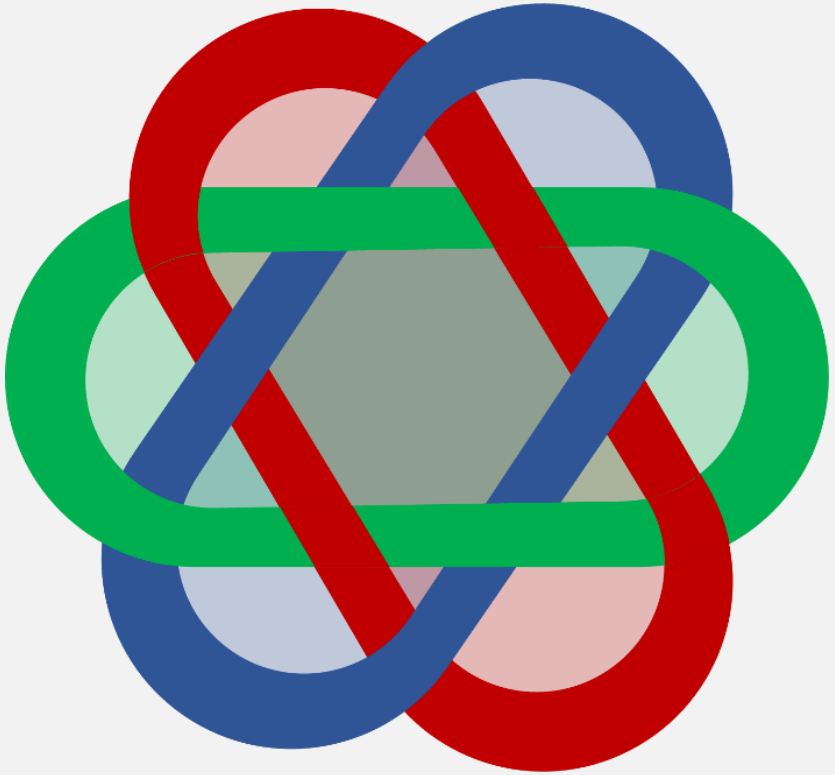
DoD Point of Need Manufacturing Challenge
RESPONSE – OPERATIONAL DIGITAL TWINE

NUMORPHO CYBERNETIC SYSTEMS
Everything Connected



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Everything Connected

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Markforged

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Microsoft

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M D
The Digital Manufacturing & Cybersecurity Institute

OPERATIONAL DIGITAL TWINE (ODT)
DoD MII Point of Need Manufacturing Challenge

The Digital Manufacturing & Cybersecurity Institute

RESPONSE ARMADILLO
(Smart Helmet for Field Operations)

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PART A: REMOTE ADDITIVE MANUFACTURING

Create a digital framework for expeditionary manufacturing of parts in-situ on the front lines.

- Manage CAD parts and STL files.
- Enable Additive Manufacturing.
- Store and analyze sensor data from embedded wearables.
- Test physical set up in austere conditions.

Our Partners:

- Microsoft Industry Solutions for Defense and Intelligence (secure data management framework; ECIF cost share, startup partner)
- Markforged (Off-line Eiger Additive Manufacturing Platform)

PART B: VANGUARD WELLBEING

Enable Warfighter Medical, Health, and Nutrition monitoring using bio-metric sensors.

- Print and attach parts on site based on predictive maintenance or on-demand.
- Embed sensors in wearables: Helmets and bracelets.
- Review and transmit data to edge servers defined in Project A

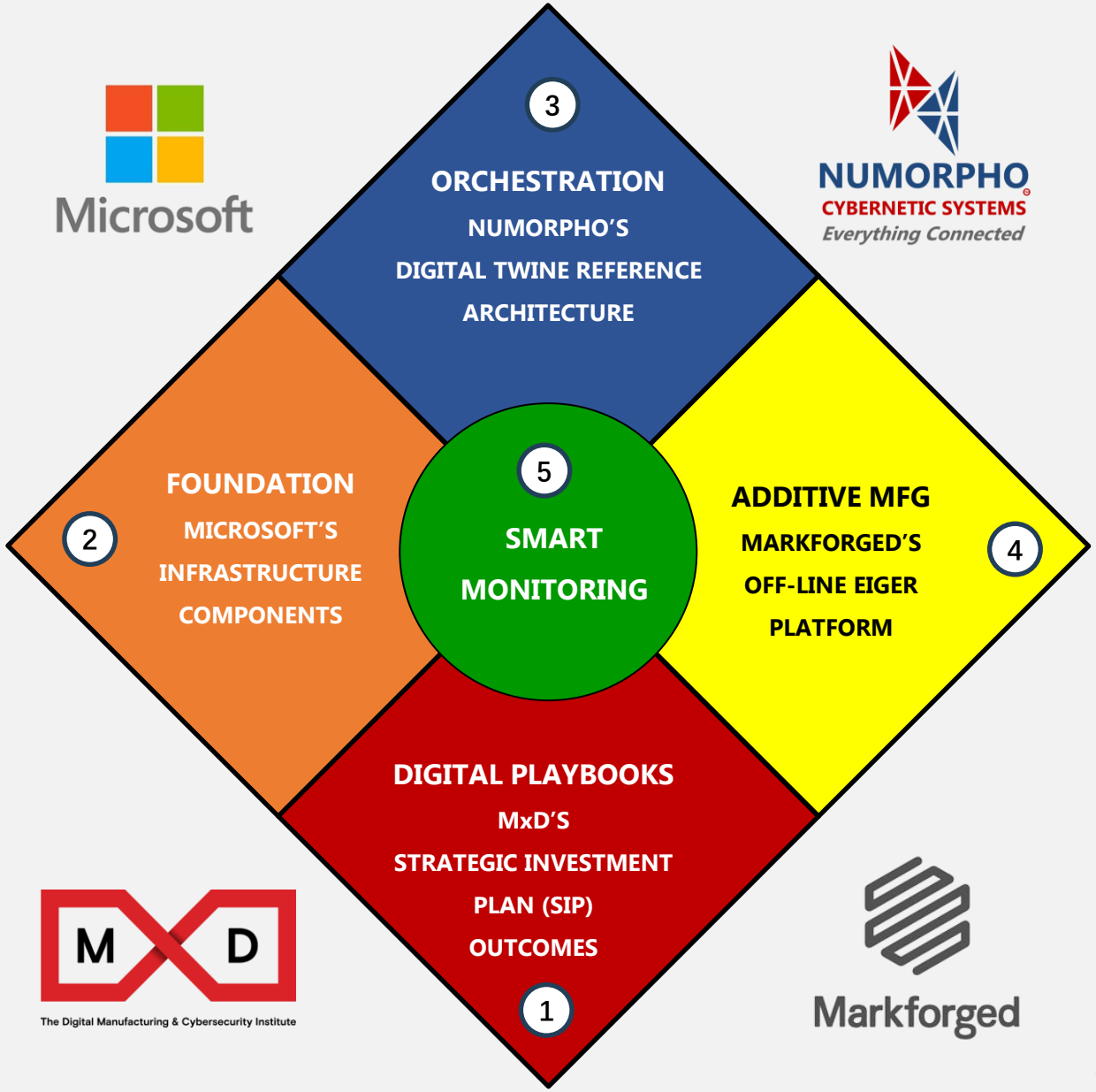
Our Partners:

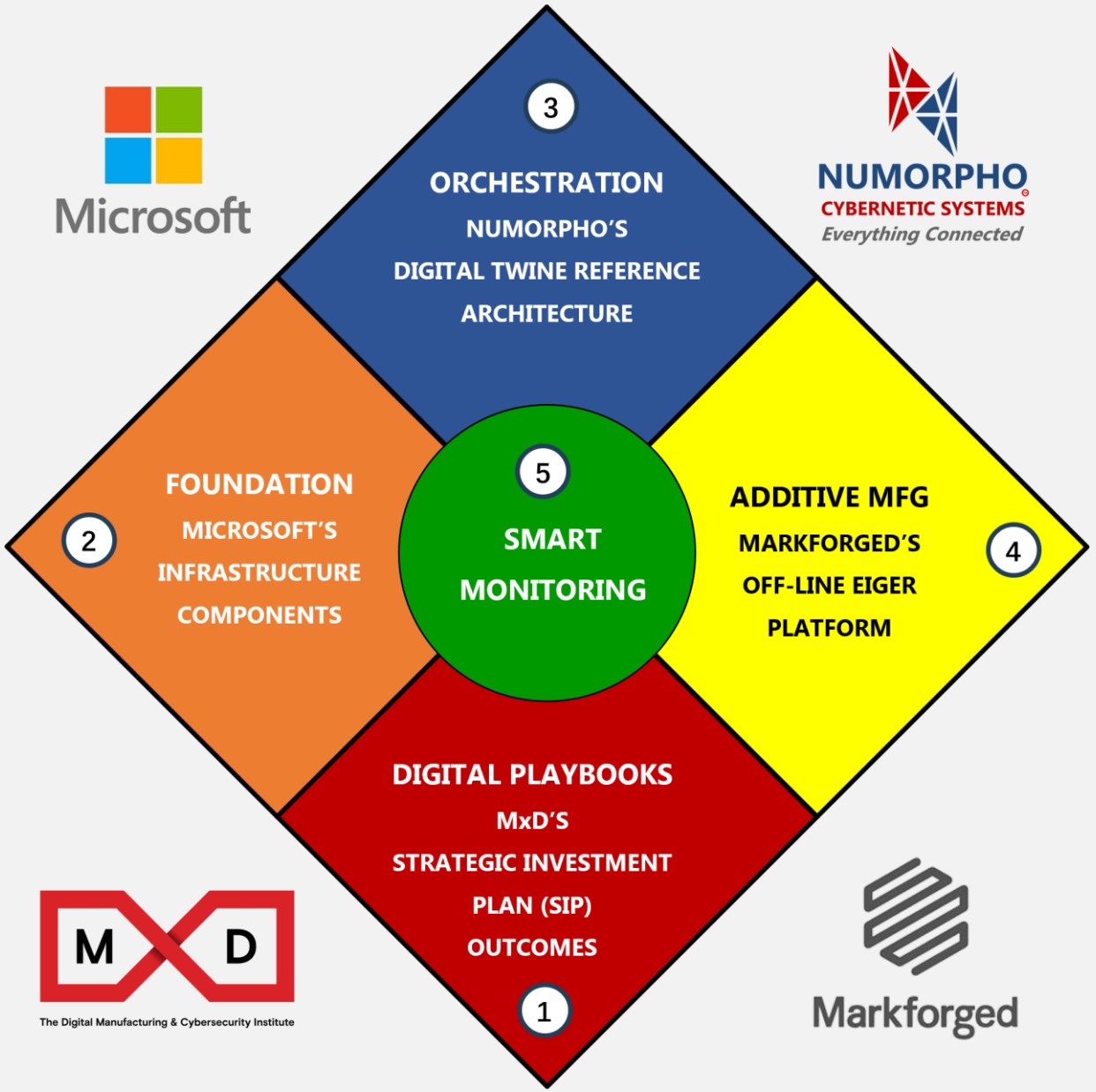
- Markforged (X7 Field Edition 3D printer)
- mHUB (Letter of Support)
  - AVNET (Sensors & Electronics)
  - NoMo Diagnostics (Brainwave monitoring)
  - HabitAware (Smart Bracelet)

OPERATIONAL DIGITAL TWINE
HIGH LEVEL INTERACTION DIAGRAM

We envisage the digital framework for expeditionary manufacturing and on-site management in the remote austere location to be comprised of the following five elements:

1. **DIGITAL PLAYBOOKS** – Leveraging MxD's knowledge base and best practices based on their smart manufacturing initiatives.
2. **FOUNDATION** – Microsoft's Azure Stack Edge provides the Infrastructure in a localized environment to securely manage files, data and processes, and integrate between systems.
3. **ORCHESTRATION** – Numorpho's Digital Twine Reference Architecture connects the different data streams.
4. **ADDITIVE MANUFACTURING** – Leveraging Markforged Federal division's off-line Eiger platform to convert CAD STL files to machine gcode based on the printer and the material composites to be used for intelligently printing parts and managing production in a remote location.
5. **SMART MONITORING** – Enable proactive and predictive maintenance as well as enhance the well being of war-fighters by adding sensors to detect brain wave and OCD behavior so that appropriate short-term and long-term help can be provided.




Microsoft
3
ORCHESTRATION
NUMORPHO'S
DIGITAL TWINE REFERENCE
ARCHITECTURE
NUMORPHO
CYBERNETIC SYSTEMS
Everything Connected
2
FOUNDATION
MICROSOFT'S
INFRASTRUCTURE
COMPONENTS
5
SMART
MONITORING
ADDITIVE MFG
MARKFORGED'S
OFF-LINE EIGER
PLATFORM
4
DIGITAL PLAYBOOKS
MxD'S
STRATEGIC INVESTMENT
PLAN (SIP)
OUTCOMES
1
M D
The Digital Manufacturing & Cybersecurity Institute
Markforged


Connecting the Warfighter
on a Global Theater by enabling Remote Manufacturing
Share Parts from Central Location
Create and Update Parts in the Field
Share Updates to Mainland
Grow Library Organically
Continuously Redistribute to All Locations
Print Super Strong Parts at Point of Need
Perform Repairs in the Field

RESPONSE ARMADILLO PART A: REMOTE ADDITIVE MANUFACTURING

By: Numorpho Cybernetic Systems in conjunction with MxD, Microsoft Corporation and Markforged

Description

Remote and Expeditionary Point of Need manufacturing by creating a digital framework to manage the complete process, logistics and fulfillment by enabling the warfighters to quickly 3D-print parts in the front lines.

In this concept project we will showcase a closed loop manufacturing system that utilizes the latest smart technologies for Industry 4.0, Digital Threads and Digital Twins, and down the line be modular enough to enable AI/ML predictive maintenance using IoT and other emerging technologies like AR/VR to quality inspect the part.

Technical Approach

- Numorpho's Digital Twine Process Management.
- MSFT Edge computing technology and devices.
- Microsoft's leading Zero Trust security products.
- Microsoft's CICD Pipeline and DevSecOps management
- Markforged Off-Line Eiger Additive Manufacturing platform for 3D print management.
- Utilizing MxD's playbooks and guidebooks from prior SIP projects will ensure that the technical underpinnings have a sound and vetted basis.

Delivering

In conjunction with our partners, we will deliver a secure, robust, reliable and localized infrastructure (hardware+software) to manage the end-to-end process of contained manufacturing in the front lines.

This will be tested using a folding Armadillo Helmet utilizing Additive Manufacturing and 3D print technologies to define, make, manage and maintain the operations in a remote austere environment.

A Standard Operating Procedure manual will also be delivered as part of the transition plan.

Benefits

Utilizing Additive Manufacturing, we will reduce waste and obviate reliance on supply chain to procure parts.

It will also provide for customizing the equipment (in this case helmet) to match with the head-form of the warfighter. Maturing the solution to using scanning tools, advanced materials like Kevlar, Carbon fiber, composites and metal will further make such products safe for the front line.

We will be leveraging Microsoft's extensive DoD Partner eco-system and Markforged military tested remote 3D print capabilities to ensure low risk to the gov

Special Topic Areas: 5a, 5b and 7a

RESPONSE ARMADILLO PART B: VANGUARD WELL BEING

By: Numorpho Cybernetic Systems in conjunction with MxD, Markforged, Avnet, NoMo Diagnostics and HabitAware

Description

We address the need for monitoring Warfighter Medical, Health, and Nutrition to enable their well-being by using bio-metric sensors embedded in wearables. Herewith we will:

- Print the Armadillo Helmet using Markforged X7 Field Edition 3D printer
- Embed NoMo Diagnostic Sensors in the Helmet, and the HabitAware bracelet as wearables on the warfighter.
- Transfer sensor data to edge servers defined in Project A for bio-metric analysis.
- mHUB will provide a letter of support (LOS) since we will be using our partners in its Ecosystem.

Technical Approach

We will utilize the Digital Framework that Numorpho has proposed in Project A – The Operational Digital Twin

- Off-line retrieval of CAD/STL files generated using parametric modeling to enable custom printing the Armadillo helmet designed by Numorpho
- Next-generation additive manufactured headgear outfitted with a set of quantitative electroencephalogram (qEEG) sensors and a miniature PCB provided by NoMo Diagnostics to monitor brainwaves.
- HabitAware's passive and discrete sensor technology to provide continuous, objective insights into one's vitals and mental health through biomechanical metrics.

Delivering

Hardware: Robust head sensors and wrist-worn bracelets with battery, sensors, wireless data transfer, and haptic feedback

Software: Edge-deployed behavior classification algorithm on-the-wrist with data transfer protocol adhering to safety, security and stringent military standards.

This will be tested in a remote austere environment.

A Standard Operating Procedure manual will also be delivered as part of the transition plan.

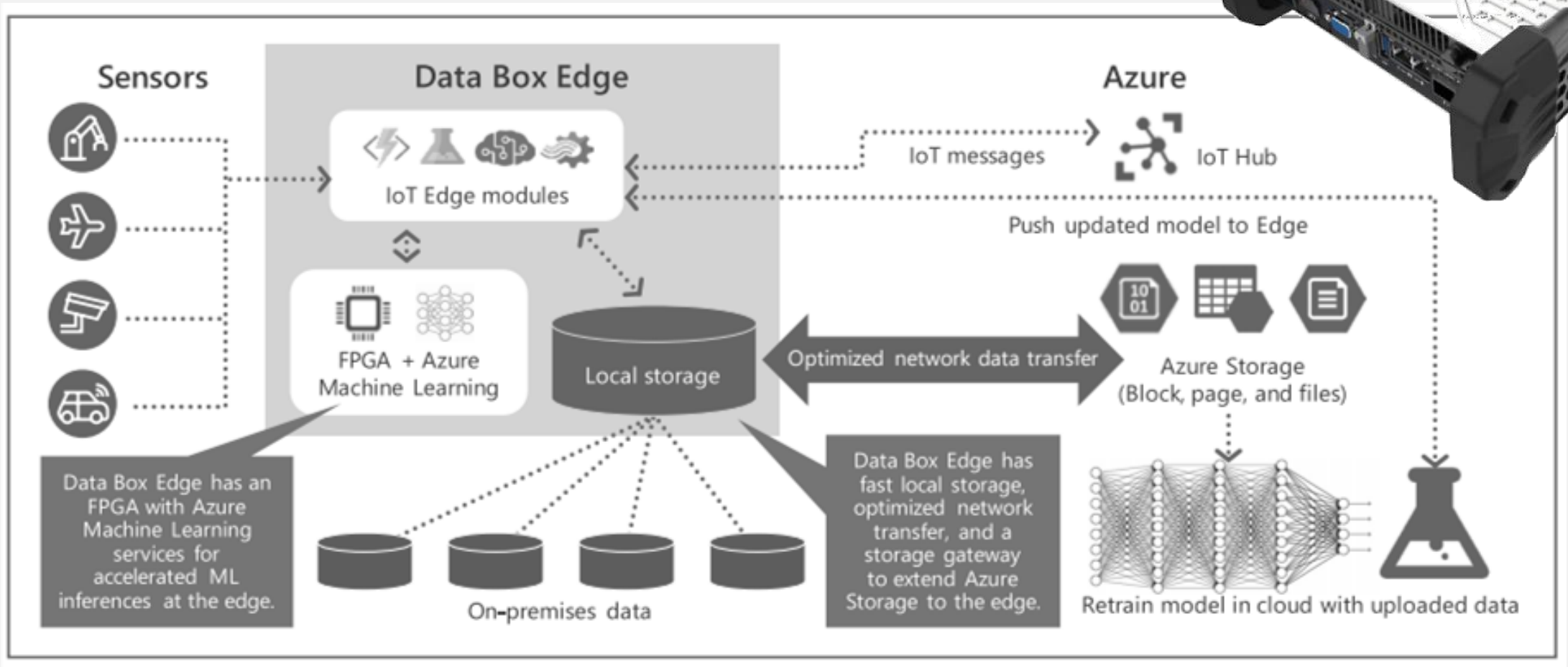
Benefits

- Warfighters be protected from high-force impacts to the helmets that provide the necessary ballistic resistance utilizing Markforged tested materials
- The NoMo Diagnostics monitoring system will be able to look for signs of issues such as concussions, head trauma, and other mild traumatic brain injuries (mTBIs). This early detection will allow for a faster, more routine recovery process.
- HabitAware's technology, through passive behavior classification, has the potential to identify undesirable behavior patterns that professionals can leverage to get to the root of a soldier's struggle.

Special Topic Areas: 3d and 7a

ODT FOUNDATION – MSFT INDUSTRY SOLUTIONS FOR DEFENSE AND INTELLIGENCE

Azure Stack Edge is a compute appliance that acts as an extension of Azure services at the tactical edge. It can be configured based on the need of the resources of remote manufacturing and scaled accordingly.



THE OPERATIONAL DIGITAL TWINE FRAMEWORK
END-TO-END PROCESS FLOW MANAGEMENT & AUTOMATION

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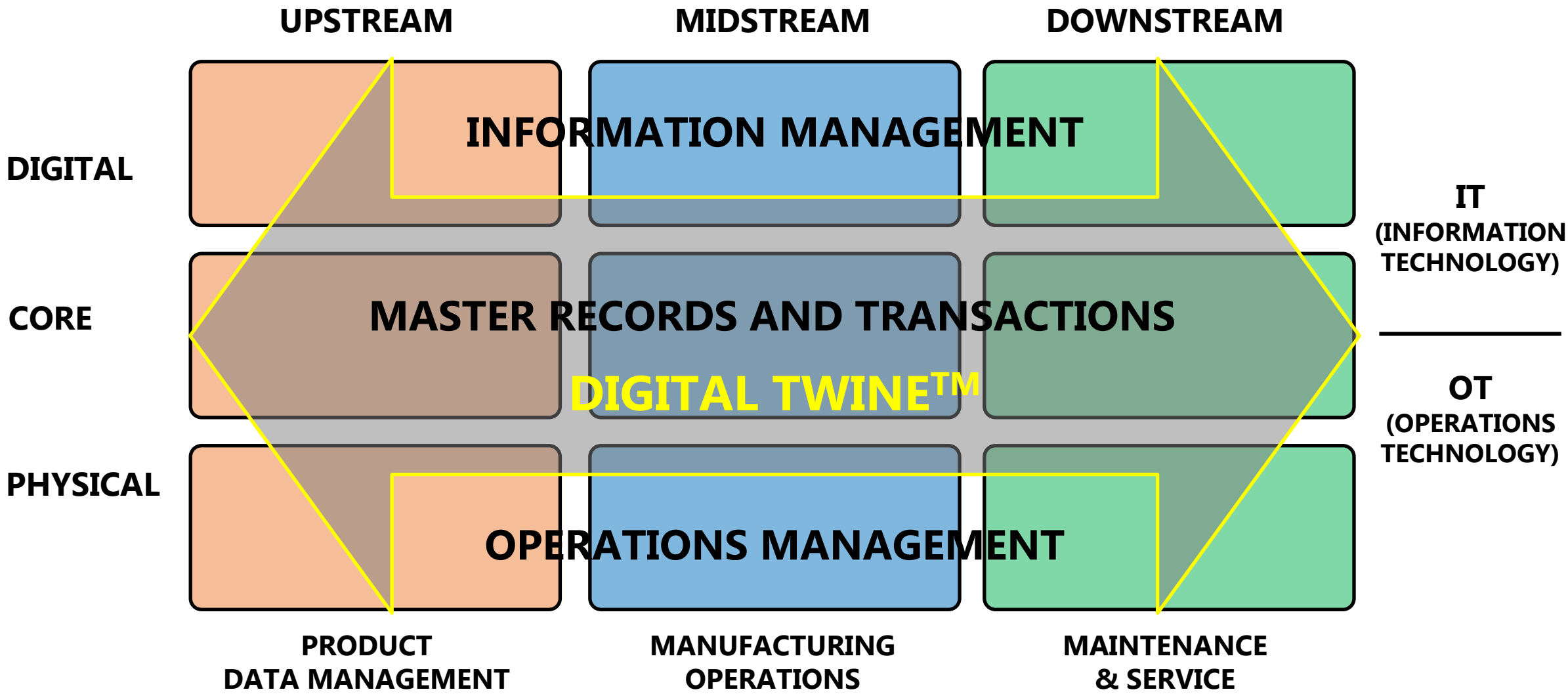

ORCHESTRATION – OPERATIONAL DIGITAL TWIN

Additive Manufacturing in Austere Locations

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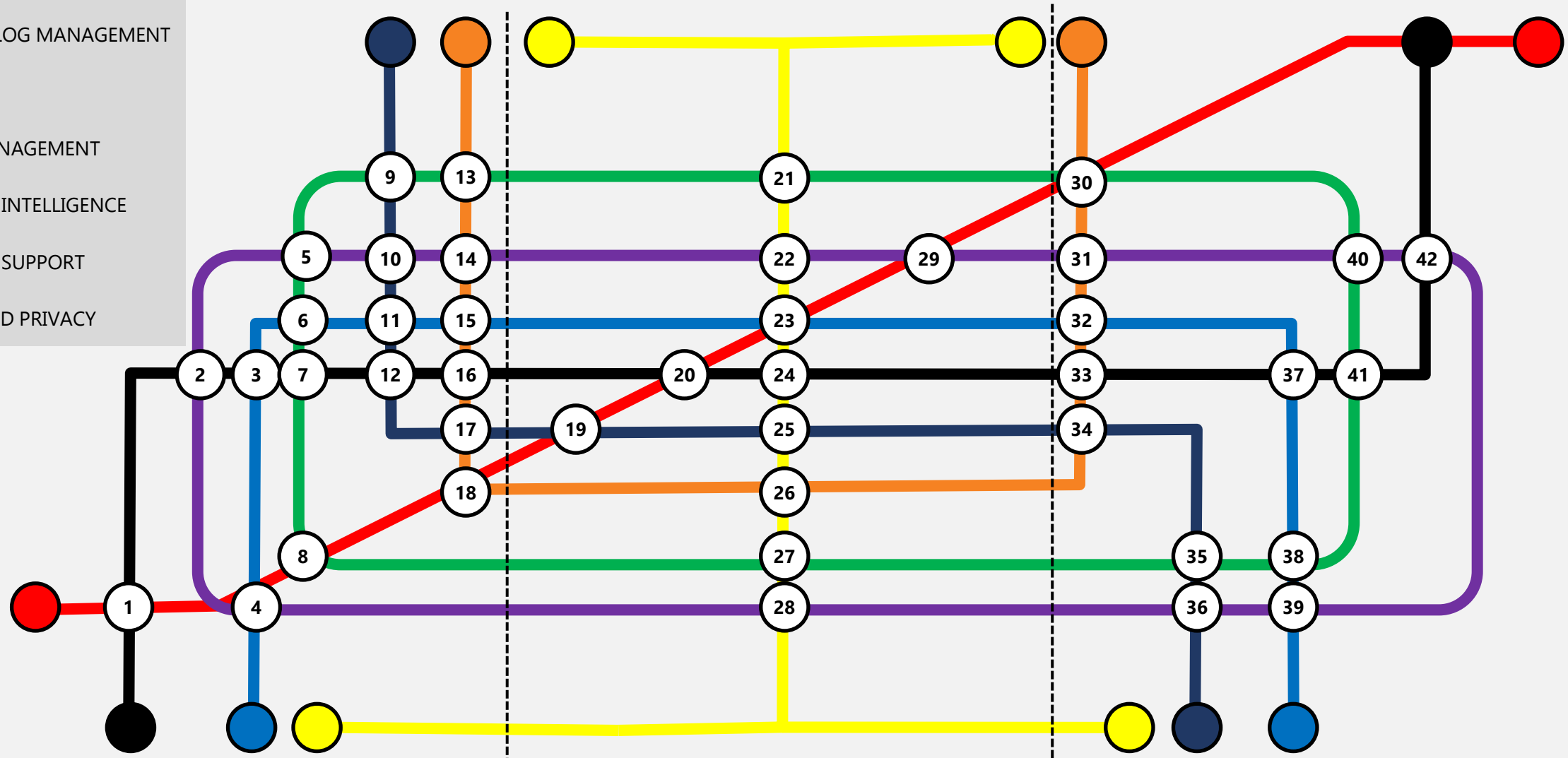
LEGEND

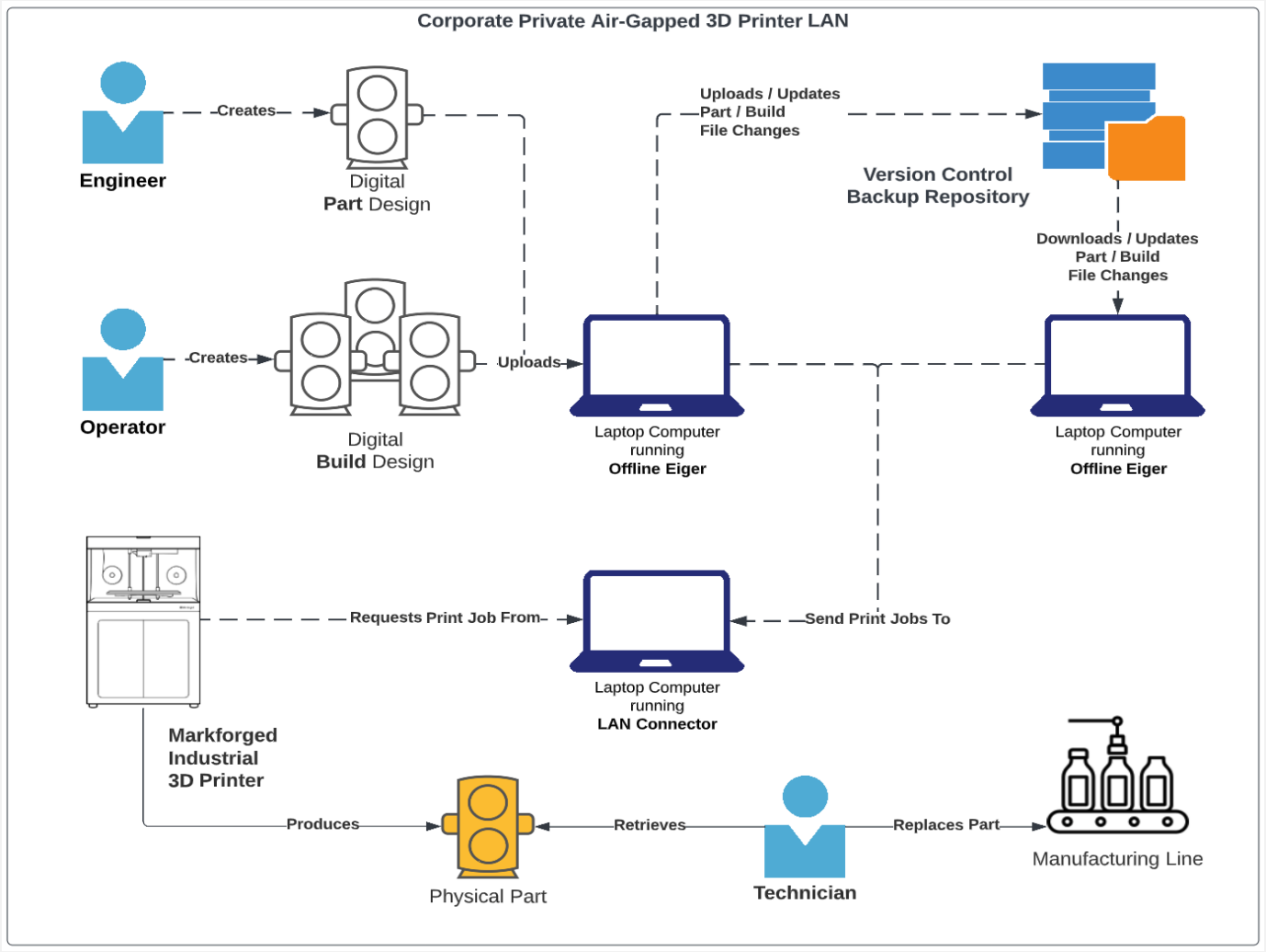
- PLANNING & GOVERNANCE
- FRONT-LINE OPERATIONS
- PARTS CATALOG MANAGEMENT
- 3D PRINTING
- DATA MANANAGEMENT
- ACTIONABLE INTELLIGENCE
- LOGISTICS & SUPPORT
- SECURITY AND PRIVACY



UPSTREAM	MIDSTREAM	DOWNSTREAM
Digital Part Assets Management	Parts 3D printing and post processing	Parts usage and maintenance

ODT - MARKFORGED ADDITIVE MANUFACTURING PLATFORM

Markforged's Eiger platform enables the complete management of additive manufacturing including setting up the files for 3D printing, its slicing based on printer type and material composites (including Kevlar, carbon fiber and metal), engineering simulation, and managing distributed manufacturing operations.



Off-Line Eiger features:

- Printers never need Connect Online
- Parts Repository Under your own Control
- Slice Parts Locally in Offline Eiger
- Unlimited Software Installations - Licensed per Printer
- Print to all Licensed Printers with LAN Connector
- Folders and Subfolders for Organizing Parts
- Check Printer Statuses and Print Remotely
- Custom Supports and Fiber Overrides
- Quarterly Software Updates Available

  (New Materials, Features, and Enhancements)

Reference: https://www.eiger.io/library

MARKFORGED Digital Forge™ OVERVIEW

Markforged

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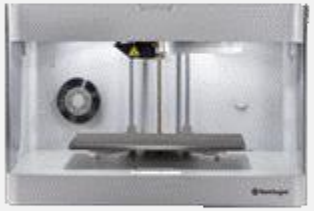


Continuous Fibers

Composites and Plastics

Metals

MARKFORGED SOFTWARE with INTELLIGENT PART QUALITY MANAGEMENT

Simple Software

Manage distributed manufacturing operations on an enterprise and global scale with increased efficiency, insight, and control

Secure Software

First FFF/FDM AM OEM to be ISO 27001 Certified

First STIG Compliant Printer Operating System

Local Area Network Printing

Ethernet / Wi-Fi / Hidden Networks / Static / Dynamic IPs

Custom Proxy, NTP, DNS Servers

Powerful Software

Custom TLS 1.2 certificates - Use your own encryption

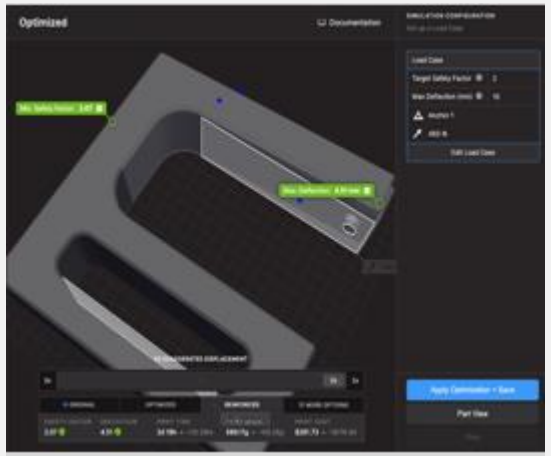
Batch workflow + Presets - Simplify repetitive tasks

Part approval workflows - Review and approve strong parts

API access - Integrate Markforged data into your existing systems for improved visibility and automation

Simulation

With our SAAS solution, validate and optimize print settings to ensure parts meet requirements



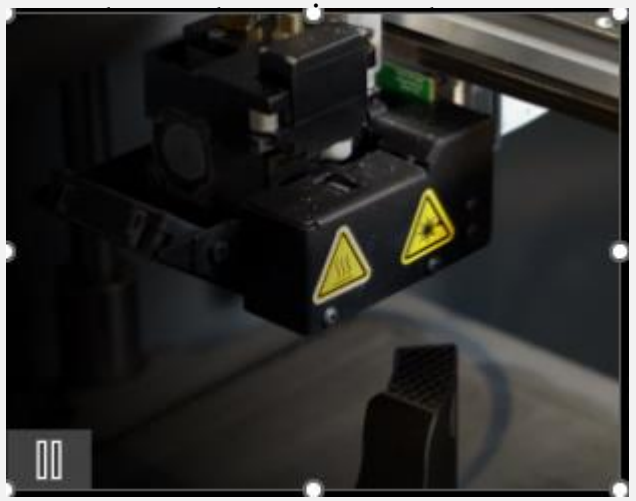
Validate - Simulate part strength and stiffness

Optimize - Automatically configure print settings to satisfy performance requirements

- Replaces costly and time-consuming physical testing
- Takes the guesswork out of configuring parts
- Gain confidence that parts will perform as expected
- Minimize print time and material costs
- Digimat FEA Export w/ Offline Eiger

Inspection

With our SAAS solution, quickly scan parts as they print to ensure



Configure - Define scan resolution

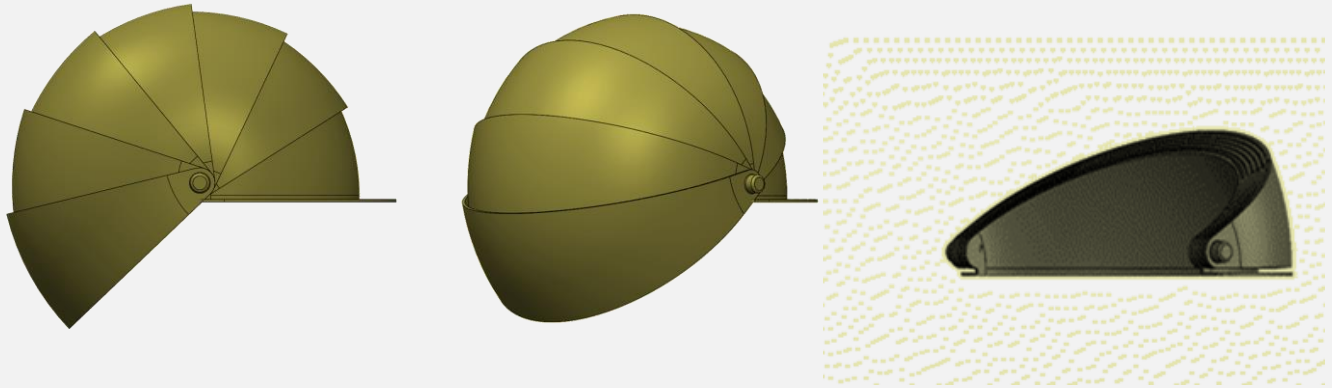
Scan - Part interior and exterior scanned during printing using on-board laser micrometer

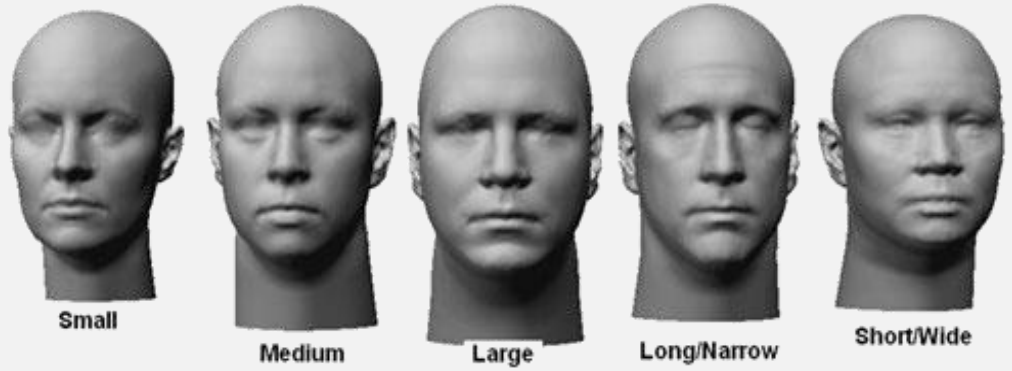
Inspect - Compare scan to design file and measure key features

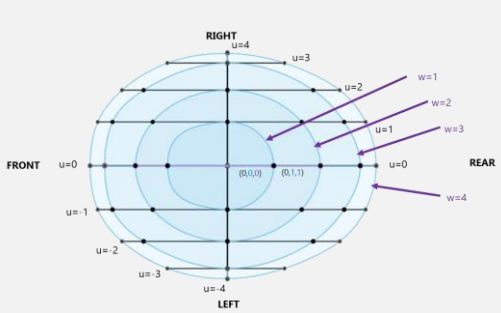
Report - Download customizable scan reports

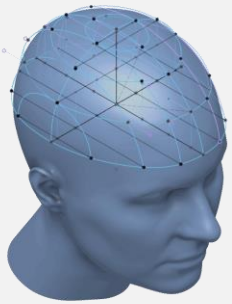
- Rapid and reliable quality control
- Scans interior and exterior features
- Print failure detection
- Consistent parts across all forces

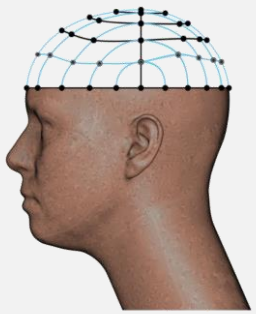
OUR TEST CASE – THE ARMADILLO HELMET











Rethinking what is possible

- **3D PRINTABLE**
- **FOLDABLE –** 1/6th the size of a regular helmet when folded
- **CUSTOMIZABLE –** can be tailored to fit warfighters head form
- **ADAPTABLE –** can include brainwave sensors for monitoring health and well being

This helmet is our testament to Additive Manufacturing, and it personifies our **"Born not Built"** philosophy to create transformational products and services.

REFERENCE: The Making of the Folding Helmet

WORKFLOW TO REMOTE MANUFACTURE PARTS

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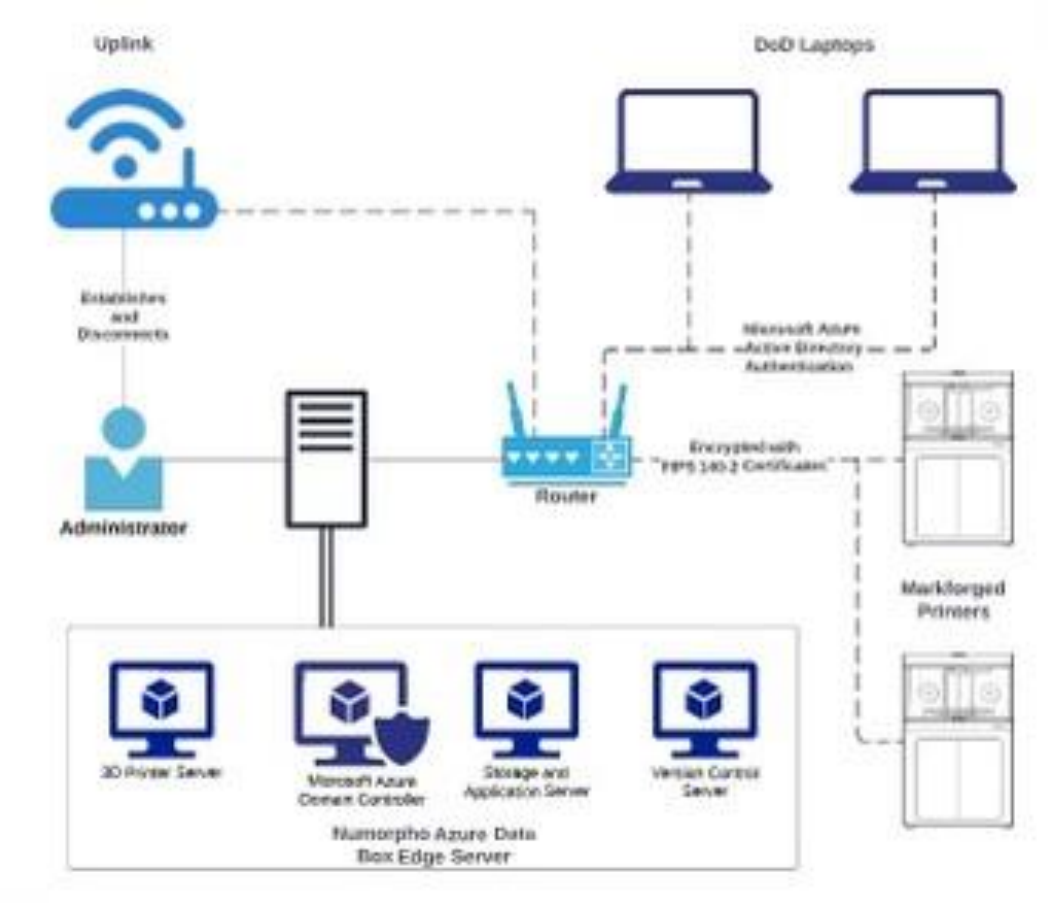

- Designer in US creates helmet and version control it
- Establish satellite uplink
- Pull an update to forward deployed bases with all latest updates including helmet, into local version control server
- Tech logs into laptop, authenticated by Identity Provider (Gov Azure)
- Update local CAD inventory from the version control software
- Import any updates needed
- Use off-line Eiger, and print
- Tech makes an update to files. Establish connection satellite. Push update.
- Mainland verifies update (why was it updated, etc.) Approves update.
- US is now updated. Next push to field, data gets pushed to everyone.

PROJECT SUCCESS EVALUATION, KPPs AND METRICS

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KEY ATTRIBUTES OF EXPEDITIONARY PoN Manufacturing

Performance	End-to-end process management in terms of accuracy, capabilities, completeness, ergonomics, generalizability, quality, re-configurability, success/error rate, and usability.	We plan to exceed industry standards in each of these metrics considering similar use case scenarios. For this, both the digital framework implemented using Microsoft tools and Markforged Eiger platform will be used as the basis to calculate our parameters. Stretch goal for the future would be to include new composite materials and metal for printing
Efficiency	We will store metrics of all processes to gauge how much time is spent on each step and how we can reduce time efficiently.	
Acquisition Cost	Microsoft infrastructure license Markforged Printer cost Numorpho orchestration cost	
Sustaining Cost	The need for infrastructure licenses, power supplies, personnel training, maintenance and on-going material cost will be determined in conjunction with Microsoft and Markforged	
Investment Prudency	We understand that we are a start-up, but we are developing strong relationships with major companies - infrastructure, engineering and technology. What you see is our in this project is how we mature our relationships with MxD, Microsoft, and Markforged. We have partnerships with Nvidia, OpenAI, PTC, Hexagon Manufacturing Intelligence and others that we will also bring to bear in future interactions.	

PROJECT SUCCESS EVALUATION, KPPs AND METRICS

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CARDINAL METRICS

Mobile	Microsoft's edge hardware and Markforged X7 field 3D printers have been tested on mobile units and can be transported and housed in shipping containers.
Rugged	All hardware and equipment will be housed in rugged Pelican cases
Secure	The Digital framework defined using Microsoft's Industry Solution for Defense and Industry meets cyber security-steps and we will adhere to its policies and that of NIST standards
Reliable	The digital and physical pieces are robust and reliable
Ease of Use	Provide Human Machine and User interfaces that are easy to use, operate and quickly trainable
Fast	Markforged has one of the fastest 3D printers in the market
Materials	Markforged composite and metal materials have been tested in Military establishments

PROJECT RISKS AND MITIGATION

- **Building the project**
  - **Collaboration** needs to maintained throughout project (Markforged, MXD, Microsoft, Numorpho)
  - **Equipmen**t – The Markforged X7 Field Edition is a ruggedized, field-deployable industrial 3D printer designed for tactical response to inventory challenges in remote locations. Increase supply chain resilience by printing tools, adapters, and replacement parts for equipment at the point of need. The Data Box Edge is a secure robust localized Azure server.
  - **Teamwork** - Markforged and Microsoft point of view - we're already done - solutions already exists. Numorpho is responsible for server and integration of all pieces.
    - Markforged, MXD, Microsoft all committed to sharing best practices with Numorpho
- **Satellite uplink**
  - Without connections, can't upload fixes
  - Can't download files
- **Too hot/cold**
  - Printer can support printing up to 120 degrees F.
  - Server – air-conditioned location
- **Could someone walk away with the server**
  - Needs to be stored in a secured location
- **Filament procurement**
  - Markforged filaments made in Boston, USA. Expanding facility to increase capacity.
  - Distributors available globally supply chain concerns
- **Parts for the printer**
  - Stored in version control so you can always ensure latest and greatest
  - Able to rapid prototype globally
- **Training - Markforged University has you covered for printing**
  - SAAS showpad solution
- **Troubleshooting and support**
  - For the servers, Microsoft and Numorpho will provide operations issues support based on SLAs.
  - For printers, Markforged offers support subscriptions that include the Software
- **Version control** software must support binary and text files and distributed servers
- **Joining Domain Controller** to DoD Domain for user authentication

TECHNOLOGY TRANSITION PLAN

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During the course of the project (6 months), we will create a detailed **Standard Operating Procedure** manual with step-by-step instructions for managing the digital framework, its troubleshooting and how to update different aspects of the processes, data and its review. Some of the tenets we will follow for this are:

- For Security, trust but verify for user access and administration.
- Safety protocol to follow in the field.
- Guided Instruction set with how to get support from experts.
- Training guide for new operators.
- Set up guides and user manuals for operations.
- Cleaning procedures
- Equipment and materials procurement details.
- Elimination of waste and improve productivity.

ODT - PROGRAM MANAGEMENT PLAN

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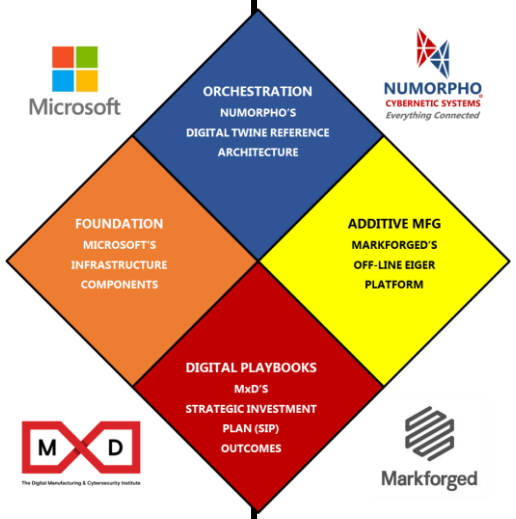
START | MONTH 1 | MONTH 2 | MONTH 3 | MONTH 4 | MONTH 5 | MONTH 6

PHASE 1 - SETUP | **PHASE 2 - IMPLEMENTATION** | **PHASE 3 - TESTING**

- PROJECT ADMINISTRATION
- DIGITAL PLAYBOOKS REVIEW
- INFRASTRUCTURE FOUNDATION BUILD
  - Hardware Config
  - Database Config
  - Process Config
- PROCESS ORCHESTRATION
  - Upstream
  - Midstream
  - Downstream
- ADDITIVE MANUFACTURING PLATFORM
  - Offline Part Mgmt Setup
  - Print Submission and Postprocessing Detailing
- UNIT AND FUNCTIONAL TESTING
- UAT TESTING AND END-TO-END VALIDATION
- DOCUMENTATION AND SOP CREATION



BUDGET/COST SHARE OVERVIEW

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PHASE	DURATION	COST
1 SETUP	2 months	$174,800.00
2 IMPLEMENTATION	2 months	$165,600.00
3 TESTING	2 months	$146,050.00
	TOTAL	**$486,450.00**

	GRAND TOTAL	Project Admin	Digital Playbooks Review	Hardware Config	Process Config	Upstream Orchestration	Midstream Orchestration	Downstream Orchestration	Offline Parts Management Setup	Print Submission and Post Processing Detailing	Testing
REQUESTED FEDERAL FUNDING											
		15%									
Labor and Indirect	232,300.00	30,300.00	20,000.00	15,000.00	15,000.00	24,000.00	24,000.00	24,000.00	25,000.00	25,000.00	30,000.00
Travel	23,000.00	3,000.00	-	-	-	-	-	-	-	-	20,000.00
Subcontract	86,250.00	11,250.00	-	-	-	6,000.00	6,000.00	6,000.00	12,000.00	25,000.00	20,000.00
Materials	46,000.00	6,000.00	-	-	4,000.00	-	-	-	10,000.00	6,000.00	20,000.00
Equipment	40,250.00	5,250.00	-	10,000.00	-	-	-	-	-	-	25,000.00
Consultant	46,000.00	6,000.00	-	15,000.00	15,000.00	-	-	-	-	-	10,000.00
ODC's	12,650.00	1,650.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	2,000.00	2,000.00
Total Requested Federal Funding	486,450.00	63,450.00	21,000.00	41,000.00	35,000.00	31,000.00	31,000.00	31,000.00	48,000.00	58,000.00	127,000.00

FROM COST SHARE – We will leverage the cost savings and benefits that Microsoft has with enterprise agreements in place with the DoD. We are also startup partners with Microsoft and can avail of their core license provisioning for this project.

TEAM QUALIFICATIONS

NUMORPHO CYBERNETIC SYSTEMS *Everything Connected* Process automation for Industry 4.0 solutions.	**Nitin Uchil, Founder & CEO** Nitin Uchil is a Strategic Thinker, Product Engineer, Enterprise Architect, and Digital Transformer with 20+ years of experience in advanced technologies (aerospace & defense), product lifecycle management and knowledge-based engineering (automotive), business process redesign (manufacturing, telecom, compliance), ecommerce, analytics, data mining, front-end experience-driven design and digital architecture (retail, CPG, high-tech electronics, finance, insurance, food, media & entertainment and hospitality). More recently he has been creating a framework to enable the articulation of Big Data and Analytics using a themed, pragmatic, and structured methodology.
Markforged Additive Manufacturing platform for expeditionary manufacturing capabilities.	**Nate Washor, Software Sales Engineer** Nate is a systems builder with 20+ years experience with a heavy focus in security. Some relevant contracts he has worked on include being the lead technical engineer for the Machinery LAN (MLAN) prototype for the USS Ford class aircraft carriers. He was one of three engineering leads for NAVAIR's submarine dive control trainer rehost, reengineering the code from modular Fortran running on DEC Alpha servers to Object Oriented C++ running on Windows Servers. He also developed a deep packet inspection firewall for secure transmittal of unclassified information from a top-secretnetwork. Since his DoD days, he has been a DevSecOps manager and now finds himself in Sales helping customers and prospects understand Markforged 3D printer technology and security. Nate is also an Army Infantry veteran.
M D The Digital Manufacturing & Cybersecurity Institute Basis for design for manufacturing, cybersecurity and supply chain logistics.	MxD is the DoD funded design for manufacturing organization that transforms ideation into reality by enabling the deployment of smart solutions at scale utilizing IoT, tenets of cybersecurity and the future for supply chain operations. It equips U.S. manufacturers with the digital manufacturing tools and expertise they need to begin building every single part better than the last. As a result, our more than 300 partners increase their productivity, win more business, and strengthen U.S. manufacturing.
Microsoft Industry Solutions for Defense and Intelligence	• Deliver a secure digital backbone • Empower personnel and modernize facilities • Transform the capability lifecycle • Optimize decision advantage • Enhance interoperability

UTILIZE BEST PRACTICES - MxD SIP PLAYBOOKS

1. **MxD-22-05 INTERACTIVE DIGITAL TWINS PLAYBOOK BUILDER**
   A playbook that simplifies a complex technical goal into a step-by-step implementation guide.

2. **MxD-22-03 DIGITAL MANUFACTURING PLAYBOOK**
   Lift-and-shift operations to include a digital framework based on the maturity and needs of the company to enable brown-field, green-field and blue-sky implementations.

3. **MxD-22-01 TECHNICAL DATA AS A SERVICE**
   Enable asset management and connected digital manufacturing thru the entire cycle of make, manage, move, market and maintain activities.

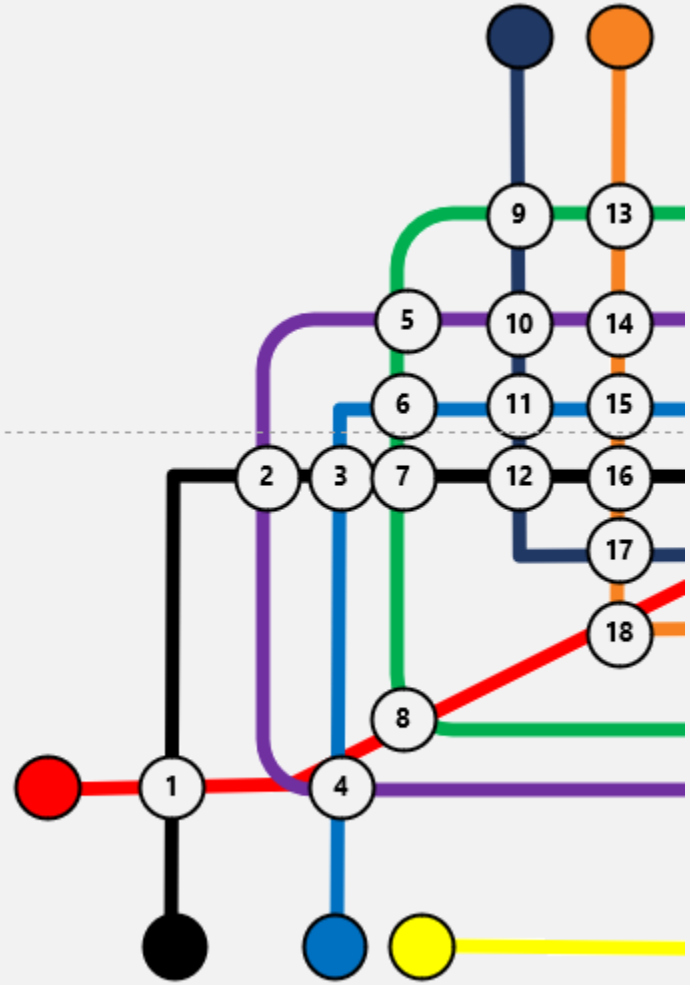
4. **MxD-21-14 PREDICTIVE MAINTENANCE IN MANUFACTURING**
   Enable proactive troubleshooting and management of equipment using condition-based or AI-based maintenance techniques rather than schedule-based Mean Time Between Failure historical analysis.

5. **MxD-21-01 AI DESIGN ADVISOR**
   A digital advisor that back feeds lessons learned and best practices from manufacturing to product development.

Other key MxD thesis we will avail of: Prior SIP projects, D3AMP, CyMOT, Cybersecurity, Supply Chain Management and Factory Modernization

ODT UPSTREAM PROCESS CONFIGURATION AND PART ASSET MANAGEMENT

NUMORPHO CYBERNETIC SYSTEMS
Everything Connected



UPSTREAM
Digital Part Assets Management

Upstream functions are to define the interacting systems and manage assets related to the operational digital twin

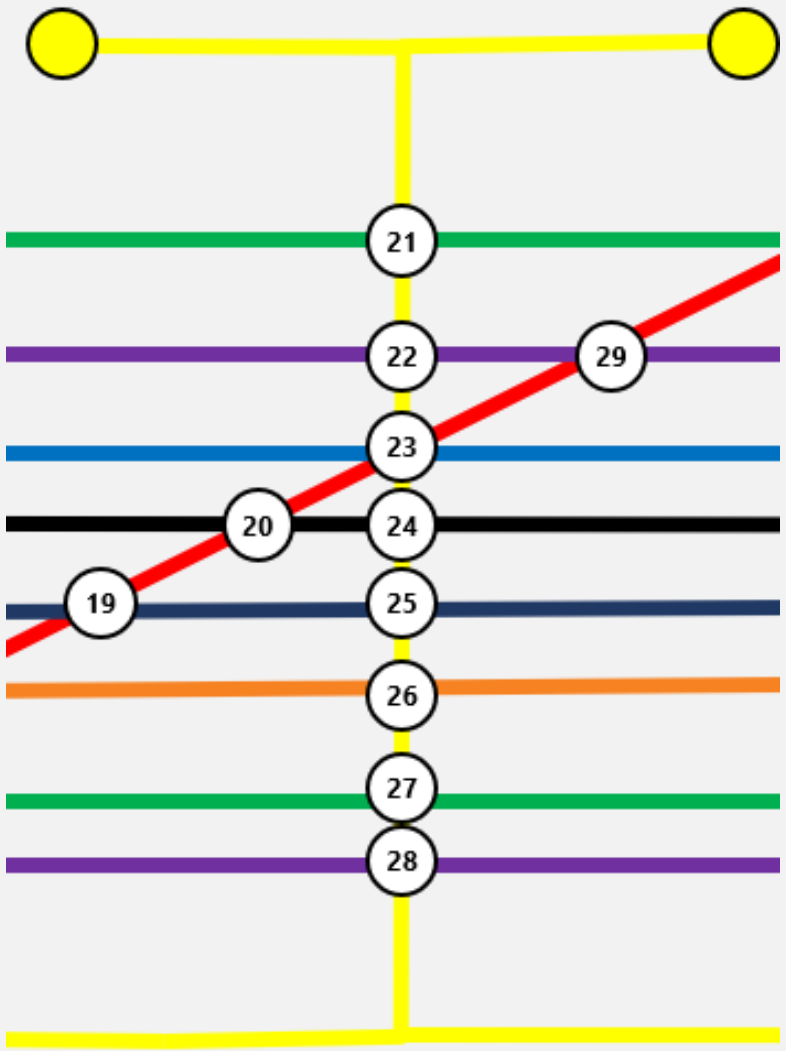
1. Define user profile, roles, access rights and permissions
2. Enable file storage and data management
3. Plan Additive Manufacturing functions for remote operations
4. Integrate with off-line Eiger
5. Define data schema for information management
6. Create part management folders in Eiger
7. Formulate an overall data governance structure
8. Enable data security
9. Store part files
10. Enable slicing of STL files
11. Enable storage of sliced files (gcode)
12. Create a versioning and tagging structure for final gcode files
13. Create SOP to manage processes
14. Define roles and responsibilities for managing the operations
15. Build a user handbook for Additive Manufacturing operations
16. Enable troubleshooting functions
17. Provide instruction manual for 3D print operations
18. Enable trust but verify features for all personnel

LEGEND

- PLANNING & GOVERNANCE
- FRONT-LINE OPERATIONS
- PARTS CATALOG MANAGEMENT
- 3D PRINTING
- DATA MANANAGEMENT
- ACTIONABLE INTELLIGENCE
- LOGISTICS & SUPPORT
- SECURITY AND PRIVACY

ODT MIDSTREAM PROCESS MANUFACTURING OPERATIONS

NUMORPHO CYBERNETIC SYSTEMS
Everything Connected



MIDSTREAM
Parts 3D printing and post processing

Midstream operations enable the production of parts using 3D printing and other additive manufacturing technologies related to the operational digital twin

19. Securely manage parts catalog and its print operations
20. Enable governance of access permissions to 3D machines
21. Manage procedures to 3D print so that there is minimum churn
22. Create a scheduling feature to manage production
23. Enable printing functions
24. Predict/Slot down-time scheduling to manage machines
25. Enable post processing of printed parts
26. Enable prompt support in event of failure
27. Log all events by timestamp and other meta data attributes
28. Streamline all operational parameters related to remote manufacturing.
29. Enable secure storage of printed parts.

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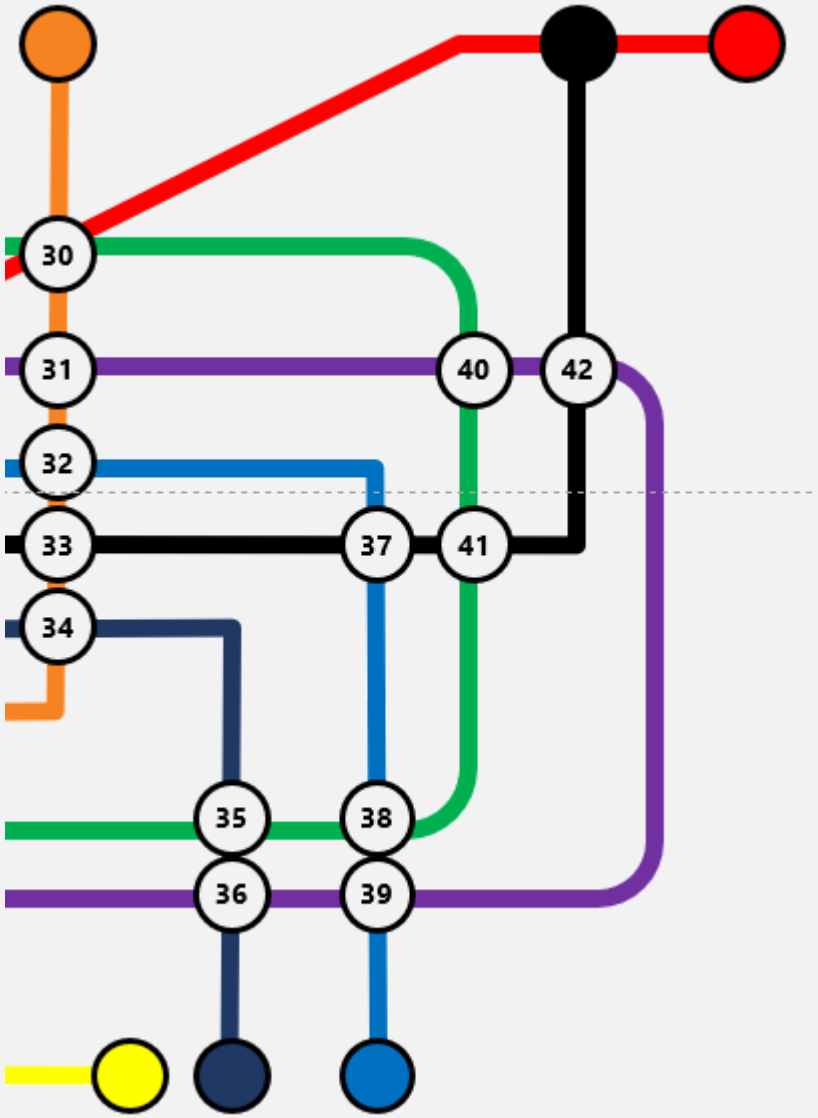
ODT DOWNSTREAM PROCESS
STORAGE, USAGE AND MAINTENANCE

NUMORPHO CYBERNETIC SYSTEMS
Everything Connected



DOWNSTREAM
Parts usage and maintenance

Downstream operations enable the parts to be utilized on the field, their maintenance and replacement.

30. Enable the correct fitment of the part to personnel or machine.
31. Enable trained personnel to post-process/affix parts with the right tools and ancillaries
32. Enable post-processing and other needs from and Additive Manufacturing perspective
33. Define the cadence for part creation and replacement
34. Enable new parts to be stored and itemized correctly
35. Manage the master data of the parts and the composition of the whole structure
36. Enable personnel to use manufactured parts effectively
37. Build the futuring for Additive Manufacturing to produce new parts with different types of printers
38. Store usage data of the part for use in preventative maintenance and analytics
39. Logistics for procurement of filaments, raw materials and printer parts
40. Data management of all functions related to after production of parts
41. Data management to accomplish future needs
42. Operations future planning

LEGEND

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