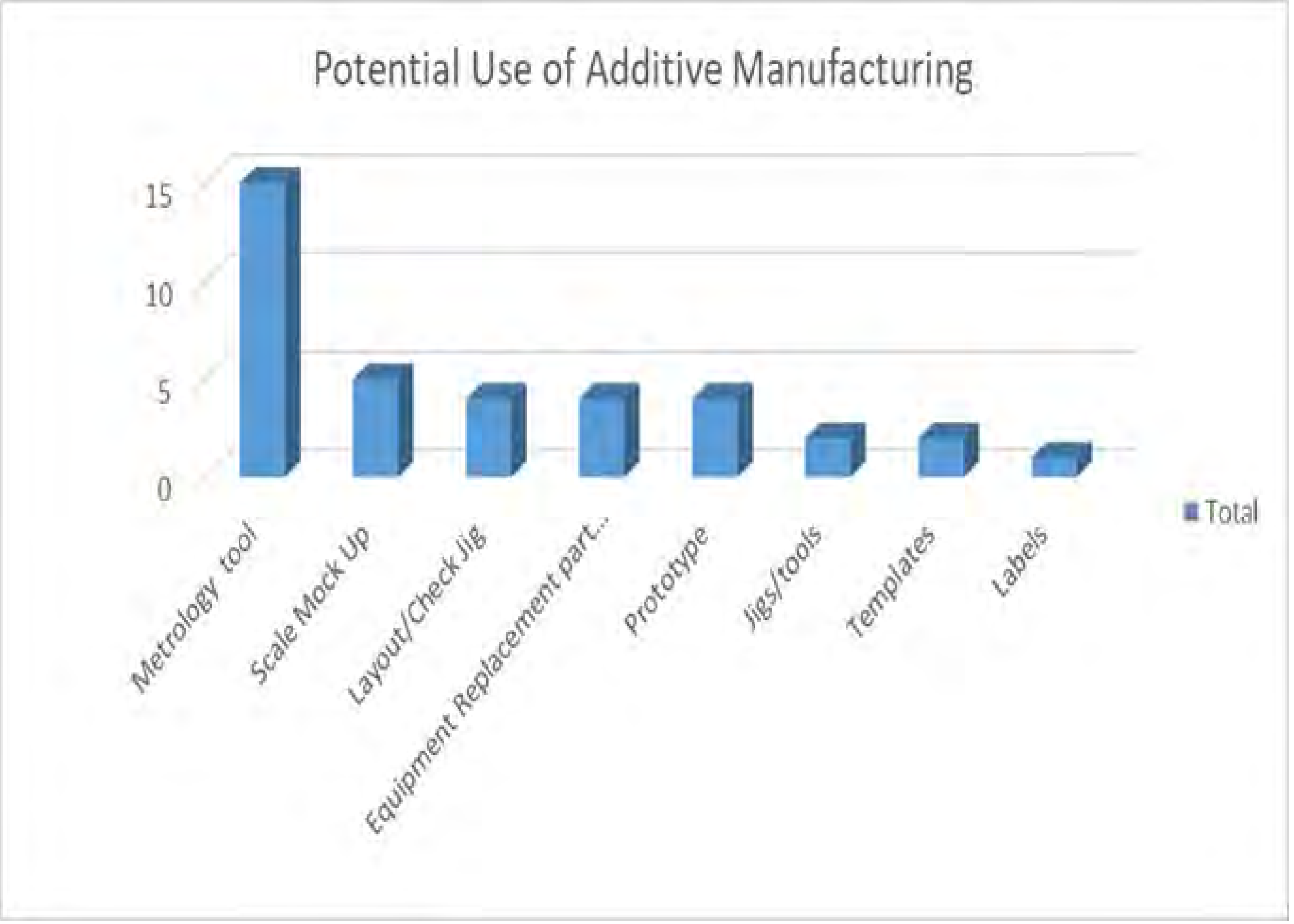
Analyze Phase

- GEMBA "the real place " Shipyard and Engineering Walks by the Team
  - To identify AM opportunities
  - Two hours weekly over six weeks overall (Shipyard and Engineering)
  - Six primary production areas in the shipyard, Fabrication, Sub-Assembly, Assembly, Block Outfitting, Grand Blocking ,Onboard , Machine Shop and Weld Service shops
  - Many potential opportunities for AM surfaced
    - Potential quick wins
    - To see results and get internal customer feedback immediately.



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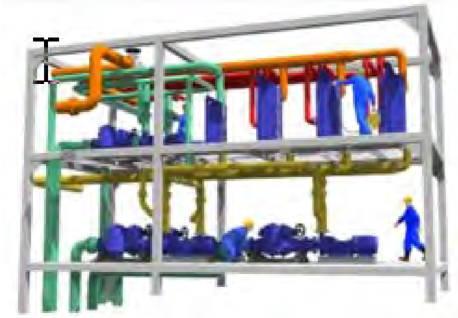
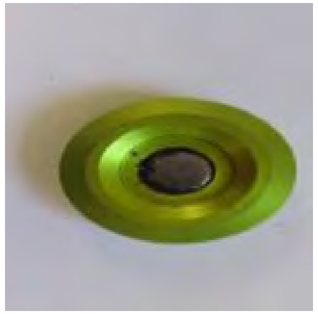
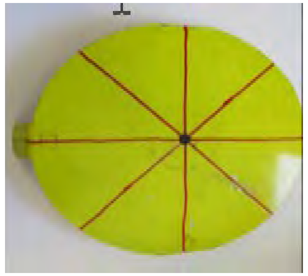
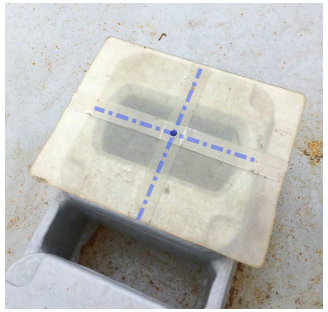
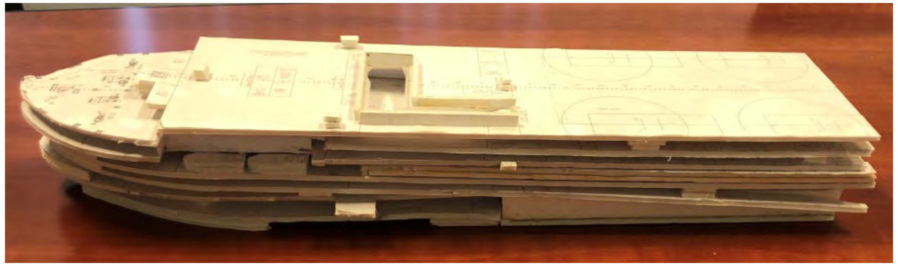
Analyze Phase

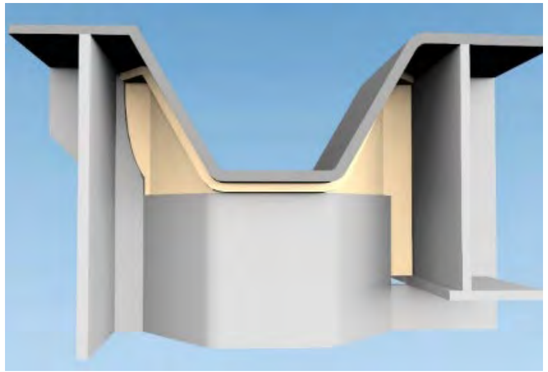
- GEMBA "the real place " Shipyard and Engineering Walks by the Team (Traditional Parts) –Potential AM Solutions





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IMPROVE PHASE   Steps

- Brainstorm of possible solutions
  - What was our rationale for the 3D Pro plus printers, number of, other equipment, material selection? (MV &Yard) (Wes)
- Value Stream Map future State
  - Supporting the key metrics to dramatically reduce elapsed days, eliminate functional disciplines involved and reduce NVA activities
- Prioritize Solutions (PICK Chart)
  - Understand which potential solutions with respect to AM (3D) introduction equating solutions as easy or difficulty to implement and payback as low or high for those that were able to be implemented by the team. additionally those items deemed as KILL (parking lot for future consideration)
- Create Improvement Plan
  - Describe those activities undertaken to introduce and indoctrinate the process
    - Describes the user request process and workflow to provide AM solutions
  - Include lessons learned on installation, training .lessons learned and examples of AM solutions

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IMPROVE PHASE Activity Timeline

01/2017 - Joined GD Additive Group

03/2018 - 1st GD Annual Additive Meeting

01/2017 - Joined GD Additive Group

03/2019 - 2nd GD Annual Additive Meeting

06/2019 - Purchased 2 Raise 3D Pro 2 Plus FDM Printers

09/2019 - Printed ESB Voids to Dial in Printer Settings on MV Printer

09/2019 - Printed Reflector Base to Dial in Printer Settings on Production Printer

10/2020 – Awarded NSRP RA Project

11/2019 - Won 2 Additive NSRP Panel Projects

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IMPROVE PHASE Evaluated 3D Technologies

- We started at the basic level of deciding which type of technology we wanted/which technology the company could afford:

- PLA – (Polylactic Acid) Fused Deposition – Nozzle lays thin layers of heated material
- SLA – (Stereo lithography) Material is laser cured in layers
- SLS/DMLS – Selective Laser Sintering, typically used for metal
- SLM – Selective Laser Melting, typically used for metal

- SLS and SLM were ruled out due to their expensive cost.
- PLA chosen over SLA as we could print multiple parts faster while avoiding dealing with the curing process time and mess associated SLA.
- SLA will probably be a future printing technology we look at purchasing specifically for printing fine detailed parts/models.
  - It was not necessary to begin our journey with, and PLA was more versatile with the material types it is capable of printing.

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IMPROVE PHASE

Evaluated 3D Equipment Capabilities and Price

- A comparison matrix was developed for the top PLA printers to aid decision making: as shown in Table 1 below:

Model	Cost	Technology	Extruder	Max Layer Resolution (microns)	Max Print Area (LxWxH) (cm)	Print Materials	Option Rank
Makerbot Replicator +	$2,499	Fused Deposition	Single	100	29.5x19.5x16.5	PLA	7
Makerbot Replicator Z18	$6,499	Fused Deposition	Double	100	30.0x30.5x45.7	PLA and "Tough"	5
Fusion 3 F410	$4,599	Fused Filament	Single	20	35.5x35.5x31.5	11+	6
Raise3D Pro2	$3,999	Fused Filament	Double	20	28x30.5x30	15	2
Raise3D Pro2 Plus	$5,999	Fused Filament	Double	20	28x30.5x60.5	15	1
Ultimaker 3 Extended	$4,295	Fused Filament	Double	20	19.7x21.5x30	10	4
Ultimaker S5	$5,995	Fused Filament	Double	20	33x24x30	10	3

- The price point of all printers was relatively the same.
- Key features desired-resulted in choice of 2 of the Raise3d Pro2 Plus Printers
- Double extruder to be able to print two materials at once. This would allow for support material to be used if we needed it for a specific part.
  - Largest build volume available to print large parts or large batches.

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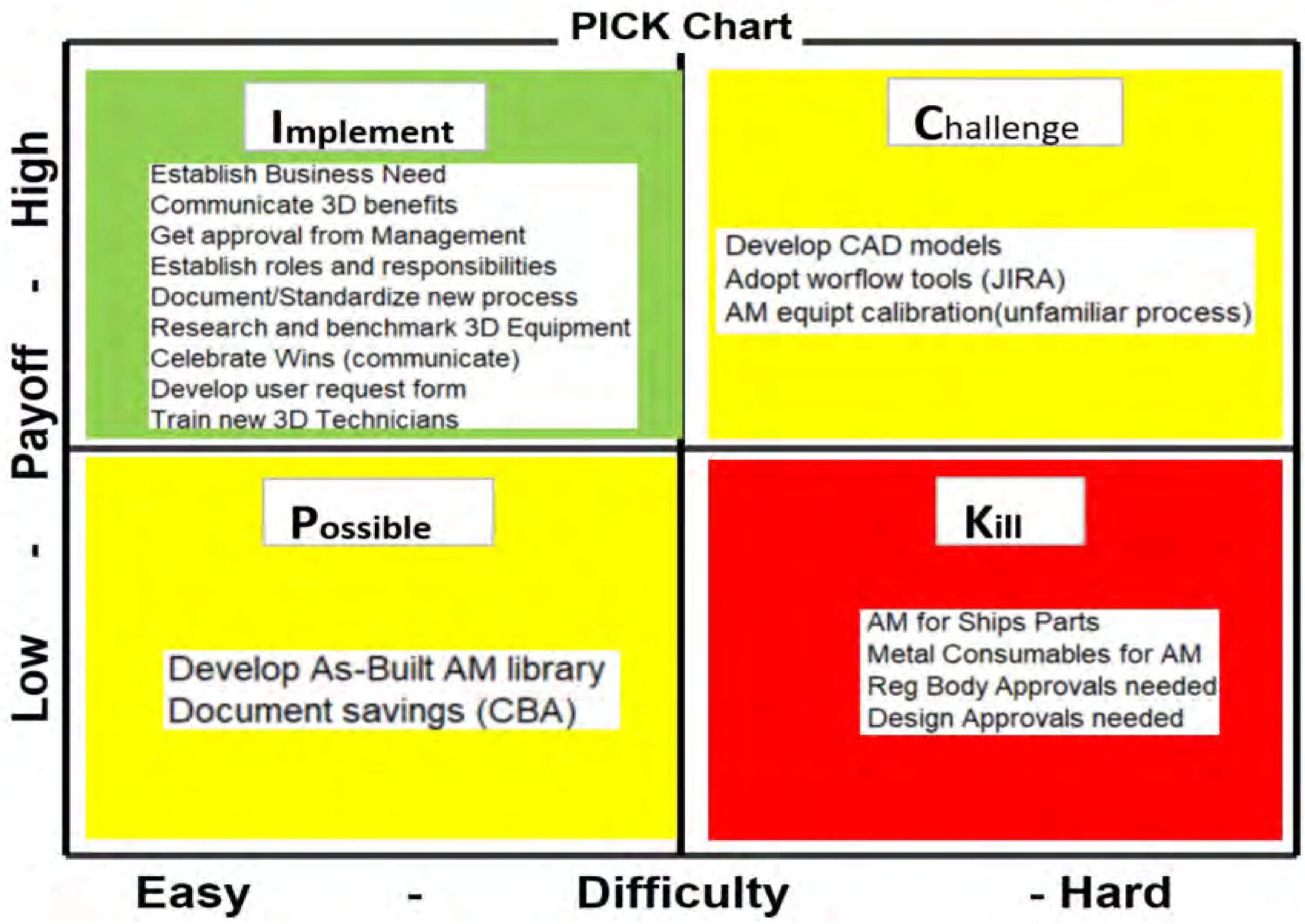
IMPROVE PHASE Prioritize Solutions

- Used PICK Chart to categorize IMPROVEMENT Ideas for inclusion or not in the FUTURE STATE PROCESS
  - X-Axis =Difficulty
  - Y-Axis= Payoff



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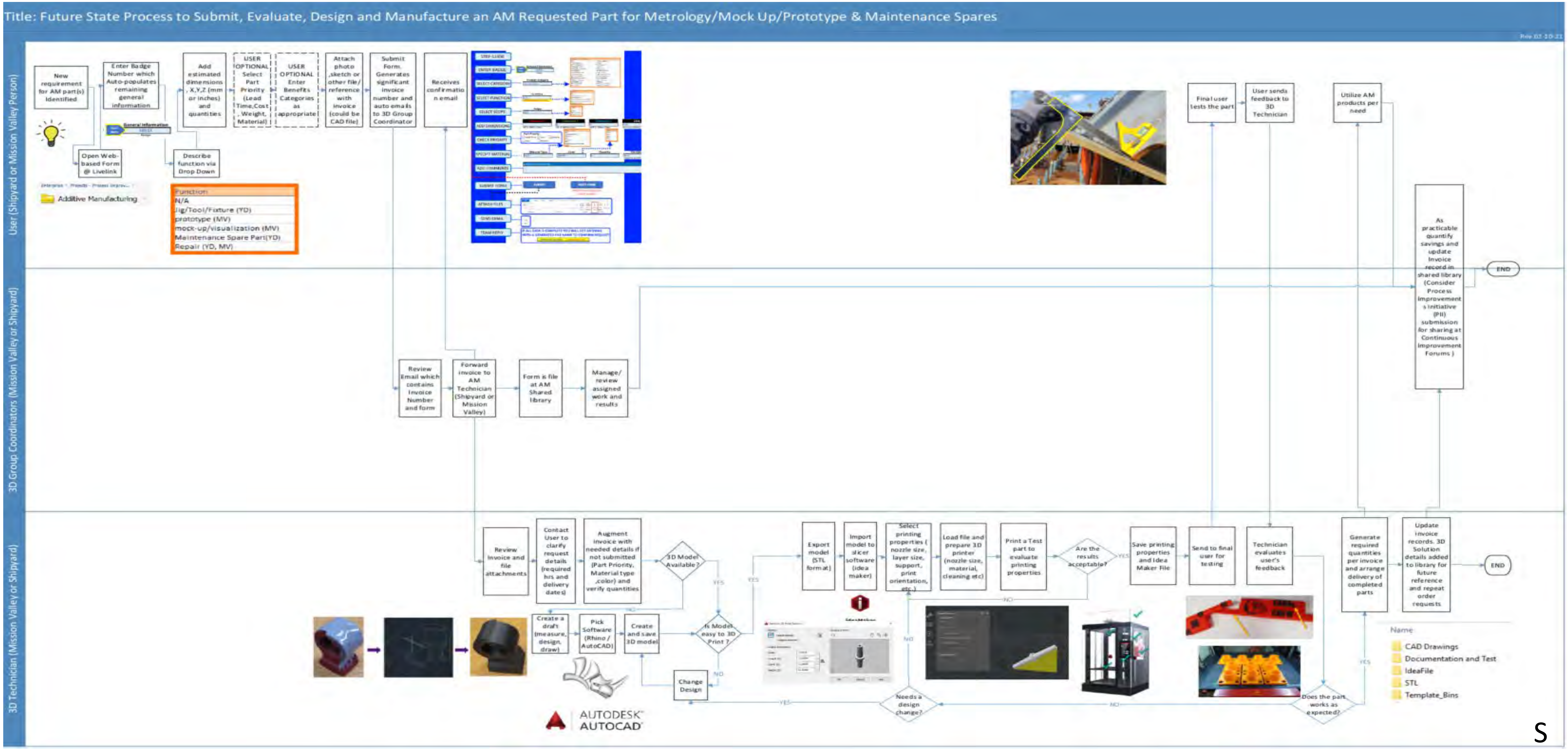
IMPROVE PHASE Future State Process Map



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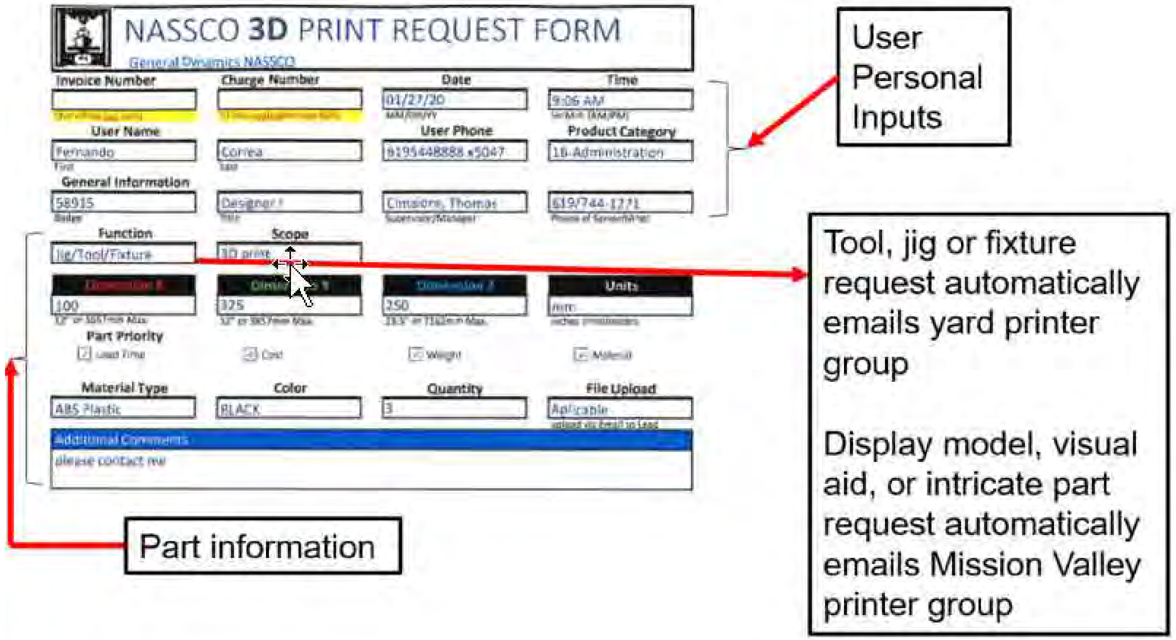
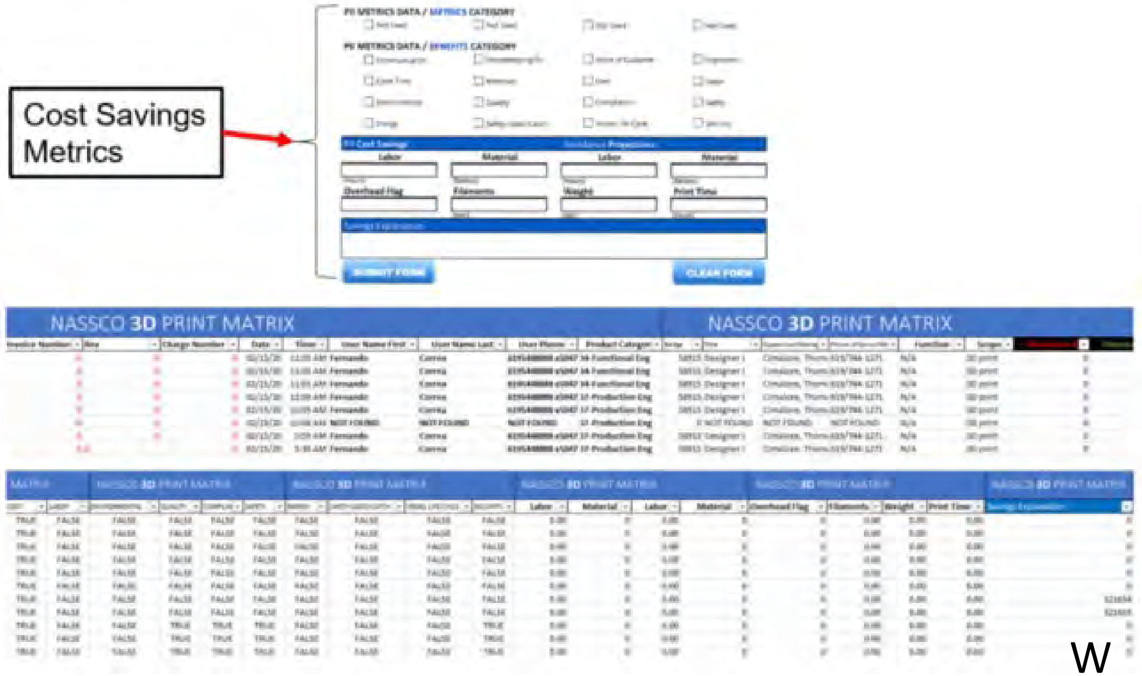
CONTROL PHASE User Request Form Process

- A user request form process was developed and communicated.
- It is intended (outstanding action to utilize JIRA workflow tools) to provide a more robust workflow process and the ability
- Collect metrics and build a library of parts for re-ordering
- Contribute to our Continuous Improvement culture ,crediting the user/originator capturing benefits and savings where appropriate





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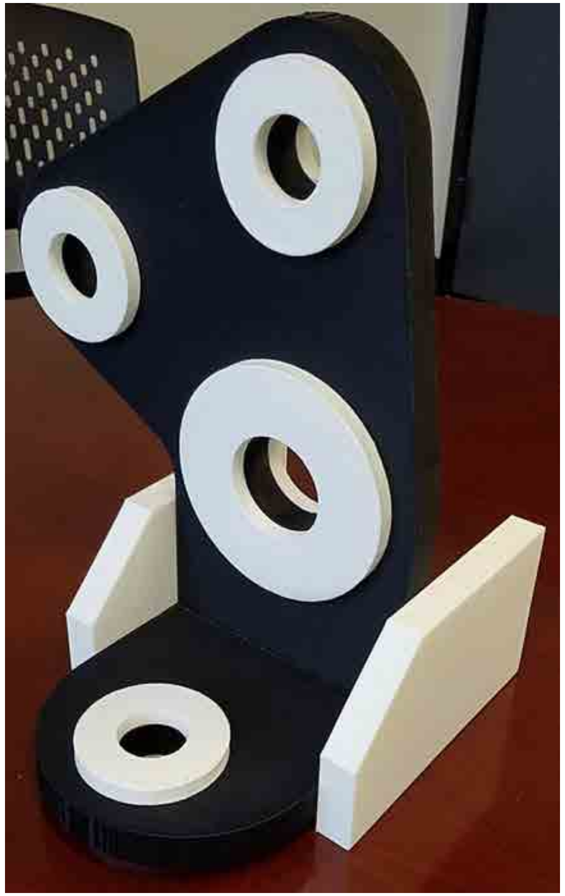
AM Examples Engineering





- **Flounder Plate**

  3D printed a to scale flounder plate which was used by rigging engineers to determine feasibility of a unique design. The unique was designed for a specific lift and turn scenario, and the riggers needed to ensure it would properly attach to their designated pick location.

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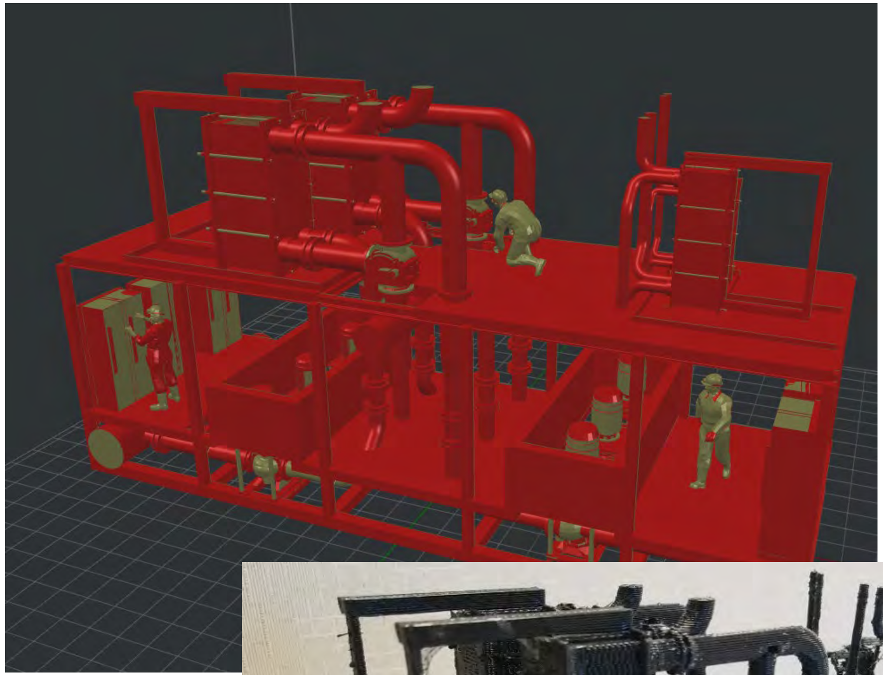
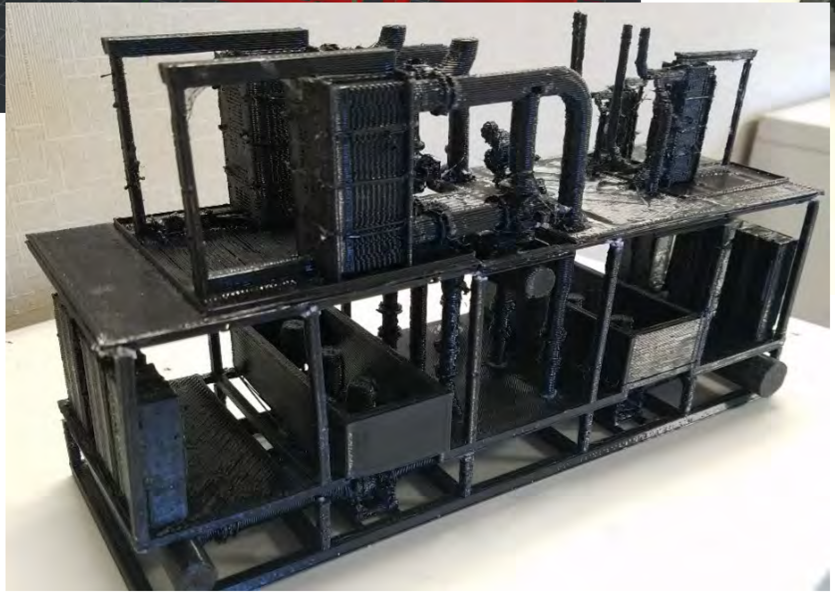
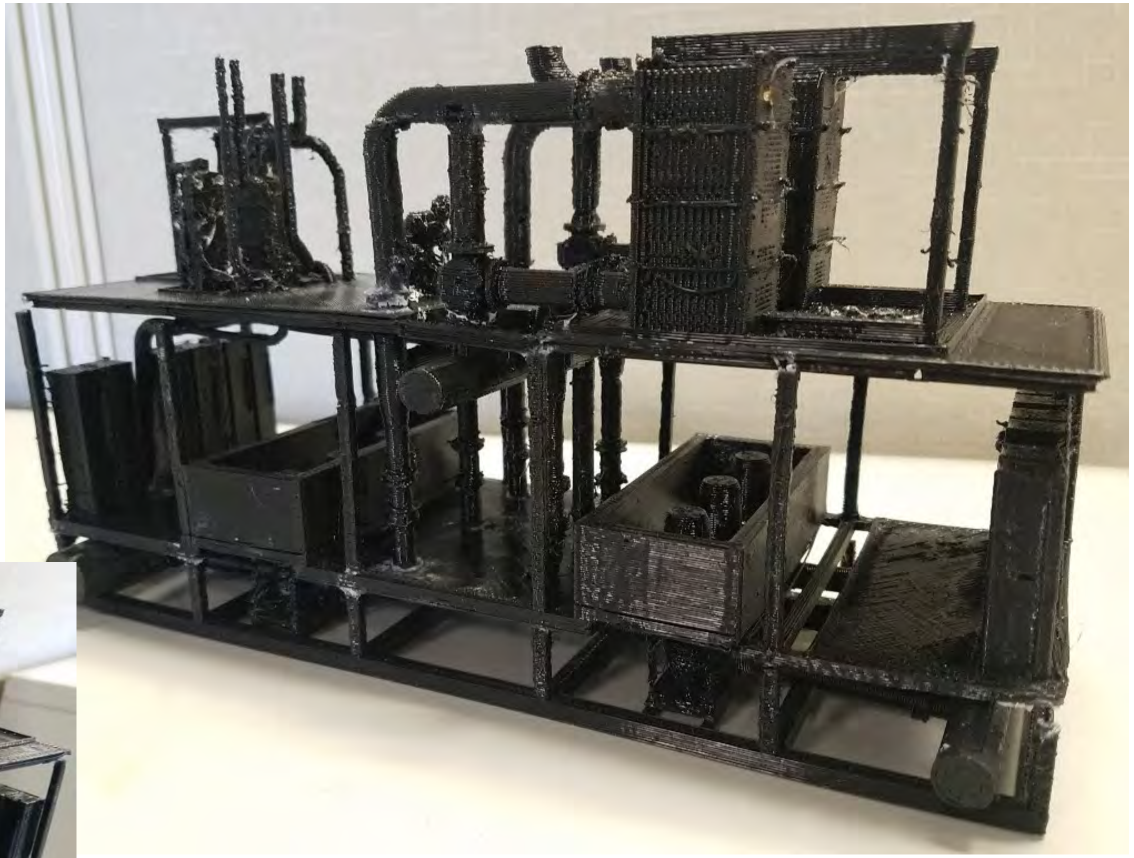
AM Examples Engineering







- **Modular Outfitting Unit**
  Printed for outfitting to gauge how it will be installed in the ship to replace current system.

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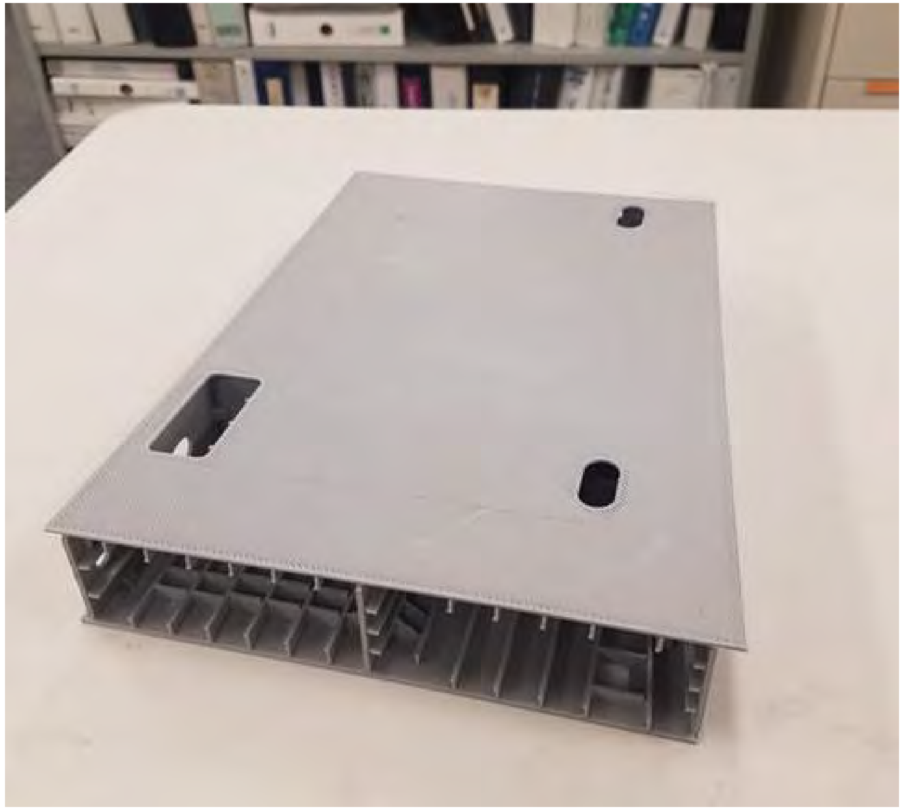
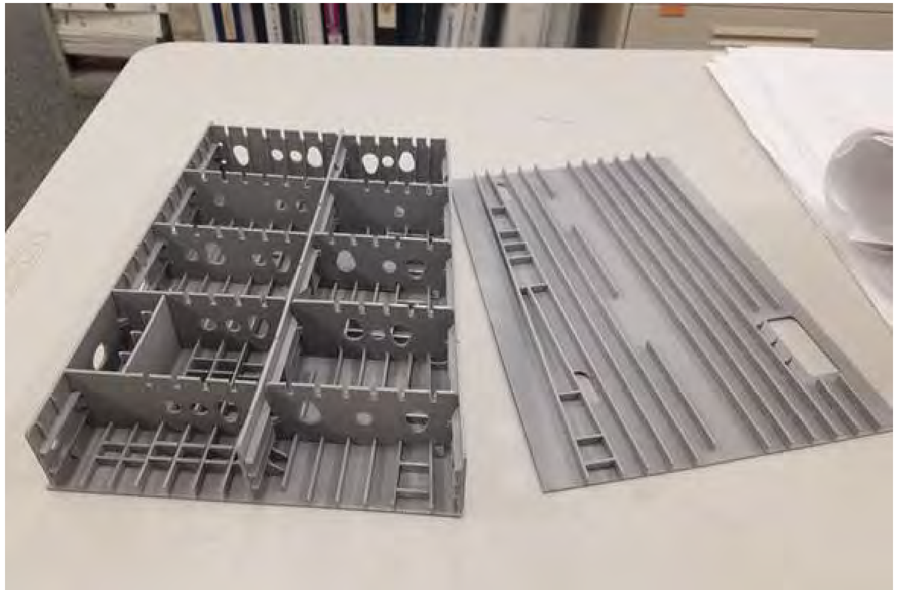
AM Examples Engineering

- **Welding School Training Block**
  T-AO Block used by the welding school for training purposes.

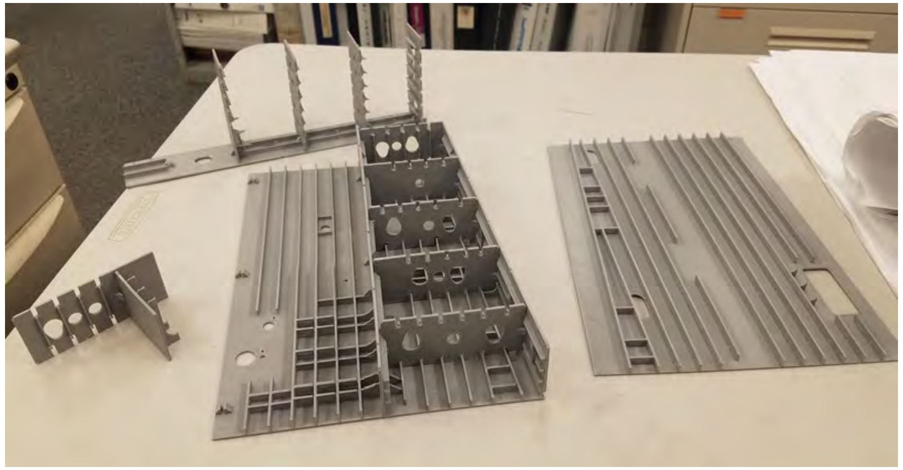
T-AO Block 224 (Inverted)





Internal View

Sub-Assembly Breakdown



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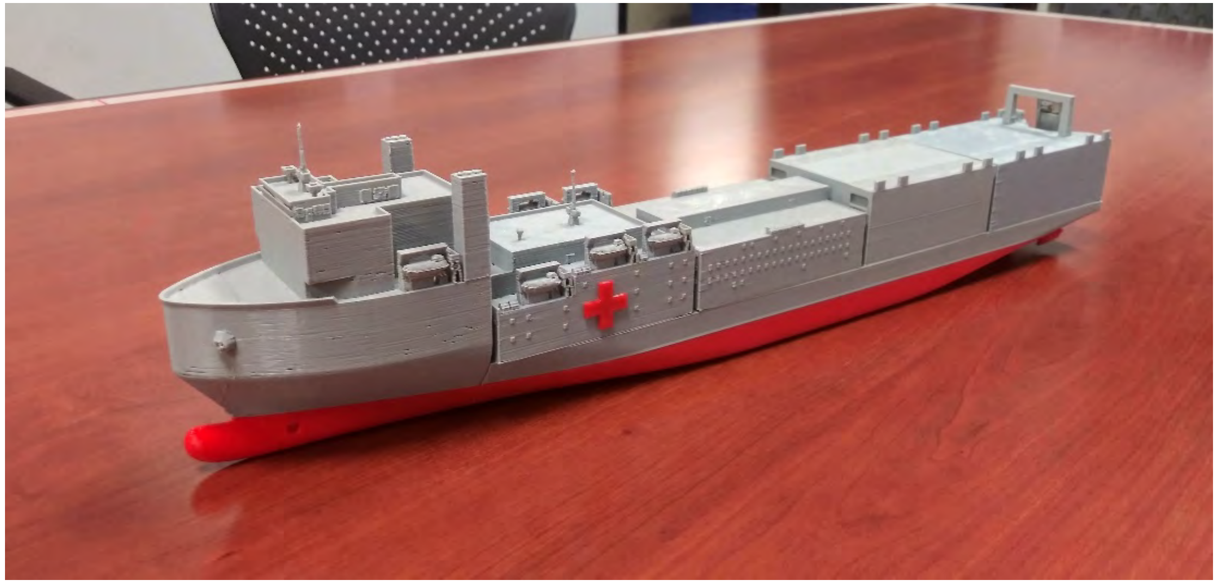
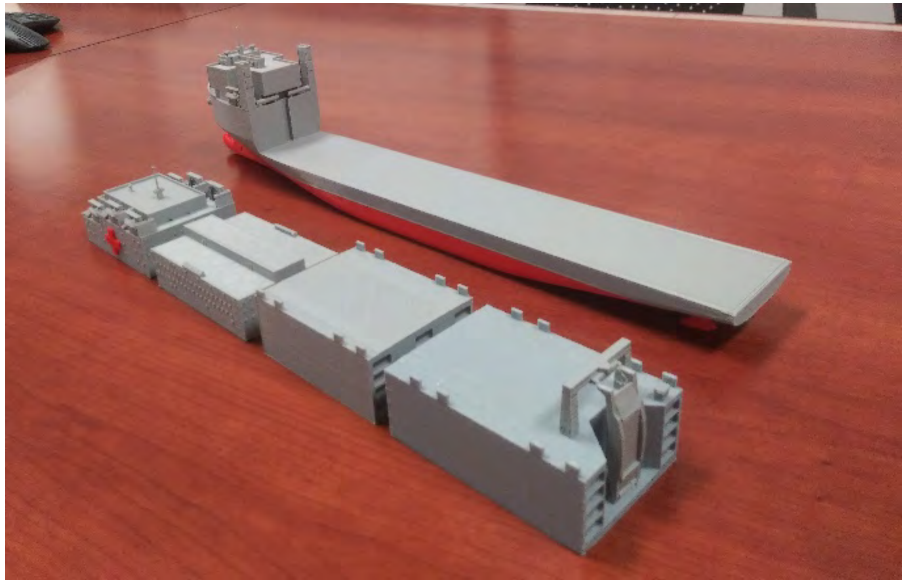
AM Examples Engineering



Future Modular Concept Design



Module Example

Additional Capabilities

- **Modular Concept Design**
  Early stage concept ship used by marketing department to promote future capabilities.

Print Design Spiral Process

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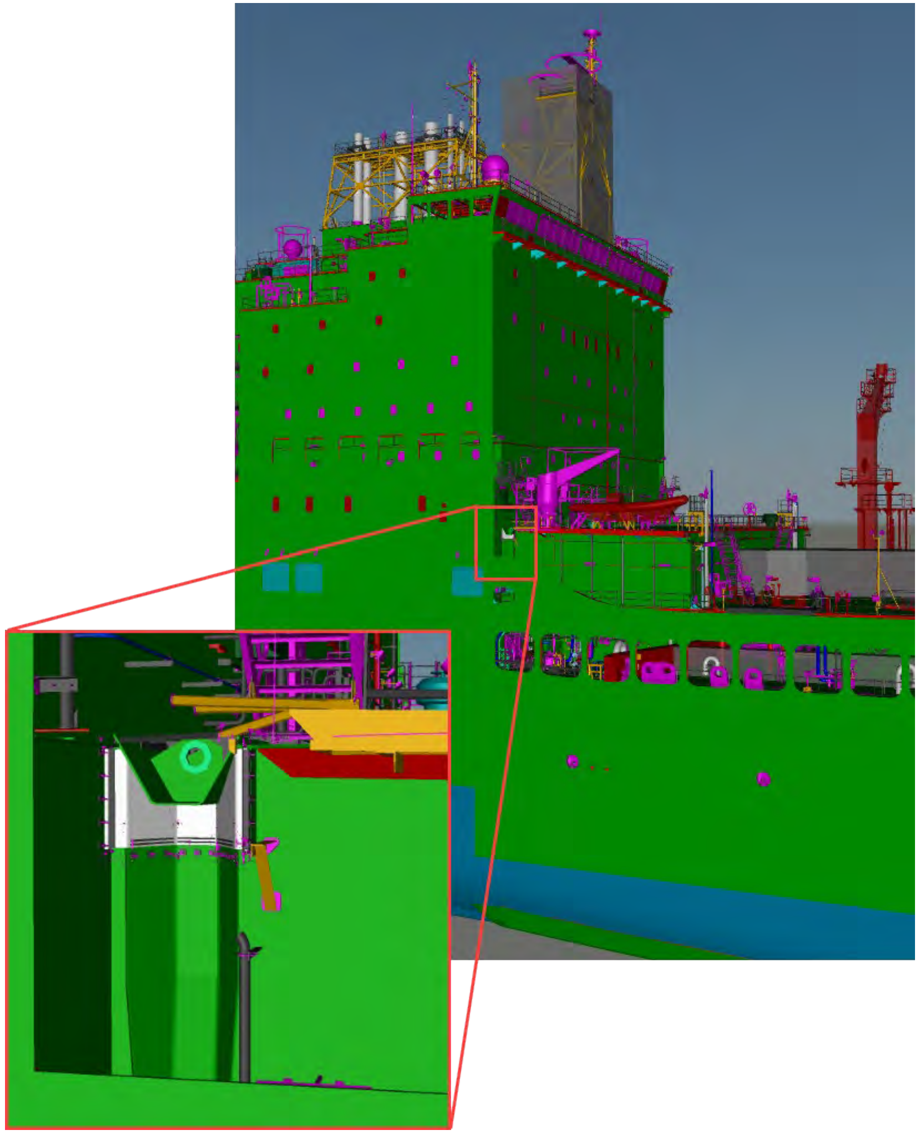
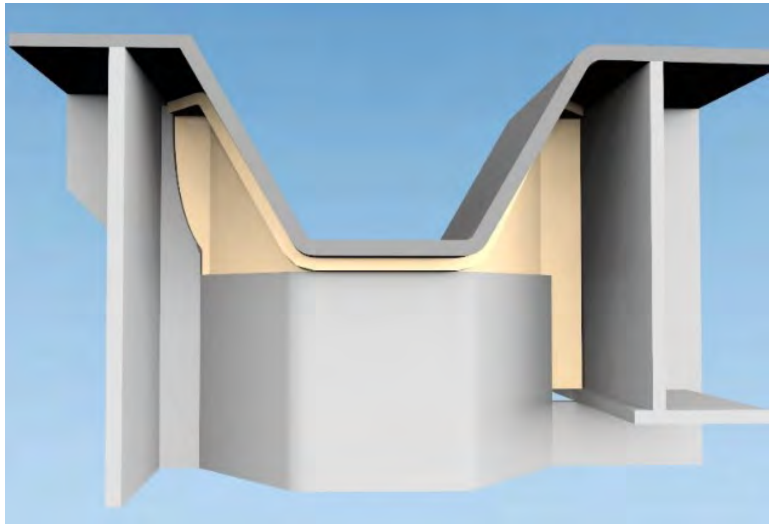
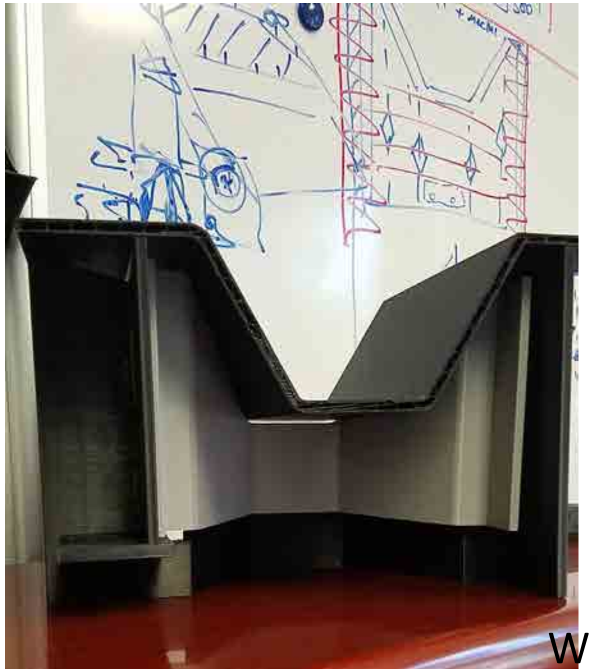
AM Examples

Engineering



- **T-AO Expansion Joint Connection**
  T-AO Expansion Joint Connection is pivotal to the ship’s operation and difficult to envision how it ties into surrounding structure. The 3D printed version was used to help with its installation.





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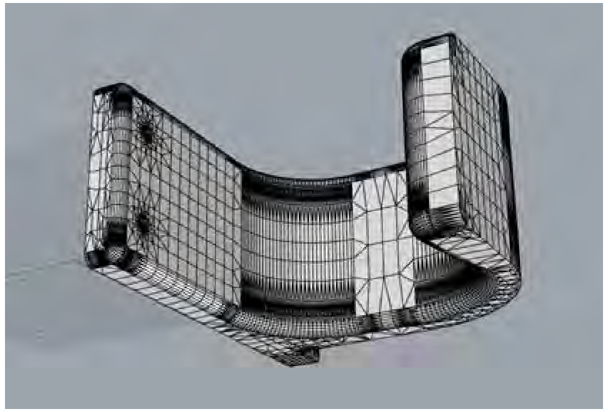
AM Examples

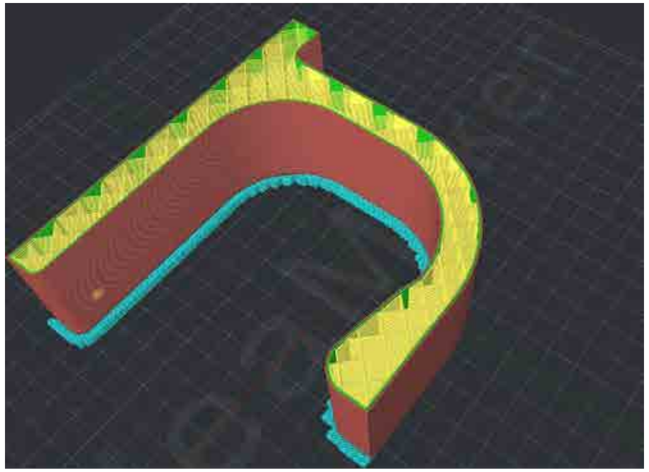
Engineering

- T-AO Expansion Joint Video

AM Examples Covid 19

- Sanitary Door Handle





Each handle cost $100 to purchase online, but only $3 to 3D print.

- **Sanitary Door Handle**
  Sanitary door handle that allows the user to open the door without touching the handle and spreading germs or viruses.

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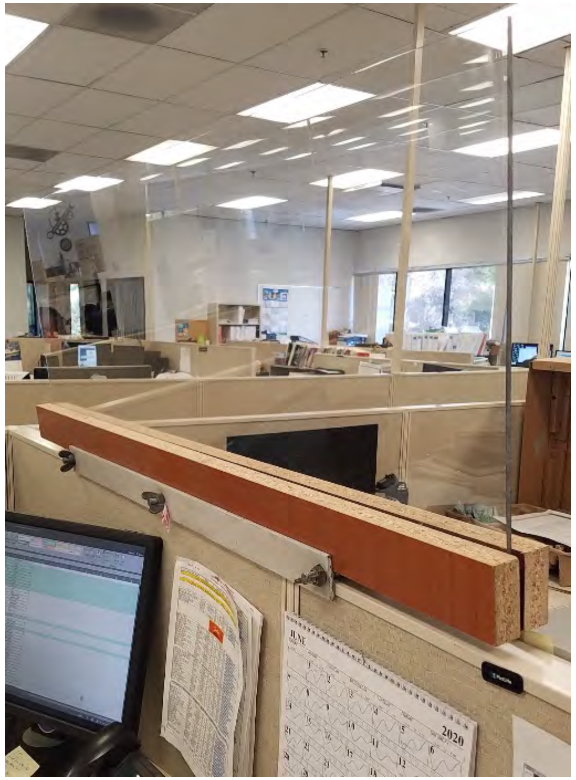
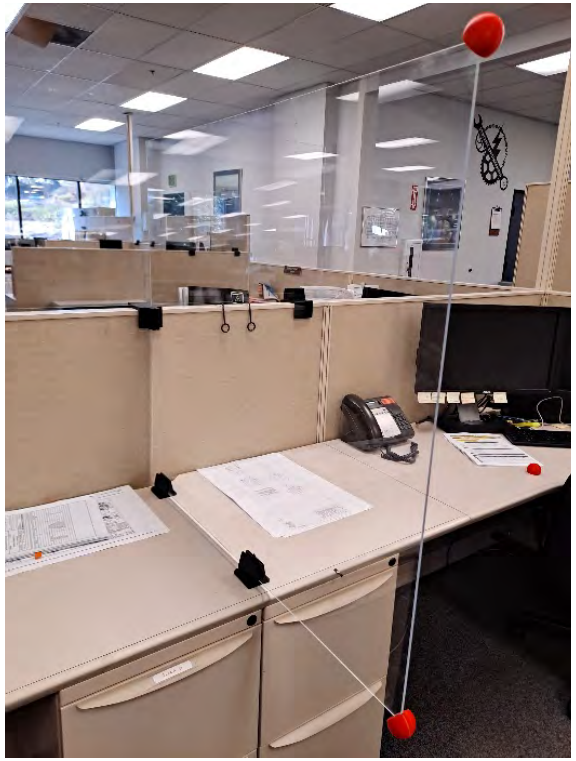
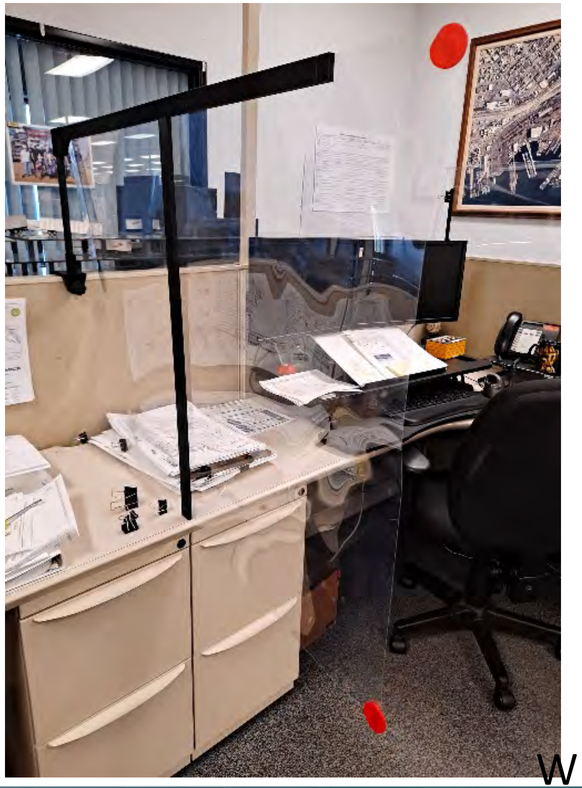
AM Examples Covid 19

- Connectors and protectors for Plexiglas virus barriers







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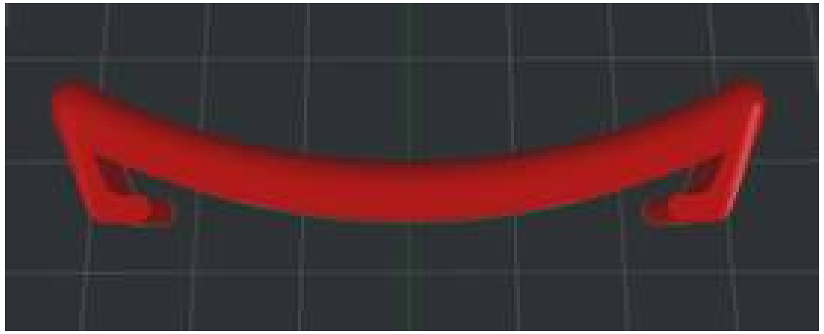
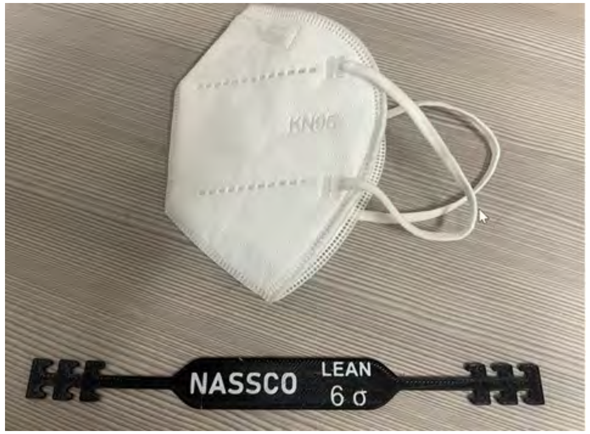
AM Examples COVID19

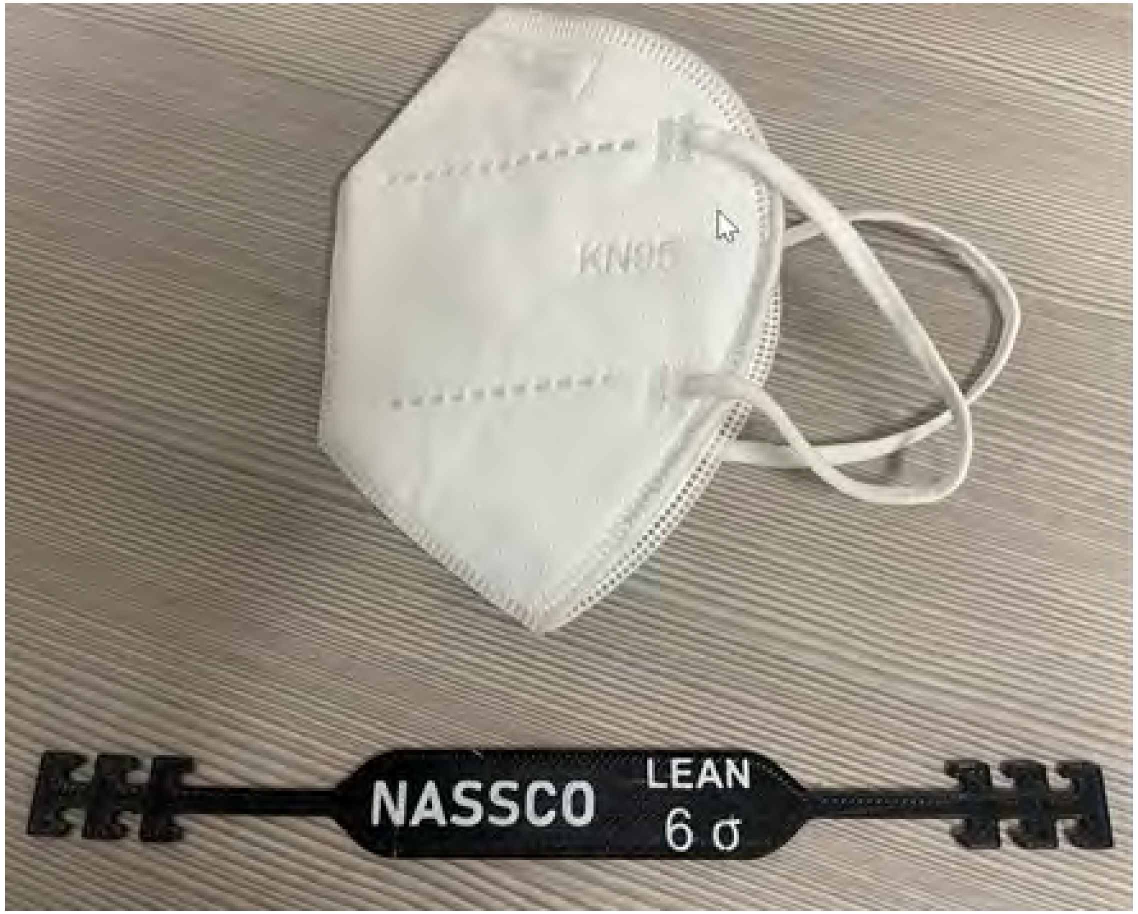
- Mask Connector- TPU PolyFlex





AM Examples Covid 19

- Mask extender clip



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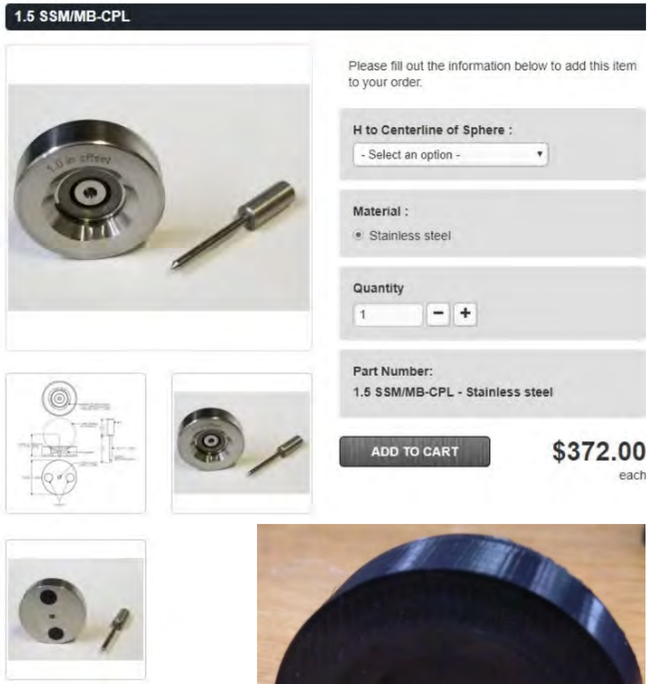
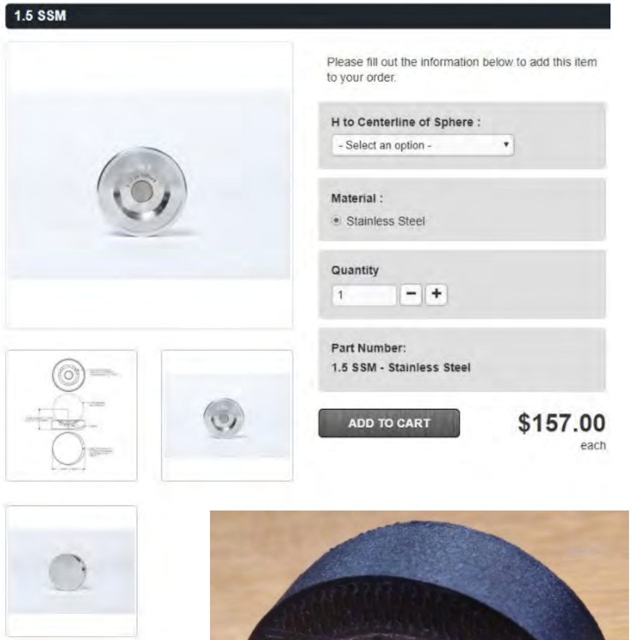
AM Examples   Production

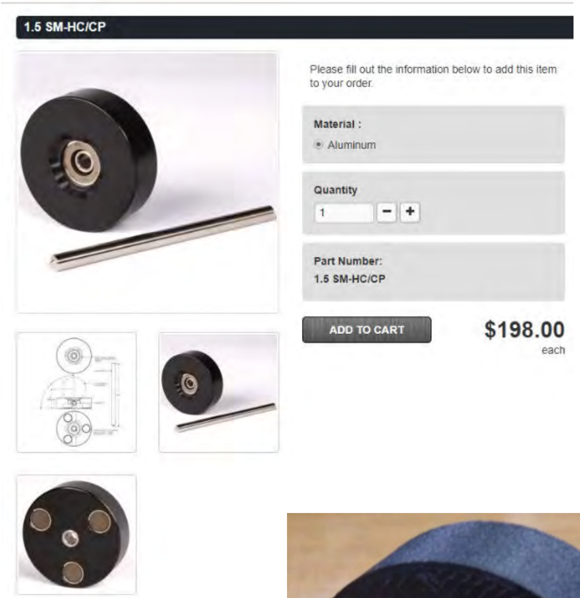
- **Reflector Base**
  - Used with metrology equipment to hold SMRs (spherical mounted reflector). Using 3D printing we can create our own designs and replicate the originals for a small fraction of the original cost while maintaining an acceptable accuracy.



Small Pen Nest



Plain Nest



Center Punch Nest

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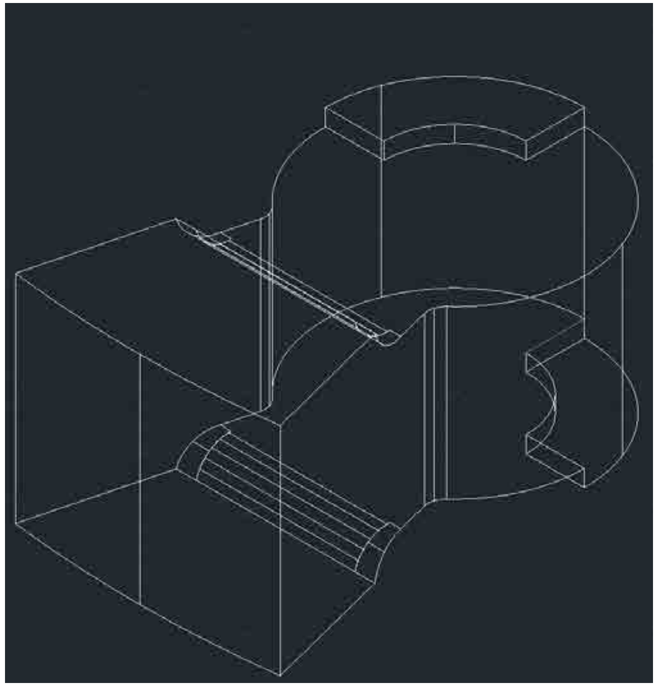
AM Examples
Production

Spare part for Crane

- Original pieces is discontinued
- Nonconductive material is required
- Original price: 10 hours machine shop + material
- 3D Printed: $1.00 (printing time 2 hrs.)



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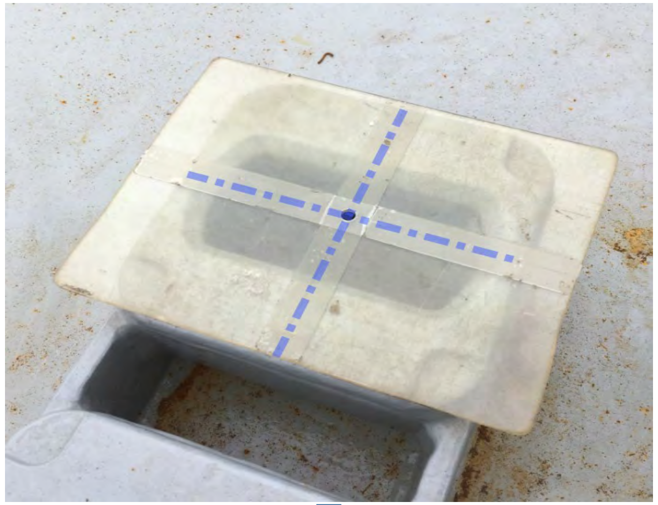
AM Examples

Production

Socket Jig



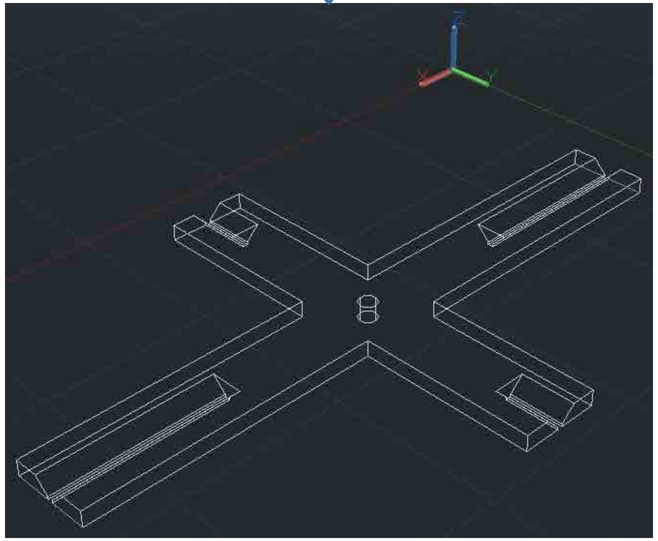
- **Socket Jig**

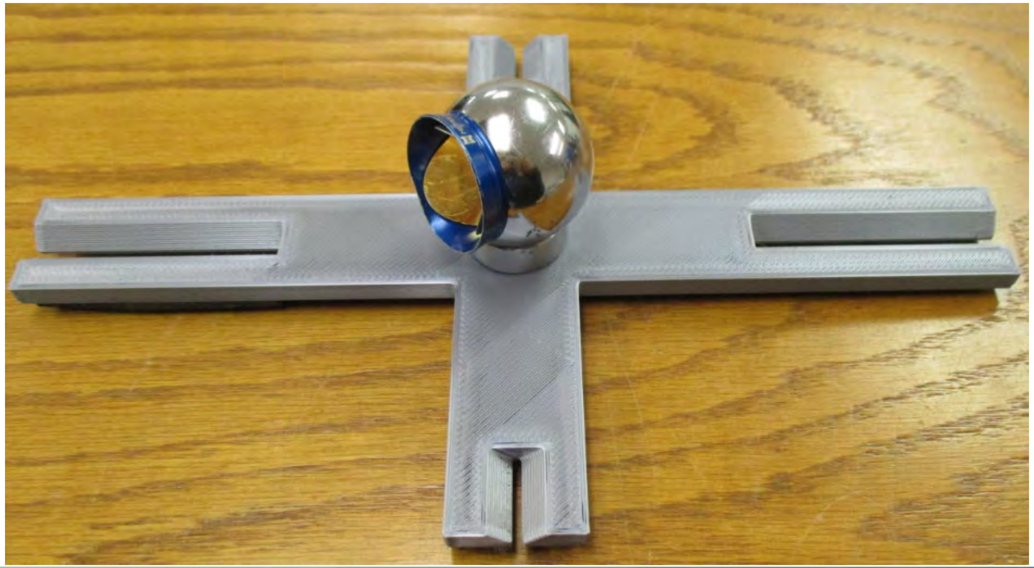
  The purpose of the Jig is to accurately align the SMR at the center of the socket. There are a lot of sockets so the faster we can align it the better. With 3D printing we can create and customize jigs to make our process faster.

3D printed

- Accuracy ±0.5mm
- Cost: $1.50 (printing time 2 hrs.)
- Faster alignment
- Easy to reproduce/replace

Re Design





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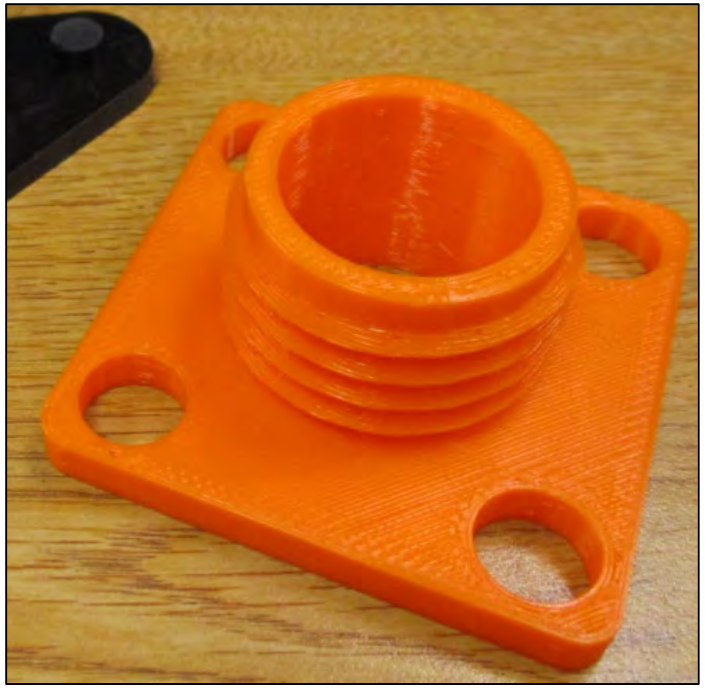
AM Examples Production

- Welding machine spare part (screw cap)

Before **(Real)**

Cost per piece: $28.25
Quantity per year: 100
Only one manufacture

After **(Printed)**



Cost per piece: $0.8
Design cost: 4 hrs.
Printing time: 1 hr.

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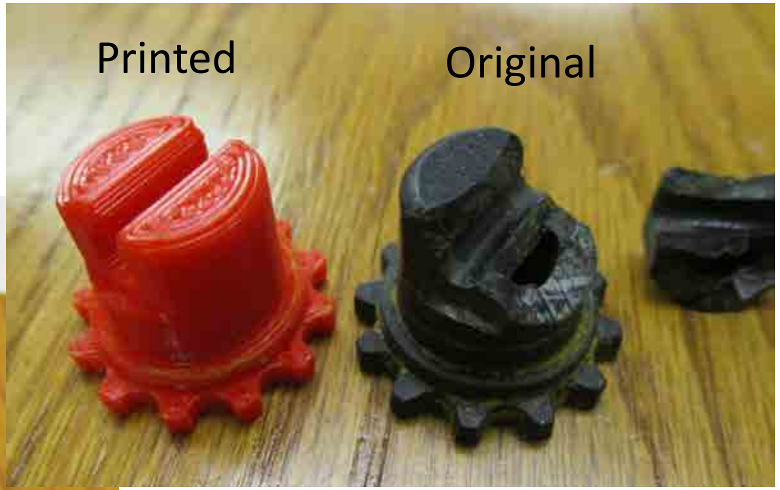
AM Examples Production

- Spare part for Chalk Line



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AM Examples Production

Shell Margin Jig

- *Nylon accessory to measure Shell margin.

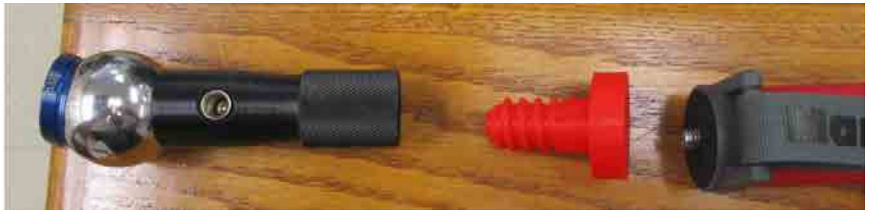
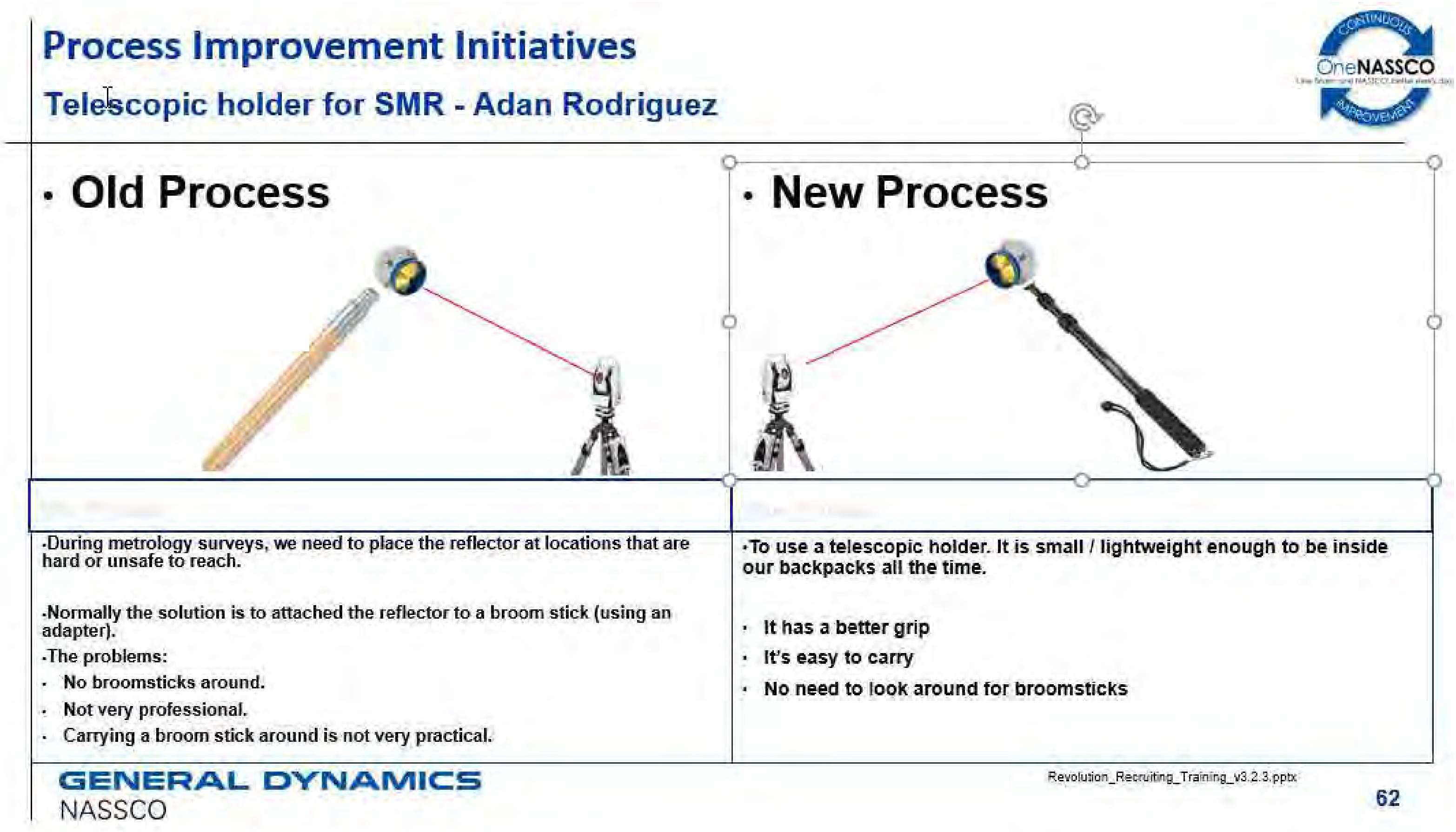
- Design to fit the combination square
- Adjustable height
- Can be held with one hand

AM Examples Production

Telescopic holder for SMR

Adapter for SMR holder



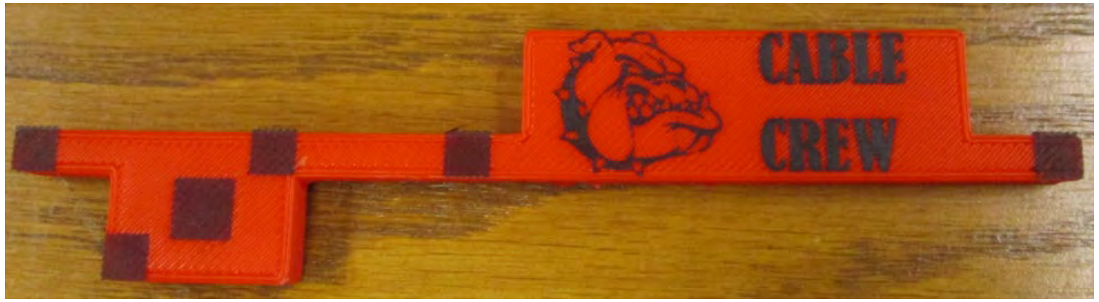
AM Examples

Production

Electrical Depth Gauge

Before

After



*Used to prove to ABS that the space and stuffing for the cables is the right size. Different sizes and depths need to be check, this new tool is design to cover all of them.

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AM Examples

Production

Disto offset accessory

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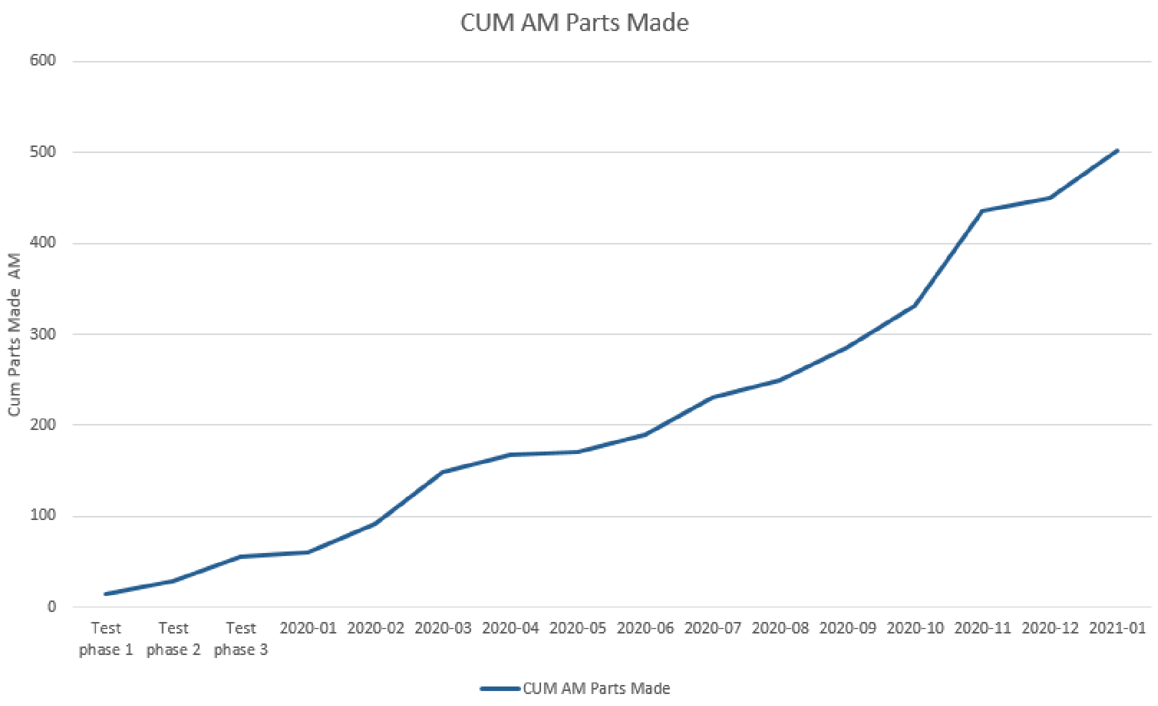
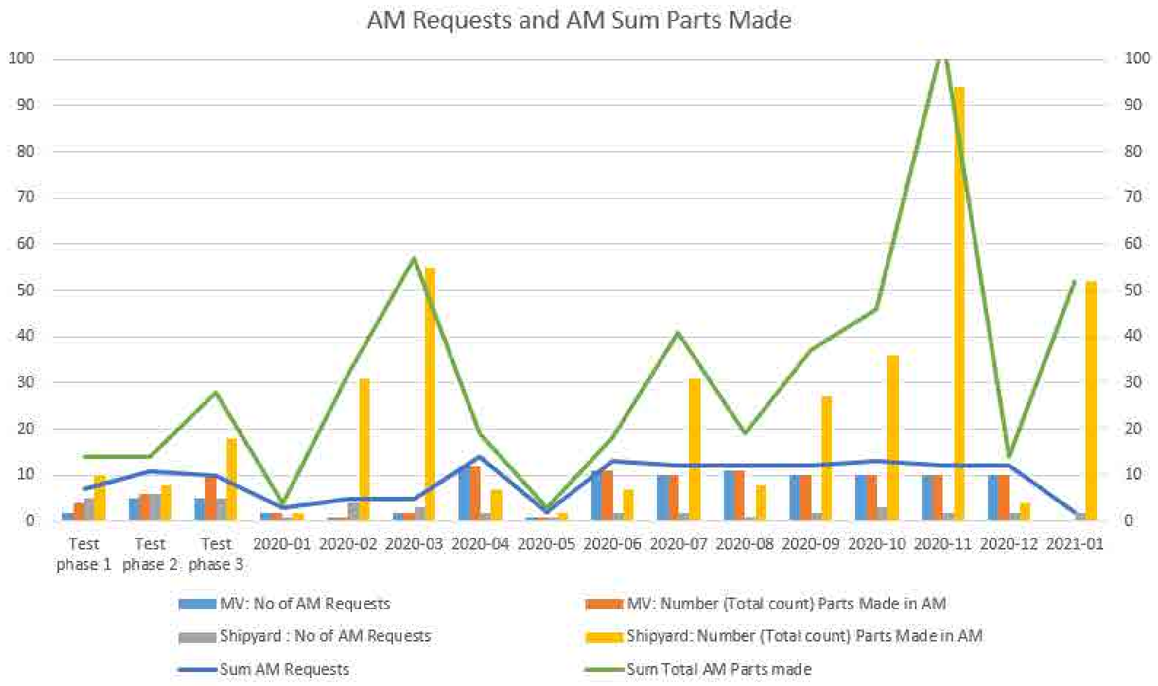
CONTROL PHASE

- Parts and Orders
  - Steady adoption 2020/21





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CONTROL PHASE

- 145 AM User requests made , 502 AM Parts made
- Savings
  - In both Shipyard and Engineering locations on average
    - Traditional Manufactured Matl +Labor $128k
    - Additive Manufactured: Matl +Labor= $51k
    - Savings $77k (60%)
    - Cycle Time reduced from 2-3 weeks down to 1 week
      - Would be 2-3 days if we had full time AM resources
    - 97% reduction in Material $ Costs
    - 48 % reduction in labor hours
    - 50-66% reduction in Cycle Time

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CONTROL PHASE

- COMMUNICATION PLAN (TO SHARE, COLLABORATE and ENGAGE)
  - Communication Mode/Description
    - Roadshow (with Hourly/Staff)
    - Screensaver, Publications
    - “Business” Card (AM)
    - Outbriefs, Forums
  - Method of Delivery
    - Meeting, Artices,Posters, Presentations
    - Virtual, In person, Email,
  - Frequency/Target Date
    - Q1,Q2,Q3 etc
  - Goal/Objective
    - Communication, Status, Share Potential, Feedback
  - Developer/Owner
    - AM Team
  - Audience/Customer
    - Shopfloor, Eng, Other Depts, Management, GD Enterprise & NSRP

ADDITIVE MANUFACTURING (AM) COMMUNICATION PLAN

Communication Mode/Description	Method of Delivery	Frequency/ Target Date	Goal /Objective	Developer/Owner	Audience/Customer
Project Review	Meeting	Q1 2020 (COMPLETE)	Communicate status of AM in Shipyard and Engineering	Kelly Christiansen (Shipyard) Wes Downs (MV)	GD Manufacturing Council (Senior Operations Staff across GD BU's)
Portable "Roadshow" with AM examples/ displays /posters and AM POC Contact information	Meeting	Start Q1 2021 (periodic after)	Provide potential of AM and encourage awareness and engagement for employee feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	Operations 5 minute meeting crews
Portable "Roadshow" with AM examples/ displays /posters and AM POC Contact information	Meeting	Start Q1 2021 (periodic after)	Provide potential of AM and encourage awareness and engagement for employee feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	Engineering Dept crew meetings (Functional Groups/Systems/COG's)
Portable "Roadshow" with AM examples/ displays /posters and AM POC Contact information	Meeting	Start Q1 2021 (periodic after)	Provide potential of AM and encourage awareness and engagement for employee feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	Trade Superintendents
AM Process Workflow	Meeting	Start Q1 2021	Provide potential of AM and encourage awareness and engagement for employee feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	IT JIRA Team
Portable "Roadshow" with AM examples/ displays and AM POC Contact information	Meeting	Start Q1 2021 (periodic after)	Provide potential of AM and encourage awareness and engagement for employee feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	Operations VP Staff Meeting (VP, Directors and Managers)
"Business" Cards with AM POC Contact information	Card	Q1 2021	Provide quick contact information for AM and encourage awareness	Kelly Christiansen (Shipyard) Wes Downs (MV)	All NASSCO employees
Computer Screensaver with AM examples and AM POC Contact information	Screensaver	Q1 2021	Provide potential of AM and encourage awareness and engagement for employee feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV) and Media/Comms Dept	All Shipyard Personnel, with access to PC/Desktop
Project Outbrief	Report by email	Q1 2021	Communicate Control Phase and Closure Report	AM Team	NSRP Committee
Project Outbrief	Published Paper/Meeting	Q1 2021	Communicate Project Report	AM Team	NSRP and participating Shipyards
Project Review	Meeting (Zoom)	Q2 2021	Communicate status of AM in Shipyard and Engineering	Kelly Christiansen (Shipyard) Wes Downs (MV)	GD 3D Printing Team (3D Printing specialists across all participating GD BU's)
Project Review	Meeting (Zoom)	Q2 2021	Communicate status of AM in Shipyard and Engineering	Kelly Christiansen (Shipyard) Wes Downs (MV)	DFX /ETC (Attendees are leaders in Design for X principles .. "Design for Additive"
Project Outbrief	Published Presentation/ Meeting (Virtual)	6/9/2021	Communicate Project "Introduction of AM into shipyard"	LEADS Christiansen, Murray,Downs	GD Manufacturing Symposium Participating BU reps
Other Publications (Shipbuilder)	Article	Q2 2021	Communicate Project re Introduction of AM into shipyard	LEADS Christiansen, Murray,Downs	All NASSCO employees
Other Publications	Posters	Q2 2021	Provide potential of AM and encourage awareness and engagement for their feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	All NASSCO employees
Operations Procees Improvement Forums	Meeting or Virtual or email	Q2 2021 and recurring	Provide potential of AM and encourage awareness and engagement for their feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	Operations Forum Audiences , in person or virtual or by email circulated to all on Ops Mgt List
Operations Procees Improvement Forums	Meeting or Virtual or email	Q2 2021 and recurring	Provide potential of AM and encourage awareness and engagement for their feedback of NEW AM opportunities	Kelly Christiansen (Shipyard) Wes Downs (MV)	ENG PII Forum Audiences , in person or virtual or by email circulated to all on the circulation

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Next Steps and Take-Aways

- Next Steps
- NASSCO and Current USA Shipbuilding Industry Initiatives
- NASSCO is looking to eventually migrate AM to create real ship parts in the future. In 2020
- NASSCO led an NSRP panel project revolving around scaling up 3D printing capabilities with metal printing. This project successfully increased the deposition rate of aluminum material. Future projects will focus on higher yielding materials.
- NASSCO is working with the NAVY and ABS to establish those future projects which will ultimately lead to developing rules, guides, and regulations for printing shipboard parts.
- THIS IS JUST a START….. (Goal is Metal/Polymer Ships Parts!!)

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Next Steps and Take-Aways

- Take Aways
- Adopt new technology in a small scale in areas you can control at the onset
- Take advantage of "process experts" to assist your journey
- Off the shelf solutions are often available and meet most needs with minimum financial investment
- The implication of 3D printed solutions is enormous well beyond this entry level project
- Maturity
  - Mature (small scale effort but implemented)

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Questions?

CONTINUOUSLY IMPROVE

GENERAL DYNAMICS
NASSCO

GOT 3D?

Let's Have Your 3D Printing Ideas

Do you have a part, tool, jig, template, or shape we can create?
We can print it for you in plastic!

- ***What is 3D Printing?***
  3D printing starts with a virtual 3D model that is transformed into a solid form one layer at a time. Each layer is built on top of the layer before, creating a solid form in plastic, it's just like laying weld beads but more controlled to build up an accurate form.

- ***What Shipyard Applications?***
  We have made weld machine parts, crane parts, electrician gauges, and all kinds of accuracy control jigs and fixtures.

- ***Traditional Material***
  Hard, soft and flexible plastics. Come see.

- ***3D Examples***

Let us help make your idea a reality!

CONTINUOUS IMPROVEMENT
OneNASSCO
One Team, one NASSCO, better every day

Contact:
Accuracy Control Office
Engineering ext. 8822 or 8686
Adan Rodriguez
Kelly Christiansen
Wes Downs

NSRP
NATIONAL SHIPBUILDING RESEARCH PROGRAM
Taking Shipbuilding and Repair to the Next Level
Proudly Celebrating 50 Years of Innovation

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