National Aeronautics and Space Administration

NASA EXPLORES

Technology Assurance for Space Systems in an Age of Rapid Diversification

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11 March 2021

This work was supported in part by the NASA Office of Safety and Mission Assurance

To be presented by J. Pellish at the 2021 European Space Components Conference (ESCCON) [virtual] on 11-Mar-2021.

Outline

- Increasing exploration & science mission throughput is forcing traditional assurance roles to evolve – also driven by acquisition policy changes
- Digital transformation of assurance processes is accelerating and will also affect the way we think about requirements & standards
- Cross-cutting needs like (heavy ion single-event effects) test facility capacity / capability and (parts & radiation assurance) workforce development require long-term focus

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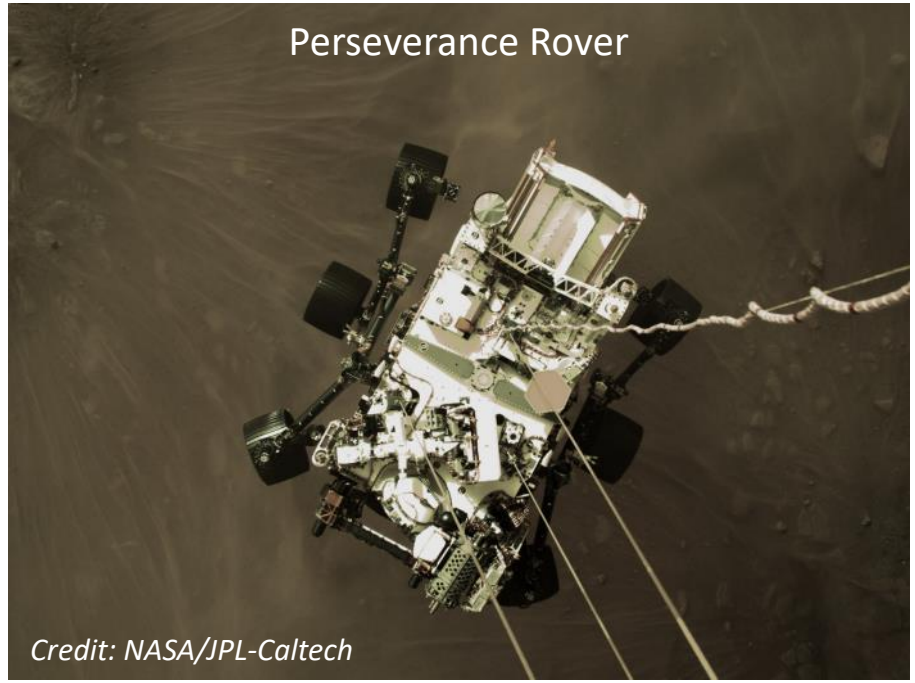
Assurance Role Evolution

Scenarios for Parts & Radiation Assurance

In-House / Internal	More Vertical Integration
Oversight	Control
Insight	Understanding methodology & processes
Collaboration	Knowledge transfer, direct support

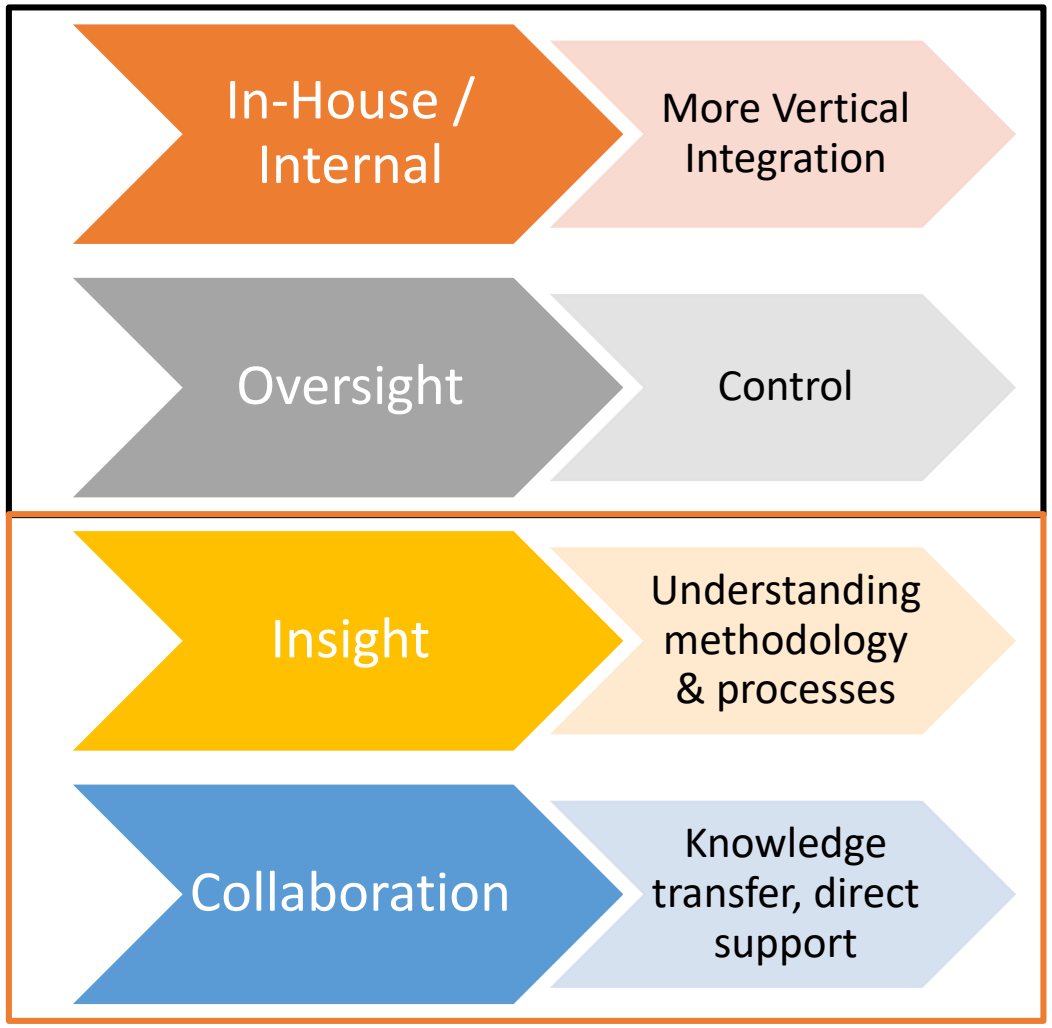
Traditional

Evolved



Assurance Role Evolution

Scenarios for Parts & Radiation Assurance



Traditional

Evolved

- Do we have the right requirements to flow down?
- How can we be sure that we understand our partners' methodologies & processes? Do they meet our requirements?
- Do we understand what our partners need & expect?
- Complexity and risk trades increase rapidly with the necessary infusion of advanced technologies

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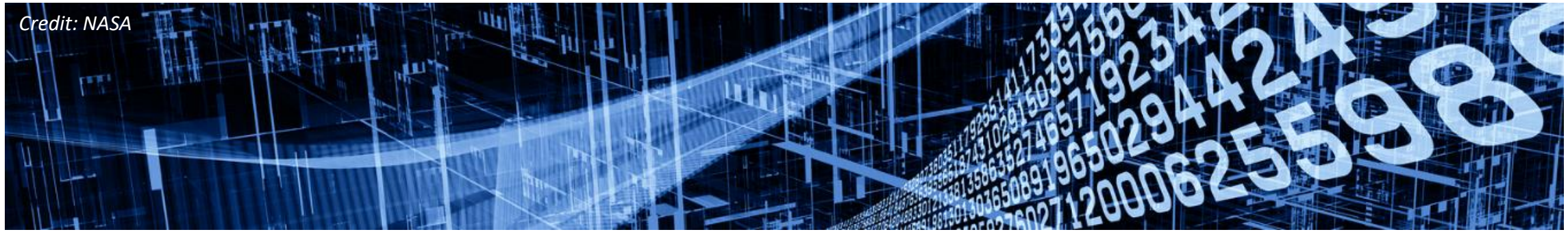
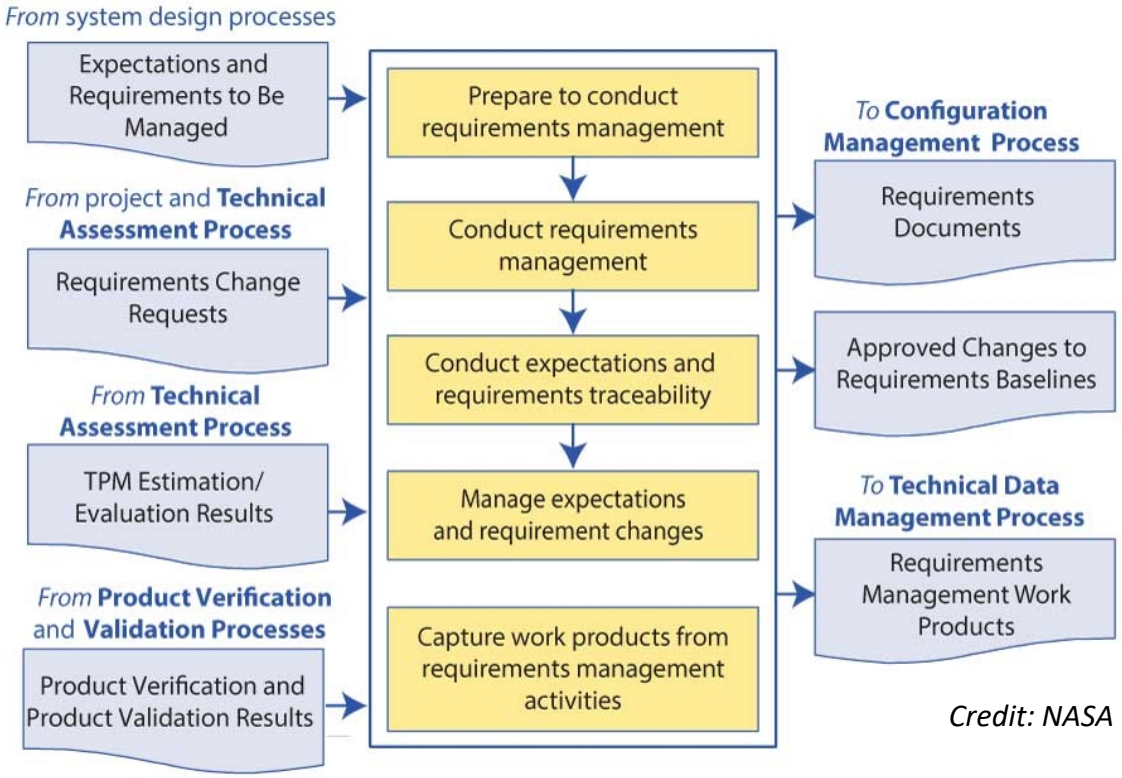
Digital Transformation of Technology Assurance



- Digitalization, the process of moving toward digital business, is occurring everywhere and remains an ongoing process for technology assurance
  - Digital transformation can lead to more informed decisions, increased operational efficiency, and streamlined processes
  - Increasingly important in age of diversification
- Model-based mission assurance (MBMA) and systems engineering (MBSE) are just two manifestations of digital transformation
  - Can also include things like digital twins (virtual representation in virtual space of a physical structure in real space and the information flow that keeps them synchronized)

Digital Transformation of Technology Assurance

- With increasing exploration & science mission throughput and rapid technology infusion, need to consider how we think about requirements and standards
- Digital transformation approaches can be used here too
- Systems for model-based requirements and standards can be more agile, efficient, understandable, and easier to maintain – *key may be self-consistent agility*



Credit: NASA

Example requirements management process

TPM = technical performance measure

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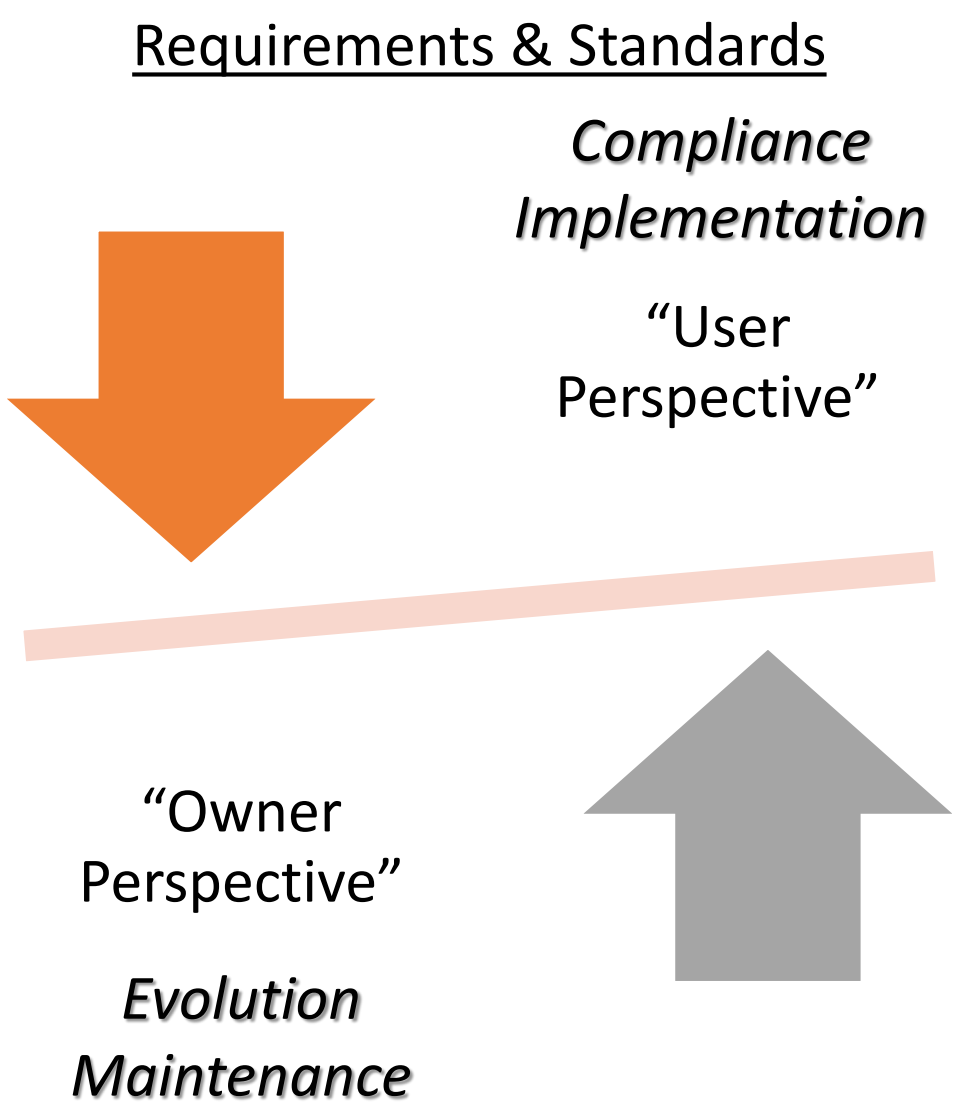
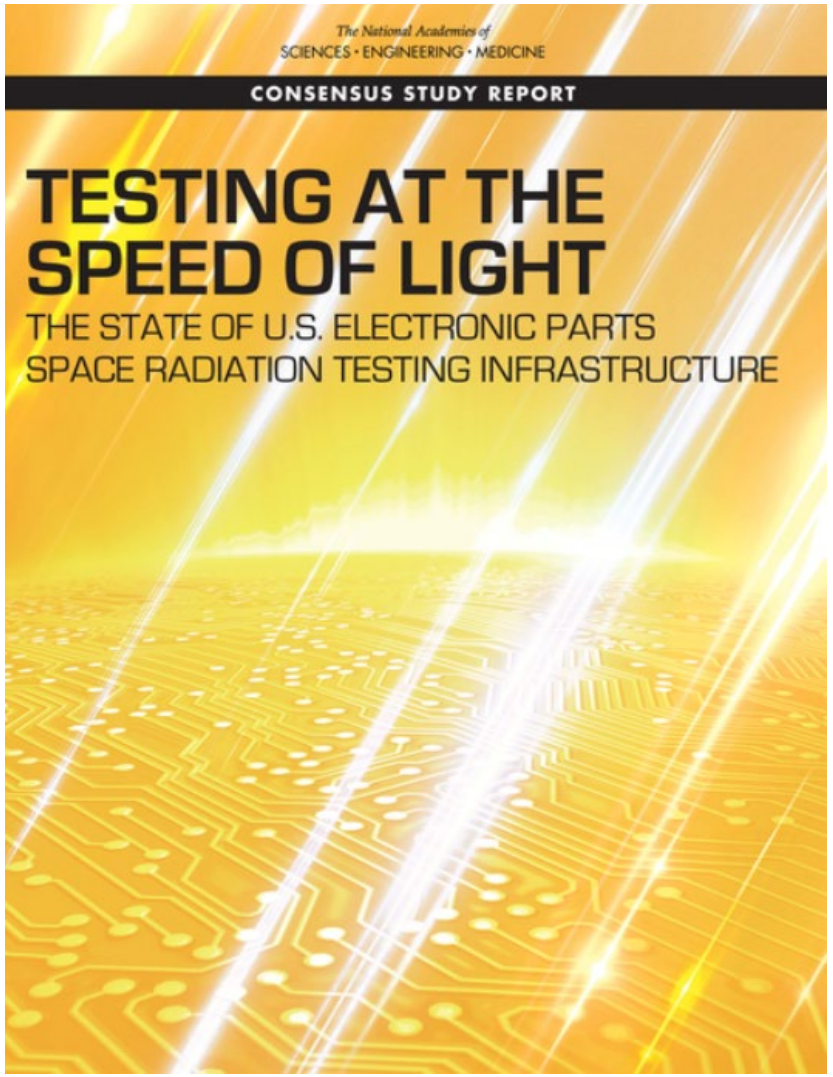


Test Facility Capacity and Capabilities

- Heavy ion single-event effects (SEE) test facility capacity and capability issues were documented in the 2010s – but impacts not immediately apparent
- Organizations recognized the need to take action – e.g., 2018 National Academies report, RADNEXT, etc.
- Consensus recommendations have taken time to implement, which has increased risk to facility users and their programs – exacerbated by COVID-19

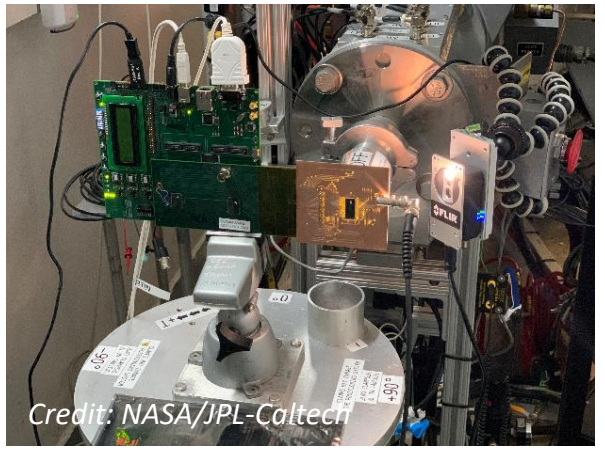


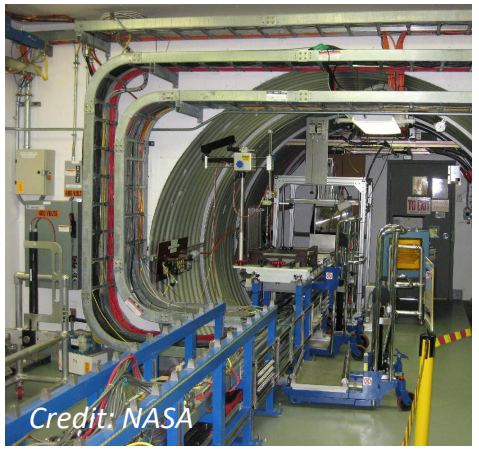
https://doi.org/10.17226/24993

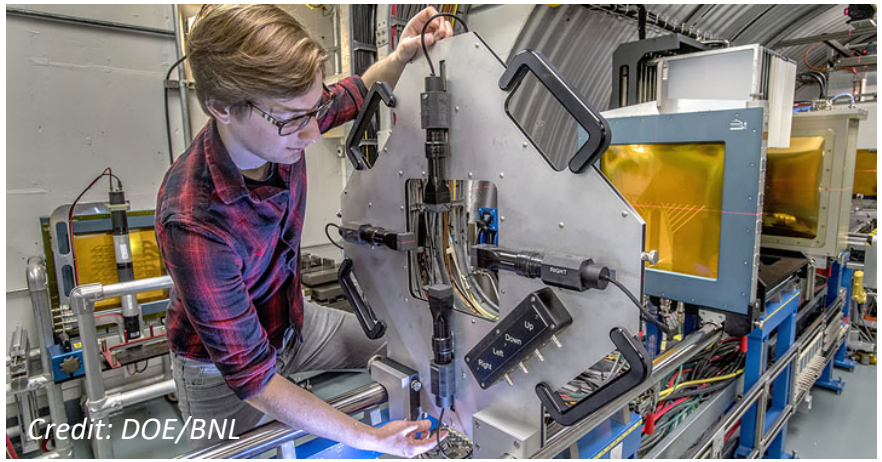
Test Facility Capacity and Capabilities

U.S.-based perspective – but appears to have broad consensus

- Existing heavy ion SEE test facilities cannot meet current or future demands
- Government and commercial space are driving significant increases in SEE testing demand
- Current heavy ion accelerators for SEE testing at Department of Energy laboratories and U.S. universities have limited capacity and capability
- More complex electronics and systems require more testing hours
- Advanced electronics and packaging require higher ion energies (e.g., >100 MeV/amu)


Credit: NASA/JPL-Caltech

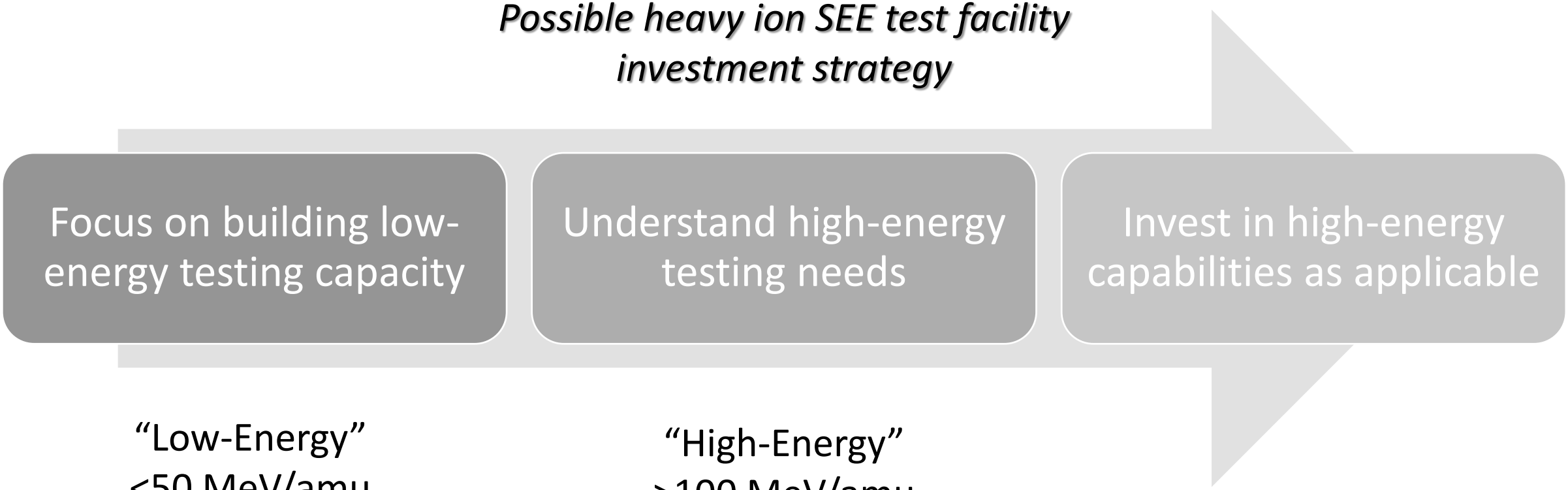

Credit: NASA


Credit: DOE/BNL

Summary points based on publicly-disclosed work conducted by the Strategic Radiation-Hardened Electronics Council

Test Facility Capacity and Capabilities

Possible heavy ion SEE test facility investment strategy

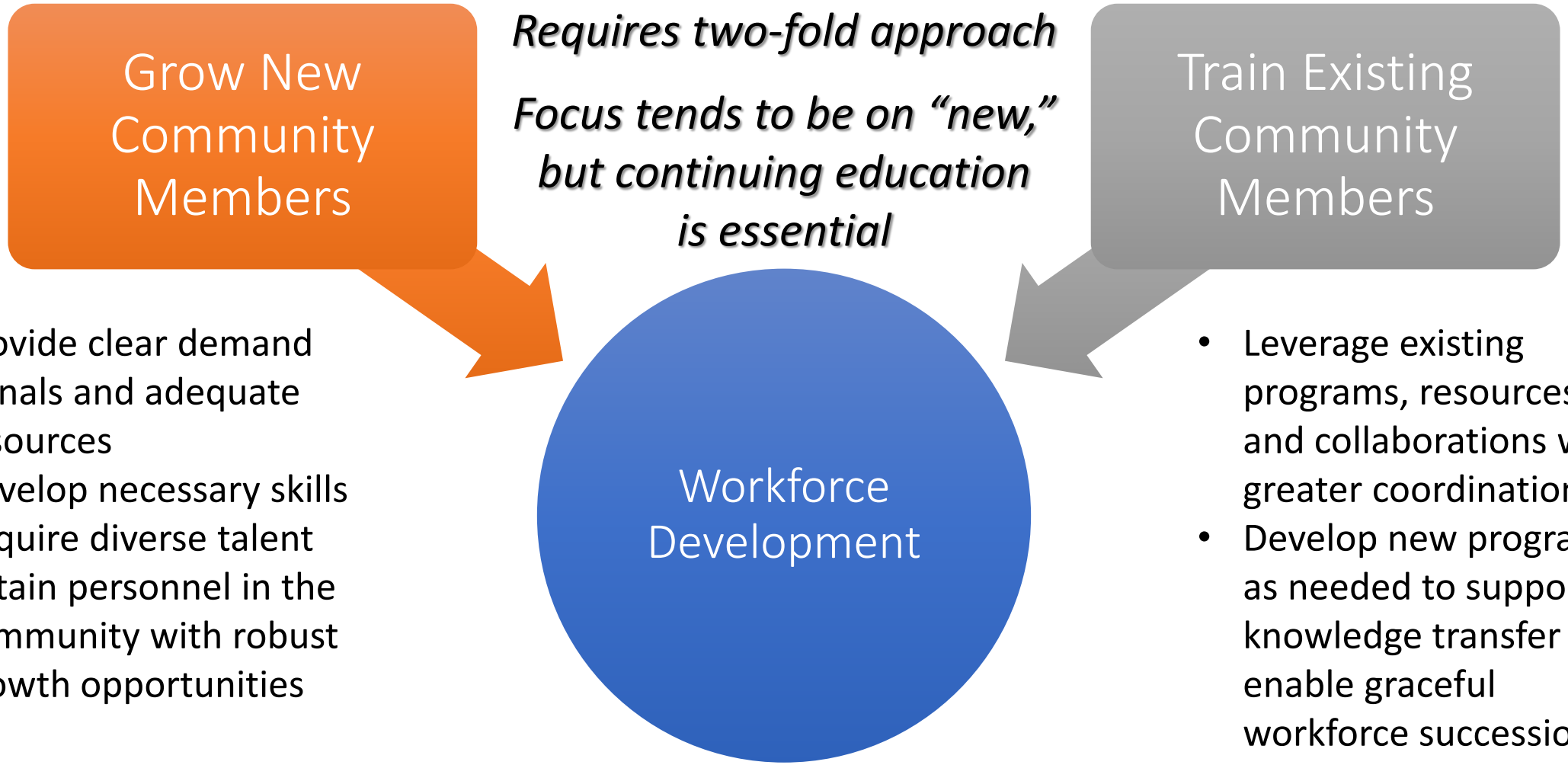


"Low-Energy"
<50 MeV/amu

"High-Energy"
>100 MeV/amu

- Being conducted in a delicate ecosystem – need to avoid unintended consequences
- Understanding future testing demands and needs is not trivial – users accustomed to parasitic operation and limited supply, which affects test planning & methodologies

Workforce Development



- Provide clear demand signals and adequate resources
- Develop necessary skills
- Acquire diverse talent
- Retain personnel in the community with robust growth opportunities

- Leverage existing programs, resources, and collaborations with greater coordination
- Develop new programs as needed to support knowledge transfer and enable graceful workforce succession

Develop sustainable workforce models with acceptable baseline capabilities – be practitioner-independent and maintain subject matter expertise

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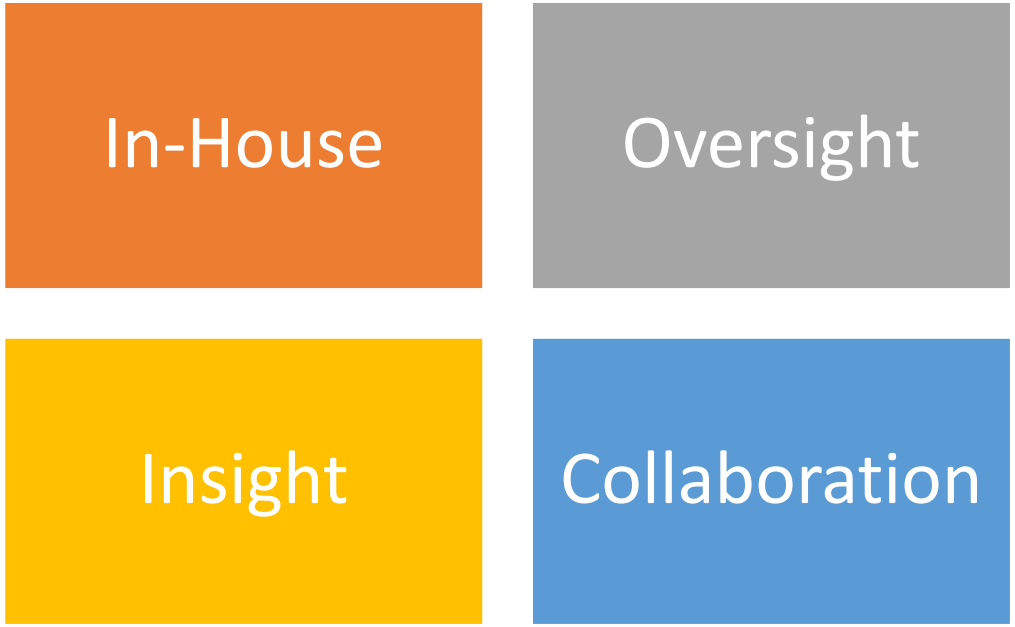
Workforce Development

Assurance Scenarios



- Workforce skill mix needs are not necessarily the same across assurance scenarios
  - In-house ≈ Collaboration (maybe…)
  - Oversight ≠ Insight
- Many workforce development efforts to-date have focused on radiation effects, radiation hardness assurance, etc. – rightly so…but…
  - Need to balance with electronics reliability and piece part commodity expertise
    - Can be harder to pursue / maintain, not as well-defined – early-career motivation?

Summary

- Mission throughput increase and diversification have had strong effects on technology assurance roles and responsibilities
  - Can impact workforce development requirements too
- Digital transformation of assurance practices as well as requirements and standards management will be increasingly important
- Heavy ion SEE test facility capacity and capability issues are likely to drive programmatic / technical risks for the next several years – at least until current investment plans *start* to mature (maybe mid-2020s…)
- Growing, training, and retaining qualified assurance professionals requires a combination of patience and foresight to ensure necessary skill mixes are developed and retained *within the community*

Acronyms

Abbreviation	Definition
amu	Atomic Mass Unit
BNL	Brookhaven National Laboratory
COVID-19	Coronavirus Disease 2019
DOE	Department of Energy
ESCCON	European Space Components Conference
eV	Electron volt
JPL	Jet Propulsion Laboratory
MBMA	Model-Based Mission Assurance
MBSE	Model-Based Systems Engineering
NASA	National Aeronautics and Space Administration
SEE	Single-Event Effects
TPM	Technical Performance Measure
U.S.	United States (of America)