Technology, Innovation & Engineering Committee Report
NASA Advisory Council

Dr. Bill Ballhaus, Chair | 03.29.18

TI&E Committee Scope

“The scope of the Committee includes all NASA programs focused on technology research and innovation.”

–NASA Advisory Council Technology & Innovation Committee Terms of Reference, signed 6/28/12

TI&E Committee Meeting Attendees: March 26, 2018

- Dr. William Ballhaus, Chair
- Mr. Gordon Eichhorst, Aperios Partners LLP
- Mr. Michael Johns, Southern Research Institute
- Dr. Matt Mountain, Association of Universities for Research in Astronomy
- Mr. Jim Oschmann, Ball Aerospace Corp.
- Dr. Mary Ellen Weber, Stellar Strategies, LLC

TI&E Committee Meeting Presentations: March 26, 2018

- Welcome to NASA GSFC
  - Mr. Chris Scolese, Director, NASA Goddard Space Flight Center
- STMD Update and FY 2019 President's Budget proposal
  - Mr. Steve Jurczyk, Associate Administrator (Acting), NASA
  - Mr. James Reuter, Associate Administrator (Acting), Space Technology Mission Directorate (STMD)
- Tour of GSFC projects
  - NICER/SEXTANT and X-Ray Communications
  - Laser Communications Relay Demonstration
  - Satellite-Servicing and Assembly

Technology: A Definition

A solution that arises from applying the disciplines of engineering science to synthesize a device, process, or subsystem, to enable a specific capability.

from July 2012

Technology Budget Challenges

Technology budgets have been disadvantaged by a lack of an urgency argument.

Lack of an urgency argument has been due to the lack of an overarching agency exploration architecture and plan, e.g. we know what technologies need to be developed to get humans to Mars, we just don't know when we need them.

The Space Policy Directive-1 provides a near-term destination for which a detailed program plan could be formulated along with required technologies and need dates.

Space Policy Directive - 1

On December 11, 2017, President Trump once again set America's sights toward the stars by signing Space Policy Directive – 1, which instructed the National Aeronautics and Space Administration (NASA) to return American astronauts to the moon for long-term exploration and utilization, followed by human missions to Mars and other destinations.

Proposed Agency Restructuring

NASA will restructure the Agency to align with our focus on accelerating human exploration beyond low-Earth orbit. There are two options currently under review:

1) Creation of two new exploration-focused mission directorates, eliminating the current HEO and STMD structure –

- a. An Exploration Operations Mission Directorate that will focus ISS, LEO operations, and cross cutting support areas required to support exploration such as communications, and propulsion testing, etc.
- b. An Exploration Systems and Technology Mission Directorate that will focus on deep space mission elements and technology developments needed for sustainable human exploration.

2) Creation of a single exploration-focused mission directorate, consolidating all the exploration-focused content in the current HEOMD and STMD organization.

NASA will assess these two options (and any hybrid options that may arise), and prepare for implementation at the start of the FY 2019 budget year.

TI&E Committee Finding – March 2018

NASA's major missions have been enabled by technology investment over a number of years.

Previous experience with housing "seed corn" and crosscutting technologies in development mission directorates produced unfortunate results

- Drastic reductions in those technology budgets
- Alienation of university connections—the major source of human capital for NASA and its contractors

STMD was established to reverse these outcomes and has produced a robust technology portfolio with university and industry partnerships.

Question: With the proposed demise of STMD, how would NASA in its new structure assure future such unfortunate results don't materialize?

Relevant Past Committee Input to the Council Dating Back to 2012

T&I Committee Agency-Level Observations

NASA "grand" missions are technology-enabled.

- JWST, MSL, ISS—type of work NASA should be doing
- Demonstrates NASA/U.S. technical leadership

"Future U.S. leadership in space requires a foundation of sustained technology advances…NASA's technology base is largely depleted." –NRC Report

from March 2012

TI&E Observations – July & Nov 2016

- **NASA needs cutting edge technologies to undertake its missions.**
  - Current missions are based on technologies developed through investments made over several decades.
- **In the timeframe FY2005-FY2009, technology budgets (basic research -$500M; applied research -$900M) were drastically reduced**
- **To reverse this decline, NASA established OCT (in 2010) and STMD (in 2013) and rebuilt the crosscutting technology program as well as made focused investments in technology development in HEOMD and SMD.**

T&I Committee Findings for the NASA Advisory Council

- NASA technology shelf depleted over the last decade due to a lack of investment. NASA has begun to correct this over the last three years (e.g., Space Technology Program (STP)).

from November 2012

Questions for NASA Administrator

- What is the appropriate percentage of NASA's budget that should be devoted to technology investment?
- What fraction of that allocation should be organizationally fenced off as "seed corn" and crosscutting investment?
- How is NASA managing its technical, critical core competencies?

from March 2012

T&I Committee Agency-Level Observations

What is the appropriate percentage of NASA's budget that should be devoted to technology investment? Ten percent?

- We couldn't find accounting that told us what percentage of NASA budget is technology investment. *(Although effort under way by OCT to determine this.)*
- Three Categories
  - Mission Support/Pull (mission specific or vehicle/architecture specific, mid-high TRL)
  - Crosscutting (mid-high TRL)
    - e.g. cryogenic fluid management in space, solar electric propulsion
  - "Seed Corn" (low-mid TRL)
    - Disruptive
    - Developing people, as well as ideas/maintaining core competencies

from March 2012

T&I Committee Agency-Level Observations

- A number of astute administrators, including present, have organizationally fenced off the budget for “seed corn” and crosscutting investments that includes research and technology and system-level demonstrations to preserve options for the future.
  - When “seed corn” investment isn’t organizationally fenced off, it gets eaten!
  - e.g. Constellation eating tech budget to fix development issues
- What fraction of the technology budget should be set aside for “seed corn”?

From March 2012

TI&E Committee Observation

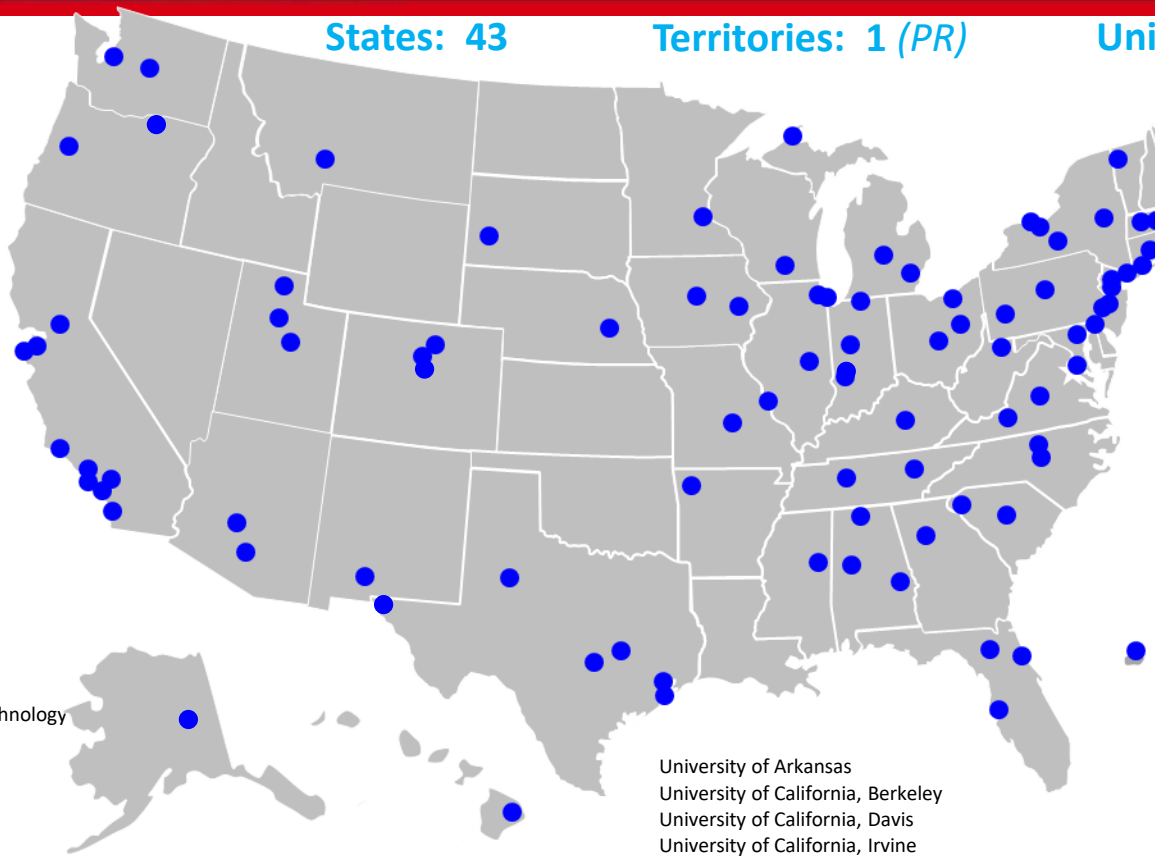
STMD University Engagement:

- During the mid-2000s, NASA's university engineering research programs were decimated.
- STMD has reestablished contacts with the university community through the Space Technology Research Grants program, including the NASA Space Technology Research Fellowship program.
- Committee met at lunch with 15 Fellows working at JPL this summer from universities across the nation
- Committee very impressed with technical knowledge and capabilities of the Fellows

from July 2015

STRG Portfolio – Awards To-Date
Universities

Awards: 539 **States: 43** **Territories: 1 *(PR)*** **Universities: 106**



Arizona State University
Auburn University
Boston University
Brigham Young University
Brown University
California Institute of Technology
Carnegie Mellon University
Case Western Reserve University
Clemson University
Colorado State University
Colorado School of Mines
Columbia University
Cornell University
Duke University
Florida Institute of Technology
Georgia Institute of Technology
Harvard University
Illinois Institute of Technology
Iowa State University
Johns Hopkins University
Massachusetts Institute of Technology
Michigan State University
Michigan Technological University
Mississippi State University
Missouri University of Science and Technology
Montana State University
New Jersey Institute of Technology
New Mexico State University
New York University
North Carolina State University
Northeastern University
Northwestern University
Ohio State University
Oregon State University
Pennsylvania State University
Portland State University
Princeton University
Purdue University
Rensselaer Polytechnic University
Rochester Institute of Technology
Rose-Hulman Institute of Technology
Rutgers University
South Dakota School of Mines and Technology
Stanford University
State University of New York, College of Nanoscale Science & Engineering
State University of New York, Stony Brook
Texas A&M University
Texas Tech University
Tufts University
University of Akron
University of Alabama, Huntsville
University of Alabama, Tuscaloosa
University of Alaska, Fairbanks
University of Arizona
University of Arkansas
University of California, Berkeley
University of California, Davis
University of California, Irvine
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara
University of Central Florida
University of Colorado, Boulder
University of Connecticut
University of Delaware
University of Florida
University of Hawaii
University of Houston
University of Illinois, Chicago
University of Illinois, Urbana-Champaign
University of Iowa
University of Kentucky
University of Maine
University of Maryland
University of Massachusetts, Amherst
University of Massachusetts, Lowell
University of Michigan
University of Minnesota
University of Nebraska, Lincoln
University of New Hampshire
University of Notre Dame
University of Pennsylvania
University of Pittsburgh
University of Puerto Rico, Rio Pedras
University of Rochester
University of South Carolina
University of South Florida
University of Southern California
University of Tennessee
University of Texas, Austin
University of Texas, El Paso
University of Utah
University of Vermont
University of Virginia
University of Washington
University of Wisconsin, Madison
Utah State University
Vanderbilt University
Virginia Polytechnic Institute & State University
Washington State University
Washington University, St. Louis
Western Michigan University
West Virginia University
William Marsh Rice University
Worcester Polytechnic Institute
Yale University

TI&E Observations – July & Nov 2016 *(cont.)*

- **NASA management has done an excellent job of formulating the technology program and executing it, within annual budget constraints.**
  - Examples of past accomplishments (2010 to 2015): Composite Cryotank, Advanced Solar Arrays, High Power Electric Propulsion Thrusters, EDL including inflatable decelerators, High Performance Thermal Protection Systems, BEAM (Commercial Inflatable Habitat at ISS), and Small Spacecraft Technologies
  - Examples of upcoming accomplishments (2016 to 2020): Green Propellant Infusion Mission (GPIM), Deep Space Atomic Clock (DSAC), Solar Electric Propulsion demo, laser comm demos, RESTORE–L satellite servicing demo, in-space robotic manufacture & assembly, ISRU demo and Terrain Relative Navigation on Mars 2020
- **STMD reengaged the academic community in engineering research and technology development and has rekindled interest in NASA among students, especially at the graduate level.**
- **STMD has effectively used internal and external partnerships to mature and develop technologies.**

TI&E Committee Finding – March 2018

NASA's major missions have been enabled by technology investment over a number of years.

Previous experience with housing seed corn and crosscutting technology in development mission directorates produced unfortunate results

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- Alienation of university connections—the major source of human capital for NASA and its contractors

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Question: With the proposed demise of STMD, how would NASA in its new structure assure future such unfortunate results don't materialize?

Proposed Council Recommendation

Recommendation:

The Council recommends that the NASA Administrator task the Acting Associate Administrator to develop and present to the Council mechanisms and/or a hybrid organizational option that promotes appropriate levels of investment in early and mid-stage technology development and University grants and fellowships. This includes defining metrics to assess effectiveness.

Proposed Council Recommendation (cont'd)

Major Reasons for the Recommendation:

- **NASA needs cutting edge technologies to undertake its missions.**
  - NASA "grand" missions are technology-enabled.
  - JWST, MSL, ISS-type of work NASA should be doing.
  - Demonstrates NASA/U.S. technical leadership.
  - Current missions are based on technologies developed through investments made over several decades.
- **In the timeframe FY2005 - FY2009, technology budgets (basic research -$500M; applied research -$900M) were drastically reduced.**
  - NASA technology shelf depleted over the last decade due to a lack of investment. NASA has begun to correct this over the last three years (e.g., Space Technology Program (STP)).
  - A number of Administrators in the past have organizationally fenced off the budget for "seed corn" and crosscutting investments that includes research and technology and system-level demonstrations to preserve options for the future.
- **To reverse this decline, NASA established OCT (in 2010) and STMD (in 2013) and rebuilt the crosscutting technology program as well as made focused investments in technology development in HEOMD and SMD.**

Proposed Council Recommendation (cont'd)

Major Reasons for the Recommendation (cont'd):

- **STMD University Engagement:**
  - During the mid-2000s, NASA's university engineering research programs were decimated.
  - STMD reengaged the academic community in engineering research and technology development and has rekindled interest in NASA among students, especially at the graduate level.
  - If appropriate mechanisms are not put in place, NASA interactions with Universities will be adversely affected as in the past.

Consequences of No Action on This Recommendation:

Narrows technology options for future programs and adversely affects human capital development for NASA and its contractors.