Powering Digital Transformation with Digital Twins

A NASA Perspective

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Digital Transformation

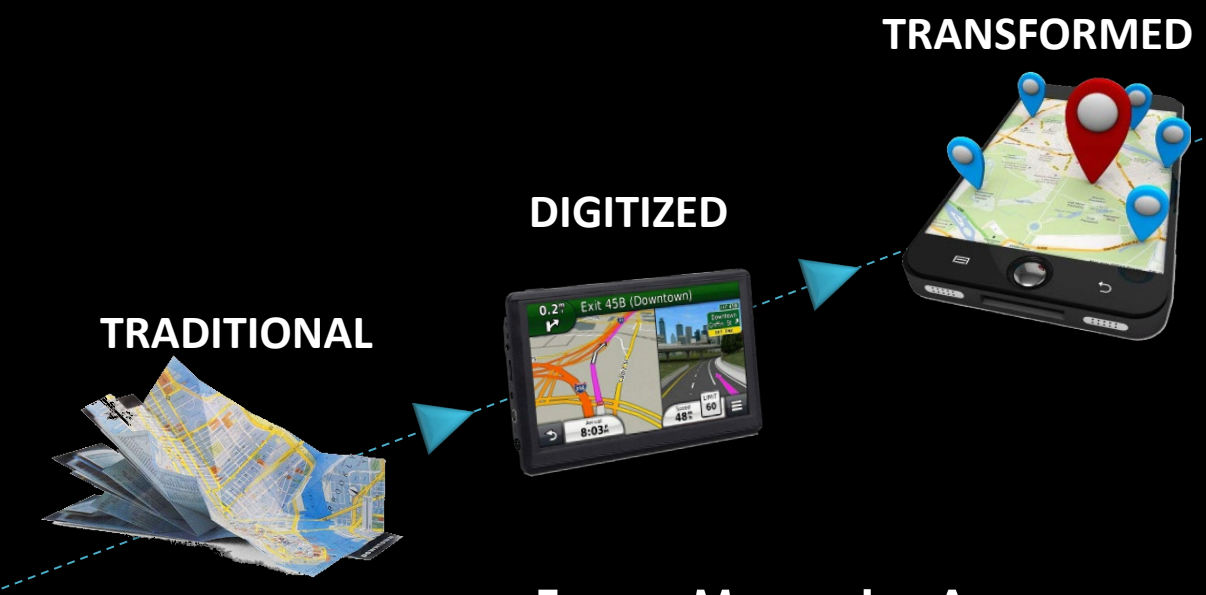
[**dij**-i-tl trans-fer-**mey**-shuhn] *noun*:

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

DT ≠ IT

DT = transformation focused

IT = technology focused



From Maps to Apps...

Digital Transformation has <u>already</u> changed our world

Enduring Bold Mission…

…now in a Changing World

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

NASA must transform

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.

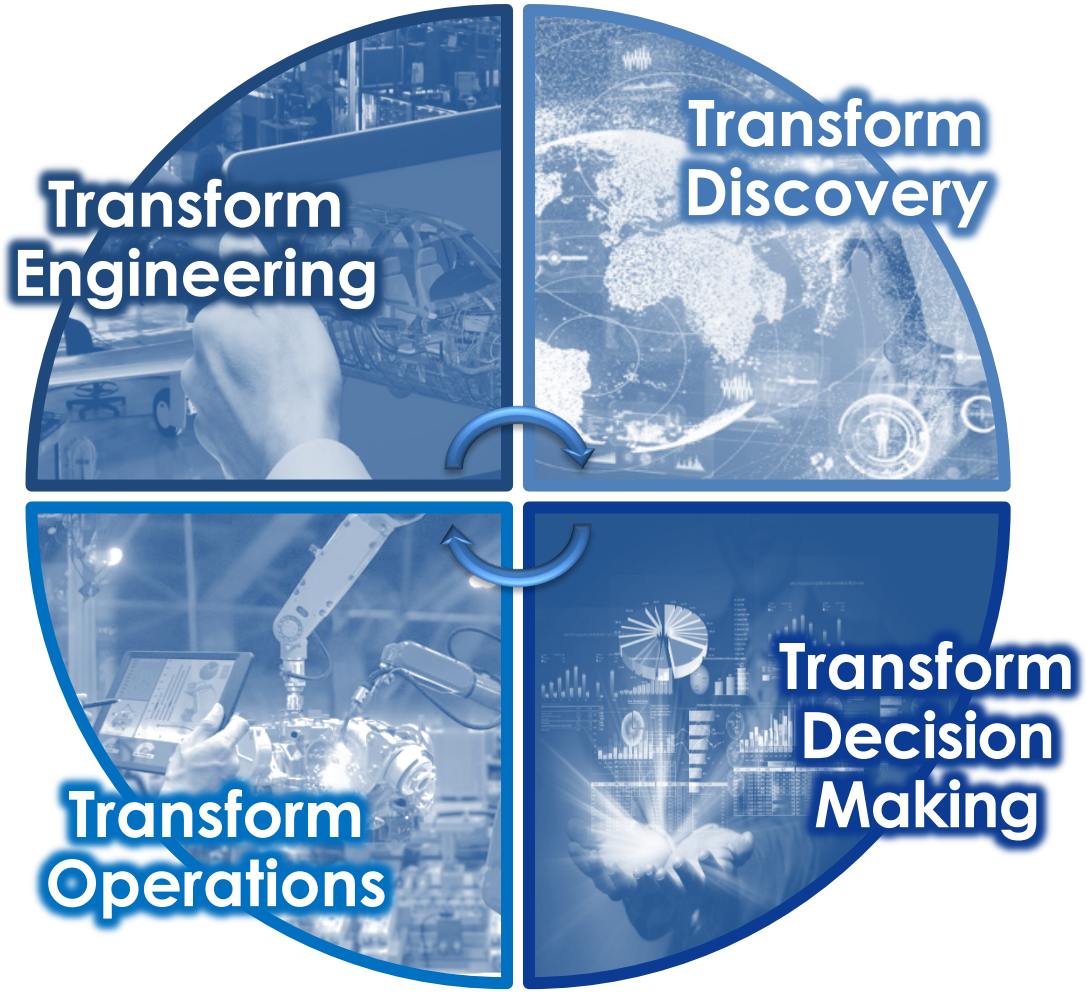
George pauses digital manufacturing of an urgent job after a critical IoT sensor alert. He imports the data history into the lab digital twin model and rapidly forecasts the job can safely continue, avoiding delays.

WHERE must we focus?

4 Transformation Targets

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

Optimize & synchronize our work environment to increase efficiencies & effectiveness



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

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 Inclusive^3 *Teaming*

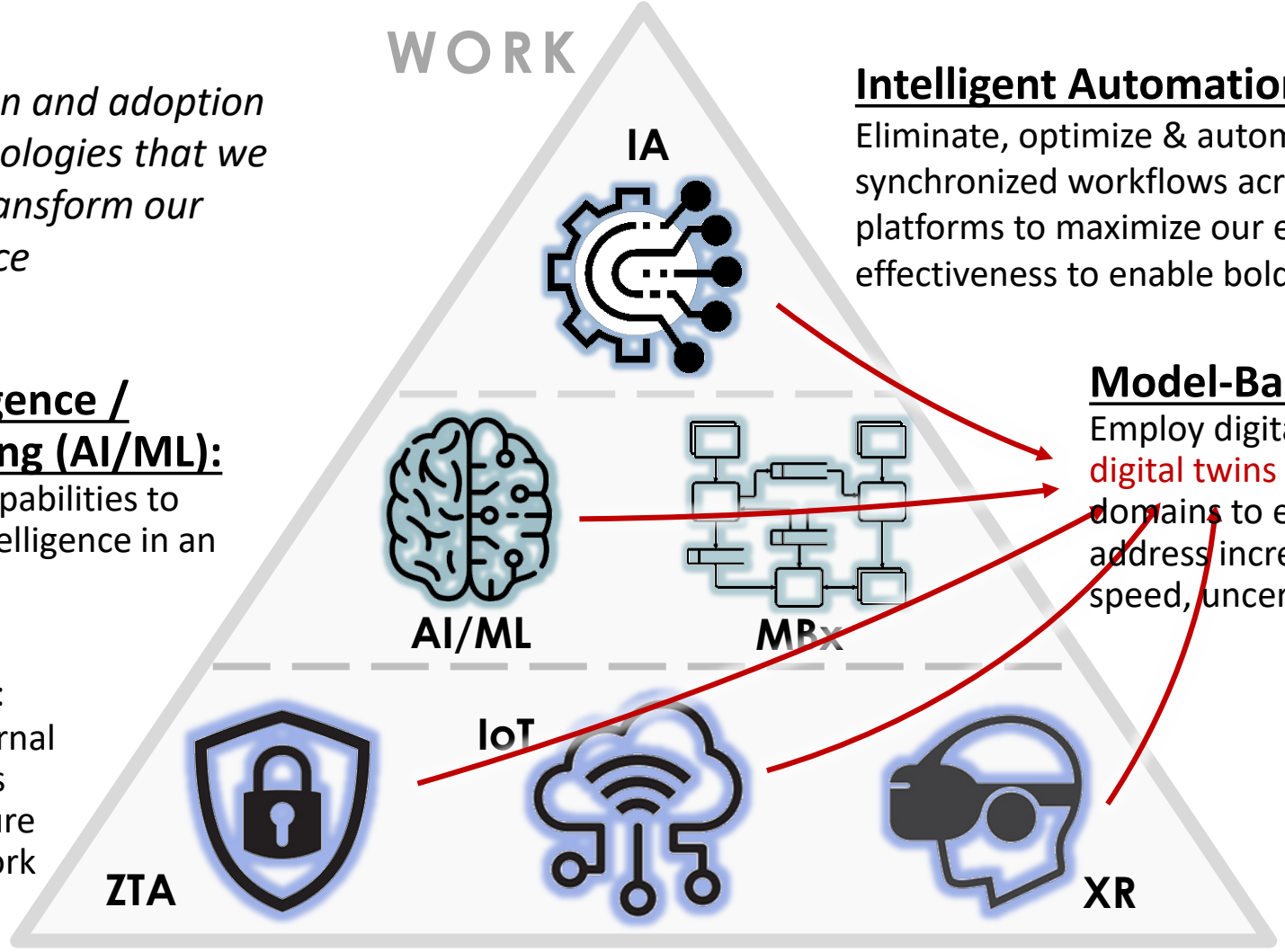
Eliminate barriers to ***strengthen inclusive teaming****:*
- Digitally-Inclusive: Establish threshold level of **digital understanding, literacy & skills**
- Geographically-Inclusive: Enable **immersive collaboration for on- and off-site** team members
- Organizationally-Inclusive: Provide **seamless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

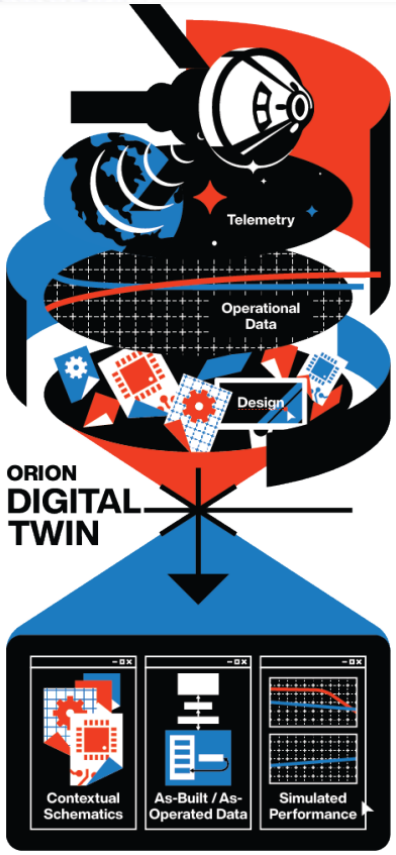
Model-Based Anything (MBx):
Employ digital models including digital twins across any/all functional domains to enable our people to address increasing complexity, scope, speed, uncertainty & changes

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

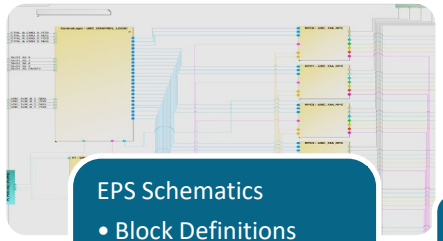
Digital Twins of our Work



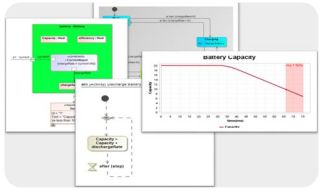
2021 2022

March April May June July August September October November December January February March April May June July August September

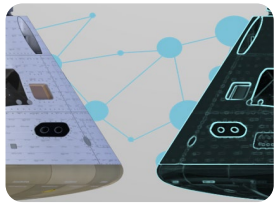
Development
- Prototype
- Depth Trade
- Domain Research



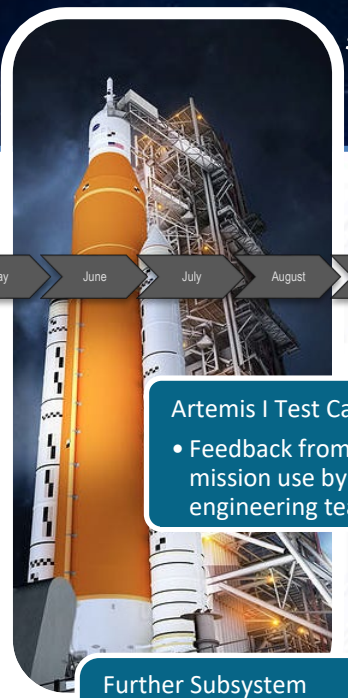
EPS Schematics
- Block Definitions
- Hierarchy
- Interfaces
- Schematic Integration
- June – Board interfaces & "Switch" details
- July – Loads
- Aug+ - Board internals



EPS Simulation
- Define Sim Scenario
- Define behavior model
- Develop GUI for live mission scenario



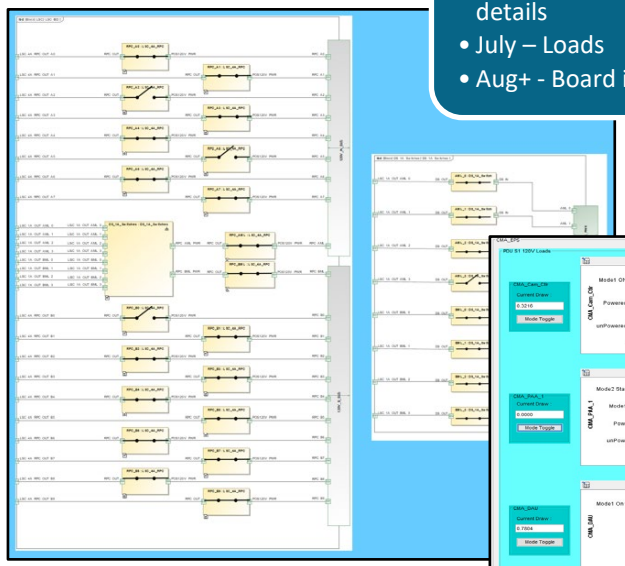
EPS Twin Integration
- Telemetry Interface
- Operational Data Interface
- Parameter Definition

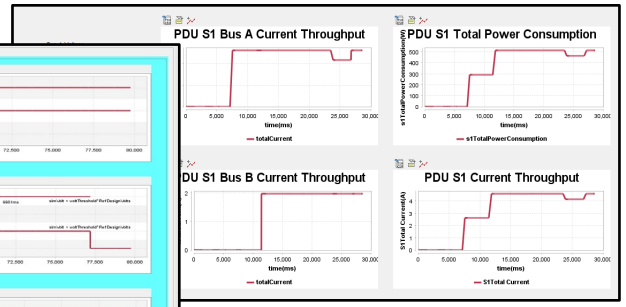


Artemis I Test Case
- Feedback from live mission use by EPS engineering team

Further Subsystem Development
- Multi-Domain Simulation
- Tool Integration
- Comprehensive Digital Twin Framework

EPS Digital Twin Validation/Evaluation
- Model-Based Review
- Live Reviews
- Automated Audits



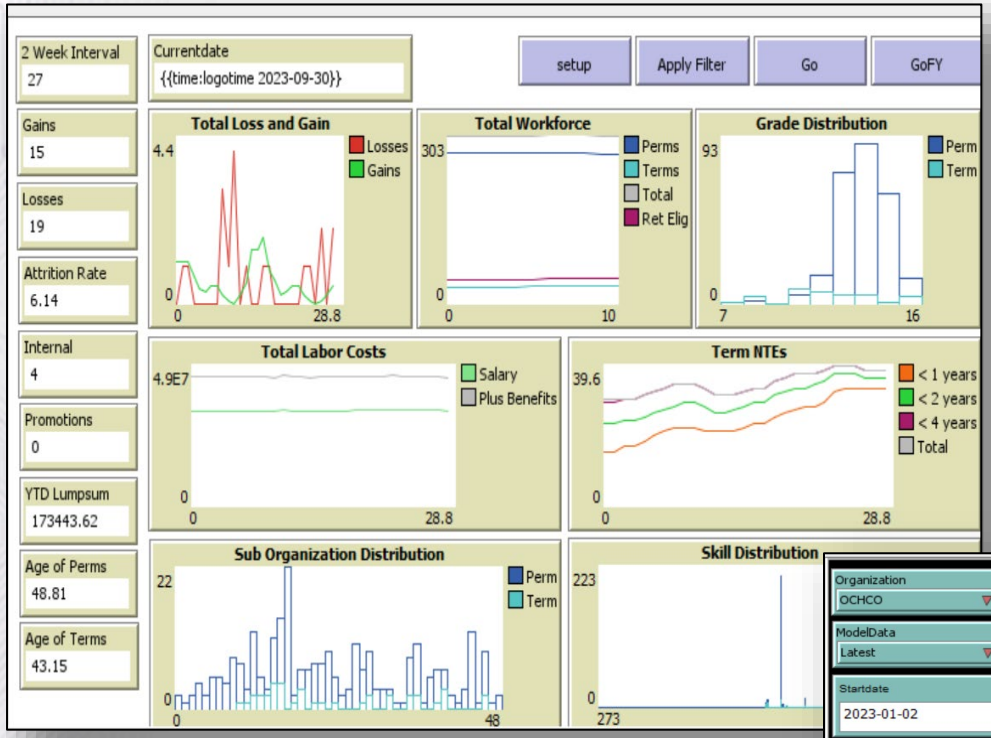


- >2,000 components
- >2,700 interfaces
- >500 loads
- Automated data sync / validation to authoritative sources
- Sim using as-built architecture & imported component specs

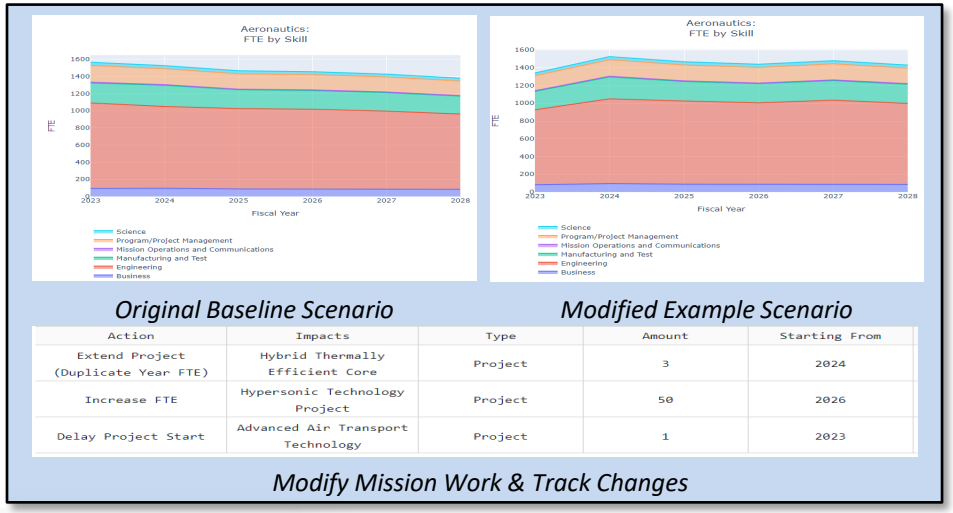
ARTEMIS

Digital Twins of our Workforce

Supply Model

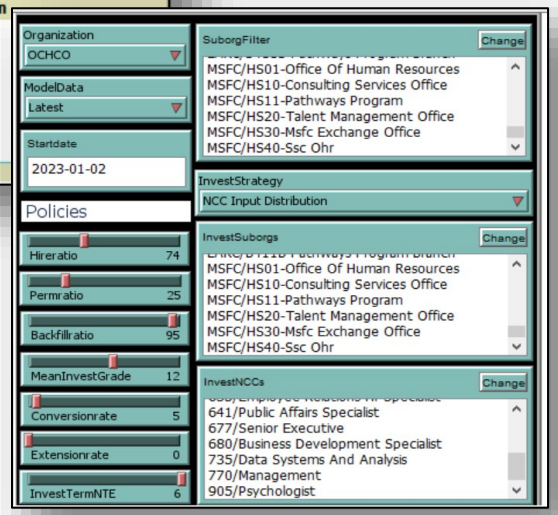


Scenario Model

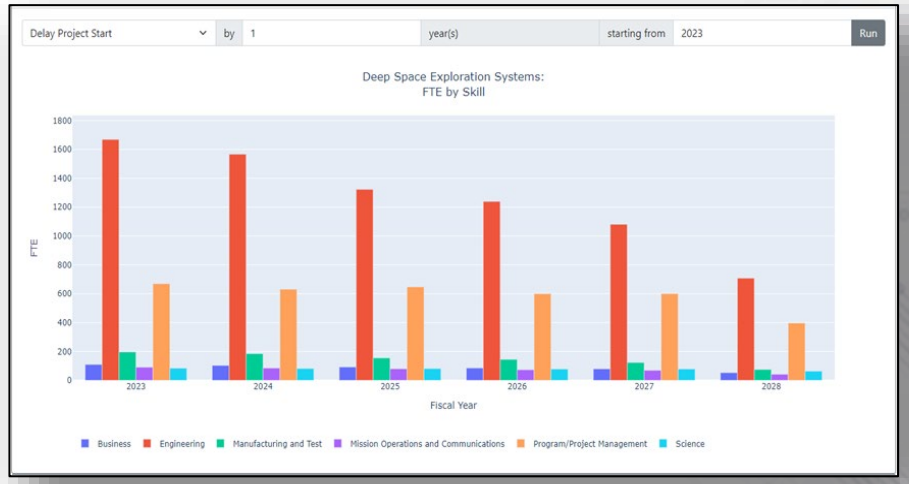


OCHCO
Office of the Chief Human Capital Officer

- Understand real-time vulnerabilities
- Explore policy effectiveness
- Assess readiness for potential mission & market scenarios
- Identify optimal workforce strategies



Policy Model



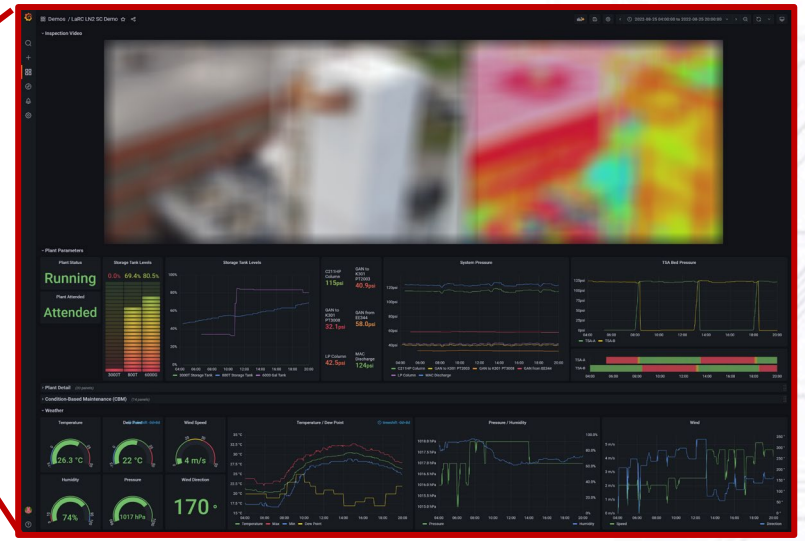
Demand Model

Digital Twins of our Workplace

Smart Centers today…

DIGITAL TWINS
DIGITAL RECONSTRUCTIONS AND DYNAMIC MODELS PROVIDE NEW ACCESS AND INSIGHTS TO DESIGN AND MANAGEMENT OF ASSETS

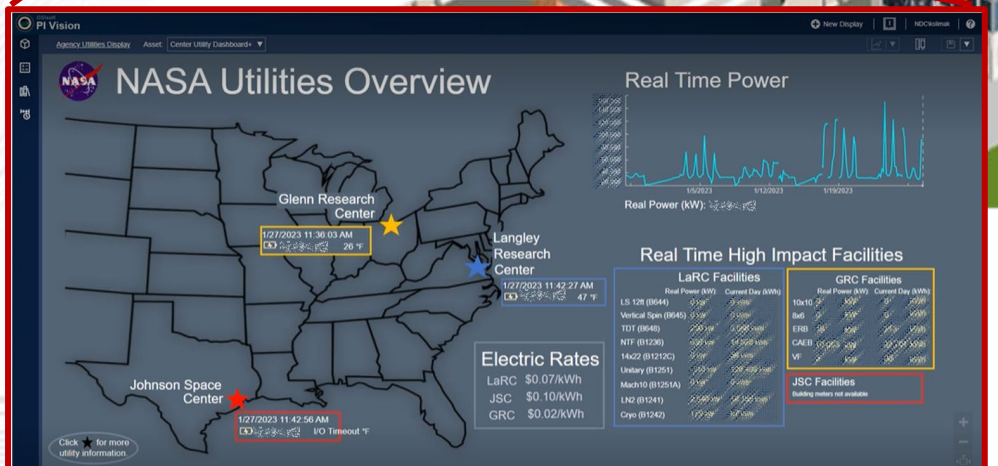
sUAS INSPECTIONS
DRONES PROVIDE GREATER ACCESS AND NEW PERSPECTIVES FOR ASSESSING INFASTRUCTURE, FACILITIES AND ASSETS

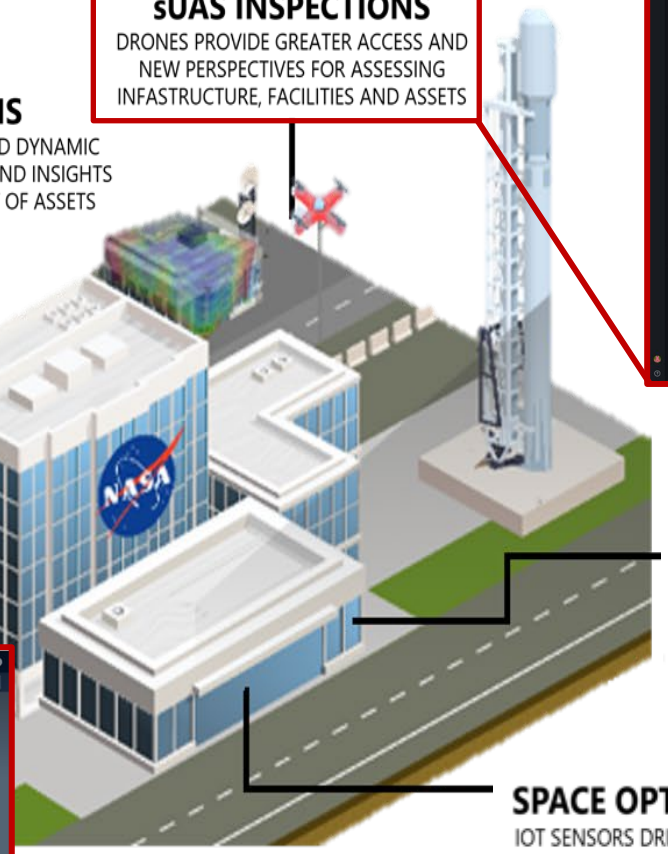


Integrating capabilities like IoT sensors, (autonomous) UAS & multi-spectrum cameras/scanners for new insights

AUTONOMOUS OPERATIONS
AUTOMATING ROUTINE TASKS AND SUPPORTING MORE COMPLEX ONES

PREDICTIVE MAINTENANCE
CBM AND AI/ML TO AVOID FAILURES AND OPTIMIZE O&M





EXTENDED REALITY
AR/VR REMOTE PRESENCE FOR COLLABORATION AND SUPPORT

SPACE OPTIMIZATION
IOT SENSORS DRIVE OPTIMAL SPACE UTILIZATION AND WORKPLACE OF THE FUTURE

Piloting real-time data, & insights into facilities/ systems previously incompatible

… enable **Smart Bases** tomorrow

NASA's DT Strategic Framework

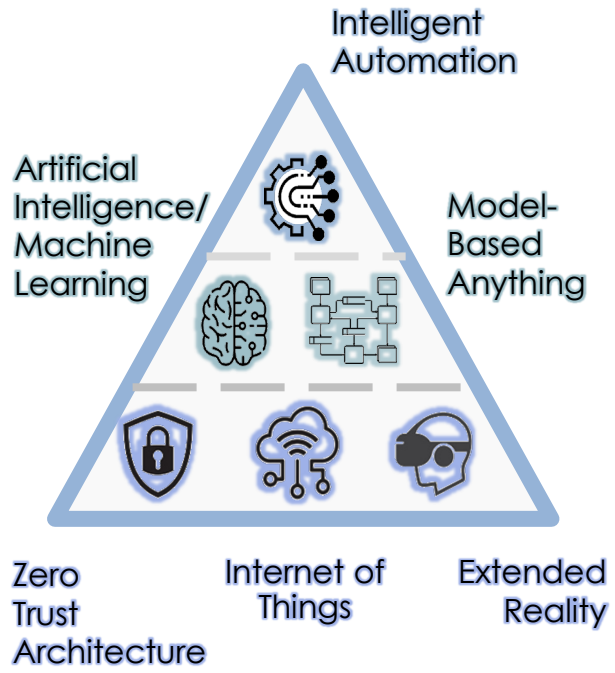
3 FUTURE STATE GOALS

4 TRANSFORMATION TARGETS

5 DIGITAL LEVERS

6 TECHNOLOGY FOUNDATIONS

7+ MISSION OUTCOMES



One Future NASA

REACH
NEW
HEIGHTS

REVEAL
THE
UNKNOWN

BENEFIT
ALL
HUMANKIND

NASA DIGITAL TRANSFORMATION

Questions?

BACKUP

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.

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

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

One Future NASA

- Bolder, More Complex Missions
- Seamless Partner Teaming
- Faster, More Agile Processes
- Affordable Sustainable Operations
- Inspired & Engaged Citizens
- Attract & Retain Workforce
- Modern Future of Work

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

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

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

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