What is Model Based Anything?

Our Vision for “MBx”

Model Based Anything Framework:

is the underlying structure of standards, rules of engagement, and functional allocations, and interfaces that exist between and amongst the MBx elements and supporting NASA infrastructure.

Model Based Anything (MBx)

MBx is “model based” anything, is an integrated digital approach that uses designated common source(s) of mission data and models as a continuum across MBx capabilities (i.e., MBE, MBIM, MBPM, MBMA) to transform mission(s) and/or system(s) performance from concept through disposal.

Model Based Engineering (MBE)

A digital engineering ecosystem that provides an integrated platform to support the entire project life cycle; identifying standard engineering processes allowing the production of consistent results. Provides designated common source(s) of mission data, tools, processes, and methods to be used by all model-based engineering functions.

MB Systems Engineering (MBSE)

MB Design Engineering (MBDE)

MB Discipline Engineering

- MB Mechanical
- MB Structural
- MB Thermal
- MB Fluids
- MB Software
- MB Optical
- Etc.

MB Mission Assurance (MBMA)

MBMA is focused on digitally transforming delivery of fundamental SMA functions (i.e., safety, mission assurance, logistics/maintenance) over the MBx capabilities (i.e., MBIM, MBE, and MBPM); SMA’s complement across the MBx Capabilities.

- MB
- MB

Model Based Institutional Management

An integrated Institutional Management information system(s) and service(s) designed to develop common tools, processes and methods to help institutional organizations (e.g., OCFO, OCHO, OP, OSI) to operate more effectively and better serve the mission(s).

- MB Acquisition
- MB Human Capital Mgmt.
- MB Facilities

Model Based Program/Project Management

An integrated digital program/ project management information system (PMIS) that leverages model-based approaches to streamline, automate, and customize Program and Project Mgmt. functions and to capture, analyze, integrate and communicate key data and information on Program and Project Mgmt. activities.

- MB Program Mgmt.
- MB Project Mgmt.

A way to self-organize MB communities & our work

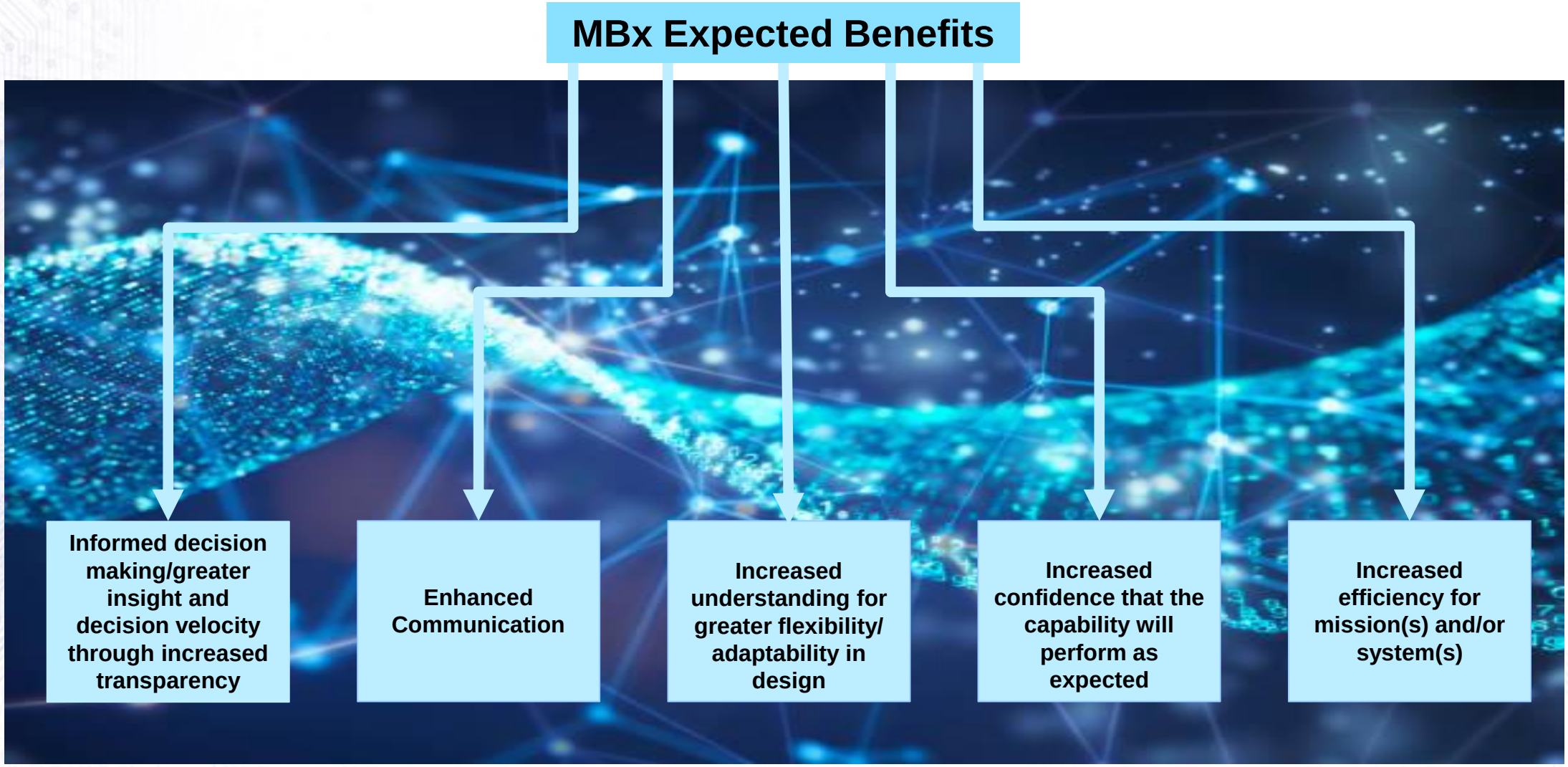
MBx Vision

Model Based Anything (MBx) Vision is to modernize how the Agency designs, develops, delivers, operates, and sustains missions. NASA Model Based transformation is an integrated digital approach that uses designated common source(s) of mission data and models as a continuum across MBx capabilities to support lifecycle activities from concept through disposal. MBx Drives the institutional, program management and engineering practices towards improved agility, quality and efficiency, which results in improvements in acquisition and execution.

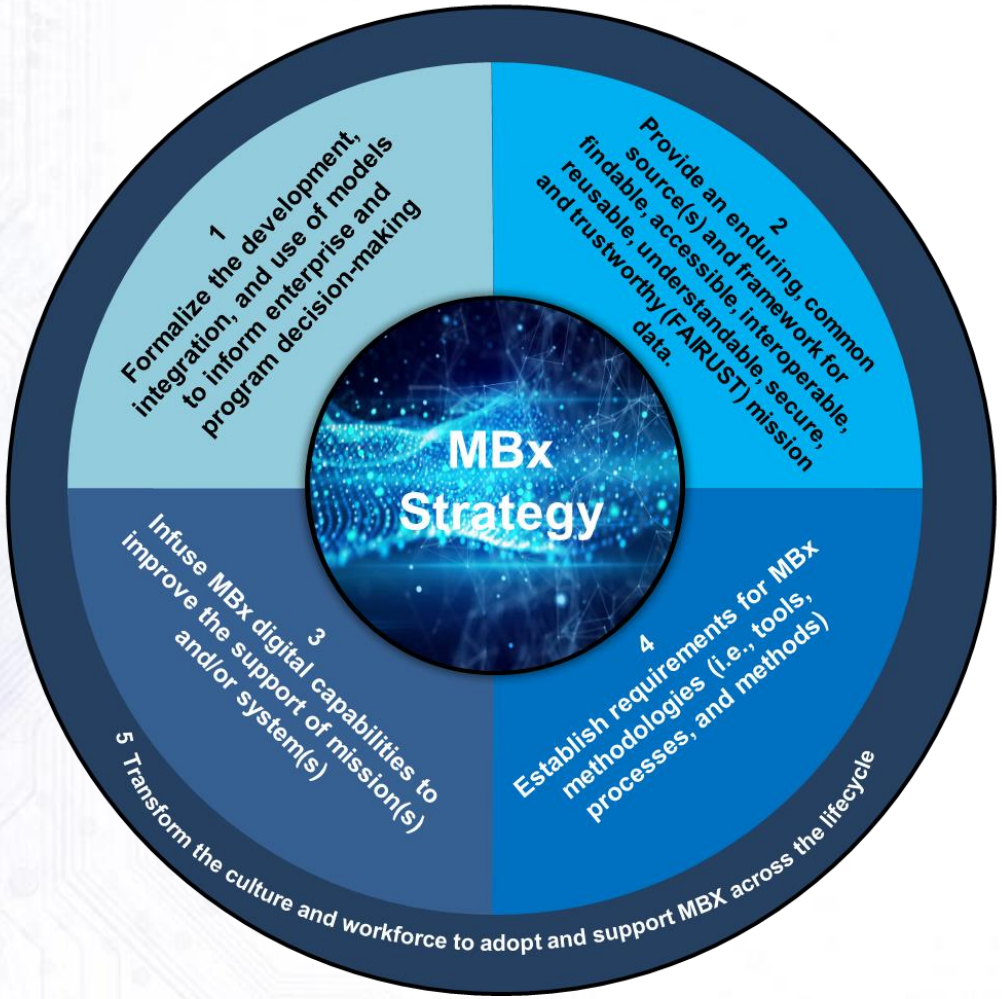
MBx Approach

MBx approach is to securely and safely connect people, processes, data, and capabilities across an end-to-end digital enterprise. MBx enables the use of models throughout the lifecycle to digitally represent mission(s) and/or system(s) of interest (i.e., acquisition, system of systems, systems, processes, equipment, facilities, products, parts) in the virtual world.

MBx Benefits



MBx Strategy

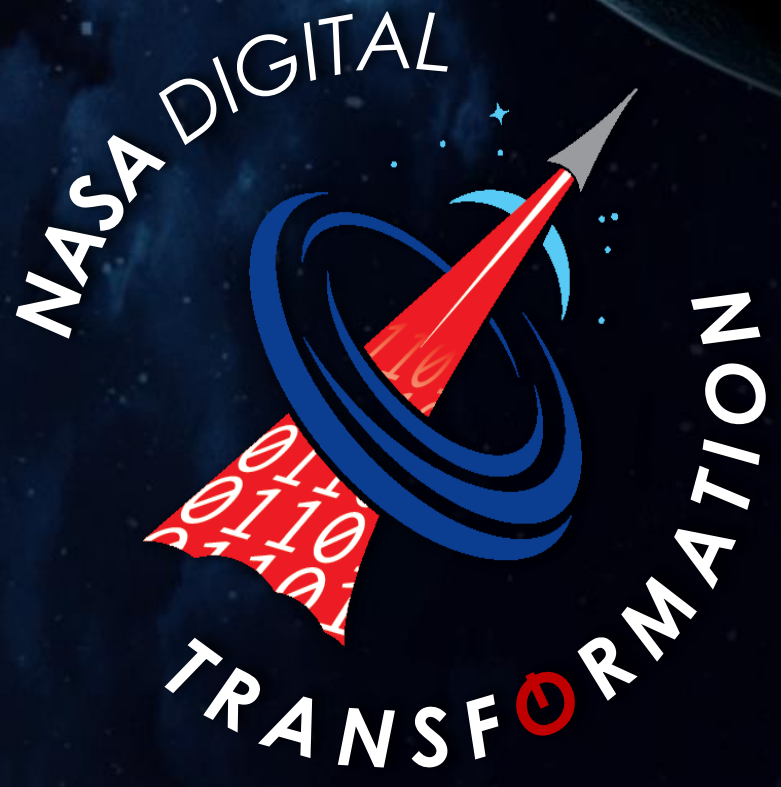


This MBx strategy is intended to guide the planning, development, and implementation of Model-Based activities across the mission(s) and system(s).

MBx Goals & Objectives

#	Strategic Goal	Strategic Objective
1	**Models are the basis for decision-making for the NASA ecosystem (e.g., to include our partners, industry, academia, and supply chain).**	1.1 Develop and implement plans to digitally represent system(s) of interest across the MBx Domains to improve communications and collaborations. 1.2 Document lessons learned to develop and adopt best practices for creation, integration, and curation (i.e., accurate, complete, trusted, and reusable) of models within/across MBx domain(s) and identify requirements to the MBx Framework and STD/HBK 7009 1.3 Prove the utility of models to inform enterprise and program decision-making across the lifecycle of missions(s) and system(s) such that models become the norm for execution
2	**Implement findable, accessible, interoperable, reusable, understandable, secure, and trustworthy (FAIRUST) to improve decision velocity and credibility across the NASA ecosystem (e.g., to include our partners, industry, academia, and supply chain) using model(s).**	2.1 Identify the common source(s) and define the framework for mission(s) and system(s) model(s) and information/data 2.2 Establish policies and procedures to ensure proper use of model(s) and model(s) information/data 2.3 Use the common source(s) and framework throughout the lifecycle of mission(s) and/or system(s)
3	**Utilize advanced MBx capabilities to increase the design cycle speed, increase mission throughput, and enable unprecedented missions.**	3.1 Establish an end-to-end MBx digital framework that connects the digital and physical worlds across mission(s) and/or system(s) lifecycle 3.2 Make use of innovations to improve breadth and depth of awareness, depth of insights, and speed of decision (i.e., earlier and faster) making to enhance the execution of NASA missions
4	**Achieve seamless integration and interoperability of model(s), information/data, and processes across the NASA ecosystem (e.g., to include our partners, industry, academia, and supply chain)**	4.1 Develop, mature, and use methodologies and standards for integrated & interoperable advanced modeling processes 4.2 Identify and specify the requirements to OCIO and use resulting IT infrastructure(s) to enable advanced modeling 4.3 Identify and specify the requirement for securing IT infrastructure and protecting intellectual property and controlled unclassified information.
5	**Adoption and support of MBx**	5.1 Capture and Improve the Mbx knowledge base and lessons learned 5.2 Adapt current policies, handbooks, processes, etc. to accommodate MBx framework 5.3 Provide MBx curriculum and training for reskilling the workforce (e.g., APPEL) 5.4 Lead and support MBx transformation efforts

National Aeronautics
and Space Administration



Enterprise Digital Transformation:

WHY

ENTERPRISE DT STRATEGY

Context: A Changing World

- Our missions are increasingly complex and integrated with industry, on constrained budgets & timelines.
- The aerospace industry, and the **world**, is transforming around us
- 21st century business processes are outpacing our legacy systems
- Top talent is expecting to work in a digitally-enabled workplace

NASA must transform…

Goals & Objectives: Harness digital technologies to…

1. Transform the way we WORK

Improve complex decision making

Make partnering easier

Speed delivery

Increase interdisciplinary innovation

Increase public & stakeholder engagement

2. Transform the experience of our WORKFORCE

Enhance employee engagement

Expand employee capabilities

Maximize employee productivity

3. Transform the agility of our WORKPLACE

Improve operational readiness & agility

Make teaming easier

Rearchitect processes that work together

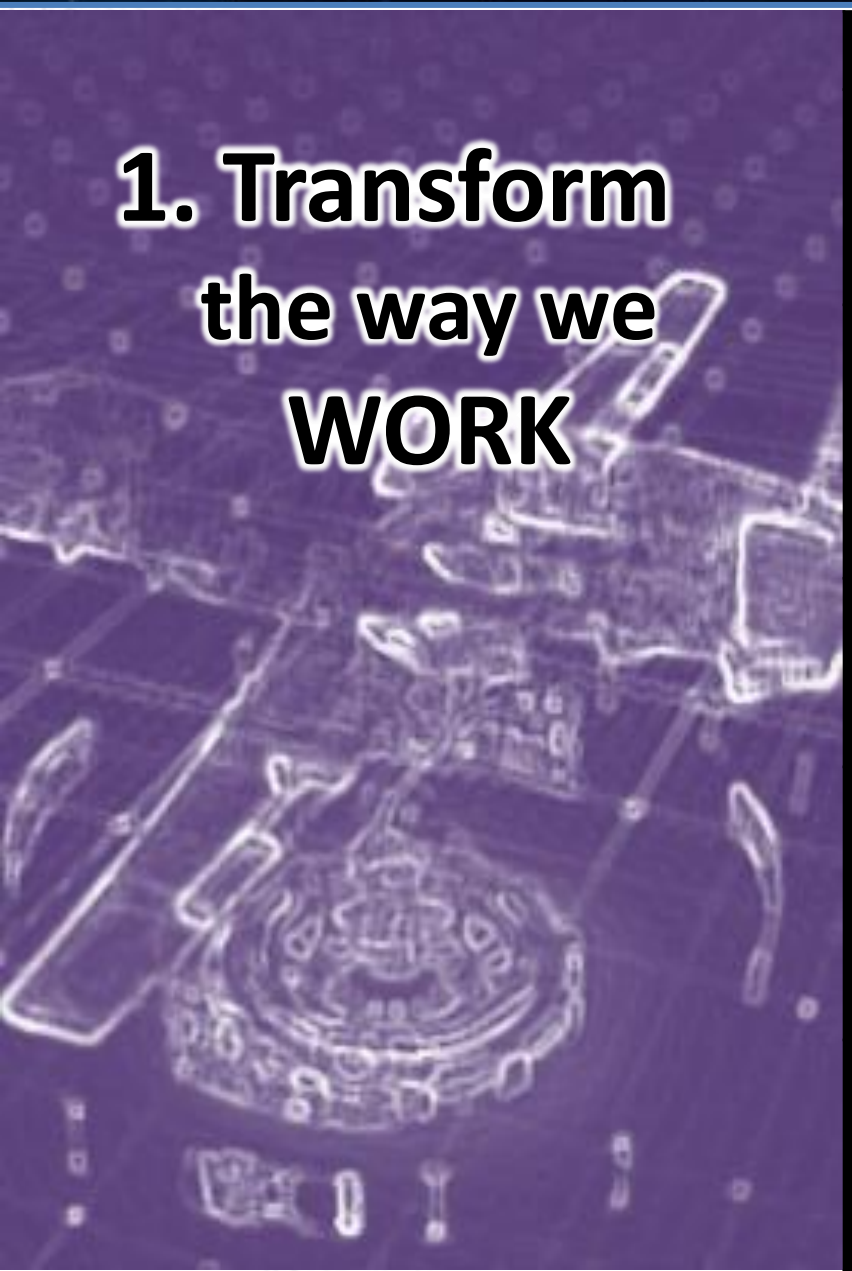
Imagine a NASA where…

Sondra's digital assistant alerts her to a newly published partner data set related to her science research. She kicks off a bot to transfer & clean the data and integrate it into her model. Using analytics to rapidly cross-check the results, she discovers a potential breakthrough.

Caryn is excited to have joined a 1-day collaboration jam session with new teammates from across NASA to quickly learn and apply AI/ML tools on an elusive space suit challenge. She loved helping the mission and can't wait to share her new ideas with her financial peers.

George pauses digital manufacturing of an urgent job after a critical IoT sensor alert. He imports the data history into the lab digital twin model and forecasts the job can safely continue, avoiding delays.

Transformation Outcomes: Work



OBJECTIVES	NEAR-TERM	MID-TERM	FAR-TERM
Improve complex decision making	Make data available & findable	Norm use of data analytics	Data-driven decision making is routine
Make partnering easier	Expand hybrid team collaboration solutions	On-board partners faster Add data/models to contract deliverables	Working with partners is fluid
Speed delivery	Identify & eliminate top process bottlenecks	Norm model & software re-use	Execute at modern speed of business
Increase interdisciplinary innovation	Define interoperable NASA modeling environments	Implement workflows & AI/ML engines	Interdisciplinary discoveries are common
Increase public & stakeholder engagement	Develop open model/data guidelines	Use data to guide stakeholder interactions	Real-time, customized stakeholder engagements

Transformation Outcomes: Workforce

2. Transform the experience of our WORKFORCE

OBJECTIVES	NEAR-TERM	MID-TERM	FAR-TERM
Enhance employee engagement	Provide universal access to basic tools Test transformation incentives	Provide consistent access to tool suites by function/discipline Connect & reward transformation adopters /exemplars	Enhanced recruitment, retention & motivation of top talent
Expand employee capabilities	Define digital skill needs by position; train 25% employees OJT via data analytics & AI/ML use-cases	Digitally upskill 75% of employees Add analysis / modeling to duties	Culture promotes continuous growth & agility
Maximize employee productivity	Deploy intelligent search to find data Optimize & automate routine processes	Test digital assistant use-cases Deploy dynamic talent finding/matching tool	Employee time optimized on high value work

Transformation Outcomes: Workplace

OBJECTIVES	NEAR-TERM	MID-TERM	FAR-TERM
Improve operational readiness & agility	Deploy plant automation, IoT monitoring, & AI/ML insight models Test Infrastructure Digital Twins	Integrate IoT & AI/ML w/Digital Twins for forecasting Deploy readiness / demand decision lens	Affordable access to best-in-class capabilities
Make teaming easier	Expand hybrid team collaboration solutions Speed approval for new networked capabilities	Add emerging tools to hybrid team solutions Start migrating systems to role-based access (vs. geography)	Smooth geographically agnostic internal & external teaming
Rearchitect processes that work together	Optimize & automate workflows for top process pain points Transform local org processes	Rearchitect integrated enterprise processes & workflows, for mission support & mission	Modern, seamless processes & services

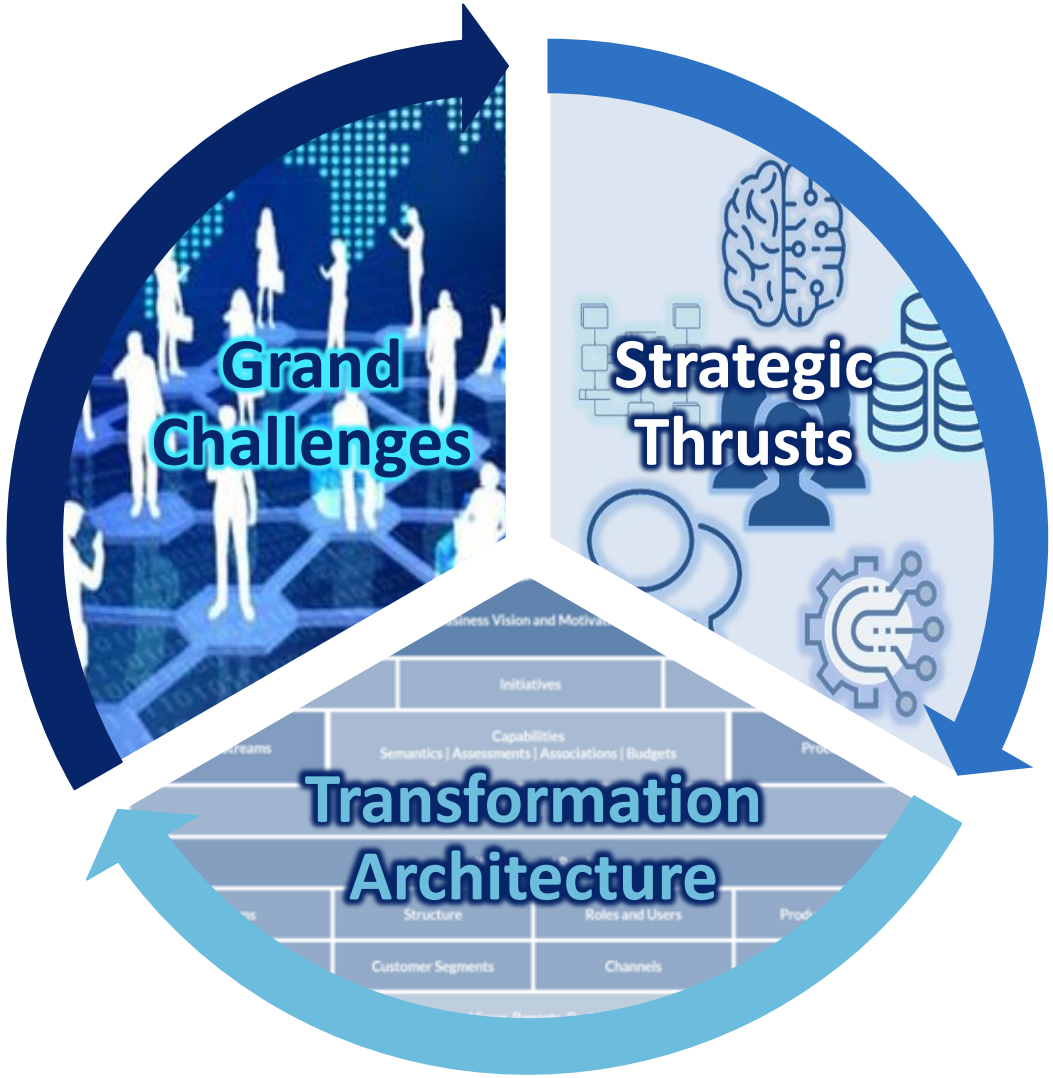
Coalition Model

- **Coalitions of the Willing:** co-invest in shared solutions to common challenges
  - Focus on cross-cutting agency challenges aligned by **Transformation Outcomes**
  - Connect orgs with needs/solutions to develop **shared solutions** to benefit all
- Engage users & owning orgs throughout **systematic test/mature of DT solutions**
  - Ensures **real solutions** to user needs
  - Ensures **sustainable solutions** for owners
- **Benefits**:
  - Minimize fragmentation / duplication / barriers
  - Maximize learning / progress / adoption


WHAT
ENTERPRISE DT SOLUTIONS

DT Portfolio Elements

Grand Challenges
Compelling transformation use cases

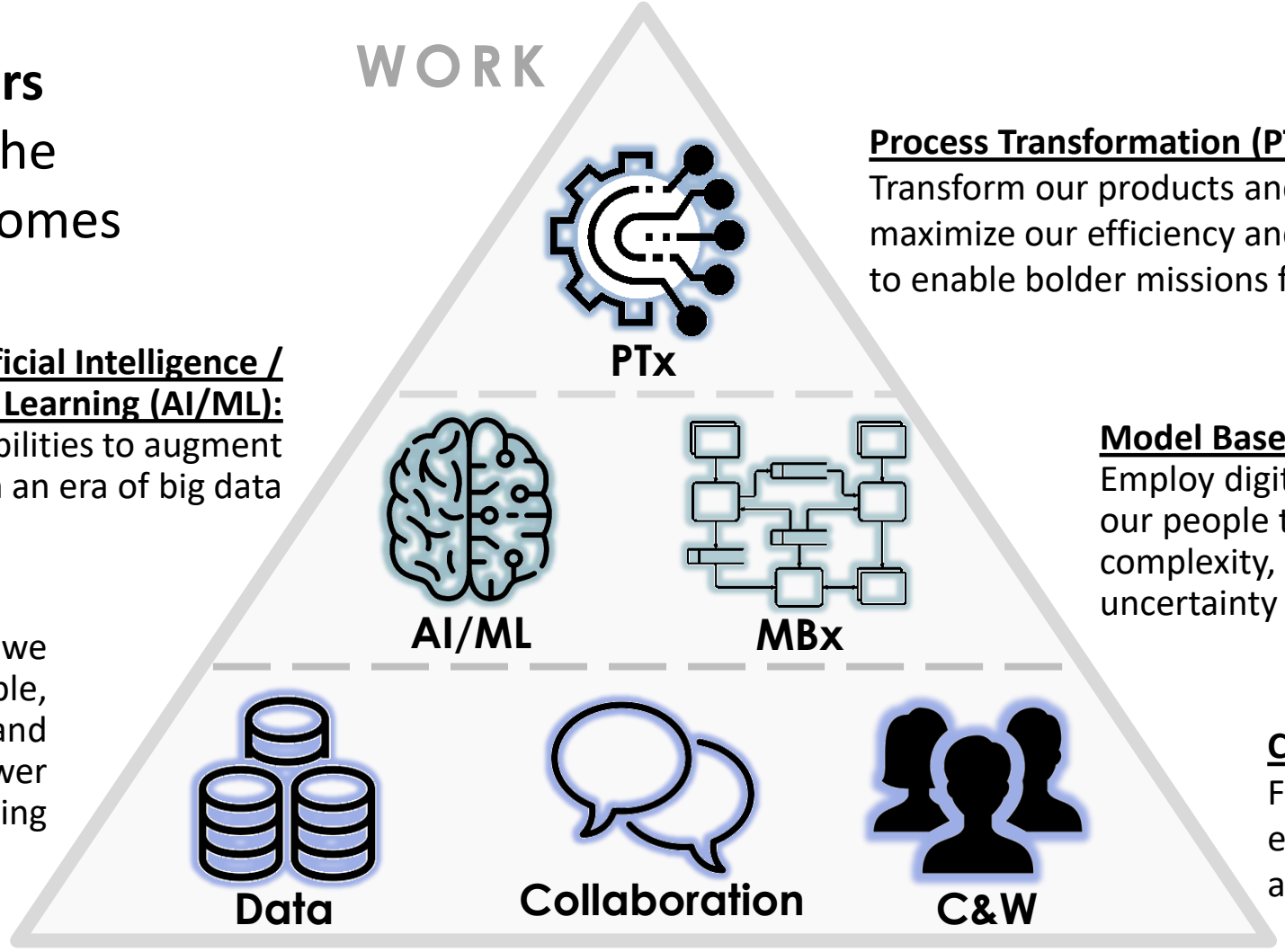


Strategic Thrusts
Cross-cutting digital enablers

Transformation Architecture
Integration framework

Enablers: DT Strategic Thrusts

Cross-cutting enablers required to achieve the Transformation Outcomes



Process Transformation (PTx):
Transform our products and processes to maximize our efficiency and effectiveness to enable bolder missions faster

Artificial Intelligence / Machine Learning (AI/ML):
Harness machine capabilities to augment human intelligence in an era of big data

Model Based Anything (MBx):
Employ digital models to enable our people to address increasing complexity, scope, speed, uncertainty & changes

Data: Ensure the data we need is Findable, Accessible, Interoperable, and Reusable (FAIR) to power data-driven decision making

Culture & Workforce:
Foster digital savvy, enterprise connection, and growth mindsets

Collaboration:
Enable agile teaming via seamless, secure internal and external collaboration

Integration: DT Transformation Architecture

DT's **Transformation Architecture** is our integration framework for communicating, connecting & integrating DT efforts across NASA into scalable interoperable solutions that benefit us all

Ignite

Define **Transformation Outcomes** to spark and collect DT solution ideas from across NASA

Connect

Communicate & share DT solutions and ideas from across NASA to promote collaboration and coalitions to build better multi-use DT solutions

Integrate

Establish **interoperability guidelines**, identify common requirements & contributing org solutions/capabilities. and **develop coalitions** to create enterprise DT solutions

Facilitate

Attack barriers to developing solutions, build prototypes & pilots, and scale to operational solutions

Aspiration: DT Grand Challenges

DT Grand Challenges are “real world” transformation pathfinder use-cases that serve as a lightning rod to catalyze enterprise DT adoption and integration and deliver tangible outcomes:

- Target **user-centric, high-priority** (important, urgent) real world challenges
- **Enterprise-wide** in applicability
- **Difficult** to accomplish yet ultimately **tractable**
- **Focused** pathfinders with **finite scope** on **finite timeline**
- Demand integration of **multiple DT Thrusts**
- **Participation** by many technical and non-technical organizations
- Have **well-defined metrics** (tangible outcomes)
- Capture **employee imagination** and **stakeholder support**

Initial DT Grand Challenges synthesized from DT Champions/OIC big pain points:

- **Future of Work** to jumpstart proficiency at fully inclusive hybrid teaming
- **Smart Centers** to attack facility sustainability

Future DT Grand Challenges = major use-cases derived from **Transformation Outcomes**

HOW

ENTERPRISE DT APPROACH

DT Management Approach

Enterprise DT is **primarily a strategic initiative,** with limited “program” role

Define **management processes ONLY where we need it**, striving for:

- **Simple** – Rightsized, streamlined and coordinated
- **Collaborative** – We will transform as a team, and aim for transparency & alignment of our efforts across NASA
- **Accountable** – What we do must accelerate NASA’s transformation, to address common challenges facing us all
- **Agile** – Deliver and try new things to meet the demand while aligning to technological advancements
- **Digitally enabled** – Use digital best practices and the best information available make agile yet objective transformation

Informed by 7120 best practices → not constrained

DT Processes

THINK BIG
Plan & Coordinate

- Partnering
- Integrating w/Other Initiatives & Organizations
- Ingesting Ideas & Selecting Investments

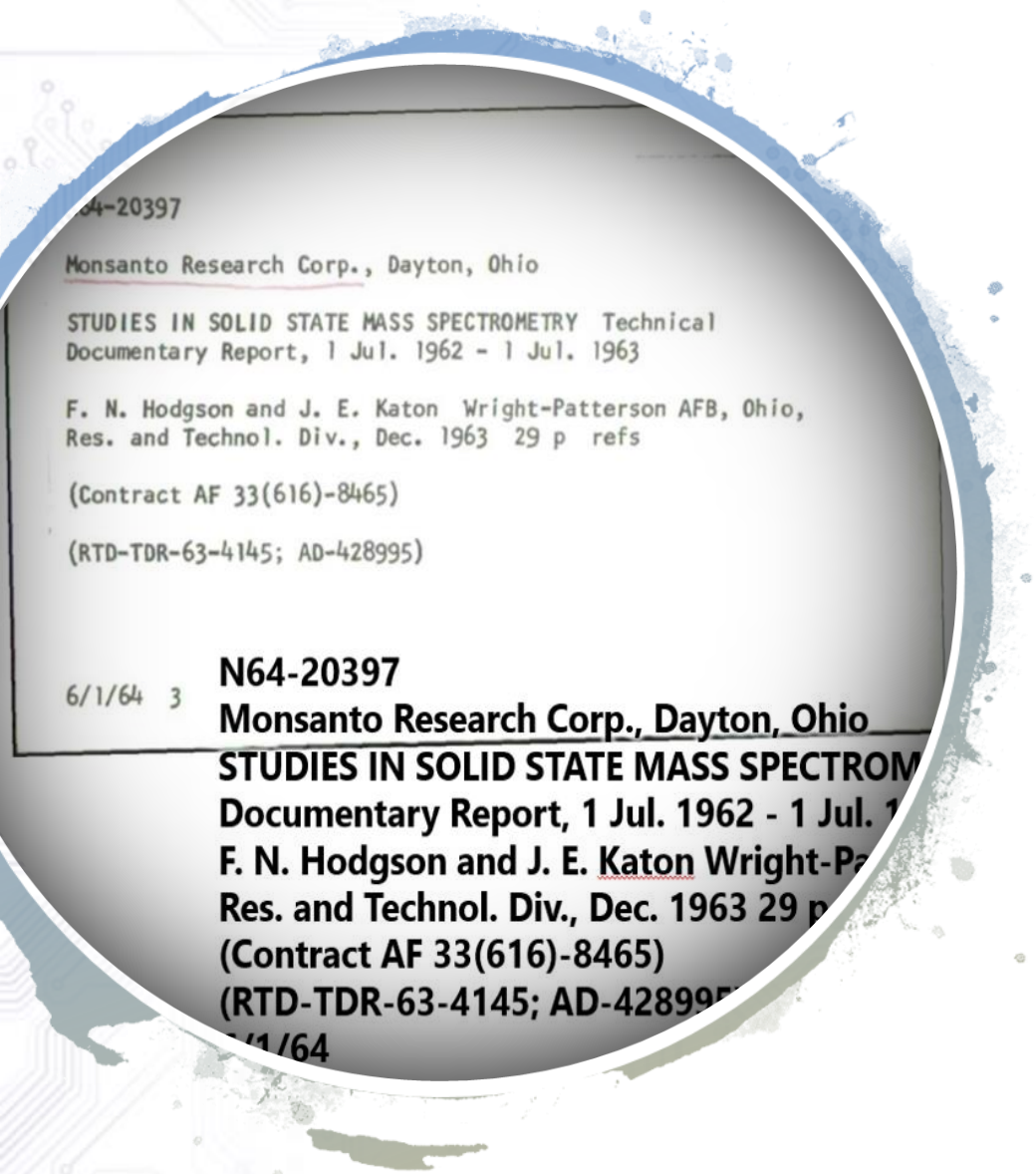
START SMALL
Execute & Manage

- Managing Execution
- Managing & Distributing Data
- Identifying & Mitigating Risks

ACT FAST
Measure & Refine

- Soliciting Feedback
- Measuring Impact
- Refining Plans

- Communication
- Stakeholder Engagement



Plan & Coordinate

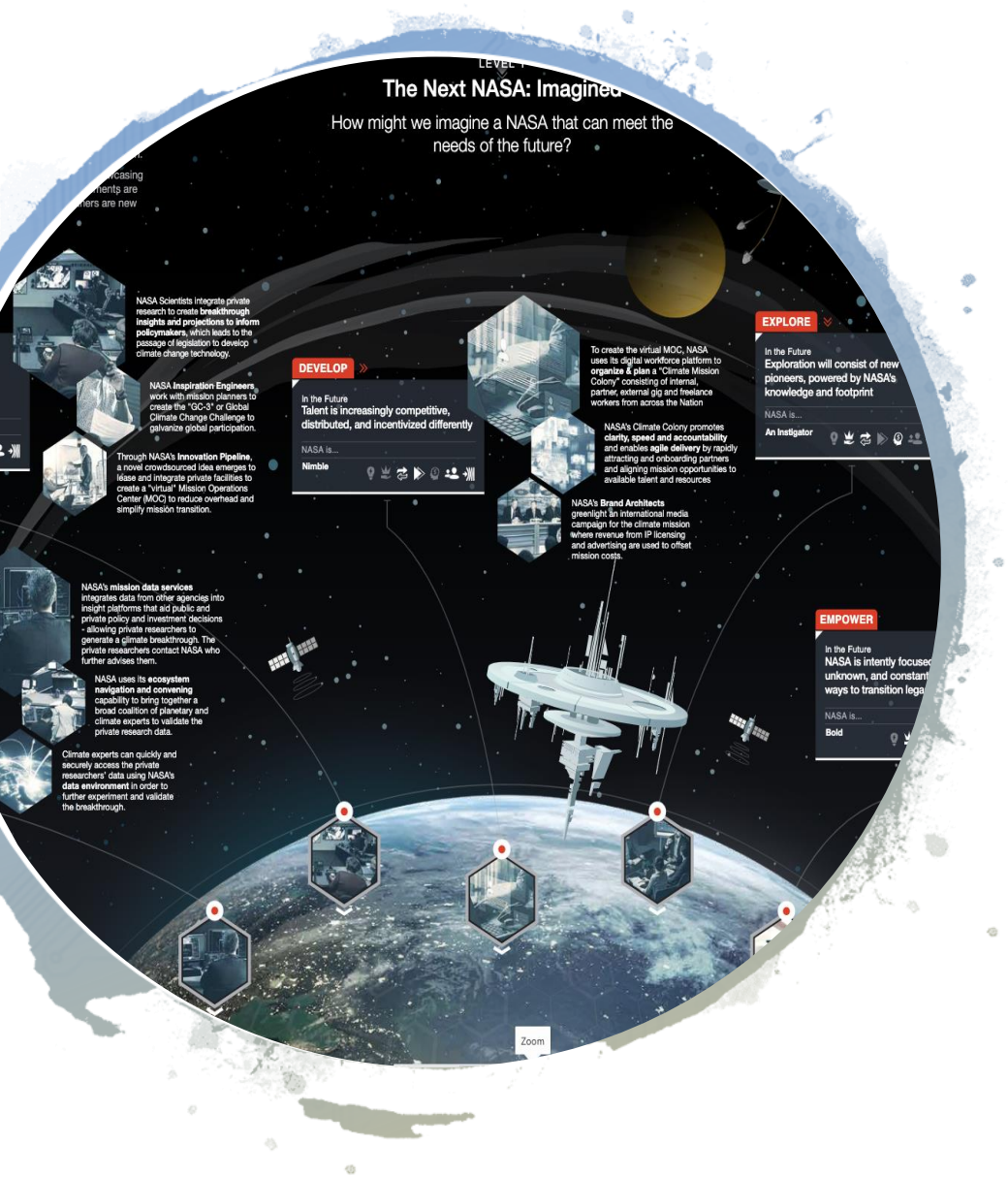
PARTNERING

NASA is a member of the aerospace and science community with **partners who are aggressively and simultaneously harnessing DT.**

Enterprise DT acts as a **catalyst** to:

- **Harvest best practices** internally across NASA and from external partners.
- **Leverage investments** through teaming to speed our collective progress.
- **Share results** to communicate how DT drives effective solutions.

FY21 Progress: *Accelerated efforts to leverage continuously improving* ***Amazon Web Services, Microsoft Azure, and Google Cloud AI/ML tools*** *developed for broader market needs, by expanding our user access, learning and diverse use-cases, such as "reading" 1960's era card catalog images for our digital library.*



Plan & Coordinate

INTEGRATING WITH OTHER INITIATIVES & ORGANIZATIONS

Enterprise DT is **one transformation effort among many** across NASA, and will coordinate DT efforts through:

- Continuously refining a **Transformation Architecture** to integrate our collective DT efforts
- Use **agency councils** to facilitate enterprise coordination and strategy alignment
- Other mechanisms, such as embedded leaders, to ensure coordination with **selected key organizations** core to DT success

FY21 Progress: *Developed initial version of a* ***Transformation Architecture*** *to organize goals of multiple transformation initiatives and conceptualized attributes of a Future NASA business model, all to lay the groundwork for defining interoperability guidelines for enabling enterprise DT solutions.*

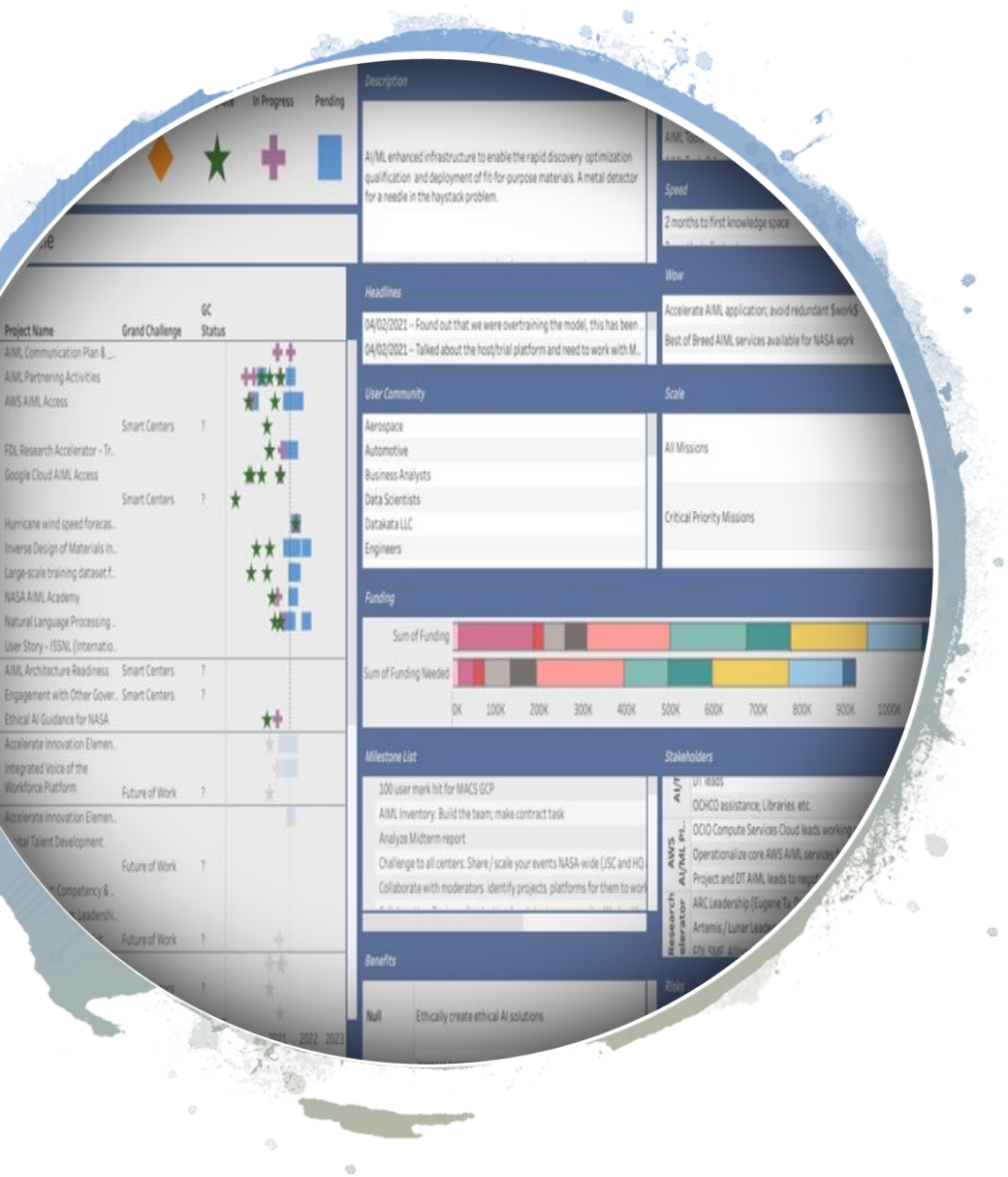
Plan & Coordinate

INGESTING IDEAS & SELECTING INVESTMENTS

Enterprise DT will focus on **enterprise solutions to Transformation Outcomes that require a catalyst**

- Ideas solicited using a variety of mechanisms to get diverse **top-down, bottoms-up and external partner ideas** and perspectives
- **Inclusive evaluation process** with stakeholder participation using **transparent selection criteria / weightings** to prioritize into shared selectable pool
- Investments selected using **data-driven decision making** to integrate recommendations & evaluate alternatives
- Backlog of **selectable ideas shared** on DT Nexus

FY21 Progress: *Hosted inaugural* ***DT Hackathon****, which enabled early adopters across NASA to team to rapidly prototype DT solution ideas that fed our portfolio, including using virtual reality to enable immersive collaboration for distant teams.*



Execute & Manage

MANAGING EXECUTION

Enterprise DT will coordinate & facilitate the execution of a **portfolio of enterprise solutions** to achieve Transformation Outcomes

- **Implementation Plans** documented using agile ~3-page (equivalent) template designed for data ingest
- **DT Portfolio Dashboard** (built on Enterprise Data Platform, shared on DT Nexus) used to measure progress wrt cost, schedule, milestones, risks
- Management approach promotes **agile decision making at lowest possible level** using start/stop/continue gates
- Enterprise DT **promotes infusion** by engaging users and ultimate owning organizations throughout development

FY21 Progress: *Created a* ***DT Portfolio Dashboard*** *on the Enterprise Data Platform that automates data ingest and visualizes performance issues to rapidly assess progress and risk/issues during DT project execution.*

Execute & Manage

MANAGING & DISTRIBUTING DATA:

Enterprise DT will be an early adopter of an **enterprise data culture** by:

- Maintaining discipline in adopting consistent data formats, classifications, naming conventions, records management for a growing list of **Data Asset Types**
- Leveraging enterprise tools to streamline **Lifecycle Data Management**, including distribution mediums, web content management, tagging/ metadata, taxonomy, quality, access, analytics

FY21 Progress: *In addition to using the Enterprise Data Platform for DT decision making, accelerated adoption to create* ***29 use-cases****, such as the* ***COVID Executive Decision Lens****, to enable NASA teams to leverage integrated enterprise tools to store, manage, aggregate and analyze data.*

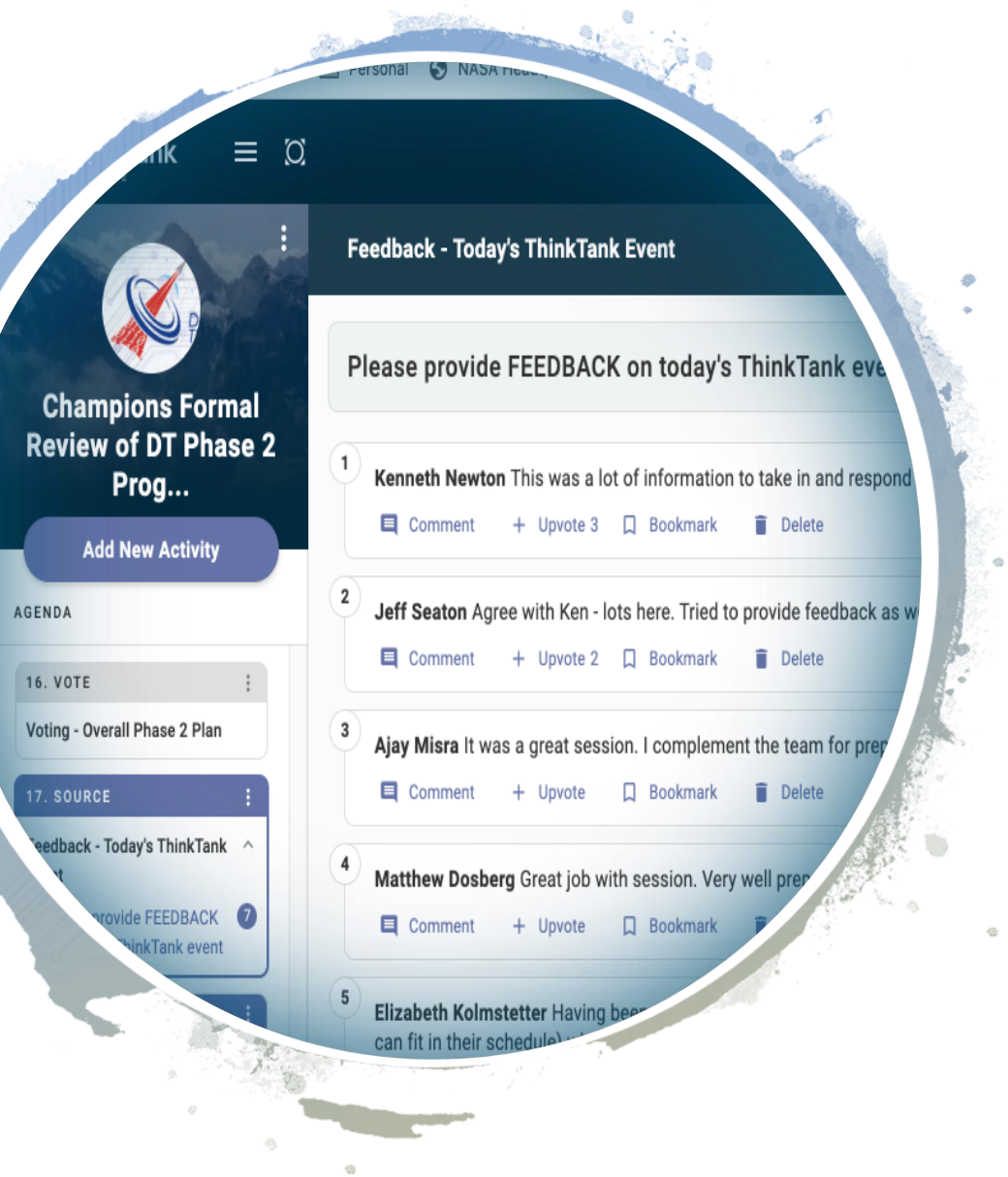
Execute & Manage

IDENTIFYING & MITIGATING RISK

Enterprise DT **accepts higher risk** in exchange for innovation and transformation, and will proactively manage risk posture by:

- **Identifying risks** associated with the overall DT strategy, the DT content, and DT project execution
- **Mitigating risks** using DT Portfolio Dashboard to evaluate progress, threats and opportunities, and using agile start / stop / continue decision making to pivot as needed

FY21 Progress: *Beyond defining a risk registry for DT that is ingested into the DT Portfolio Dashboard, launched a prototype project to create a* ***Risk Digital Assistant*** *using AI/ML to alert project managers to trends where past projects have realized risks.*



Measure & Refine

SOLICITING FEEDBACK

Enterprise DT will solicit feedback to both **ensure stakeholder alignment** and to **reveal unexpected issues/opportunities** for early decision making through:

- **Formulation Reviews** to ensure alignment with enterprise priorities, organizational strategic needs, user/employee solution requirements, and early adopter insights
- **Execution Reviews** to monitor and adjust performance of the portfolio: monthly internal project level, quarterly portfolio level reviews, and semi-annual BPR enterprise level
- **External Assessments** to evaluate alignment & opportunities with external partners and digital thought leaders

FY21 Progress: *Experimented with mechanisms such as* ***ThinkTank*** *and O365 review features to rapidly solicit targeted feedback on formulation plans, which many DT Champions then incorporated into their organizations' repertoire of collaboration / feedback tools.*

Measure & Refine

MEASURING IMPACT

Enterprise DT will work with stakeholders develop a methodology, to be **presented at initial BPR,** to measure:

- Progress on **Transformation Outcomes** – and **building the right solutions** to enable NASA transformation
- Progress on adoption, aka **Digital Maturity** – are **organizations using the solutions correctly** to achieve NASA transformation?

Methodology will calibrate for level of effort required:

- Begin with qualitative, indirect measures
- Over time develop quantitative, direct measures

FY21 Progress: *As part of the* ***Orion Digital Twin*** *project, created a MBSE electrical system model used for real-time evaluation of anomalies/solutions during operations, making progress toward our "Improved Complex Decision Making" objective.*

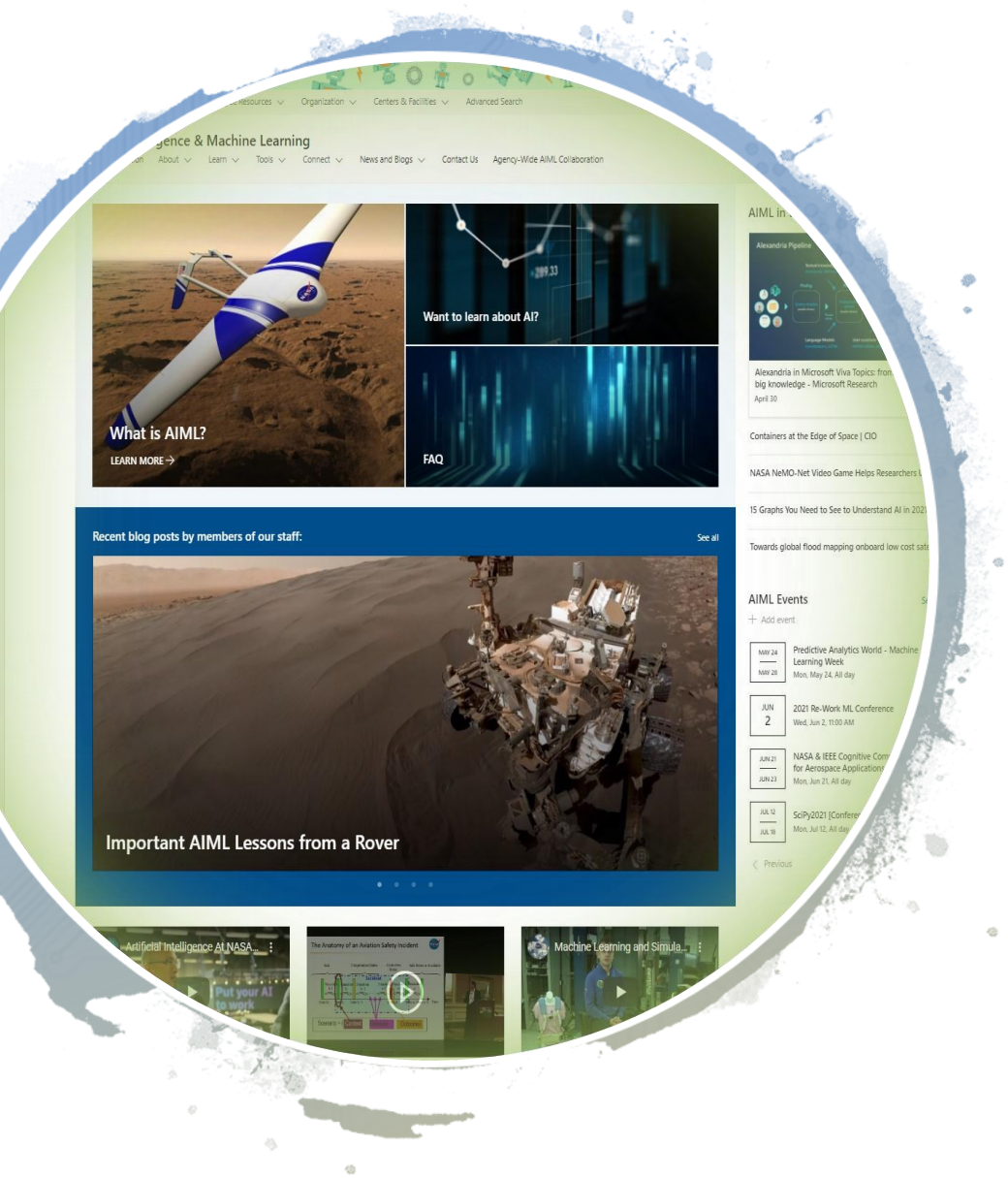
Measure & Refine

REFINING PLANS

Enterprise DT will use data-driven **opportunity management** to track and evaluate alternative courses of action and make risk-informed decisions to refine plans at all levels, specifically:

- Maintain a **backlog of unfunded opportunities**, shared on DT Nexus, as alternative solutions if/when risks on funded work materialize and efforts are terminated
- Keep up a list of **technology trends** and **emerging transformation needs**, again shared on the DT Nexus, as triggers to periodically assess the DT strategy, content and/or projects.

FY21 Progress: *Prototype projects are highly exploratory, and when not successful, prototypes are terminated making room for additional awards from the backlog. The* ***Mission, Science & Engineering Platform*** *was a successful prototype that demonstrated efficacy of using HoloLens for partners outside of Mission Control to consume/visualize telemetry data; it is now being adapted for Smart Centers and possibly Moon/Mars autonomous operations.*



Measure & Refine

COMMUNICATING

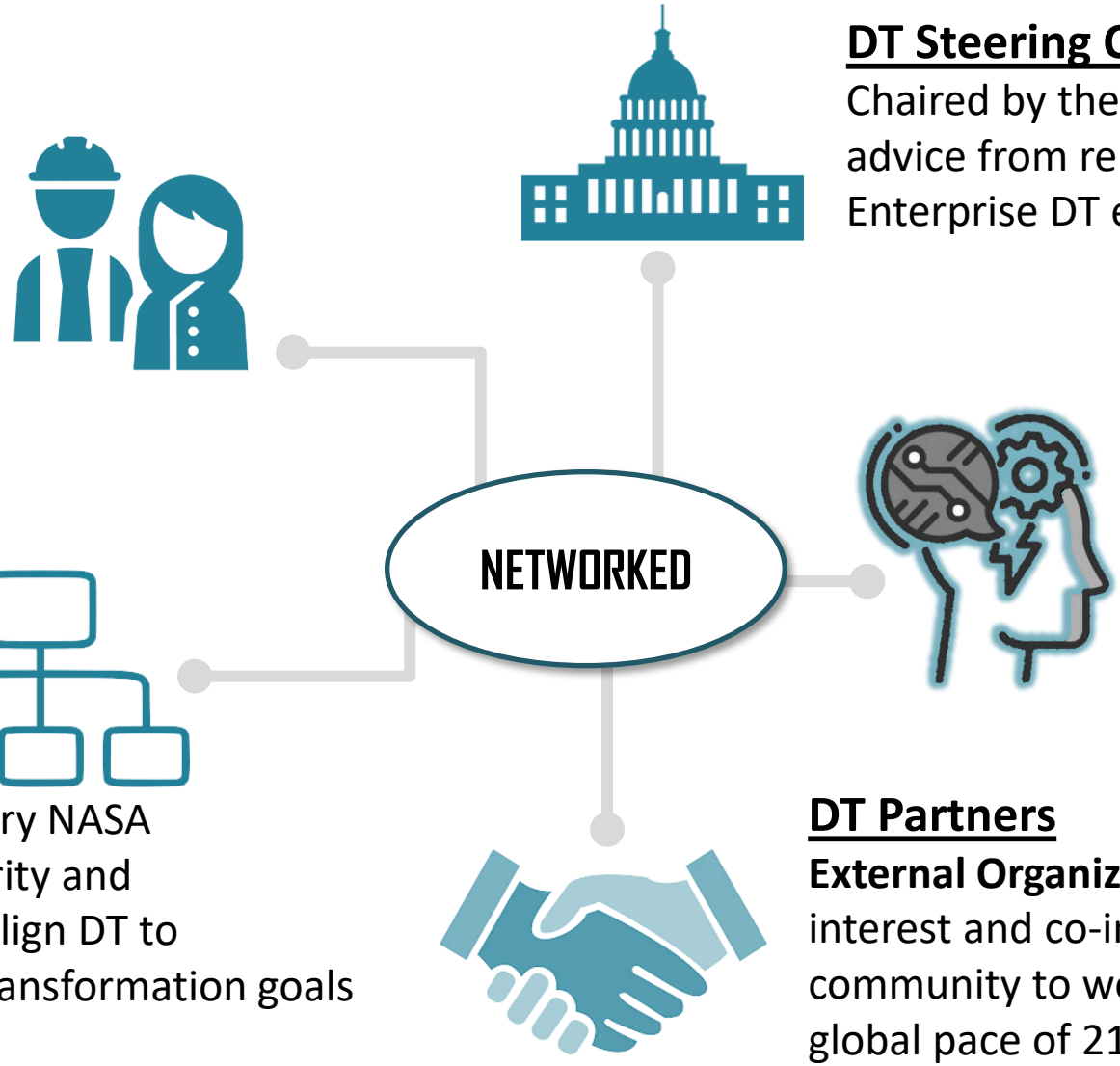
Partnered w/OCOMM to create a comprehensive Enterprise DT **communications strategy** defining:

- **Objectives & Outcomes:** create internal awareness and adoption, external partnership opportunities, and public excitement about how we work
- **Audiences & Messages:** strategically select who we are communicating to, and customize messages tailored to audience interests and change receptivity
- **Mediums & Cadence:** both regular “push” of headlines and on-demand “pull” mechanisms based on audience interests & curiosity

DT Nexus migration to the new SharePoint based NASA Intranet will now serve as a primary internal communication / connection hub for Enterprise DT

FY21 Progress: *Piloted DT integrated communication strategy on the new SharePoint based NASA Intranet through the* ***AI/ML Knowledge Space****, which created a hub to aggregate/share learning resources, tools, relevant news, and more.*

Stakeholder Engagement



NASA's Employees
The **ultimate customers** of DT efforts, who play a critical role by being open to new ways of working and new opportunities created by the digital age

DT Steering Committee
Chaired by the **Associate Administrator** with advice from representative OICs to ensure Enterprise DT enables federal & NASA priorities

DT Thrust Teams
Early Adopters from across NASA who follow DT trends and propose/explore DT applications to attack working level barriers to accomplishing high-value work

DT Champions
Senior Leaders from every NASA organization with authority and influence to adopt and align DT to enable organizational transformation goals

DT Partners
External Organizations who have a shared interest and co-invest in enabling our aerospace community to work seamlessly together at the global pace of 21st Century business


NEXT STEPS
ENTERPRISE DT WAY AHEAD

Conclusion

- With APMC/MSC approval, ***Formulation* is complete:**

WHY: **DT Strategy** → **IGNITE *transformation***

✓**DT Goals & Objectives** ensure DT focuses on accelerating larger NASA transformation
✓**DT Transformation Outcomes** provide clear targets to rally & align all of our DT efforts
✓**DT Coalition Model** ensures DT solutions yield results needed for users/investors

WHAT: **DT Results** → **CONNECT & INTEGRATE *solutions***

✓**DT Elements** continuously refine a portfolio of digital enablers (Thrusts), an integration framework (Transformation Architecture), & pathfinder use-cases (Grand Challenges)
✓**DT Implementation Plans** detail current plans being executed across NASA to achieve enterprise-level DT Transformation Outcomes

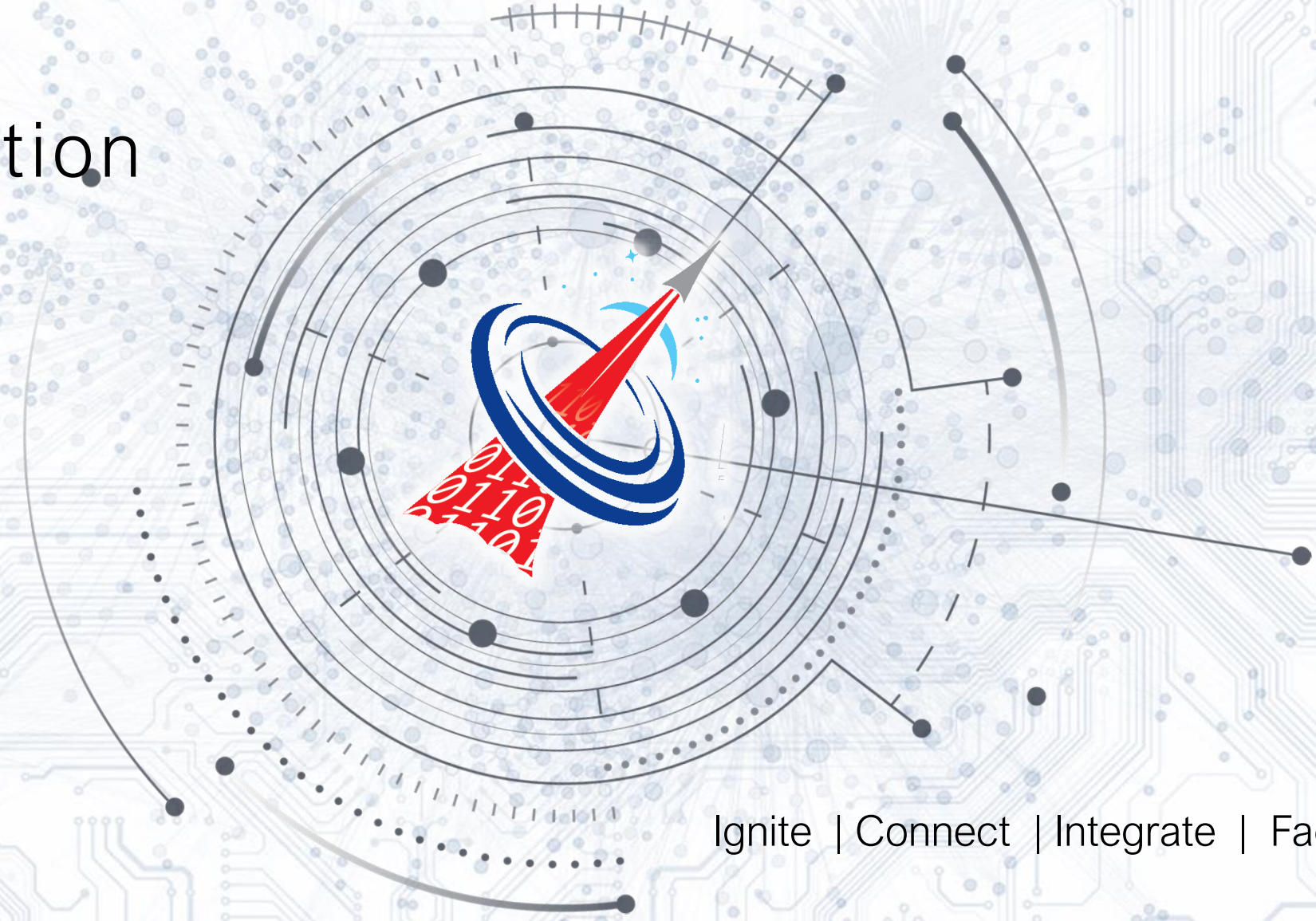
HOW: **DT Approach** → **FACILITATE *progress***

✓**DT Processes** provide enough structure only where needed: *Simple, collaborative, accountable, agile, digitally-enabled*
✓**DT Stakeholder Engagement** coordinated through a network that integrates federal, organizational, partner, early adopter and employee perspectives

- Next steps: **enter *Implementation***, with full attention on **Connecting enterprise DT efforts** and **execution of FY22 projects**, designed to solve initial Transformation Outcomes:
  - **Large Coalition Projects**: *Data & Knowledge Hub, Smart Standards, MBx Digital Engineering, Smart Reviews*
  - **Small Prototype Projects:** *Early-adopter led emerging technology exploration*
  - **Grand Challenges:** *FOW/MICS (FY22) to jumpstart fully inclusive hybrid teaming, Smart Centers (FY23) to attack facility sustainability*
  - **Integration:** *DT Nexus to share & connect DT efforts, Transformation Architecture to ensure interoperability of solutions*

Decision: Approve Enterprise DT Plan?

NASA Transformation *by Design*



Ignite | Connect | Integrate | Facilitate

NASA's Digital Transformation Overview

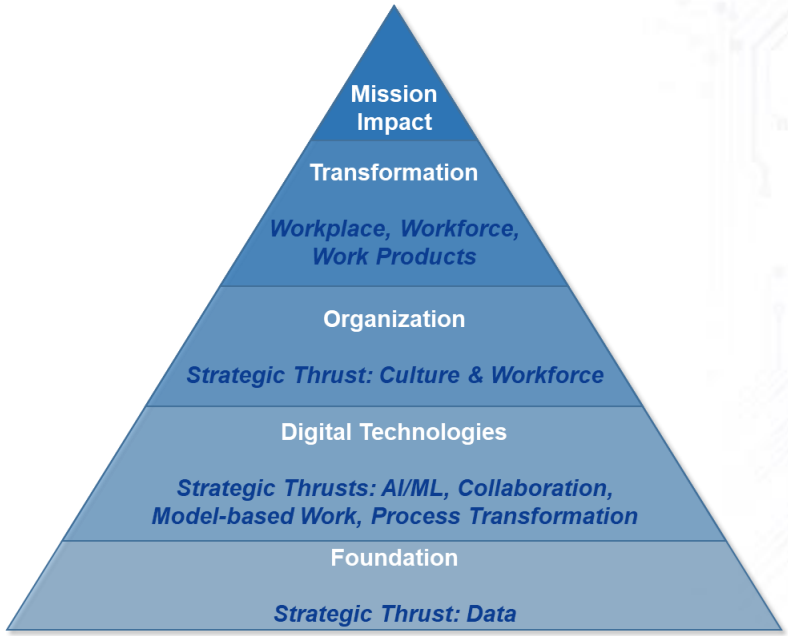
The What?

TRADITIONAL → **DIGITIZED** → **TRANSFORMED**

10x or more improvement

DT is employing digital technologies (e.g., AI, mobile, cloud, data) to **change a process, product, or capability so dramatically** (e.g., real-time, intelligent, personalized, anywhere, anytime) that it's **unrecognizable compared to its traditional form.**

The How?



The Why?

Enable the Future

Rearchitect our WORK
Deliver increasingly **complex missions** leveraging increasingly **complicated partnerships**, on **shorter timelines** to achieve **bolder outcomes** that **inspire** the world

Elevate our WORKFORCE Experience
Create a seamless, integrated, and inclusive **employee experience** that **energizes** our people by feeling **connected** to the NASA enterprise, continuously **grow,** and take **pride** in rapidly delivering **high-value work**

Create Adaptive WORKPLACES
Optimize a sustainable 21st Century **cyber-physical work environment** that powers **flexible, adaptable, efficient, and effective** employee and partner **teaming**.

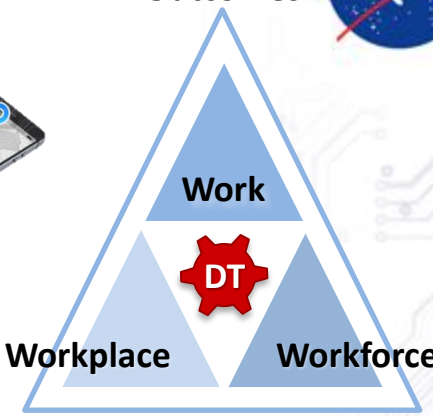
Built on NASA's Strategic Thrust Focus Areas:

- Data
- Culture & Workforce (C&W)
- Process Transformation
- Collaboration
- Artificial Intelligence/Machine Learning (AL/ML)
- Model-Based Anything

Digital technologies can radically accelerate NASA's transformation goals.

Back-up Slides

Digital Transformation – More Than Tools



*Empower **our people (and partners)** to*
***reinvent our products, processes, and capabilities** by*
taking <u>full</u> advantage of data and cutting edge digital technologies
*to **transform mission outcomes & enhance mission success***

TODAY

"My" data culture

Time spent on "paperwork"

Strategic decisions require time-consuming data collection and analysis

Industrial partners cannot get access to NASA SharePoint/ MS Teams

NASA best large federal agency to work for

TRANSFORMED

"One" data culture

Automation frees employee time for more meaningful work

Real-time data and model-based analytics drive decisions

Work seamlessly with partners from any platform, anywher

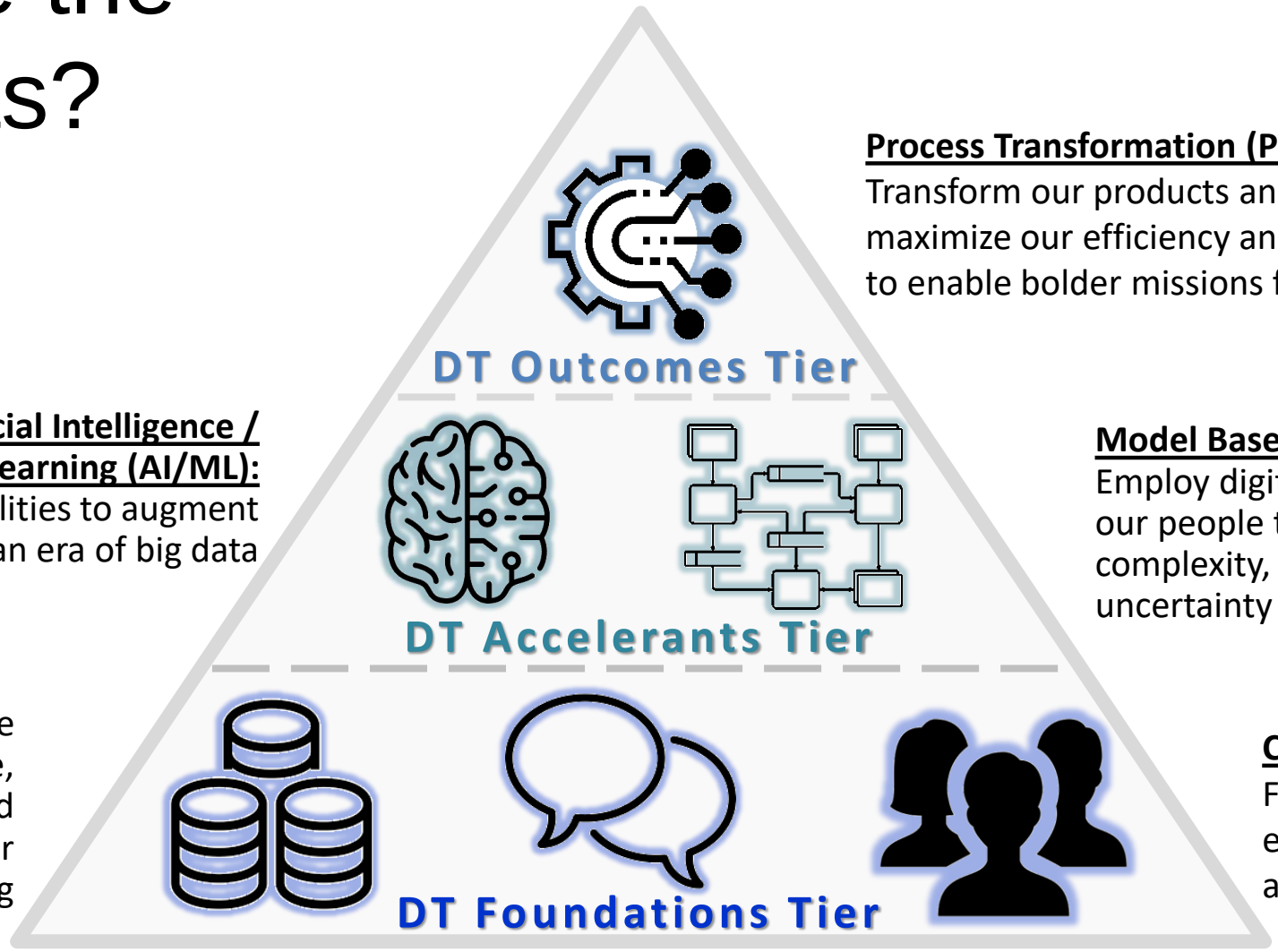
NASA is the best place to w anywher

Digital Transformation is not the goal, it's a lever. A big one.

NOT a tool or platform development program

WHAT are the DT Thrusts?

WORK



Process Transformation (PTx):
Transform our products and processes to maximize our efficiency and effectiveness to enable bolder missions faster

Artificial Intelligence / Machine Learning (AI/ML):
Harness machine capabilities to augment human intelligence in an era of big data

Model Based Everything (MBx):
Employ digital models to enable our people to address increasing complexity, scope, speed, uncertainty & changes

Data: Ensure the data we need is Findable, Accessible, Interoperable, and Reusable (FAIR) to power data-driven decision making

Culture & Workforce:
Foster digital savvy, enterprise connection, and growth mindsets

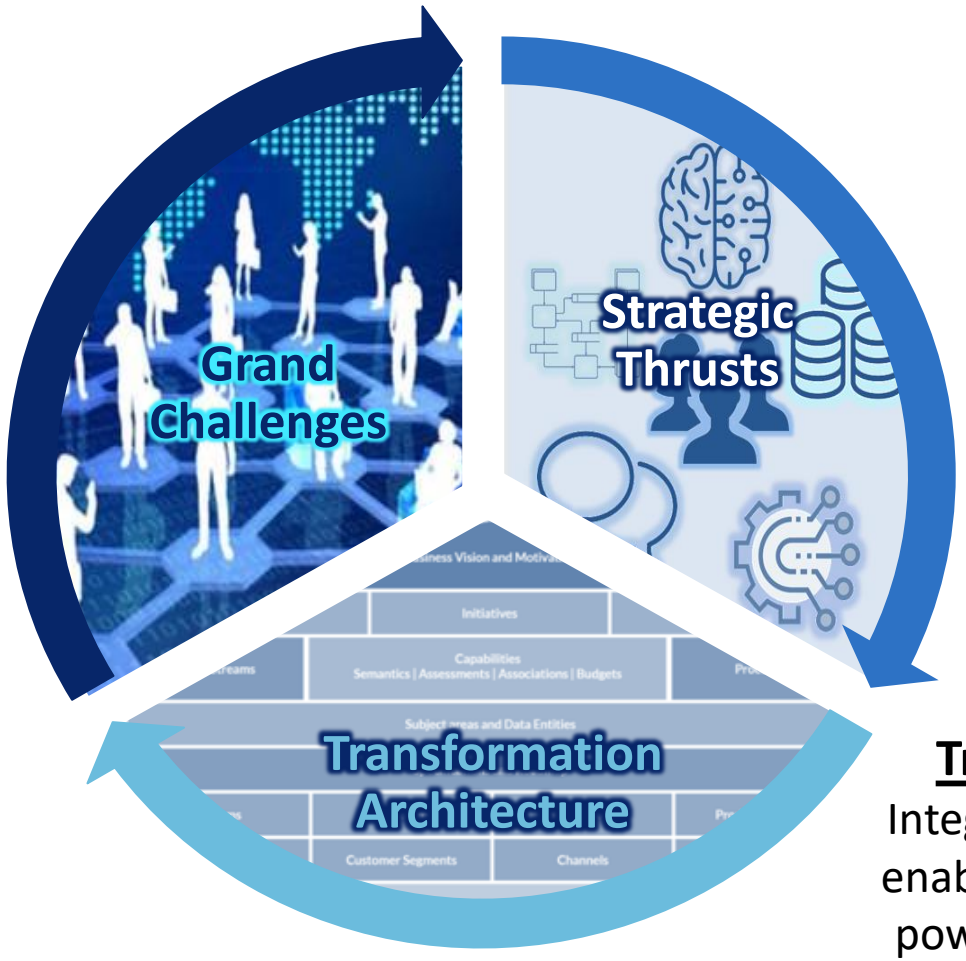
WORKPLACE

Collaboration:
Enable agile teaming via seamless, secure internal and external collaboration

WORKFORCE

WHAT will we actually do?

Grand Challenges
"Real world" transformation pathfinders that serve as a lightning rod to catalyze enterprise DT adoption and integration and deliver tangible end-to-end outcomes, using integrated digital enablers



Strategic Thrusts
Catalysts for transformation → key shared enterprise-level digital enablers that orgs can use to accelerate transformation outcomes

Transformation Architecture
Integration plan for how those digital enablers can/should work together to power our future transformed NASA

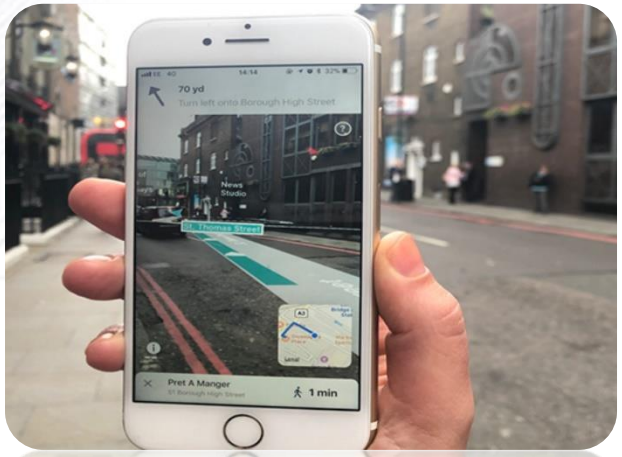
We will field core digital building blocks (Strategic Thrusts) in an integrated way to create the NASA of the future (Transformation Architecture) and solve big problems (Grand Challenges).

What is Digital Transformation (DT) ?

Digital Transformation has already changed our world…

Employing digital technologies (e.g., AI, mobile, cloud, data) to **change a process, product, or capability so dramatically** (e.g., real-time, intelligent, personalized, anywhere, anytime) that it's **unrecognizable compared to its traditional form**

… & technology discovery and convergence is accelerating change!



- Cloud Computing
- Mobile Access
- Automation and Robotics
- Big Data / Data Mining / Analytics
- Artificial Intelligence / Machine Learning
- Model-Based Systems Engineering
- Agile Software Development / DevOps / DevSecOps
- Internet of Things / Sensors
- Digitized Manufacturing (e.g., 3-D Printing)
- Augmented Reality / Virtual Reality
- Multidisciplinary Modeling and Simulation
- High Performance Computing
- Collaboration Platforms
- Social Media / Crowdsourcing
- Virtual Meetings
- **And more…**

Home & Work: Common Denominators

Similar challenges at both home and at work:

- More demands
- More complex & complicated
- More interactions
- Faster paced
- More frequent changes
- More budget pressures

The same kinds of **digital solutions** that are helping us navigate modern life at home will also **transform our work world**

What is Digital Transformation?

Employing digital technologies to change a process, product, or capability so dramatically that it's unrecognizable compared to its traditional form.

From Maps to Apps...
Digital Transformation already has changed our world.

TRADITIONAL **DIGITIZED** **TRANSFORMED**

Why pursue DT?

Transform NASA's
Work

Deliver increasingly **complex missions** leveraging increasingly **complicated partnerships**, on **shorter timelines** to achieve **bolder outcomes** that **inspire** the world.

Transform NASA's
Workforce

Create a **seamless**, **integrated**, and **inclusive** employee experience that **energizes** and **connects** our people.

Transform NASA's
Workplace

Optimize a **cyber-physical work environment** that powers **flexible, adaptable, efficient, and effective** collaboration.

NASA's Digital Transformation Overview

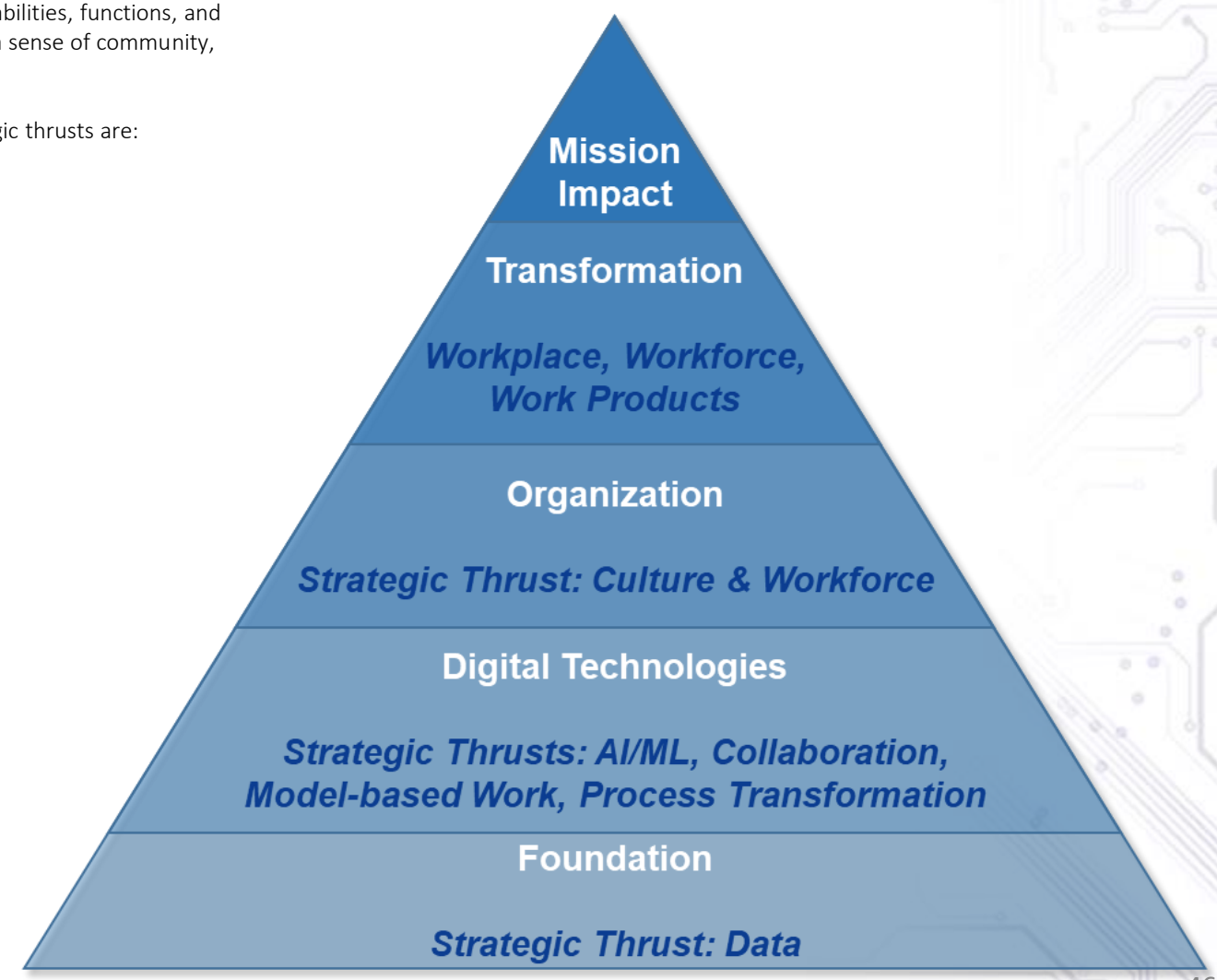
NASA's Office of the Administrators' Business Innovation Office is executing an enterprise Digital Transformation (DT) program. DT will empower NASA's people to reinvent products, processes, and capabilities by taking full advantage of data and cutting-edge digital technologies to transform mission outcomes and enhance mission success.

Critical to NASA's DT is its Transformation Architecture (TxA) which will guide the operationalization of DT at NASA, ensuring that DT efforts are coordinated and scalable. The TxA is both tangible and intangible. Tangibly, it depicts NASA's future capabilities, functions, and relationships, and how digital will power them. Intangibly, it is a mindset and way of working that requires a sense of community, discipline, and practice.

The TxA blueprint is comprised of six strategic thrusts to guide seamless enterprise integration. The six strategic thrusts are:

- Data
- Culture & Workforce (C&W)
- Process Transformation
- Collaboration
- Artificial Intelligence/Machine Learning (AL/ML)
- Model-Based Anything

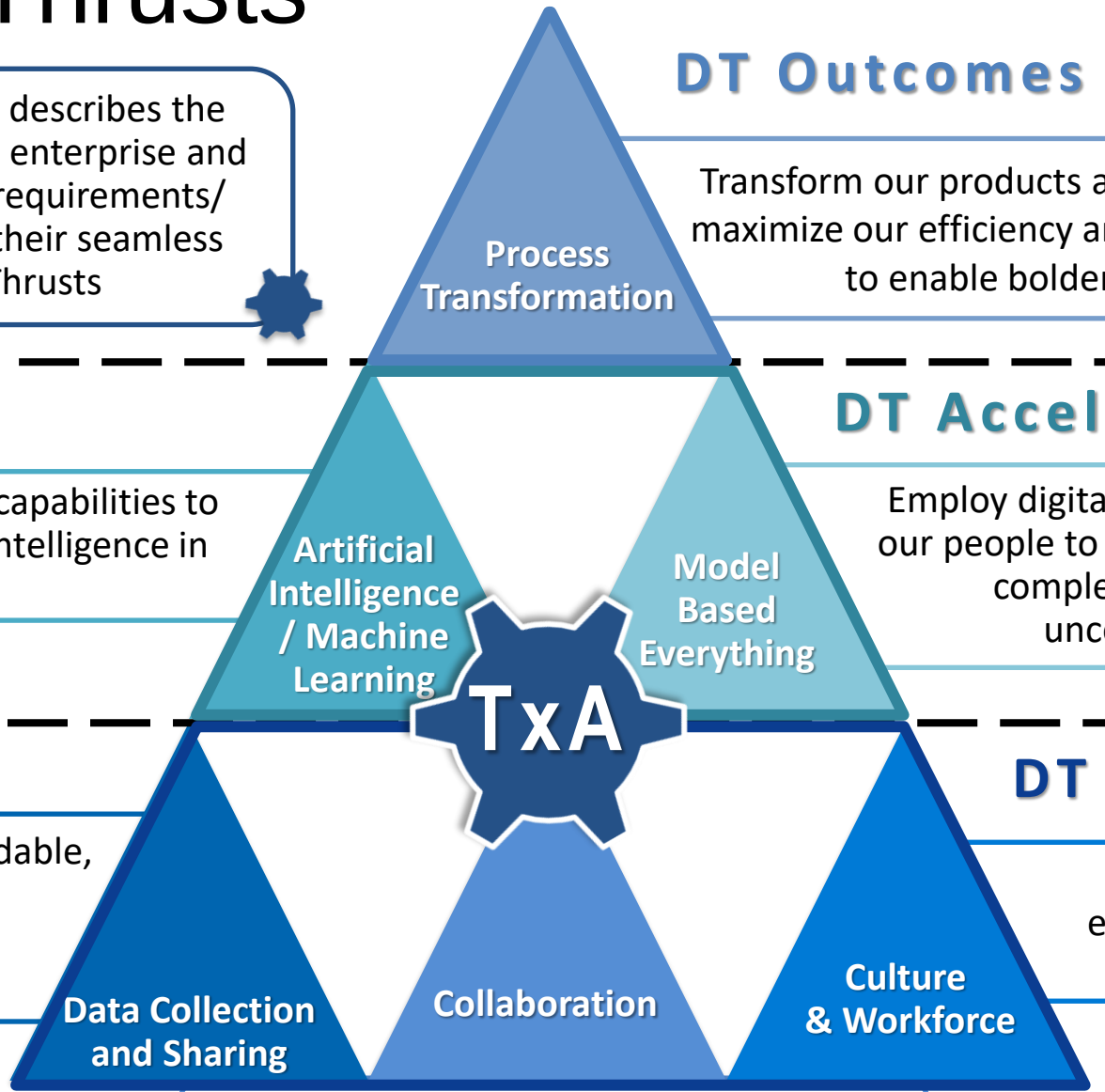
Employing digital technologies (e.g., AI, mobile, cloud, data) to **change a process, product, or capability so dramatically** (e.g., real-time, intelligent, personalized, anywhere, anytime) that it's **unrecognizable compared to its traditional form**



DT Strategic Thrusts

Work = Mission Outcomes

Transformation Architecture (TxA) describes the functions in our transformed NASA enterprise and their relationships, along with the requirements/ standards/ guidelines for assuring their seamless integration harnessing the six DT Thrusts



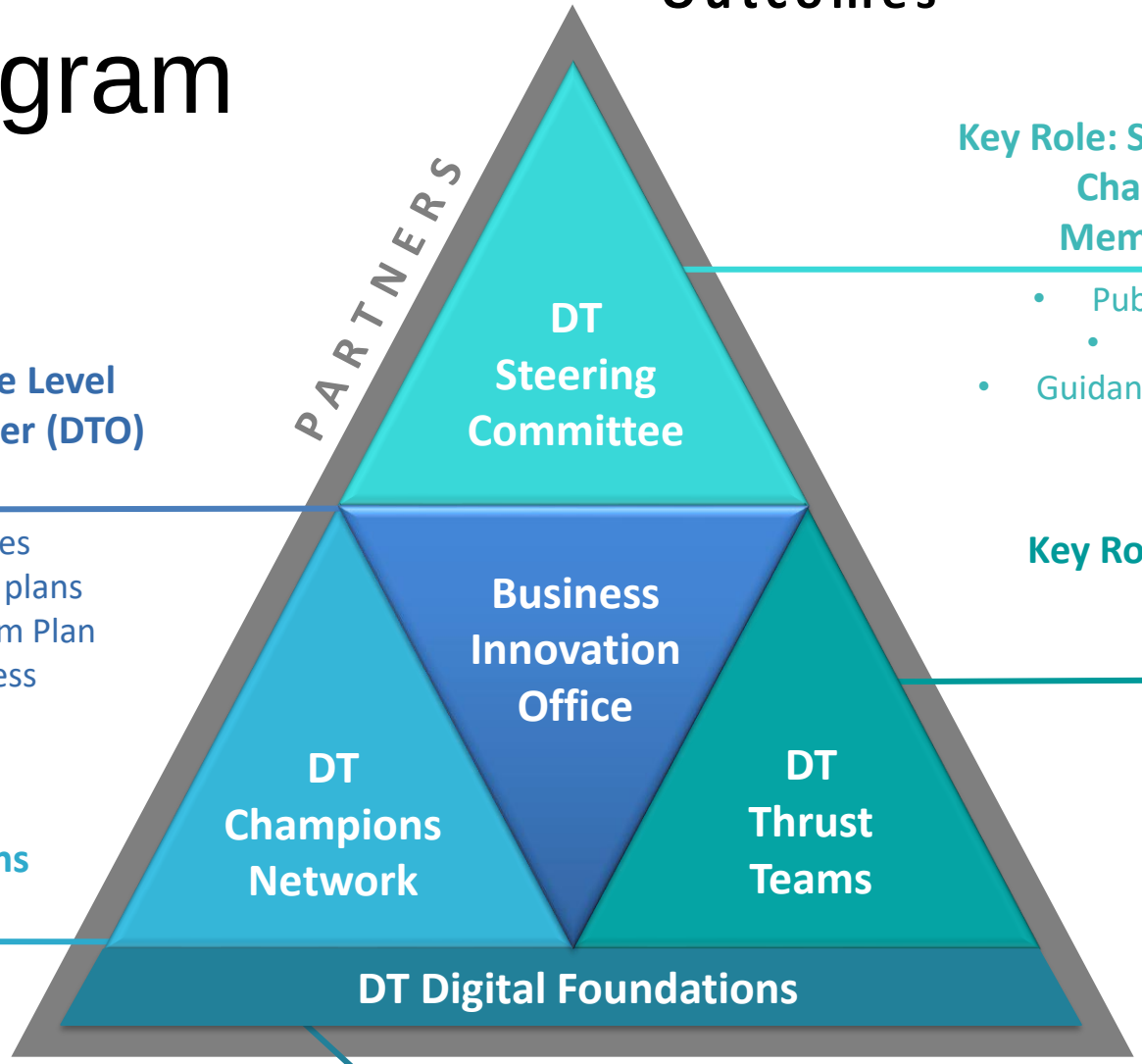
Workplace = Cyber-Physical Environment

Workforce = Innovation Core w/ Growth Mindset

Stakeholder Definition & Engagement

NASA DT Program

Mission Outcomes



Key Role: Strategy @ Agency/Federal Level
Chaired by: Associate Administrator
Members: Selected OIC Stakeholders

- Public Sector interests/federal alignment
- Overall agency transformation vector
- Guidance on resources, approach, outcomes

Key Role: Coordination @ Enterprise Level
Led by: Digital Transformation Officer (DTO)
Members: DT Thrust Leads

- Lead consensus on enterprise priorities
- Define architecture to accelerate OIC plans
- Develop & execute integrated Program Plan
- Catalyze partners & evangelize progress

Key Role: Outcomes @ Employee Level
Led by: DT Thrust Leads
Members: Early Adopters, SMEs

- Raise working-level barriers
- Watch digital trends
- Propose & prototype solutions

Key Role: Outcomes @ OIC Level
Facilitated by: DTO/DDTO in Domains
Members: OIC DT Champions

- Collaborate on enterprise priorities
- Align OIC modernization plans
- Team to pilot common solutions
- Drive & share OIC progress

Key Role:
Scalability @ Operations Level
Led by: CIO
Members: Center OCIOs & Service Leads

- Design, scale, integrate & sustain enabling DT Digital Foundations

Back-Up Slides

Model Based Anything (MBx)

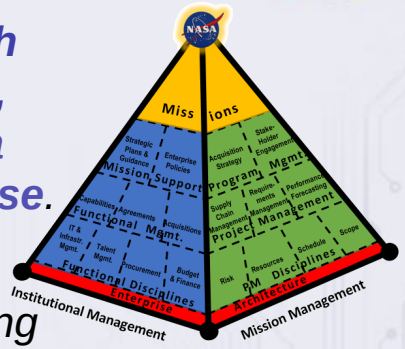
DEFINITION

MBx is "**model based" anything**, from engineering to safety to finance, and beyond.

MBx is characterized by a **well-defined framework for describing a system**, resulting in the creation of a functional digital workflow over the lifecycle of all NASA missions.

VISION

*To modernize NASA to **make decisions with increasing complexity, velocity, accuracy, confidence, and adaptability by creating a digitally integrated, Model Based Enterprise**.*



Model-based processes and tools will be integrated across NASA disciplines, leveraging a digitally connected Enterprise that drives transformative gains in engineering, institutional, and management practices.

CHALLENGES & GAPS – Solve via Strategy

- Lack of access to appropriate modelers *(Workforce)*
- Lack of discipline specific and integrated workflows (*Process)*
- Production level cluster and/or cloud environments *(Tools and Infrastructure)*
- Talent is segregated *(Workforce)*
- Best practices not developed *(Process)*
- Lack of enterprise infrastructure for creating authoritative sources *(Tools and Infrastructure)*

GOALS

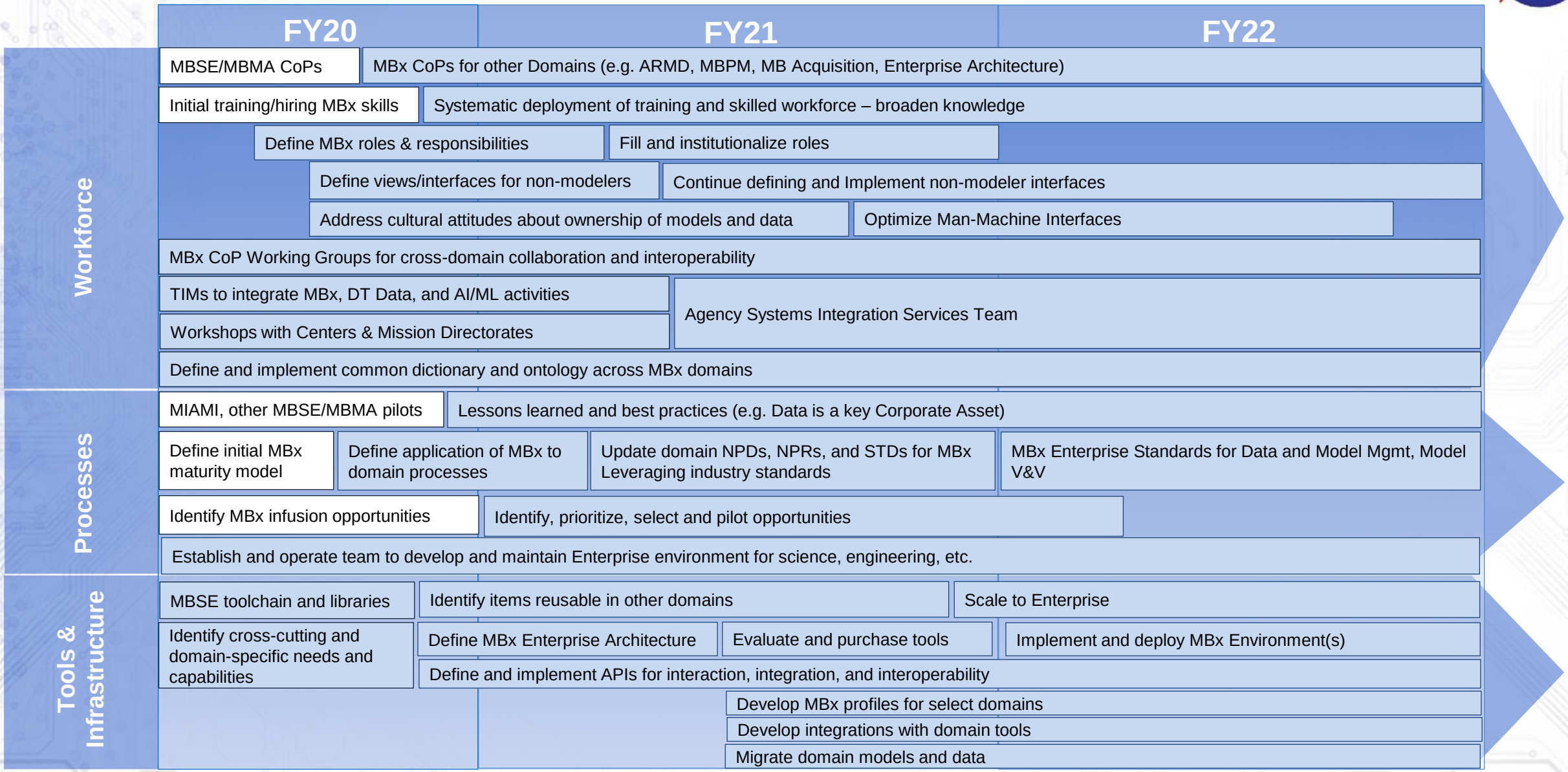
- Formalize development, integration, and use of models to inform decision making – **accelerate from concept to operations up to 50%***
- Provide enduring, authoritative sources of validated models and data – **40-60% less cost and time in design***
- Radical productivity improvement to NASA practices – **20-25% reduction in errors and waste***
- Establish a supporting infrastructure and environment to automate activities within and across disciplines, collaborate, and communicate – **100x concepts with same resources***
- Transform the culture and workforce to adopt and support MBx across the lifecycle – **75%-100% employee engagement; 40% increase in employee satisfaction***

***Notional metrics/subject to change**

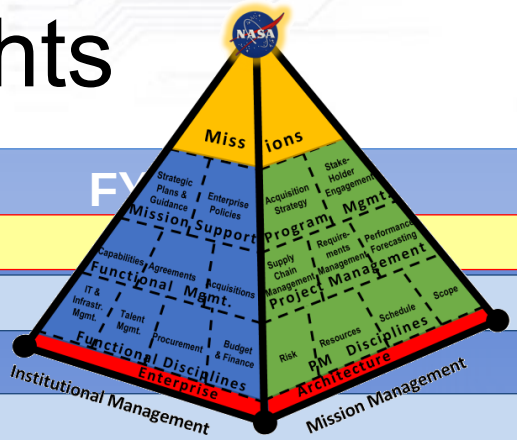
MBx DT Capability Roadmap

Track	Work to Date	Near Term (2 years)	Long Term (5 years)	Future State
Workforce	• NASA MBSE, MBMA WG, CoPs • NASA Pathfinders (use case demos) • Open MBEE.org (JPL-led) • Basic MBSE/MBMA training • Introductory NASA training (APPEL & SATERN)	• Develop and socialize MBx terminology • Identify skill set gaps; targeted training and hiring • Initial job description revisions • Initial comprehensive MBx training • Views for expert/non-expert modelers	• Dedicated MBx team to respond to goals • Agency governance boards balance needed skillsets • Most staff trained in established tools/processes • Optimize man-machine interfaces	• Informed engineering decisions from real-time data and analytics • Workforce flexible to changing environment • Workforce current with emerging MB technologies
Process	• Various model-based efforts • Vertical and horizontal integration • Updated processes for new tools • Targeted specific uses cases between tools • Sharing of handbooks, best practices, and knowledge	• Prioritize use cases to specific domains; expand based on needs/benefits • Identify opportunities to leverage/augment existing models, assets, and data • Initial standardization of processes/workflows • Integration, model, or data exchange between tools for process improvements leveraging industry standards • Target NPRs to update by lessons learned	• Pilot opportunities for advanced MBx capabilities • Implement tool integration/ interoperability/consolidation • Share workflows and models • Expand library to acquisition and risk/impact process models • Key NPRs updated; relevant NPD, STD, HBK in work	• Key processes modeled • Data/analytics collection processes in place to support engineering decisions in modeling environment • Partnerships (internal/external) to leverage new capabilities • NPDs/NPRs fully compatible with MBx across key domains
Tools and Infrastructure	• Inventory of tools ongoing • Surveys/benchmarking continuous • Digital engineering tools in use (e.g. requirements, discipline-specific, design, work control) • Capture current capabilities	• Inventory of tools, models, assets, data • Understand data architecture/ decision making processes • Deploy available infrastructure to enable program pilots • Initial IT infrastructure in place to support cross center activities • Identify center governance boards (prioritize opportunities, tools selection, funding)	• Develop Agency library of enterprise tools, models, authoritative data sources • Can create, exchange, and reuse models & adv. tools (AI/ML, AR/VR) • Implement criteria for determining the credibility of models • Required infrastructure in place (e.g., cloud services)	• Standards and customization procedures enable rapid initialization • Immersive interfaces enable advanced capabilities (AI/ML & AR/VR) • MB tools governed through Agency collaboration

MBx Near-Term Roadmap



MBx Near-Term Implementation Highlights



	FY20	FY21	FY
Workforce	MBSE/MBMA CoPs	MBx CoPs for other Domains (e.g. ARMD, MBPM, MB Acquisition, Enterprise Architecture)	
	Training and hiring MBx skills	Systematic deployment of training and skilled workforce – broaden knowledge	
	Define MBx roles & responsibilities	Fill and institutionalize roles	
	Define views/interfaces for non-modelers	Continue defining and Implement non-modeler interfaces	
	Address cultural attitudes about ownership of models and data	Optimize Man-Machine Interfaces	
	MBx CoP Working Groups for cross-domain collaboration and interoperability		
	TIM		
	Wo		
	Define and implement common dictionary and ontology across MBx domains		
Processes	MIAMI, other [illegible] MBA pilots	Lessons learned and best practices (e.g. Data is a key Corporate Asset)	
	Define initial MBx maturity model	Define application of MBx to domain processes	Update domain NPRDs, NPRs, and STDs for MBx leveraging industry standards
	MBx Enterprise Standards for Data and Model Mgmt, Model V&V		
	Identify MBx infusion opportunities	Identify, prioritize, select and pilot opportunities	
	Establish and operate team to develop and maintain Enterprise environment for science, engineering, etc.		
Tools & Infrastructure	MBSE toolchain and libraries	Identify items reusable in other domains	Scale to Enterprise
	Identify cross-cutting and domain-specific needs and capabilities	Define MBx Enterprise Architecture	Evaluate and purchase tools
		Define and implement APIs for interaction, integration, and interoperability	Implement and deploy MBx Environment(s)
		Develop MBx profiles for select domains	
		Develop integrations with domain tools	
		Migrate domain models and data	

Implementation Activities cross-cut Roadmap Elements:
Approach is to attack multiple roadmap elements across multiple domains concurrently

Model Based Institutional Management

Model Based Mission Management

Model Based Engineering

Model Based Enterprise Architecture

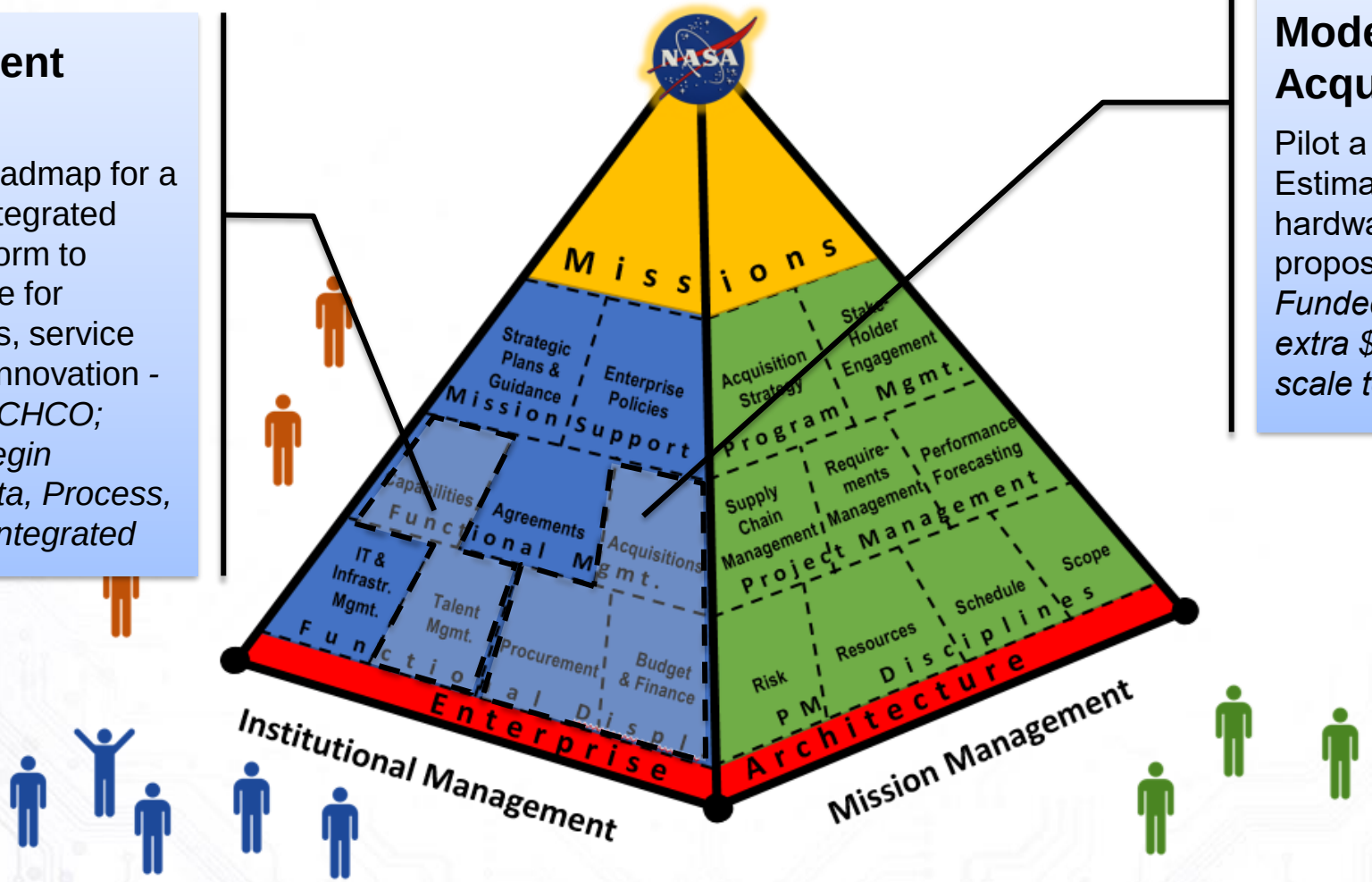
Activity Complete	Current or Future Activity	Included in Implementation Planning

MBx Initial Implementation Activities

Use MBx Roadmap as best practices to **prototype** and **accelerate** **model based approaches in selected (willing/ready) areas** across the NASA Enterprise, to learn/illustrate benefits and inform scaling

Model Based Talent Management:

Develop a long-term roadmap for a technology enabled, integrated Human Capital IT platform to optimize HR experience for employees, supervisors, service providers @ speed of innovation - *Roadmap funded by OCHCO; Request $1.8M/yr to begin execution; includes Data, Process, AI/ML and MBx work, integrated*



Model Based Acquisition:

Pilot a Model Based Realistic Cost Estimating (RCE) approach for hardware contract RFP and proposal evaluation process - *Funded by OCFO/OP; Request extra $200K to expedite pilot and scale to enterprise*

Model Based Institutional Management

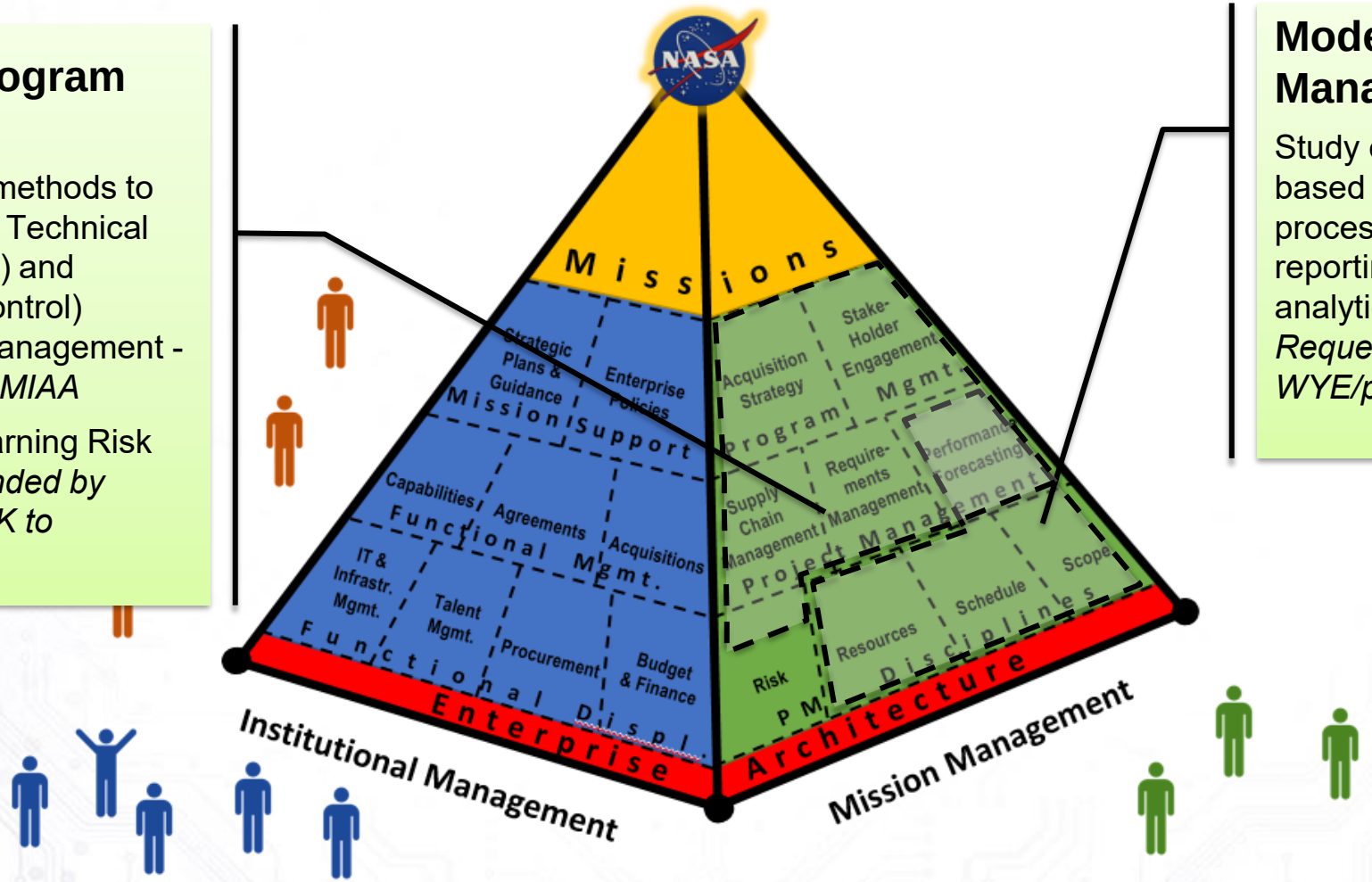
MBx Initial Implementation Activities

Use MBx Roadmap as best practices to **prototype** and **accelerate** **model based approaches in selected (willing/ready) areas** across the NASA Enterprise, to learn/illustrate benefits and inform scaling

Model Based Program Management:

Identify model based methods to bridge divide between Technical (Systems Engineering) and Financial (Program Control) aspects in Program Management - *Funded – leverages PMIAA*

Prototype machine learning Risk Digital Assistant – *Funded by STMD; Request $100K to accelerate*



Model Based Project Management:

Study efficacy of common model based Project Management processes/tools to automate reporting and enable forecast analytics - *Funded by ARMD; Request extra $250K for WYE/project FTE to accelerate*

Model Based Mission Management

Model Based Program & Project Management

Identify model based methods to **bridge divide between Technical (Systems Engineering) and Financial (Program Control)** aspects in Program Management; Pilot efficacy of **common model based Program & Project Management practices** to automate reporting, improve consistency/ accuracy and enable forecast analytics

Roadmap Alignment: Support enterprise goals for PM through MB integration; reinforce change management for other areas

User Community: NASA Program Management, Project Management, PP&C, Systems Engineering communities

BENEFITS & RISKS

Benefits

- SOA Capability growth in Program Management – NASA can lead
- Increased efficiency, less manual integration between SE and PP&C
- Reduced project planning & reporting time, with quantified uncertainties
- Automated, intelligent metrics/trends for early, rapid insight on risks
- Faster communication of requirements and progress
- Facilitate coordination across rapidly expanding partner network

Risks

- Requires enterprise culture shift in PM community, centers
- MDs don't typically prioritize potential common enterprise approaches
- MBSE models are less mature than program control models
- May miss important content/considerations that are not explicit in current program/project structure
- Need to reinforce data fidelity throughout model

KEY MILESTONES

	Year 1						Year 2						Year 3				
Concept development in coordination with PMIAA team																	
Charter ARMD Study Team																	
Review current processes and tools, including GCD models																	
Develop recommendations for standard tools & Review options																	
Pathfind STMD/GCPO Program Risk ML digital assistant																	
Develop implementation plan and schedule for recommendations																	
Pilot implementation																	
Document lessons learned and explore scalability																	

STAKEHOLDERS

- PMIO – lead PMIAA to develop rqmnts/concepts for common MBPM
- Mission Directorates – support through PMIAA
- OCFO – support through PMIAA; process owner for PP&C
- OCE – owns PM policy, coordinates MBSE with Centers
- STMD – add machine learning risk predictor to Game Changing MBPM
- ARMD – develop MD-wide MBPM rqmts (as feasibility test), explore common tools → conduct cross-center MBPM pilot
- LaRC, GRC, ARC, AFRC – participate in MBPM pilot

FUNDING

- Requirements development/alignment and civil servant labor funded
- Require modest annual WYE above project $ ($100K STMD, $250K ARMD)

MBx Initial Implementation Activities

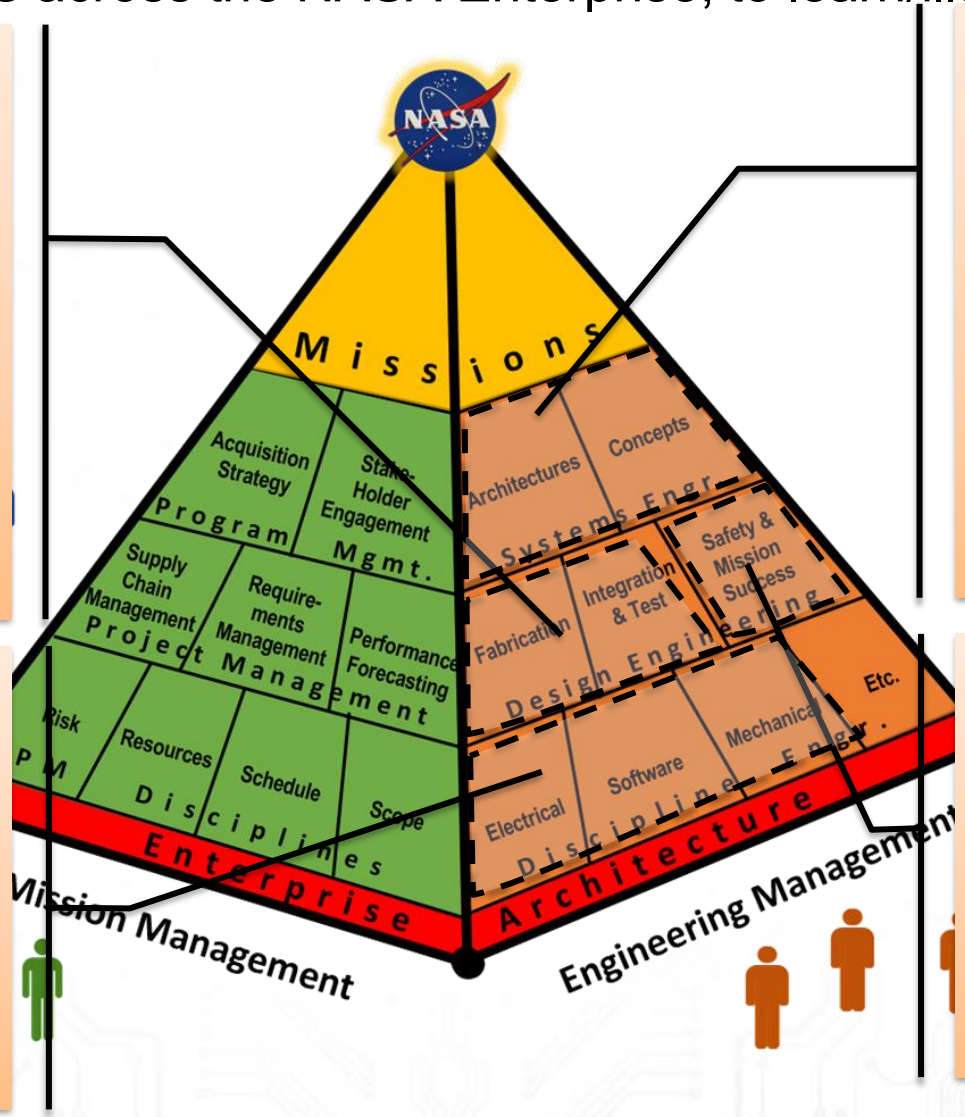
Use MBx Roadmap as best practices to **prototype** and **accelerate** **model based approaches in selected (willing/ready) areas** across the NASA Enterprise, to learn/illustrate benefits and inform

Model Based Design Engineering:

Develop architecture requirements, benchmarking and conduct pilots for full model based definition (MBD) digital engineering environment spanning research & development from concept to flight. Prototype digital thread from concept to manufacturing. *(Requirements development, benchmarking funded; pilots $390K)*

Model Based Discipline Engineering:

Advance and integrate discipline tools using automated workflows to enable Certification by Analysis, including uncertainty quantification - *CBA funded by ARMD; Request $10M reconsideration for OCE R&A advanced tools*



Model Based Systems Engineering:

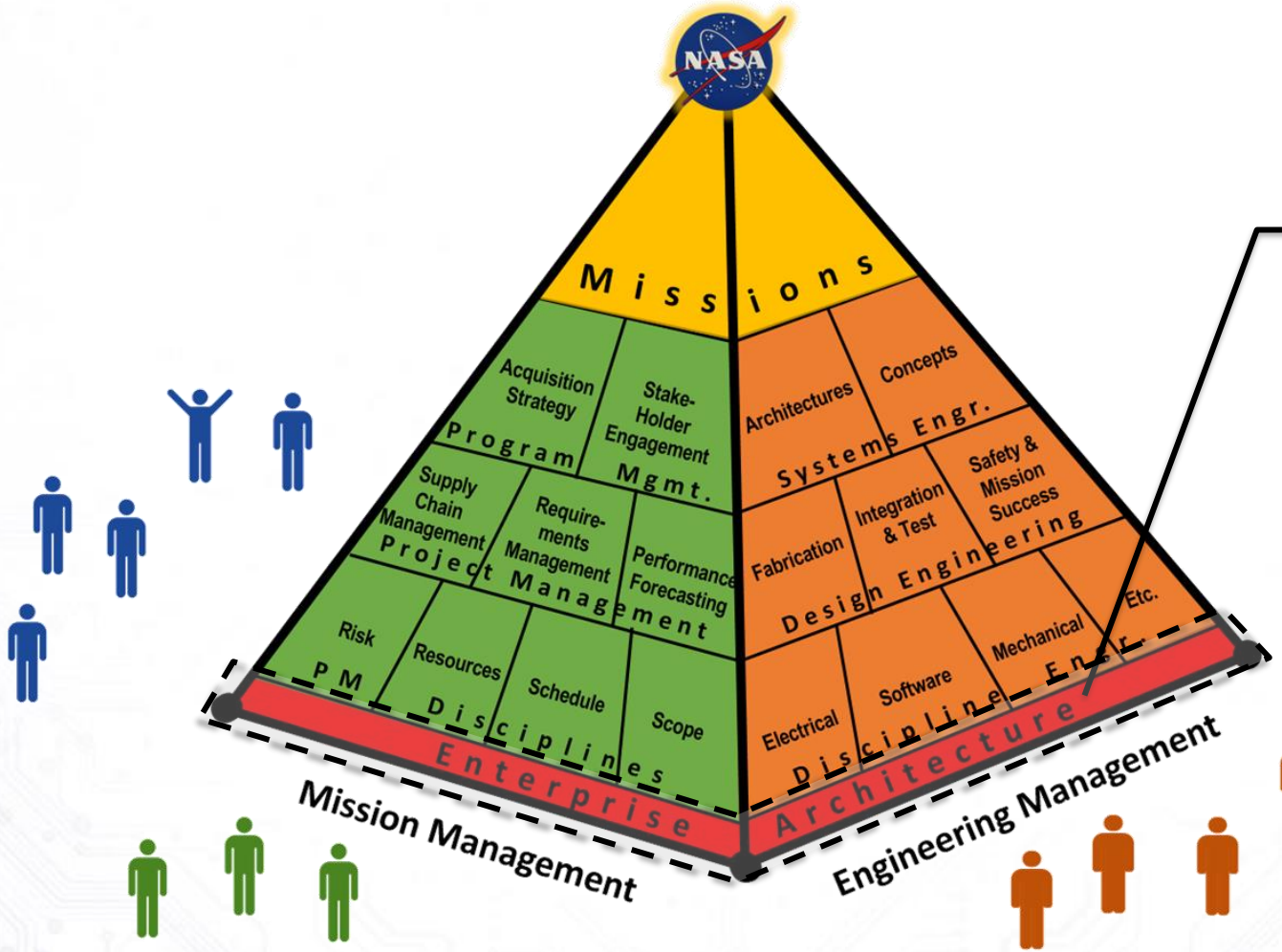
Establish MBSE Leadership Team (center reps) to work as integrated team to leverage/ align investments, share lessons learned/ models in library, and remove project barriers to entry for lifecycle MBSE adoption, via MD pilots *(Funded – leverage current center MBSE investments; Request $150K to jump start tool/model development so projects don't fund learning curve)*

Model Based Mission Assurance:

Use GMIP model to auto-generate future surveillance plans & forecast costs from supply chain risk weighted solutions; Pilot inter-Center product collaboration; MBMA Pilot Inventory/Prioritization (*Request $100K for data support*)

MBx Initial Implementation Activities

Use MBx Roadmap as best practices to **prototype** and **accelerate** **model based approaches in selected (willing/ready) areas** across the NASA Enterprise, to learn/illustrate benefits and inform scaling



Model Based Enterprise Architecture

Use MB Institutional, MB Mission and MB Engineering pilots as use cases to drive development of MB Data & Architecture *(Unfunded, Request $540K)*

Model Based Enterprise Architecture

Measuring Progress

Dimension
Workforce/Culture
Process
Tools
Initial Activity Progress

Model Based Maturity Level

Level 0: Absent
- Individual is King
- Selected Models
- Duplicate/Custom Tools

Level 1: Present
- Local Team is King
- Models Emerging
- Tools Inventoried

Level 2: Strategic
- Organization is King
- Models Typical
- Exploring Tool Standards & Integration

Level 3: Formalized
- Mission is King
- Models Sustained
- Tools Interoperable

Level 4: Converged
- Enterprise is King
- Models Converged
- Integrated Baseline Tools Provided

Level 5: Innovative
- Future Enterprise is King
- Models Anticipate
- Generative Tools to Adapt

MB Acquisition

MB Human Capital Management

MB Program Management

MB Project Management

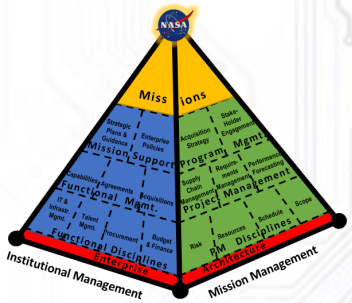
MB Systems Engineering

MB Design Engineering

MB Discipline Engineering

MB Mission Assurance

MB Enterprise Architecture



Taken together, the **MBx Initial Implementation Activities** will accelerate the use of digitally integrated models **across multiple domains** to **enable data-driven decision-making** with increasing complexity, velocity, accuracy, confidence, and adaptability for NASA's missions.

MBx Initial Implementation Activities

Use MBx Roadmap as best practices to prototype and accelerate model based approaches in selected (willing/ready) areas across the NASA Enterprise, to learn/illustrate benefits and inform scaling

- **Model Based Institutional Management**
  - **Model Based Acquisition:** Pilot a Model Based Realistic Cost Estimating (RCE) approach for hardware contract RFP and proposal evaluation process *(Funded by OCFO/OP; Request extra $200K to expedite pilot and scale to enterprise)*
  - **Model Based Talent Management:** Develop a long-term roadmap for a technology enabled, integrated Human Capital IT platform to optimize HR experience for employees, supervisors, service providers @ speed of innovation *(Roadmap funded, $1.8M/yr to build)*
- **Model Based Mission Management**
  - **Model Based Program Management:** Identify model based methods to integrate Technical (Systems Engineering) and Financial (Program Control) aspects in Program Management; develop AI/ML risk assistant *(Funded – leverages PMIAA & STMD; request $100K)*
  - **Model Based Project Management:** Pilot efficacy of common model based Project Management processes/tools to automate reporting and enable forecast analytics *(Funded by ARMD/STMD; Request extra $350K for WYE/project FTE to accelerate)*
- **Model Based Engineering**
  - **Model Based Systems Engineering**: Establish MBSE Leadership Team (center reps) to work as integrated team to leverage/align investments, share lessons learned/models in library, and remove project barriers to entry for lifecycle MBSE adoption *(Funded – leverages current Center investments in MBSE; Initially requesting $150K to jump start tool/model development so projects don't fund learning curve)*
  - **Model Based Design Engineering:** Develop architecture requirements, benchmarking and conduct pilots for full model based definition (MBD) digital engineering environment spanning research & development from concept to flight. Prototype digital thread from concept to manufacturing. *(Requirements development, benchmarking funded; pilots $390K)*
  - **Model Based Discipline Engineering**: Advance and integrate discipline tools using automated workflows to enable Certification by Analysis, including uncertainty quantification *(CBA funded by ARMD; Request restore of $10M OCE Engineering R&A, min. $980K to cover CBA gap)*
  - **Model Based Mission Assurance:** Use GMIP model to auto-generate future surveillance plans and forecast costs from supply chain risk weighted solutions; Pilot ICD/ERD enterprise process model; MBMA Pilot Inventory/Prioritization (*Request $100K for data science support*)
- **Model Based Enterprise Architecture** – Support development of MB Data & Architecture for pilots *(Unfunded, Request $540K)*

MBx Implementation Highlights – MBSE & MB Acquisition

Model Based Acquisition

- **Activity:** Pilot a Model Based Realistic Cost Estimating (RCE) approach for hardware contract RFP and proposal evaluation process
- **Approach**: Eliminate cumbersome, time consuming labor/material BOE cost evaluation by assessing offeror supplied realistic cost models against NASA models and historical data
- **Participants**: OP as process owner, OCFO as realistic cost estimation model/data owners, SMD/ESD exploring for future AO
- **Outcome**: More realistic estimated costs at contract award, less cost growth throughout project life cycle

Model Based Systems Engineering

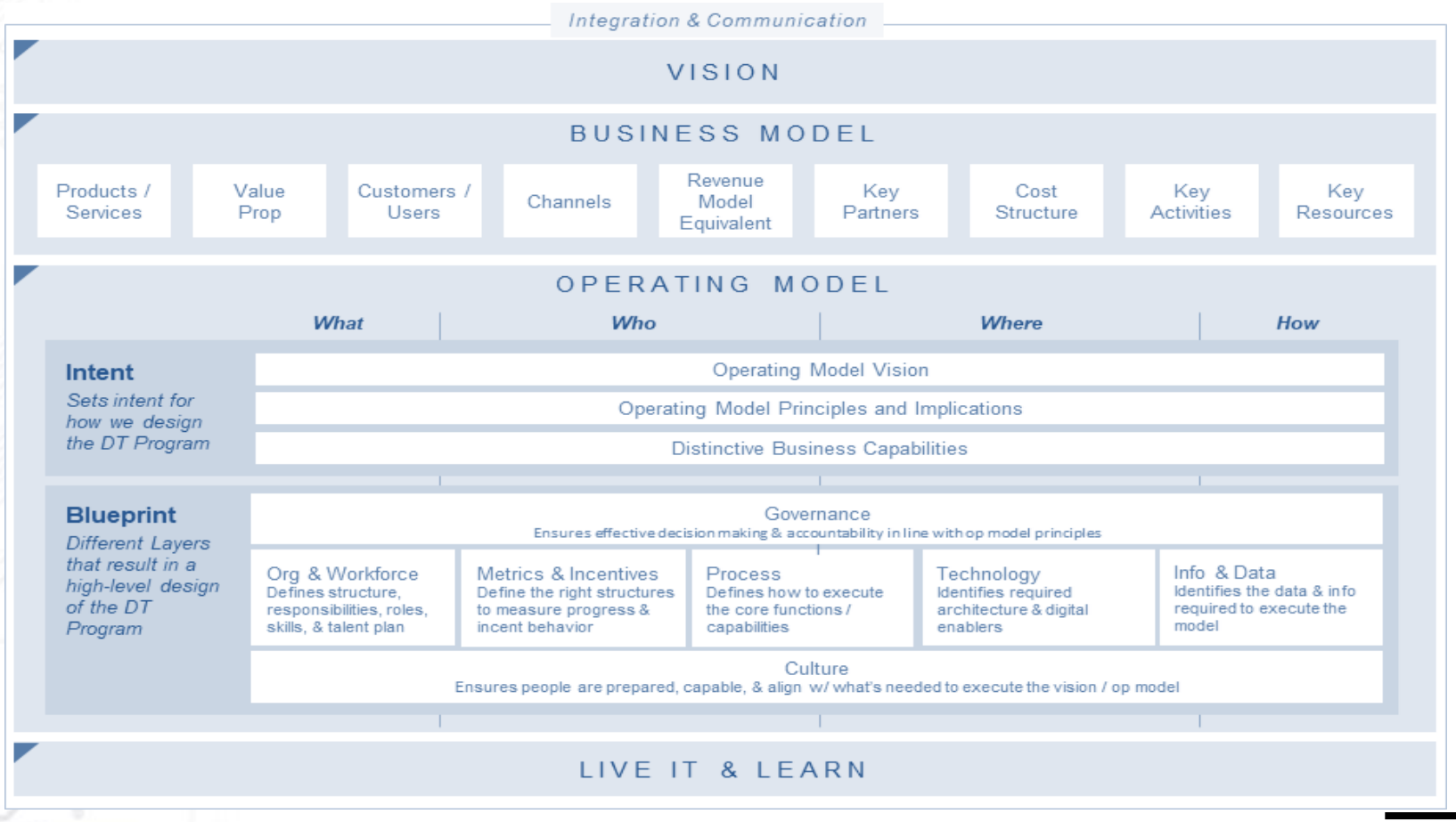
- **Activity**: Establish formal MBSE Leadership Team (center reps) to remove barriers to entry for lifecycle MBSE adoption
- **Approach**: Work as integrated MBSE Leadership Team to formalize goals, leverage & align investments, share lessons learned and models in library, and coordinate to systematically remove barriers to entry for lifecycle MBSE adoption, easing project adoption
- **Participants**: OCE as champion, all NASA Center Engineering Directors
- **Outcome**: Synchronize increasingly complex requirements & designs with expanding participants, shorter schedules

Integration: DT Transformation Architecture

DT's **Transformation Architecture** includes an aspirational future version of NASA's Enterprise Architecture:

- Flows the needs of our future transformed NASA business model into our future operating model
- Focus on developing guidelines to ensure integration/interoperability of future enabling technology / data layers

THINK BIG



START SPECIFIC

Transformation

Conceptualizes (attributes of) *NASA's transformed Business Model*

Architecture

Framework to define how the layers of *NASA's transformed Operating Model,* including process, technology & data, must integrate to enable seamless operations