NASA's Digital Transformation, *AI, ML and Cloud*

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Why Digitally Transform NASA?

Enduring

Bold

Mission…

…now in a Changing World

Increasingly bold & complex missions
Increasingly partnered
Increasingly fast
Increasingly affordable
Increasingly transparent
Increasingly inclusive

WHY digitally transform NASA?

3 Future State Goals

NASA must transform…

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 virtual collaboration jam session where she connected 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.

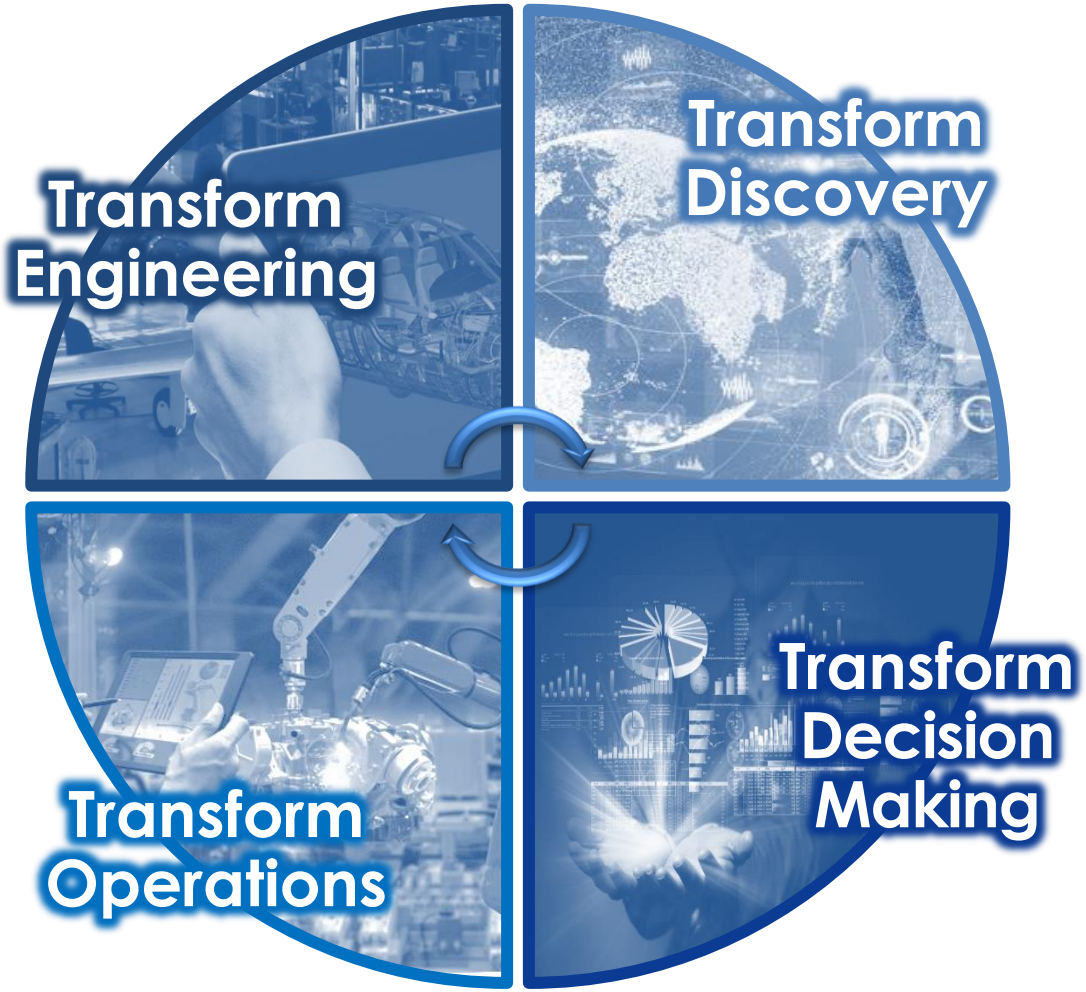
George pauses digital manufacturing of an urgent job after a critical IoT sensor alert. He imports the data history into the lab digital twin model and rapidly forecasts the job can safely continue, avoiding delays.

WHERE must we focus?

4 Transformation Targets

Enable agile multi-center/partner engineering teams to solve frontier problems

Multiply science & technology breakthroughs by leveraging diverse global minds/advances



Optimize & synchronize our work environment to increase efficiencies & effectiveness

Accelerate risk-informed, evidence-based, self-consistent decision making

HOW will we get there?

5 Digital Levers

For any/each Transformation Target…

Delivers

Establish Interoperable *Architectures*

Define value streams & associated organizational conops *within the domain:*
- Update **policies, standards & guidelines** that define domain digital processes & governance
- Define framework for **interoperable platforms/systems** to integrate domains and processes

Integrates

Transform Critical *Processes*

Streamline critical workstreams *within the domain:*
- **Eliminate, Optimize, Automate workflows** to address process bottlenecks & redundancies
- Evolve from paper-centric to **integrated data/model-centric approaches**
- Maximize **shared services & role-based access** to enable geographically agnostic Future of Work

Feeds

Maximize the Impact of our *Data*

Expand ***data search, access, interoperability, re-use and analysis****:*
- Baseline **data inventory/repositories** & name **data stewards** → integrate into **data architecture**
- Establish **data governance**, including data classifications/sensitivities & role-based access
- Enable **data fusion** as well as **data analytics & AI/ML** capabilities to mine insights

Produces

Adopt Common *Tools*

Reduce domain tool sprawl / chaos *by driving to shared capabilities by tier:*
- Tier 1 – **agency-wide common tools** (w/ deviation by exception)
- Tier 2 – functional interoperable **community core shared tools**
- Tier 3 – **local unique one-off** and/or home-grown tools (with justification)

Leverages

Strengthen Inclusive³ *Teaming*

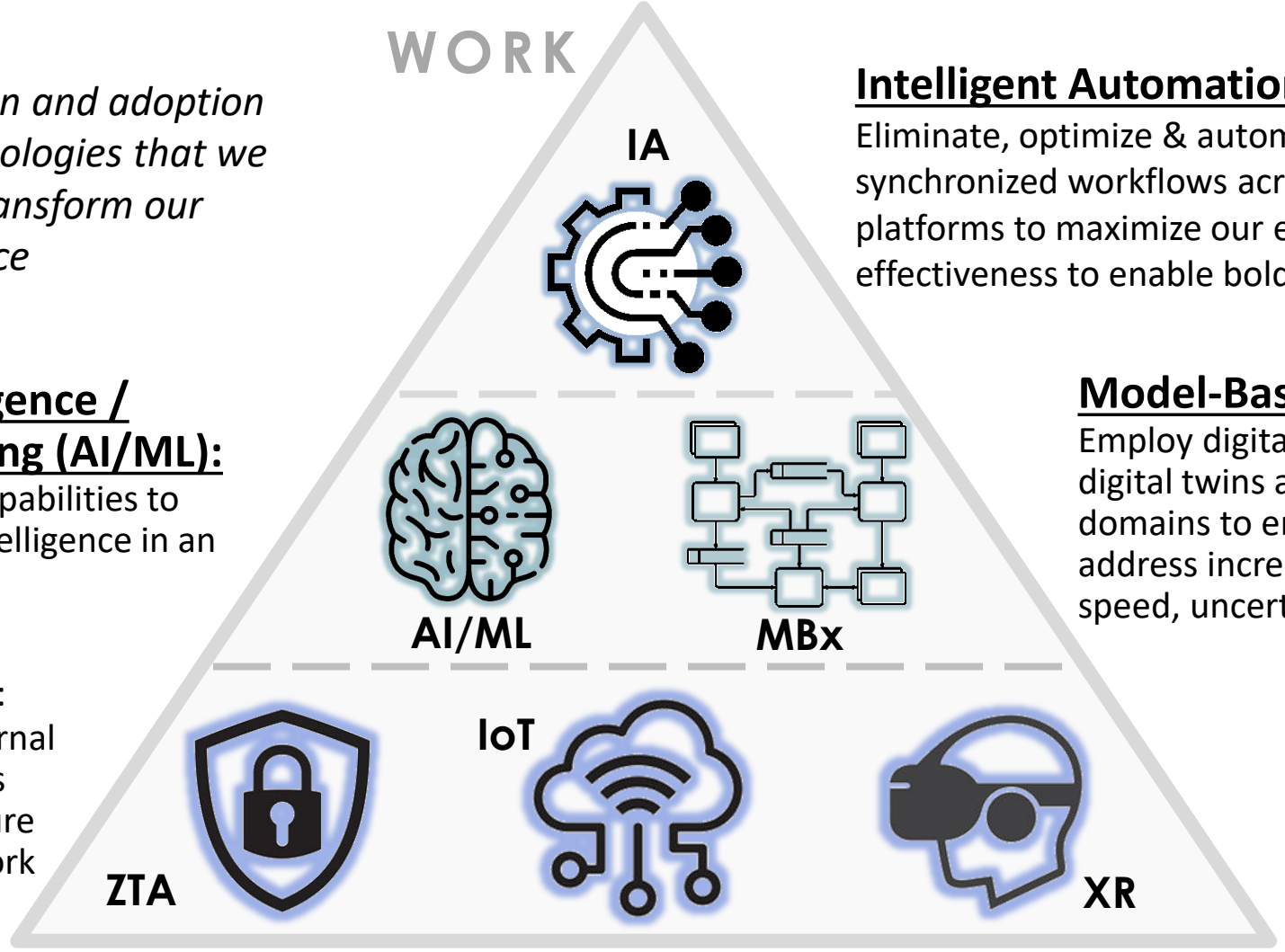
Eliminate barriers to ***strengthen inclusive teaming****:*
- Digitally-Inclusive: Establish threshold level of **digital understanding, literacy & skills**
- Geographically-Inclusive: Enable **immersive collaboration for on- and off-site** team members
- Organizationally-Inclusive: Provide **seamless data access across multi-center/partner** teams

… we can accelerate change by systematically facilitating & coordinating organizational plans to **harness Digital Levers**

WHICH digital technologies will we use next?

6 Technology Foundations

DT will catalyze investigation and adoption of the next key digital technologies that we can & should leverage to transform our work, workforce & workplace



Intelligent Automation (IA):
Eliminate, optimize & automate processes into synchronized workflows across enterprise platforms 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 including digital twins across any/all functional domains to enable our people to address increasing complexity, scope, speed, uncertainty & changes

Zero Trust Architecture:
Enable dynamic internal/external collaboration wherever teams need to work, leveraging secure infrastructure, identity, network & data architecture

Extended Reality:
Enhance agile internal/ external teaming via seamless, immersive, secure visualization & collaboration

Internet of Things:
Integrate wireless, networked sensors & controls at scale to enable real-time hindsight, insight & foresight of smart assets

WHAT does a digitally transformed NASA look like?

7+ Mission Outcomes

Continuously improve technical, programmatic and operational hindsight, insight and foresight to enable complex decision making and increase reliability and consistency.

Harmonize NASA work products & processes with our partners' diverse and continually changing processes, expectations and business models

One Future NASA

Seamless Partner Teaming

Modern Future of Work

Bolder, More Complex Missions

Attract & Retain Workforce

Faster, More Agile Processes

Affordable Sustainable Operations

Inspired & Engaged Citizens

Optimize investments, readiness, access and utilization of best-in-class capabilities (facilities and tools) at the right time

Work at the modern "speed of business" by maximizing productivity and minimizing error/ rework.

Continuously enhance NASA's ability to recruit, retain and motivate top talent in a competitive, dynamic marketplace… accelerating their growth, agility and productivity to enable all of our people to thrive in the digital age

Rapidly, repeatedly create customized inspirational engagements based on stakeholder individual needs and interests.

Enable geographically & organizationally agnostic teams to work efficiently and effectively anytime, anywhere.

NASA's DT Strategic Framework

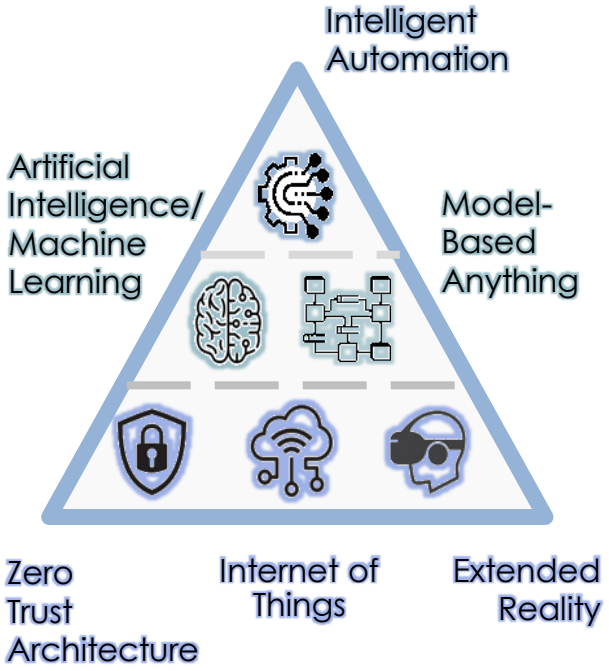
3 FUTURE STATE GOALS

4 TRANSFORMATION TARGETS

5 DIGITAL LEVERS

6 TECHNOLOGY FOUNDATIONS

7+ MISSION OUTCOMES



One Future NASA

[NASA TM 20220018538]

NASA's AIML Transformation Strategy (Since 2019)

Context:

- NASA is forming a Digital Transformation (DT) Strategy and Roadmap, led by the Office of Chief Technologist and Office of Chief Information Officer. This strategy includes AI/ML as one of six key strategic thrusts.
- NASA has a rich history of applying artificial intelligence (AI) to our hardest problems, such as autonomous behaviors in Mars rovers, deep analysis of space suit data, or image analysis to understand material strength. With the advent of powerful, plentiful, and affordable AI in business and industry, NASA is crafting a strategy to use AI as an accelerant for all NASA missions and business functions.

Strategy: As part of NASA's overall Digital Transformation, NASA's AI strategy includes:

- **Apply:** Solve relevant mission and mission support problems via AI / ML.
- **Teamwork:** Lead and synchronize NASA AI/ML via an open Agency AI / ML community.
- **Reskill:** Expand AI training, education, hiring, and retention across the workforce.
- **Tools:** Assess, recommend, and establish AI / ML platforms for NASA-wide adoption.
- **Data:** AI-enabled! Establish secure, authoritative access to the right data.
- **Outreach:** Make selected data and problems available for public / partner AI / ML work.
- **Adapt:** Leverage industry AI / ML work and adapt it to NASA use rather than reinventing.
- **Scale:** Plan to promote selected AI / ML capabilities from pilot to production operations.

The AI/ML team is from across NASA with nearly 200 active members; additional contributors are always welcome.

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FY22 and 23 AIML Horizon Scan Results

Macro Disruptor: Generative AI

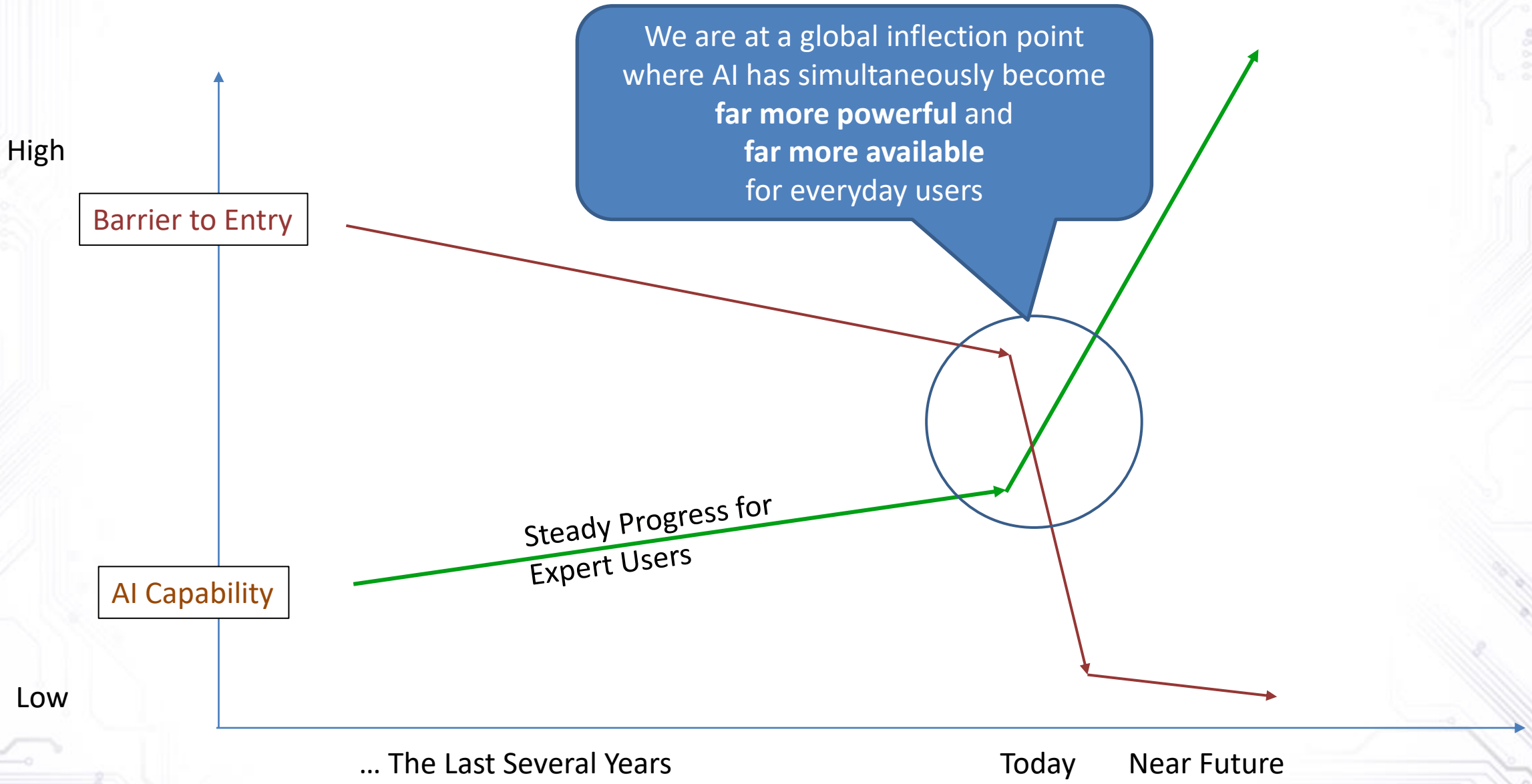
FY22 Insights	FY22 Recommendations	**FY23 Insights**	**FY23 Recommendations**
AIML Tools Booming	•Make Tools Available via Clouds •Grow Skills	AIML Tools Booming	• Continue Cloud Scaling & Training • Make Generative AI Tools Available
AIML Driving Global Business	•*Inject in all DT Targets* •*Complement M&S*	AIML Driving Global Business	• Amplify AI in DT Roadmap Projects • Encourage All Orgs to Embrace AI
AI Ethics Top of Mind	•Debate, Learn, Guide •Responsible AI Plan, Policy	Trust, Risk, Ethics	• Amplify Ethics Work with RAIOs to… • Establish Policies, Debate, Learn, Guide
Operationalizing AIML	•Begin scaling via cloud •*Accelerators*	Operationalizing & Scaling	• Continue Cloud AI Scaling • Issue Crowdsourced Challenges
Hype & Confusion	•Wheat from Chaff •Educate Ourselves	Hype & Confusion	• Continue Industry Briefs • Foster CoP Discussion: Hype vs. Real
Workforce	•Attract, Retain •Upskill - Classes	Power to the People	• Continue & Scale Training • Awards / Rewards for AI Adoption
All About the Data	•Encourage EDP •*Make Data AI-Ready*	All About the Data	• Leverage EDP when Ready • AI-Enabled Data Discovery
		Workplace Disruption	• Guidance, Guard Rails, “How To” • Workshops on Human-Centric Elements

Summary of FY23 AIML Horizon Scan

Continued AIML Transformation Emphasis in Five Focus Areas:

- Invest in Impactful AIML Mission Infusion
- Scale Pervasive AIML Tool Availability
- Conduct a Robust AIML Training Campaign
- Continue Cultivating an Open AIML Community of Professionals
- Enhance Efforts in Driving AI Ethics for NASA

Multiple Factors Contributing to AI Inflection Point



NASA CIO Issued Guidance on Generative AI in May

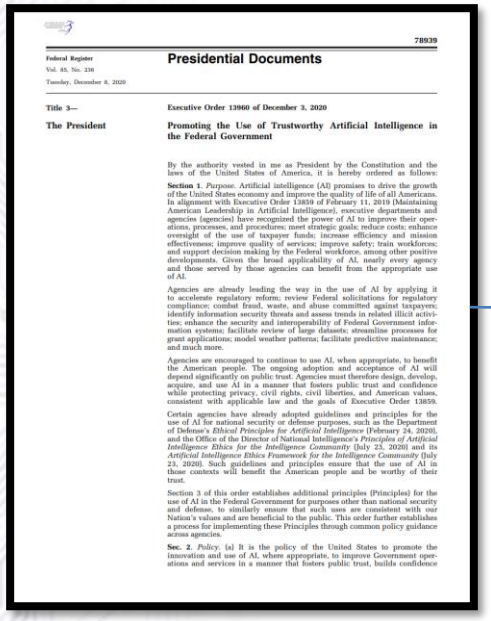
Summary* of Current NASA CIO Guidance RE: Gen AI

- Without implicating sensitive, non-public NASA data, You may…
  - …Use NASA devices to access personal Gen AI accounts
  - …Use personal devices to experiment with Gen AI
  - …Participate in formal NASA controlled tests of Generative AI
- You may not…
  - …Expose / upload sensitive, non-public NASA data to Gen AI systems
  - …Use NASA email to register for un-approved Gen AI systems
  - …Download client applications for Gen AI systems
- You should… Verify / validate / judge outputs of Gen AI to check for quality

**As paraphrased by the speaker for discussion… not official guidance verbiage*

- Notes / Lessons:
  - Balance of timely guidance vs perfection
  - Highly-scientific workforce eager to experiment

“Signals:” Safe AI Innovation & Adoption



78939

Federal Register
Vol. 85, No. 236
Tuesday, December 8, 2020

Presidential Documents

Title 3—
The President

Executive Order 13960 of December 3, 2020

Promoting the Use of Trustworthy Artificial Intelligence in the Federal Government

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

Section 1. *Purpose.* Artificial intelligence (AI) promises to drive the growth of the United States economy and improve the quality of life of all Americans. In alignment with Executive Order 13859 of February 11, 2019 (Maintaining American Leadership in Artificial Intelligence), executive departments and agencies (agencies) have recognized the power of AI to improve their operations, processes, and procedures; meet strategic goals; reduce costs; enhance oversight of the use of taxpayer funds; increase efficiency and mission effectiveness; improve quality of services; improve safety; train workforces; and support decision making by the Federal workforce, among other positive developments. Given the broad applicability of AI, nearly every agency and those served by those agencies can benefit from the appropriate use of AI.

Agencies are already leading the way in the use of AI by applying it to accelerate regulatory reform; review Federal solicitations for regulatory compliance; combat fraud, waste, and abuse committed against taxpayers; identify information security threats and assess trends in related illicit activities; enhance the security and interoperability of Federal Government information systems; facilitate review of large datasets; streamline processes for grant applications; model weather patterns; facilitate predictive maintenance; and much more.

Agencies are encouraged to continue to use AI, when appropriate, to benefit the American people. The ongoing adoption and acceptance of AI will depend significantly on public trust. Agencies must therefore design, develop, acquire, and use AI in a manner that fosters public trust and confidence while protecting privacy, civil rights, civil liberties, and American values, consistent with applicable law and the goals of Executive Order 13859.

Certain agencies have already adopted guidelines and principles for the use of AI for national security or defense purposes, such as the Department of Defense's *Ethical Principles for Artificial Intelligence* (February 24, 2020), and the Office of the Director of National Intelligence's *Principles of Artificial Intelligence Ethics for the Intelligence Community* (July 23, 2020) and its *Artificial Intelligence Ethics Framework for the Intelligence Community* (July 23, 2020). Such guidelines and principles ensure that the use of AI in those contexts will benefit the American people and be worthy of their trust.

Section 3 of this order establishes additional principles (Principles) for the use of AI in the Federal Government for purposes other than national security and defense, to similarly ensure that such uses are consistent with our Nation's values and are beneficial to the public. This order further establishes a process for implementing these Principles through common policy guidance across agencies.

Sec. 2. *Policy.* (a) It is the policy of the United States to promote the innovation and use of AI, where appropriate, to improve Government operations and services in a manner that fosters public trust, builds confidence

Industry AI Supply
At Full Tilt

Existing and Emerging
Federal Directives

Heavy Workforce
Demand For AI

‘Time to Amplify our AI Leadership Approach

By “AI Leadership,” we mean how we set the conditions for widespread adoption across NASA, when 99.9% of the people implementing AI have bosses other than AI advocates / officials

Philosophy: AI Transformation Leadership

- **How do we lead AI innovation & adoption safely and securely, without directing everything or stifling innovation?**
- ***For NASA's creative, curious, scientific mindsets, aligning, encouraging, empowering, guiding, and checking AI approaches seems far better than micromanaging***
  - Add Thrust
  - Reduce Drag
  - Provide Guardrails
- **Tee up relevant topics for professional discourse**
  - Get experts thinking about relevant considerations instead of…
  - …~~Attempting to exhaustively delineate "shall" checklist~~
- **Leverage existing checks & balances – engineering or software reviews, etc.**
- **Encourage communities to adopt AI best practices, tailored to their culture & missions**
- **Fill gaps with new AI practices, processes, staff**
- **Avoid big new separate AI processes!**

Initial Thoughts RE: AI Directives

We are conducting mission analysis regarding the emergent Federal guidance.
DRAFT topics under consideration include:

- Senior Leadership:
  - Spearhead NASA's Approach to AI
  - Engage with Fellow Executives Up & Out
  - Engage with Fellow Executives Across the Agency
- AI Compliance and Governance
  - Meet Emerging Federal Directives
  - Inject AI Governance into Existing Policies and Processes
  - Add Select New AI Policies and Processes
  - Specific Procurement Requirements
  - Yearly AI Inventory – in progress
  - Model Cards for All AI
  - AI Advisory Council
- Promoting Innovation in AI
  - Continue Growing AI Adoption
  - Iteratively Onboard New AI Toolsets
  - Coordinate and Promote Widespread AI Training
  - Outreach / Strategic Communication
  - Measure Progress
- AI Documentation – Directed and Implied Plans, Policies, etc.
  - Responsible AI Plan – v1.0 complete
  - AI Strategy - New
  - Trustworthy AI Policy – in progress
  - Practitioner's Handbook – in progress
  - AI Governance Framework – in progress

Approach for AI Governance Framework

- Leveraging existing processes, policies, boards as much as possible
- Considering three-tiers of AI oversight
  - Executive level steering council – strategic direction & top cover
  - Working leader AI board – practical advice for AI practitioners
  - Working group / community of practice – best practices, sharing, teaming
- Advice should:
  - Support Federal guidance
  - Adapt to NASA culture (e.g., added focus on scientific & technical robustness)
  - Be tailored by communities, missions, organizations as needed
- Way ahead
  - Refine core framework w/ emergent Federal guidance
  - Get tailored input & buy-in from variety of communities
  - Begin using, learn, iterate

Cloud as an Axis of Innovation

- NASA uses clouds from multiple vendors, to include, but not limited to: Amazon Web Services, Google Cloud Platform, and Microsoft Azure
- With core Managed Cloud Environments in-place, Cloud can act enable rapid onboarding of AI, ML, or other emerging services (e.g., Internet of Things)
  - Inherit the overall environment's controls
  - Focus on new controls for your new service
- Building trust with cloud vendors can make onboarding faster and easier
- Standard government processes for technology onboarding may need to be adjusted to maximize benefits of cloud speed
- If you try it and it's great, scale it, operationalize it
- If you try and it doesn't work out, turn it off

Testing Cloud-Based Generative AI

- Testing OpenAI on Microsoft Azure this Summer
  - Risk-based decision before FedRAMP completion
  - ONLY public, non-sensitive data before Authority to Operate
  - Assessing
    - Ease of use
    - Accuracy of results
    - Supportability
    - Cost
    - Security
    - Intellectual Property Considerations
    - …and more

Key Use Cases to Test:

- Summarize Scientific Materials
- Write "Starter" Documents
- Code Assistant – Create, Document, Debug, Translate
- Analyze Numerical Patterns
- Create Art Inspirations

- Insights so far:
  - We're doing "back-end cloud service" testing but many users just want an approved front-end interface
  - Limit to public, non-sensitive data limits some use cases (e.g., code, internal documents)
- Additional team-mates beginning to test with other cloud generative AI – Google Vertex, AWS Bedrock
- Interested in others too… Meta, NVIDIA, IBM, and friends
- Can't afford to test absolutely everything, but attempting to be inclusive

We Have a Front Row Seat to History's Next Disruptor

- If you had a front-row seat to key historical technology advances, how might you have leveraged them?
  - The invention of fire, the wheel, or written language?
  - Harnessing the power in the atom?
  - The invention of electricity?
  - The advent of the internet?

- This is exactly where we find ourselves with AI… **how will each of us harness it?**
  - How will you set your org up for success with AI?
  - What guidance do you need to give our teams?
  - How can you envision using AI?
  - Where do you need to be careful?

REACH
NEW
HEIGHTS

REVEAL
THE
UNKNOWN

BENEFIT
ALL
HUMANKIND

NASA DIGITAL TRANSFORMATION

Questions?