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Nuclear Proliferation and Arms Control Monitoring, Detection, and Verification: A National Security Priority

Interim Report

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FY2020 NDAA required independent review of U.S. capabilities for monitoring, detection, and verification (MDV) of nuclear weapons and fissile material.

Assess and evaluate:

- the current national MDV research enterprise, and
- the integration of the roles, responsibilities, and planning for the MDV mission in the USG.

Identify opportunities:

- to leverage the national research enterprise,
- for international engagement,
- for new/expanded R&D efforts,
- for improved interagency and external coordination, and
- for leveraging commercial capabilities.

- Due to COVID constraints, the study was divided into two phases, the first virtual and the second in-person.
- This interim report is the result of the first phase.

Definitions

Monitoring: Collection of relevant signatures and/or information.

Detection: Analysis of information that establishes the probability and location of activity of concern.

Verification: Assessment of compliance to a treaty, declaration, or other obligation.

MDV Mission: Monitoring, detection, and verification of nuclear weapons and fissile materials to meet national security goals.

MDV Enterprise: The set of federal departments and agencies that collectively carry out the MDV mission.

Interim Report Key Takeaways

1. Technological advances provide unprecedented opportunities for staying ahead of complex and expanding MDV challenges.
2. The MDV mission should be a higher national security priority with an interagency coordination process that includes development of a shared long-term vision, assessment of needs, and regular evaluation of progress.
3. Research and development organizations should prioritize:
   - Developing capabilities for emerging/non-traditional MDV challenges
   - Stewarding and further developing capabilities for more traditional MDV challenges
   - Developing integrated processes to collect and leverage all available data
4. Emerging and future challenges will require new MDV tools and capabilities. R&D on these hard issues should begin well before planned operation and be sustained through deployment.

Monitoring, **detection**, and **verification** (MDV) demands are expanding.

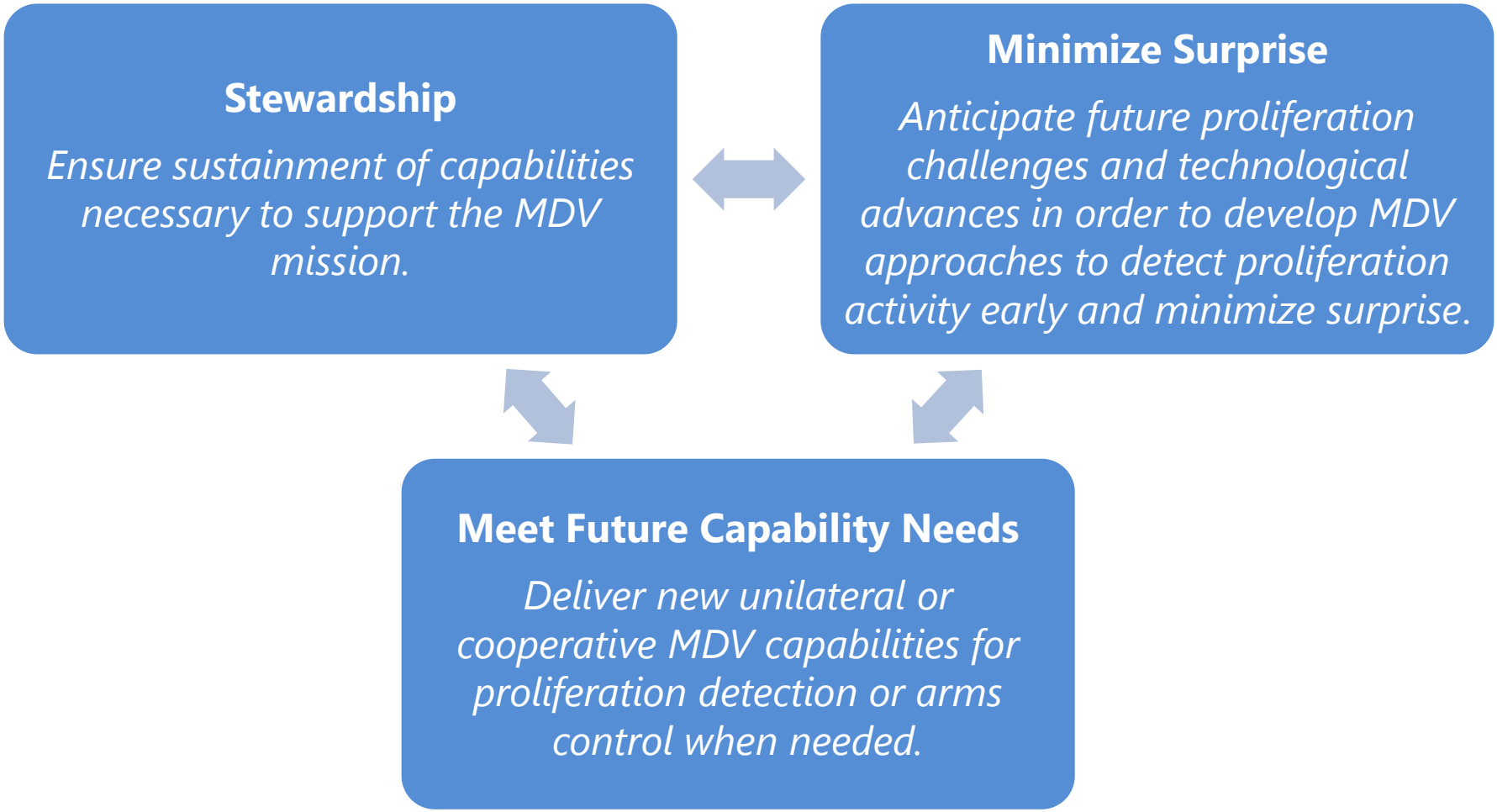
Proliferation

- Increasing nuclear energy deployment, including pursuit of enrichment and reprocessing technologies.
- Emerging special nuclear material production technologies have unknown signatures and may be harder to detect.
- Cross-border illicit networks call for more global detection approaches.

Arms Control

- Nuclear weapons development may no longer require nuclear testing.
- Nuclear weapons states are modernizing weapons and delivery systems.
- Non-strategic and/or non-deployed weapons are of increasing concern.

MDV should be a national security priority with three key functions.



Report Organization

Interim report includes 17 findings and 16 recommendations

- [Rec X] Throughout the presentation, report recommendations are highlighted with red bullet points and a references to the recommendation number.

Part 1: Governance of the MDV Enterprise

- Policy, Operations, and RDT&E Integration
- Stewardship of MDV Capabilities
- Increasing RDT&E Efficacy and Innovation

Part 2: Technical MDV Capabilities and R&D

- Nuclear Fuel Cycle MDV
- Nuclear Test Explosions MDV
- Arms Control MDV
- Leveraging Data
  - Open-Source Assets and Data
  - Data Analytics

Part 1: Governance of the MDV Enterprise

- Responsibility for the MDV mission is spread across USG departments (DOE, DoD, DoS, DHS, IC), the NSC and OSTP, and international organizations (IAEA and CTBTO).
- This distributed nature demands high level of coordination.

Policy and Coordination (Decision Making)

- National Security Council
- Office of Science and Technology Policy
- Office of the Director of National Intelligence – NCPC
- Department of State – AVC, ISN
- Department of Defense – OSD, JCS
- National Nuclear Security Administration – NPAC

Operations (Collections and Analysis)

- Intelligence Community
- Department of Defense – DTRA, AFTAC
- Department of Homeland Security – CWMD
- International Atomic Energy Agency
- Comprehensive Nuclear-Test-Ban Treaty Organization
- National Nuclear Security Administration – NPAC
- Department of State – AVC, ISN

Research, Development, Test and Evaluation (Capability Development)

- **National Nuclear Security Administration – DNN R&D, NPAC**
- Department of Defense – DTRA, AFTAC, AFRL
- Department of Homeland Security – CWMD
- Department of State – AVC, ISN
- Intelligence Community – NCPC

Establish MDV Interagency Coordination

- [Rec 1] Due to distributed nature of the MDV mission, the NSC should ensure that there is an enduring interagency coordination process and produce a strategic plan with regular periodicity.

Interagency Planning Process

- Evaluates current and future proliferation and arms control challenges
- Assesses the adequacy of current organization and capabilities to address these challenges
- Develops strategic guidance for R&D planning, and advocates for funding

- [Rec 1] The NSC should establish an external advisory board to provide independent advice to the enterprise, including a long-range vision and assessment of current capabilities and gaps.

Enhance the Stewardship of MDV Capabilities

Stewardship of Capabilities & Infrastructure

NNSA DNN Nonproliferation Stewardship Program
est. FY2020

MDV Test Beds
est. 2009 –

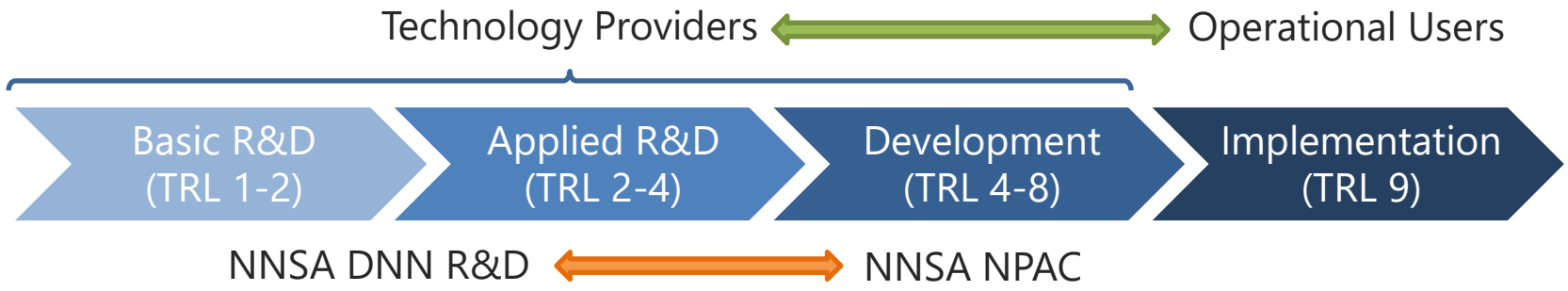
- Important progress on stewarding MDV capabilities has been made
- ❖ [Rec 2] Both programs should be sustained and expanded where appropriate
- ❖ [Rec 2] Test beds should:
  - Assess expanding access to academic, commercial, and international partners
  - Learn best practices from other user facilities

Stewardship of Expertise

NNSA DNN R&D University Consortia
est. 2011

- New cadre of experts for MDV enterprise
- ❖ [Rec 3] Increasingly addressing future needs in fields such as the data sciences
- ❖ [Rec 3] Consortia should incorporate benchmarks similar to other university consortia programs

Strengthen Sustainable Innovation and Technology Transition



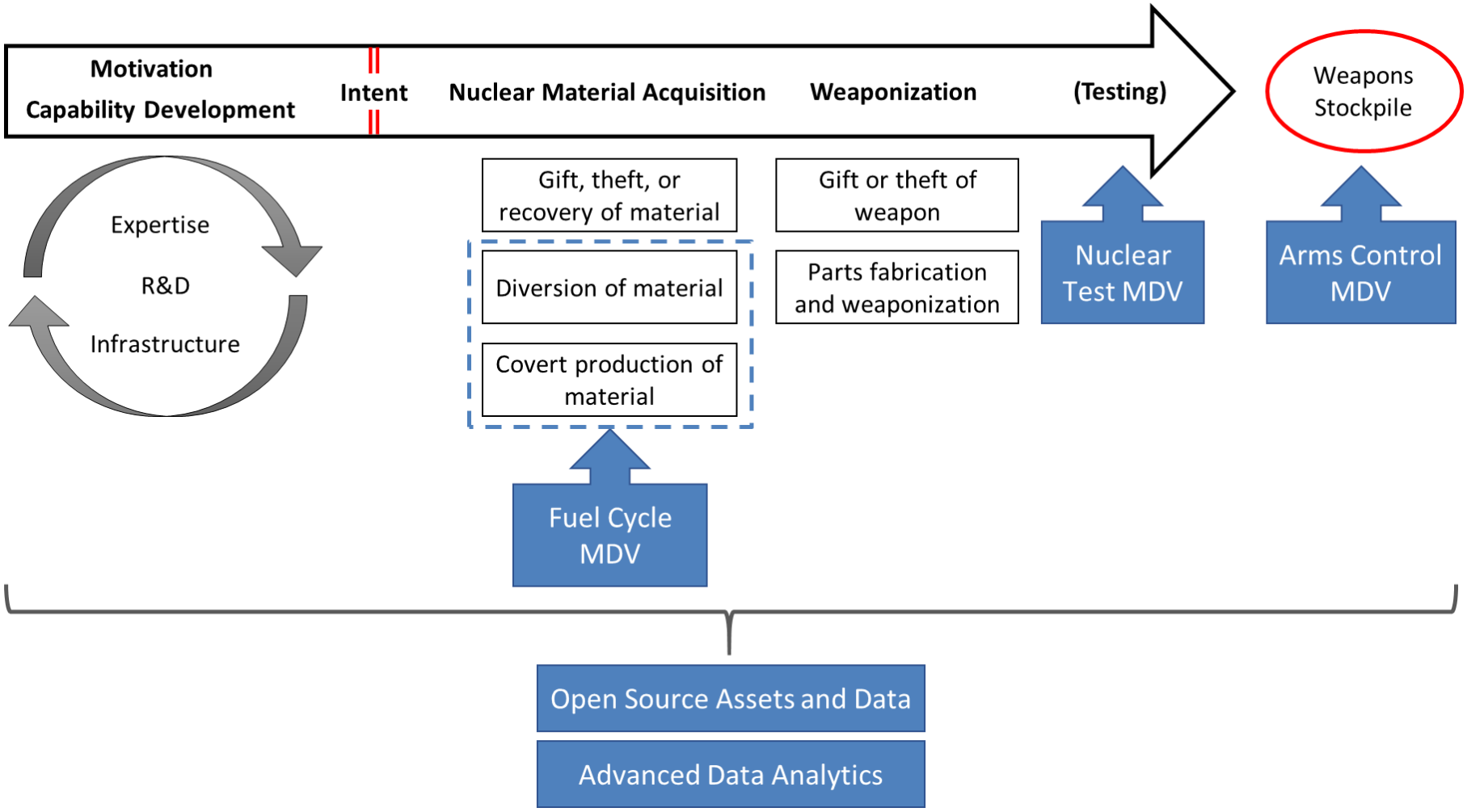
Attention to all elements and all transitions in the technology pipeline:

- [Rec 5,6] Increase the innovation pipeline:
  - *Academia*: agile university consortia
  - *Nat'l labs*: expanded Innovation Portfolio
  - *Industry*: technology scouting, incorporation

- [Rec 4] Strengthen and institutionalize the technology transition process between NNSA DNN R&D and NNSA NPAC.

- [Rec 4] Increase operational user involvement in requirements as technology matures.

Part 2: MDV Capabilities

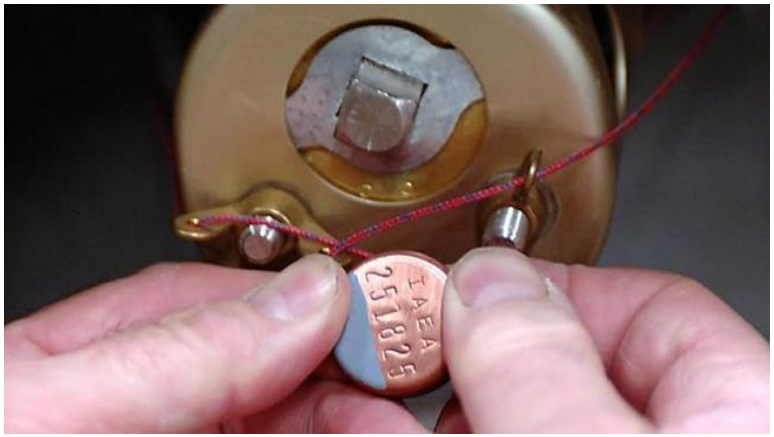


Fuel Cycle MDV: Declared Facilities

- MDV capabilities for the nuclear fuel cycle must evolve to keep pace with emerging technologies and the growing amount of global nuclear activity

❖ [Rec 7] NNSA should prioritize R&D efforts that:

  - Enhance efficiency, ease of use, and sustainability of safeguards tools and technologies (e.g. unattended monitoring, effective & inexpensive tags and seals)
  - Address MDV for emerging/non-traditional technologies
  - Enhance capabilities to monitor and detect early capability development



Images sources: IAEA

Fuel Cycle MDV: Undeclared Activities

Images sources: Wikipedia, USGS

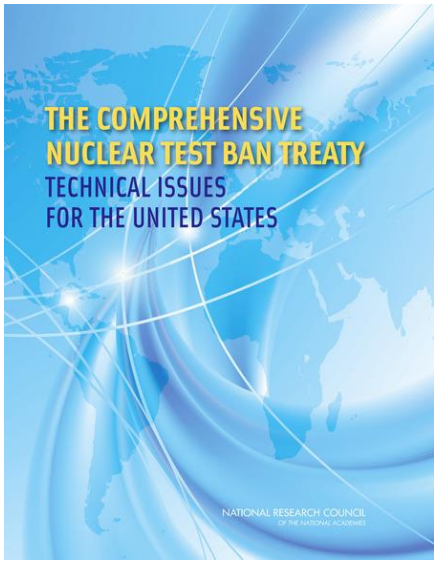
- Local and wide-area environmental sampling are key tools for monitoring and detecting nuclear activity.
- ❖ [Rec 8] R&D support (from DNN R&D and interagency partners) is necessary to improve sampling and analysis capabilities:
  - Understanding source term mechanisms, environmental fate, and atmospheric/aquatic transport of proliferation effluents
  - Developing integrated analytic processes to analyze results from multiple sampling locations as a network
- New cross-cutting MDV technologies, such as advanced data analytics, may improve early detection of undeclared facilities
- ❖ [Rec 9] These R&D efforts are also relevant to nuclear test explosion MDV

Nuclear Test Explosions MDV

- Capabilities for global detection of nuclear explosions have improved since the 2012 NASEM CTBT report.

❖ [Rec 10] NNSA and DoD should expand support for R&D to improve nuclear explosion detection sensitivity and confidence, as well as yield estimate accuracy.

  – Uncalibrated test sites and low-yield tests
  – Fusion of radionuclide and seismological data



❖ [Rec 11] The U.S. should continue to support improvement of CTBTO's International Monitoring System (IMS) because a fully functioning IMS is beneficial to the U.S.

Images sources: NASEM, CTBTO

Arms Control MDV

- Future arms control agreements may rely on warhead identifiers or tags, advanced seals, and possibly new warhead confirmation techniques.

❖ [Rec 12] To ensure that these capabilities are mature enough for implementation NNSA's arms control MDV portfolio should be a sustained, core element of its program.

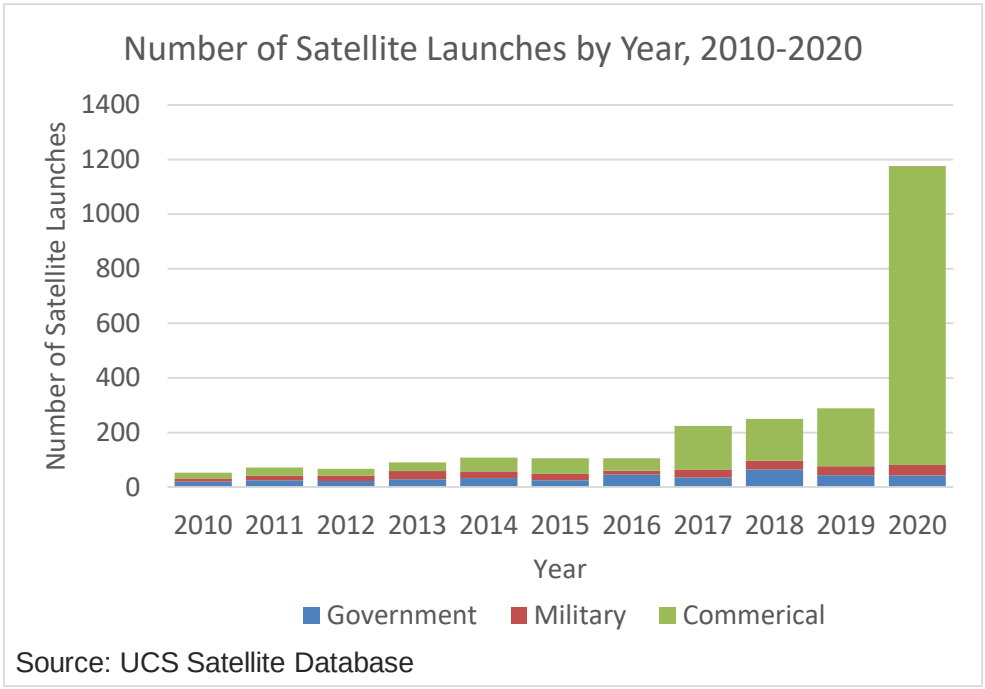
❖ [Rec 12] NNSA should develop a test bed for warhead verification and consider access to universities and international participants.

❖ [Rec 13] The U.S. should establish and encourage bilateral and multilateral international engagements to develop MDV techniques.

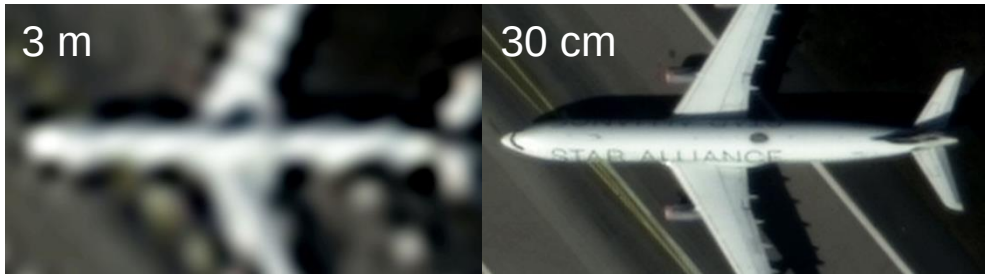
❖ [Rec 12] NNSA, with DTRA and others, should plan to address future MDV challenges such as the discrimination of dual-capable missiles.

Image source: DOE

Open-Source Assets and Data



Source: UCS Satellite Database



Images source: Maxar

- The amount of commercial remote sensing data is rapidly expanding
- Advances in spatial, temporal, and spectral resolution allow additional applications to the MDV mission

❖ [Rec 14] The MDV enterprise should:

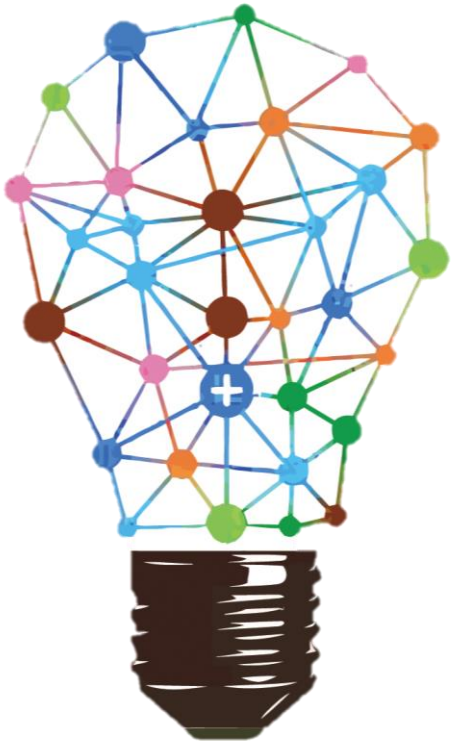
  - Monitor open-source capabilities
  - Look for opportunities to use open-source data
  - Explore techniques such as advanced data analytics to more fully leverage open-source data

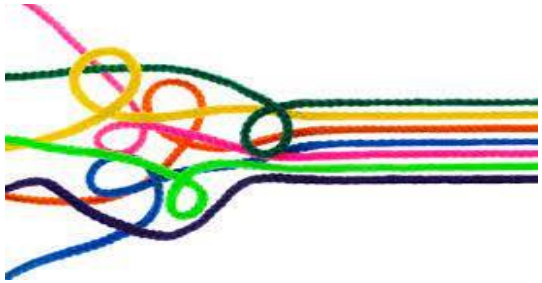
Advanced Data Analytics

- Advanced data analytic capabilities may help detect signs of proliferation earlier and should be an MDV R&D priority.
  - Sparse data sets, physics-based modeling, classified and unclassified merger
  - ❖ [Rec 15] R&D may be beyond the typical 3-year time frame
- Data availability, both labeled and unlabeled, will be the limiting factor.

❖ [Rec 16] The NSC should orchestrate an interagency program (recommend NNSA as lead agency) to build MDV-relevant data pipelines. The effort should involve:

- Multi-point data collection and curation
- Open-source data
- International partners





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