Office of the Chief Technologist

An Update to the NASA Advisory Council
Technology Innovation and Engineering Subcommittee
30 April 2019
Our Office

Agency Leadership
Admin. Bridenstine
Deputy Administrator
Associate Administrator

Chief Technologist
Doug Terrier
Deputy (acting) / Chief of Staff
David Steitz
Admin. Darcia Stewart

NASA Technology Executive Council (NTEC)

Mission Directorates

Centers

Center Chief Technologist

Agency Digital Transformation Coordination
J.F. Barthelemy

Innovation Initiatives
Ken Wright

Center Support Teams
Ad Hoc

Strategic Integration
Al Conde

Detailee Team
ARMD – Bill Kimmel
HEO – David Miranda
STMD - Vacant
SMD - Lisa Callahan

S&T Partnerships
Erica Rodgers

Contractor Support
Elaine Gresham
Carie Mullins
Will Bryan
Husna Aziz
Erica Marquardt

ARMD – Bill Kimmel
HEO – David Miranda
STMD - Vacant
SMD - Lisa Callahan

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DRAFT
NASA Technology Portfolio

**Science Mission Directorate ~ $480M**
- Advanced Component Technology
- Advanced Information Systems Technology
- Astrophysics Research and Analysis
- Europa Technology
- Heliophysics - Tech and Instrument Development for Science
- In-Space Validation of Earth Science Technologies
- Instrument Incubator
- Maturation of Instruments for Solar System Exploration
- Nancy Grace Roman Technology Fellowships
- Planetary Instrument Concepts for Adv of Solar Sys Objectives
- Planetary Science and Tech Through Analog Research
- Strategic Astrophysics Technology
- + Mission-Directed Technology

**Space Technology ~ $686M**
- Centennial Challenges
- Center Innovation Fund
- Flight Opportunities
- Game Changing Development
- NASA Innovative Advanced Concepts
- SBIR/STTR
- Small Spacecraft Technology
- Space Tech Research Grants
- Technology Demonstration Missions

**Human Exploration and Operations**
- Advanced Exploration Systems
- Space Life and Physical Sciences Research
  - Human Research Program
  - Life and Physical Sciences
- Space Communications and Navigation

**Human Exploration and Operations Mission Directorate ~ $440M**

**Aeronautics Research Mission Directorate ~ $640M**
- Advanced Air Vehicles
- Airspace Operations and Safety
- Integrated Aviation Systems
- Transformative Aeronautics Concepts

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Technology Integration Framework

National policy, agency-level strategic plans or other activities that drive missions.
Examples: National Space Council, agency strategic plan, decadal surveys, Exploration Mission

Mission/Outcomes
“Why”

Technical Challenges
“What”

100 m landing footprint, challenging terrains like Europa

Strategy for Development
“How”

Fast Transit Deep Space Transportation

Technology Investment
“When”

Nuclear Propulsion

~5 MT to Surface Lander Capability

Missions (Agency posture)

Archive

Mars 2020

Mars Sample Return

Deep Space Transportation

Mars 2030

Mars-Clipper capability

Aerospace Mission Research, Science, and Capabilities

Aerospace Mission Research, Science, and Capabilities
Technology Integration Framework

- Framework concept of four steps completed December 2017
- Proof of concept with data from the Mission Directorates completed August 2018
- Plan to use TechPort for TIF database
- The TIF was presented and approved at NASA Technology Executive Council (NTEC) meeting 16 April

<table>
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<th>Framework Step</th>
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<th>HEOMD</th>
<th>SMD</th>
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Moving Forward

• OCT Technology Integration Framework briefing during NASA leadership retreat, May 2018

• Schedule
  • April - September 1
    • Work with TechPort to accept Framework data
    • Directorates identify and populate TechPort with current
      • Strategic Goals
      • Long Pole Capability Needs
      • Strategies to achieve Needs
    • Develop report out format
    • Develop Roll-out campaign to broad community
  • September
    • Report out at BPR/APMC
      • Framework implementation Status
      • Format for periodic MD reporting
      • Overview on Roll-out to broad community campaign

• Informs the NASA Strategic Technology Investment Plan (STIP)
The Innovation Framework

Innovation culture essential to achieving agency missions within budget and schedule.

Outcomes  
“Why”

Technical Leadership

Fiscal Efficiency

Performance to Cost and Schedule

Required Characteristics  
“What”

Teams of unlike minds (innovators, doers, crazy ideas)

Diverse workforce, diverse ideas

Definition of what success looks like

Ability to partner and adopt

Customer interaction when possible

Path to incorporate new ideas

Provide Feedback loop for innovative ideas

Identify and support innovation catalyst

Focus where you are good and differentiated

Communication share knowledge

Innovation Initiatives  
“How”

Identify customer pulls

Freedom and award workforce innovation

Don’t decide too early

Innovation Plans  
“When”

NIAC

SAAs

NARI

NASA Tournament Lab

NASA @work

OHC Culture Strategy

CIF

PPPs

Centennial Challenge

CoECI

LaRC Fast Track to Market

STMD BIG Ideas

Early Career Initiative

Innovation Awards

Human Health Risk

Innovational Portal

Flight Opportunities

OCE Tech Fellows

Innovation culture essential to achieving agency missions within budget and schedule.
OCT Survey to Identify Barriers to Innovation at NASA

OCT NAC briefing rolling out “Innovation Framework” March 2017

EC Decision: “NASA Innovation Framework will be the responsibility of OCT under the direction of the Deputy Administrator” April 2016

National Academies Innovation Summit November 2018

Ongoing efforts:
- Innovation Portal
- Innovation Experiments
- Recommendations from Summit

Agency innovation efforts cataloged & mapped
Potential solutions to barriers identified

National Academies Innovation Summit November 2018
National Academies Meetings on Experts – innovation best practices from government and industry Early 2018


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Innovation Framework

INNOVATIVE WORKFORCE:
- Reward teaming, diversity and inclusion

INTENTIONAL INNOVATION CULTURE
- Outcome – “Why”

OPTIMAL USE OF TECHNOLOGIES

INNOVATIVE PARTNERING:
- Internal and External

COMMUNICATION
- Mission Needs
- Lessons Learned
- Best Practices
- Story Telling

INNOVATIVE PROCESSES:
- Risk Mgmt
- Resource Mgmt

 Clarify the Need
- Mission and Mission Support Objectives
- Strategic Integration Framework
- Taxonomy

Assess Ecosystem
- State of the Art Assessments/Studies
- Partnership Opportunities
- S&T Partnerships
- Communities of Practice

Define Desired Future State
- Intentional Innovation Process
- Stakeholder Innovation Sessions

Define Innovation Experiments and Initiate Campaigns
- Develop and Utilize Innovation Tools
- Assess & Communicate Existing Innovation Initiatives
- Develop & External Tools

Communicate Lessons Learned
- Lessons Learned Database
• The Continuous Improvement of NASA’s Innovation Ecosystem

• Held at the National Academy of Sciences

• Goal was to identify actionable and implementable, phased initiatives that build on NASA’s innovation culture to reach a future that ensures continued success in an evolving environment

• Activities included

  • Analysis of NASA’s successful transformation to an innovation eco-system that is fully responsive to the evolving environment.
  • Examination of the steps needed to get from our current state to this future successful innovation culture in four distinct tracts:

  1. **People** – How do we reduce/remove barriers to innovation? How do we inspire and retain an innovative workforce? How do we communicate mission challenges to harness diverse ideas from the workforce? How do we grow an innovation culture?

  2. **Partnering** -- How do we forge partnerships to allow NASA to learn from the outside and specialize on what makes us unique? How do we foster collaborative partnerships among Centers?

  3. **Processes** – How do we ensure passion outweighs bureaucracy?

  4. **Portfolio management** – How do we introduce more risk and innovation into our portfolio but still ensure mission success? How do we introduce good shocks to the system? How do we ensure alignment of innovation funding with desired outcomes?
What We Heard

• Be more intentional – leadership can make a real difference
• Leadership should “Seek, Support and Celebrate” innovation
• Irrelevance is failure for NASA
• Develop ways to introduce “good shocks” to the system
• Make sure passion outweighs bureaucracy
Moving Forward

• May 30 Leadership Retreat session on Innovation
  • Present findings and forward plan for innovation initiative
  • Leadership discuss four theme areas and identify gaps
  • Solicit leadership feedback and buy-in

• Complete development and deploy Innovation Portal by September
  • Serves a digital framework to link innovations initiatives
  • Provide single point access to innovation ecosystem
  • Enables cross-center access and sharing of innovation tools

• Conduct high-impact innovation experiments to drive change
  • Center innovation funding applied to cross-agency projects
  • Partner with Mission Support Architecture initiatives
In-Space Assembly Topic:
Findings, Recommendations, and Transition

NASA Advisory Council
Technology, Innovation and Engineering Committee
April 30, 2019

Dr. Erica Rodgers
Office of the Chief Technologist
• Traditional way of building spacecraft leads to cycles of spiraling costs
  – Higher-cost payloads -> higher-reliability launch vehicles -> increased launch costs
  – Larger payloads mandate larger and heavier-lift launch capabilities
• Low-cost commercial launch systems have potential to break spiral
  – iSA will take advantage of these launch systems
• Advances in automation and robotics make iSA possible
  – Building up large structures beginning with relatively simple components
• Technologies will reduce cost of developing & launching new systems
  – Enable repair or upgrade satellites

In-Space Assembly (iSA)
In-Space Servicing (iSS)
In-Space Manufacturing (iSM)

Significant economic impact and performance benefits

Current state-of-the-art (SOA)
5-10 year-old technology at launch
25+ year-old technology at end of mission life

Ensure capabilities remain on the cutting edge
iSA and iSS enable advancements beyond SOA
## Benefits of In-Space Assembly and Servicing

### Assembly
- Bring about new capabilities enabled by spacecraft dimensions, masses, or configurations that cannot otherwise be launched from Earth

### Servicing
- Individual spacecraft can evolve in response to new knowledge, techniques, and technologies
- Mission success less dependent on launch and less susceptible to on-orbit failure -> options for recovery -> which in turn could reduce the costs of making systems extremely reliable

### Reduce Cost
- Structures assembled in space designed for **operational loads**, not launch loads
- Avoid system complexity and parasitic mass of on-orbit deployment
- **Extensible/reusable** spacecraft support broader range of missions and conditions
- **Remove/replace** modules during operation -> improve life cycle costs & mission risk
- **Modularity** enables launches of small components on lower cost comm vehicles
- Only lose modular elements if failure, not entire spacecraft
- **Incremental buildup** distributes cost across time -> pay as you go approach
- **Facilitates cost sharing** by multiple programs and multiple government agencies

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TALISMAN = Tension Actuated Long-reach In-Space Manipulator
CIRAS = Commercial Infrastructure for Robotic Assembly and Servicing

Credit: NASA/LaRC

TALISMAN is critical to the CIRAS project, which seeks to enable space-based, robotic assembly of flight hardware and space systems. (Northrop Grumman/Orbital ATK, NASA, NRL)
A New Paradigm for Spacecraft Development and Operation

In-Space Assembly and Servicing

Persistent and resilient space assets to be assembled and routinely upgraded in space

Transform space operations capabilities with economic and performance benefits for both U.S. Government and commercial space endeavors

Common core of high-leverage capabilities provide path towards a robust and flexible capability for the spectrum of users

Interagency Science & Technology Partnership Forum
Leverage synergies and influence agency portfolios

DARPA - Affiliate Partners - NRL

1. Facilitate cross-agency collaboration and strategize on technical solutions to common pervasive needs
2. Maintain awareness of each agency’s space S&T investments to reduce duplication and identify areas worthy of collaboration
3. Identify impediments to collaboration and formulate solutions

Strategic forum established to identify synergistic efforts and technologies

Other Topics
- Small Satellite Technology
- Big Data Analytics
- Cybersecurity

Identified and prioritized pervasive goals that focus on key game-changing technologies across government space

DARPA = Defense Advanced Research Projects Agency
NRL = U.S. Naval Research Laboratory

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Overview

S&T Partnership Goals
- Coordinate S&T issues across space agencies (Leverage synergies)
- Efficiently and effectively manage S&T resources (Influence agency portfolios)

S&T Partnership Objectives
- Facilitate synergistic collaborations
- Strategize technical solutions
- Maintain awareness of S&T investments
- Identify impediments and formulate solutions

Execute

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Govt Papers
- Establish baseline of govt iSA work
- Collectively describe benefits of iSA
- Establish value for partnering on iSA
- Communicate and document

Public Papers
- Collect commercial iSA data
- Perform commercial iSA capability analysis
- Assess potential commercial demo platforms
- Make govt/commercial partnering recs

Partnering

Value Proposition
- Collect and prioritize data
- Perform govt iSA capability analysis
- Assess potential iSA demo platforms
- Communicate results / make recs

Roadmap Analysis
- Synergy & Gap Analysis
- Prioritization
- Demo Platform Analysis

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Findings

Capability Areas with potential for interagency collaboration

1. Relevance to:
   • Organization
   • Operational mission

2. Stakeholder goals & Design drivers

14 Capability Areas
46 Capabilities

AF SMC
Advanced
Space-based
Testbed

NASA
On-orbit
Servicing
Assembly
Manufacturing

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Agency Need & Investment: Collaboration

For need: E=enabling
S=supporting
N=not applicable

For investment:
H=high (significant)
M=medium (some)
N=none

Increasing partnership investment
Findings

Identified current government landscape of in-space assembly

- Specific technology development activities the various Agencies are working
- Technology demonstration missions (TDMs) that are underway or planned

Cadence of in-space assembly Technology Demonstration Missions → Map to future operations missions

Potential Operational Missions

- NASA
  - Concept A
  - Concept B
- DARPA
  - Concept C
- Air Force
  - Concept D
  - Concept E
Findings

Evaluated how well various platforms could demonstrate prioritized capability needs

**Platform Evaluation**

- Platform Access Costs
- Certification Costs
- Programmatic Realism
- Timeframe
- Access to Manifest

**Capability Needs Evaluation**

- Payload Cost
- Payload Certification Costs
- Payload Launch Mass Cost Factor

All 5 government demonstration platforms can be modified (cost, time, programmatic realism) to demonstrate prioritized iSA capability needs

- International Space Station
  - Credit: NASA
- Restore-L servicing demo w/ Landsat-7
  - Credit: NASA
- Robotic Servicing of Geo Sats
  - Credit: DARPA
- James Webb Space Telescope Pathfinder
  - Credit: NASA
- TALISMAN for CIRAS
  - Credit: NASA

TALISMAN = Tension Actuated Long-reach In-Space Manipulator
CIRAS = Commercial Infrastructure for Robotic Assembly and Servicing

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Recommendations

**Strategic**
- Continue to strengthen partner agency relationships
- Develop coordinated approach to better align govt/industry efforts

**Transition**
- Data
- Analyses
- Relationships

**Programmatic**
- Establish interagency pathway forward to developing architectures and capabilities

**Technical**

OCT will lead NASA coordination team (SMD, HEOMD, STMD)
- Provide NASA strategic oversight
  - Leadership & Guidance
  - Work with the S&T partner agencies

iSA = In-Space Assembly
OSAM = On-Orbit Servicing, Assembly, & Manufacturing

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DT Recommendations

Approve the proposed Digital Transformation strategy, conceptual approach and six prioritized initiatives as the basis for completing an implementation plan to be recommended by the Chief Technologist, as OIC of the implementing organization, in partnership with the Chief Information Officer, and approved by a joint APMC/MSC.

The final plan will include:

- Definition of the scope, organizational approach and resourcing of the Digital Transformation effort as a virtual office, reporting to the OCT to coordinate and integrate the function.
- Proposed updated charter for the NTEC as the advisory body for the DT effort, realigned to the APMC or MSC, as appropriate.
- Definition of how investment opportunities for the effort will be accommodated within existing resources through collaboration, both for areas within OCIO’s IT investment decision authority and governance (Information Technology Council), and areas outside the ITC’s decision authority, including Mission Directorates, Mission Support Directorates, and Centers.
Outline

• BLUF
• Quick Reminder: What is DT?
• Proposed NASA DT Strategy - Vision, Goals, Strategic Initiatives
• DT Ecosystem and Proposed Governance
• Funding DT
• DT Implementation - next 18 months
• Recommendations to APMC

DT Working Definition:
Employing digital technologies to transform a process, product, or capability so fundamentally that it brings substantial performance improvements
DT Example
Data Access/Integration for EVA Safety

Astronaut on spacewalk had serious water leak in helmet. To assess incident after the fact, it took 6 contractors 2 weeks to gather all related data from file cabinets, hand written notes, and contractor and NASA databases.

Technical challenges (why DT was needed):
- Access to authoritative data: disparate data sources, various formats and standards; data not integrated, accessible
- Interoperability: no integrated search, analytics

Approach (how DT was employed):
- Created unified data access with cognitive search, 3D graphical browsing, intelligent linking, provenance, metadata management
- Flexible architecture to leverage Gov Cloud, industry standards and open source software

Benefits to date:
- Enables product data lifecycle management and model-based systems engineering
- Decreases EVA readiness review time
- Resolves anomalies accurately, in time
- New space suit is using same approach

Lessons learned, best practices:
- Integrated data is key to reducing cost and risk
- Data management approach definition is needed
- Senior management commitment important
What We Found

• DT is about **reinventing** processes and products to take full advantage of data and state-of-the-art IT technologies

• NASA is **already engaged** in DT initiatives
  + Mostly bottoms-up, innovation/ experimentation
  + Many OCIO projects are already enabling DT
  + All potential DT technologies are investigated
  + Some Centers have DT focused staff/org

• DT is **an enabler** of the Agency Mission

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**Scale-up challenged by:**
- **Stovepipe developments**
- Resistance to change
- Lack of resources for start-up/scale-up
- Limited awareness of DT and best practices across the Agency

**Considerable potential for:**
+ Focused efforts and collaborative developments
+ Integrated approach to acquisition and developments
What We Propose

- **Embrace** DT to transform Agency processes, to bring substantial benefits
- **Focus** efforts in selected strategic directions, driven by Mission needs
- **Engage** involved communities in designing enterprise solutions
- **Implement** DT collaboratively, every organization has a role in DT
- **Seek** critical DT skills through hiring, training, judicious partnering
- **Realign** process, process improvement resources to process transformation
- **Fund** early wins/jump-start efforts
- **Employ** light touch governance, to advocate for DT, steer, and coordinate efforts
### DT Drivers, Vision, Goals

**Drivers**

- Digital Convergence
- Collaboration Needs
- Resource Constraints

**Vision**

- Establish and infuse an Agency-wide, high-impact DT Initiative
- Advance DT through opportunity-driven transformative strategic initiatives
- Coordinate and align with mission-enabling, secure, agile enterprise IT services

**Goals**

- Big Data Challenges
- Research Complexity
- Cybersecurity

**NASA employs powerful digital practices and strengthens its culture of innovation on a transformation journey to enhance efficiency, agility, and insight in the advancement of NASA’s mission.**

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DT Strategic Initiatives

• Based on inputs collected during the fact-finding phase of this effort, the DT working group selected 6 Strategic Initiatives (SI):
  1. Data
  2. Collaboration
  3. Model Based x
  4. Process Transformation
  5. Culture (and Workforce)
  6. AI/ML

• Empower a working group for each SI to engage the associated Agency communities, and develop, by the end of CY2019,:
  – a **detailed enterprise strategy** to reach digital maturity for the initiative
  – a **roadmap**, goals, objectives, schedules, and metrics
  – a plan to engage the **capabilities required** to enable the strategic initiative
  – advance **early win** initiatives
DT Strategy

Drivers

Vision

- Advance DT through opportunity-driven transformative strategic initiatives
- Establish and infuse an Agency-wide, high-impact DT initiative
- Coordinate and align with mission-enabling, secure, agile enterprise IT services

Initiatives

- Data Strategy
- Collaboration Strategy
- MBx Strategy
- Process Transformation Strategy
- AI/ML Strategy
- Culture and Workforce Strategy

- DT Ecosystem
- Governance Model
- OCIO, MDs, and MSD Activities, Center
NASA’s Digital Transformation Ecosystem

Proposed DT Office (DTO) Facilitates Robust Coordination, Communication, and Support

**OCIO**
- Insert DT in IT Strategic Plan
- Lead DT SI, strategy, policy, as needed
- Provide Enterprise IT infrastructure for DT
- Design/Fund/Implement
  - Unique IT-focused DT solutions
  - Cross-cutting DT solutions (jointly)

**Mission Support Directorate**
- DT elements into org plans
- Lead DT SI, strategy, policy as needed
- Enable DT education and training
- Design/Fund
  - Unique MSD-centered DT solutions
  - Coordinate with DT for MAP
  - Workforce, Infrastructure strategies
  - Cross-cutting DT solutions (jointly)

**Mission Directorates**
- Insert DT element in program plans
- Lead DT SI, strategy, policy, as needed
- Design/Fund
  - Unique MD-centered DT solutions
  - Cross-cutting DT solutions (jointly)

**Centers**
- Insert DT into strategic plans
- Lead DT SI, strategy, policy, as needed
- Design/Fund/implement
  - Unique Center DT solutions
  - Cross-cutting DT solutions (jointly)

**DTO**

OCT, OCE, OCS…

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What We Propose To Do

By 3/2018 APMC

✓ Scoping assessment
✓ Benchmarking
✓ Management models

Output:
✓ Recommendations on next steps and management model

By 3/2018 APMC

Formulation - Complete

By 4/2019 APMC

✓ Engage mission directorates, Centers, and functional offices
✓ Create awareness. Conduct internal inventory
✓ Benchmark industry
✓ Conduct analysis and assessment
✓ ID candidate technologies/concepts
✓ ID early wins

Output:
✓ Draft Strategic Plan
✓ Draft high-level implementation framework

By 7/2019 APMC/MSC

Begin Implementation & Institutionalization

By 7/2019 APMC/MSC

DT Implementation plan
• DTO Virtual Office
• Updated NTEC charter
• Investment approach

By 9/2020 (sampling)

• Set up DTO (4Q/FY19)
• Charter SI WGs (3Q/FY19)
• Approve SI Strategic Plans (2Q/FY20)
• Early wins (3Q/FY19), (1Q/FY20)
• Videos (3Q/FY19, 2QFY20)
• DT status (4Q/FY19, FY20)

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