National Aeronautics and Space Administration

NASA* Update: "Testing at the Speed of Light"

Looking Back at the National Academies Consensus Study Report

*primarily discussing NASA efforts & perspective – others involved and not meant to be exhaustive

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Acronyms

Abbreviation	Definition
BNL	Brookhaven National Laboratory
CERN	Conseil européen pour la recherche nucléaire (European Organization for Nuclear Research)
CNL	Crocker Nuclear Laboratory
COTS	Commercial Off The Shelf
DoD	Department of Defense
DoE	Department of Energy
EEE	Electrical, Electronic, and Electromechanical
ETW	Electronics Technology Workshop
IEEE	Institute of Electrical and Electronics Engineers
IUCF	Indiana University Cyclotron Facility
LBNL	Lawrence Berkeley National Laboratory
M&S	Modeling and Simulation
MGH	Massachusettes General Hospital
NAS	National Academies of Sciences, Engineering, and Medicine
NASA	National Aeronautics and Space Administration
NEPP	NASA Electronic Parts and Packaging (Program)
NSCL	National Superconducting Cyclotron Laboratory
NSRL	NASA Space Radiation Laboratory (at BNL)
RADSAGA	RADiation Space, Avionics, Ground, & Accelerators
SEE	Single-Event Effects
SMC	(USAF) Space and Missile Systems Center
SRHEC	Strategic Radiation-Hardened Electronics Council
TAMU	Texas A&M University
TRIUMF	(formerly) Tri-University Meson Facility
USG	U.S. Government
VdG	Van de Graaff (accelerator)

Outline

- Generally focused on single-event effects testing
- Joint effort between the Department of Defense (Air Force / SMC), Department of Energy (Office of Science / Nuclear Physics), and NASA
- Released January 2018

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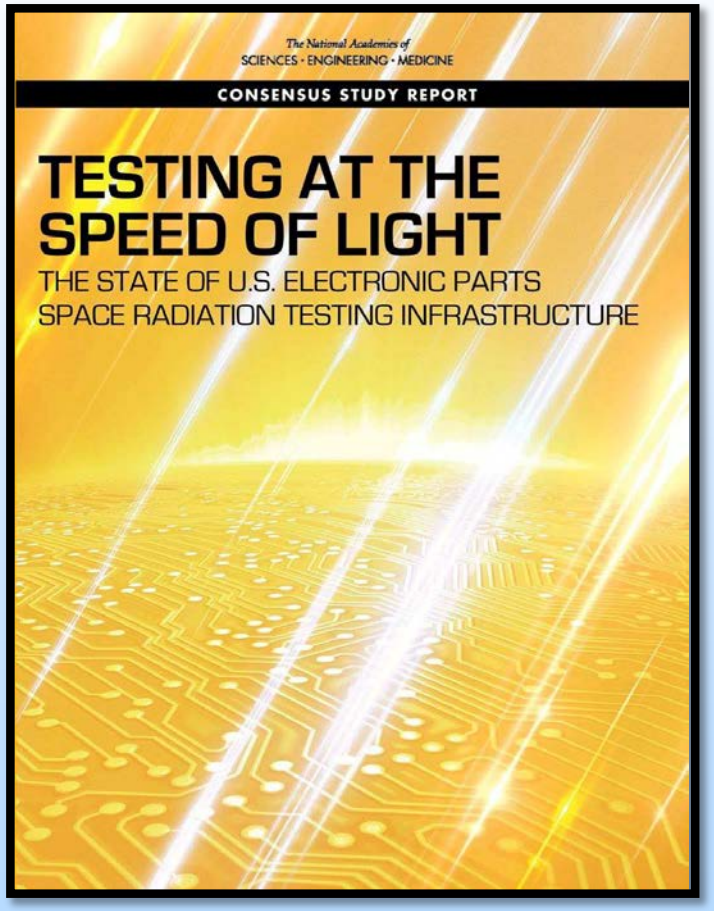
- Recap task statements
- Summarize findings and observations
- Highlight progress on recommendations
- Summarize remaining gaps

Tasking Statements

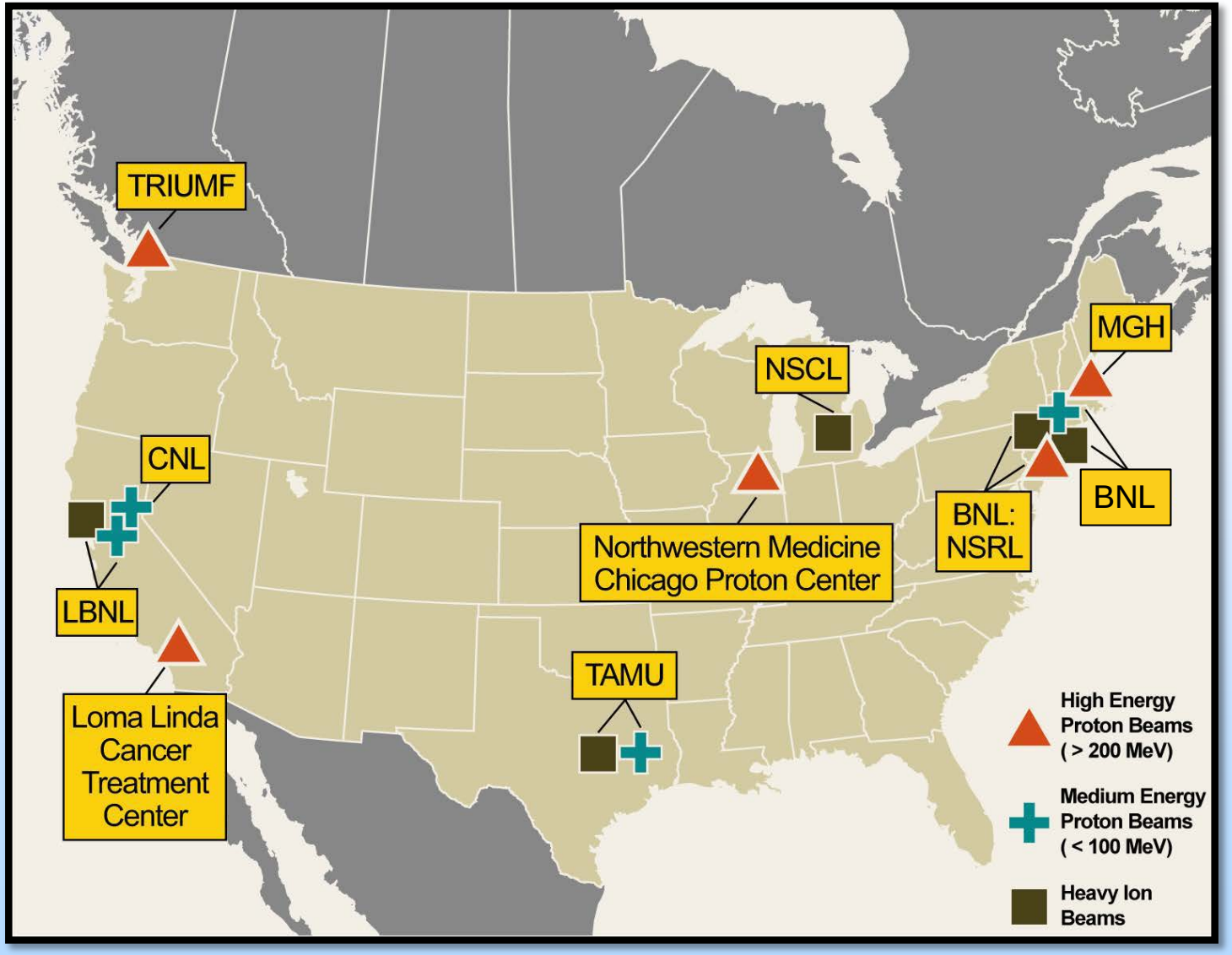
- **Assess the existing infrastructure**
  - Facilities and related infrastructure
  - Simulation capabilities
  - Workforce
  - Training and research experience programs
- **Identify the principal gaps** that exist between existing and needed infrastructure
- **Recommend steps** that eliminate, or reasonably minimize, any identified gaps
- Recommend steps required to provide **effective stewardship** of the necessary radiation test infrastructure for the foreseeable future



https://doi.org/10.17226/24993

Facilities Included in the Study

- Several different machine types (cyclotron, synchrotron, VdG)



- 6 cyclotrons *capable* of producing heavy ions (CNL)

National Academies of Sciences, Engineering, and Medicine. 2018. Testing at the Speed of Light. Washington, DC: The National Academies Press.

Major Findings

1) **Growing use and tightening supply**
   a. More spacecraft (e.g., commercial space) – other users coming (e.g., nuclear modernization, autonomous vehicles, etc.)
   b. Capacity issues impact schedule
   c. Higher per hour use costs

2) **Infrastructure showing signs of strain**
   a. Major facilities have closed in recent years (e.g., IUCF in Oct. 2014)
   b. Existing facilities are ageing with critical systems more likely to fail (e.g., helium refrigeration for superconducting cyclotrons)
   c. For high-energy proton facilities, space users are often parasitic
   d. Little to no margin for fail-safe or capacity growth

Major Findings

3) **Aging workforce is in a domain that requires specialized training and skills**
   a. **Workforce has bimodal distribution – how to mentor next generation when senior engineers are strapped with program/project work and little bandwidth to spare?**
   b. **Transferring and capturing knowledge at an insufficient rate**
   c. **Need additional access to informal learning, short course material, and things like summer schools**

4) **Technology moves fast**
   a. **COTS component technologies will continue scale and evolve – true rad-hard devices may reach scaling limit sooner due to uncertainties in predicting and mitigating SEE**
   b. **Increasing COTS component integration (e.g., 3-D) will make it difficult to test using conventional heavy ion accelerators**
   c. **Body of knowledge for the field advances more rapidly than it can be accommodated [in test standards]**

Other Observations (at the time)

- No clear roadmap on what is required and who will provide it
- There are some relatively new testing approaches with promise
- DoE budget for test facilities remains under threat
  - Political snapshot in time – always a moving target

- Demand
  - Load increasing
  - Need for greater reliance on electronics in advanced systems
  - Fundamental changes to electronics technology creates need for new kinds of test approaches (& more testing)
- Supply
  - More options for M&S and in situ testing, likely not adequate to address the demand
  - Ageing and growing costs of test facilities
- Mismatch between demand for both more and different kinds of testing, and shrinking supply

Recommendations and Progress

1. **The Department of Energy, in collaboration with the Department of Defense and NASA, should establish a joint coordination body to define the usage needs for parts radiation testing and assure the adequacy and viability of radiation test facilities out to 2030. The joint coordination body should be inclusive and recognize the needs of the broader space community.**

Chartering of the Strategic Radiation-Hardened Electronics Council (SRHEC) has bound DoD and NASA together for this purpose. The Air Force (SMC) and NASA are working on building a path to link DoE Office of Science – Nuclear Physics

Recommendations and Progress

2. **The joint coordination body or an equivalently empowered entity should accomplish the following:**
   a. **A review of testing under way at facilities across the country and internationally**
   b. **A strategic forecast of both government and commercial satellite launches that will require radiation-hardened microelectronic and optoelectronic components to include reliability and lifetime requirements**
   c. **A joint roadmap developed by representatives from commercial device suppliers and the radiation-hardening testing community to ensure test procedures and facilities are capable of testing the latest electronics technologies**
   d. **A facilities plan, updated periodically**

The SRHEC, in coordination with other groups, is addressing part of this recommendation. Gaps still exist.

Recommendations and Progress

3. **The Department of Energy, NASA, the U.S. Air Force, and other interested parties should stabilize funding for proton and heavy-ion accelerator facilities in order to restore resilience in national testing capabilities.**

NASA and the U.S. Air Force have moved to set up block buys of test time at Lawrence Berkeley National Laboratory (LBNL) – at least one other agency has begun the process for a third agreement at LBNL. NASA is pursuing a blanket purchase agreement to stabilize the demand signal for high-energy proton test facilities.

Recommendations and Progress

4. **The Department of Energy, NASA, and the U.S. Air Force should cooperate with professional organizations (e.g., the Institute of Electrical and Electronics Engineers (IEEE)) and other interested parties to accelerate career development of the younger testing and modeling scientists and engineers through summer schools, short courses, university certificate programs, and internal mentoring to enable them to more rapidly achieve mid-career proficiency levels.**

Several efforts are underway via the SRHEC. Los Alamos National Laboratory is hosting a radiation effects summer school this year (right now). NASA will be discussing partnership opportunities with the IEEE Nuclear and Plasma Sciences Society this summer. NASA has engaged CERN to become an associate of the RADSAGA innovative training network (https://radsaga.web.cern.ch/).

Recommendations and Progress

5. **The joint coordination body should assess and support university capabilities for improving space electronics testing and development infrastructure, including the following: the development of advanced accelerator concepts, improved testing strategies, improved radiation hardening solutions designs, and radiation mitigation techniques.**

The recent Defense Threat Reduction Agency announcement (HDTRA1-19-S-0004 Interaction of Ionizing Radiation with Matter University Research Alliance) and possible offerings from the Air Force Office of Scientific Research will help fulfill this recommendation. The SRHEC and NASA are examining additional pathways for more focused work on design of experiments. NASA has engaged CERN to become an associate of the RADSAGA innovative training network (https://radsaga.web.cern.ch/).

Recommendations and Progress

6. **The joint coordinating body should engage with the commercial space sector to ensure testing norms meet the needs of this sector as well as the conventional satellite design and radiation testing communities.**

Some proactive efforts in this area,
but formal coordination is largely serendipitous.

Could increase engagement via the Space Collaboration Council, for example.
Where can our community be more present? How can we reach out?

Recommendations and Progress

7. **The joint coordination body, in combination with existing working groups, should establish a mechanism to (1) assure the preservation and maintenance of existing modeling and simulation codes for the analysis of space radiation effects on microelectronic and optoelectronic components and (2) support basic research for the development of new codes.**

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Remaining Gaps – Ideal Forward Work

- Do we have the "right" joint coordination body(ies)?
  - The SRHEC has gone a long way to basic address needs – purpose mismatch (?)
  - How can we include "new space"?
    - Make better use of the IEEE Aerospace Conference and Small Satellite Conference to engage and build partnerships, for example…
  - Are we (USG) utilizing the Joint Mission Assurance Council and/or Space Collaboration Council to maximum extent?
- Ramp up collaboration efforts with IEEE and probably the American Institute of Aeronautics and Astronautics as well
- Support additional consideration of stabilized funding for heavy ion and proton test facility access, as well as recurring and non-recurring maintenance and strategic upgrade costs – remains elusive
- Examine new approaches for M&S, as well as design of experiments, to yield more efficient use of existing test facilities – e.g., increase engineering knowledge per unit fluence