Characterization of new threats and the application of explosive simulants

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When the adversary adapts, how do we respond?

Need to reduce the time from identification to deployment

- Mission: Rapid adaptation of fielded equipment to detect evolving materials of interest

- Challenges: Field response before adversary can act
  - *Material identification: which materials are adversaries are likely to use*
  - *Extent of testing: which formulations, synthesis methods, and preparations need to be prepared and tested*
  - *Material characterization: determine x-ray features, explosive properties*

- There are no simple, perfect solutions, but there are approaches that could provide more rapid risk mitigation
  - *Adaptive ATR algorithms: supplement certified algorithms*
  - *Application of simulations: reduce time to data collection on vendor systems*
  - *Requires a new testing and certification paradigm, aspects of which are already in development*

Path to deployment is complicated, begins with identification

Threat Identification

Modeling

Down Select

Safety/Synthesis

Formulation and preparation of material(s)

Data Acquisition for each material

Data Analysis

Material or aggregate ROR

TSA Acceptance and inclusion in Detection Standards

Vendor Algorithm Development

CRT/CERT and Deployment to fleet

1. Intelligence reports adversary interest in material
2. TSA evaluates impact on detection

- Subsequent steps may vary depending upon what is known about the threat
  - Previously known or new application
  - Form: e.g., press, cast
  - Density range
  - May be specific configuration (density, packaging, etc.) or broad in scope

Assess what needs to be tested

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3. Evaluate which formulations, synthesis, and preparations are of interest

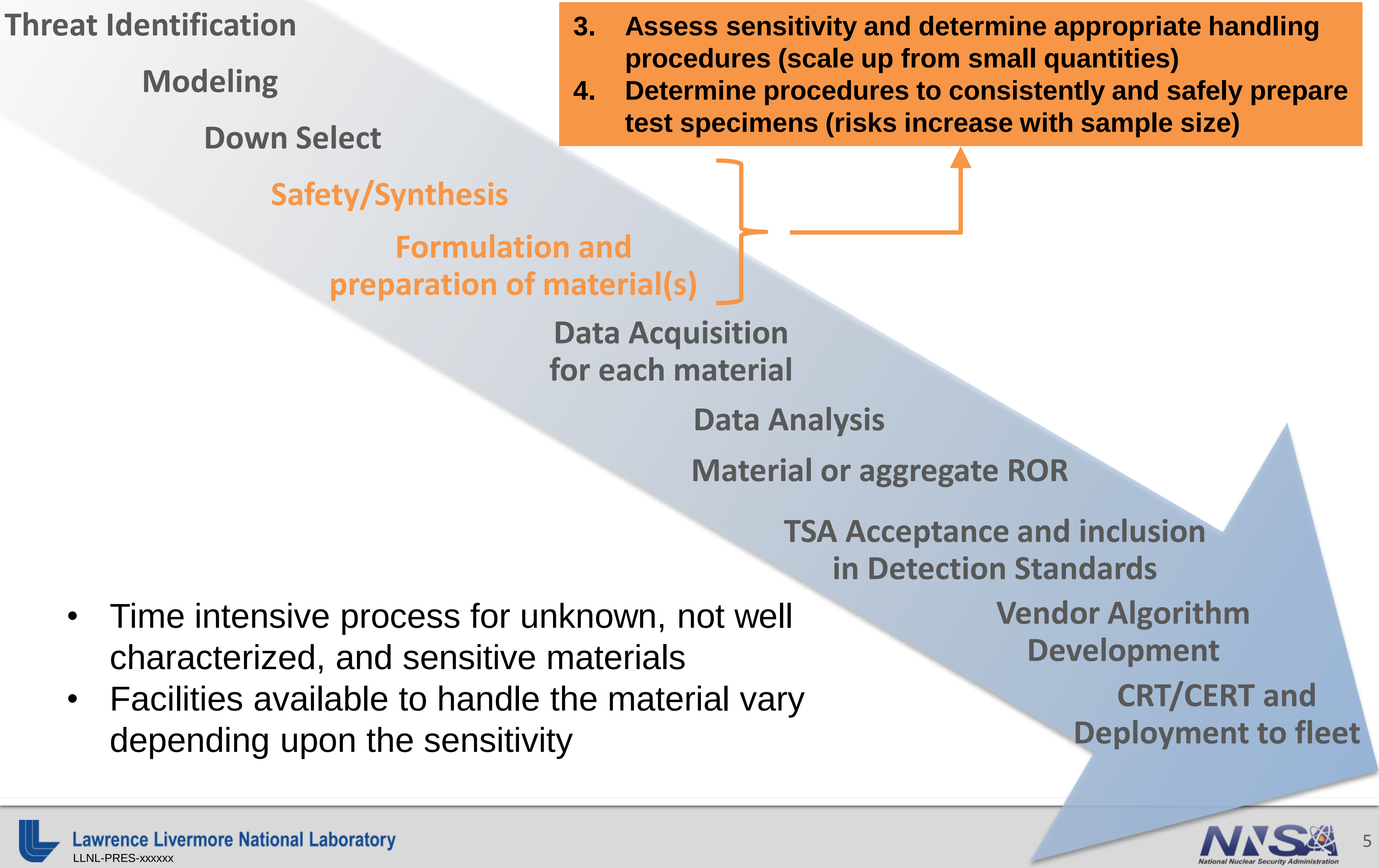
4. Determine which combinations bound the features of interest

- Theoretical x-ray feature estimates based upon chemical composition (e.g., ZeCalc)
- Density variations according to preparation method (e.g., poured, tapped, tamped, pressed, melt cast)
- Different mixtures of fuel(s) and oxidizer

Determine how to safely handle the material:

Contact or remote operations

3. **Assess sensitivity and determine appropriate handling procedures (scale up from small quantities)**
4. **Determine procedures to consistently and safely prepare test specimens (risks increase with sample size)**



- Time intensive process for unknown, not well characterized, and sensitive materials
- Facilities available to handle the material vary depending upon the sensitivity

Specify what needs to be detected

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Specify x-ray features

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5. **Acquire x-ray data on laboratory (MicroCT) and deployed explosive detection systems for multiple specimens from different batches**
6. **Analyze data for variations, proximity to other materials of interest in x-ray feature space**
7. **Specify the expected range in the material's x-ray features**

- Relatively quick process once specimens are available
- Scans on vendor systems may require larger specimens than laboratory systems
- Process may end if existing algorithms detect the new material

Requirements formalized and equipment deployed

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8. **TSA sets detection standards**
9. **Vendors adapt algorithms to include new material**
10. **Algorithms are tested (DT&E) and certified (IT&E)**
11. **Capability is deployed to the field**

- Typically, a time intensive process
- Significant expense to vendors and government
- Algorithm alterations may increase P_{FA}
    - Limited margins between P_D and P_{FA}

Spiral 1: Initial detection capability based upon theoretical features from chemical composition

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- **Limited but rapid detection capability**
- **Requires Adaptive ATRs, ability to push modifications to the field**
- **May have a significant impact on P_{FA}**
  - **How much increase is tolerable and for how long?**

- Can the impact on P_D and P_{FA} be estimated prior to inserting modified algorithms into the field?
- Standardized third-party software interface to push one modified algorithm?

Spiral 2: Use non-validated simulants for sensitive and poorly characterized materials

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- **Bypasses time required to determine safe handling procedures**
- **Mean properties from theoretical estimates, but feature distributions may lack similarity**

- DHS currently developing simulant validation procedures and metrics
    - Purpose specific
- Requires a quick process for determining a simulant formulation to be useful
- Vendors could safely collect data on their systems
- Risk associated with using non-validated simulants

Spiral 3: Use validated simulants once material's features have been measured

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- **Validated formulation could be based upon small specimens and data acquired on laboratory systems**
- **Vendors could use the simulant to collect data for larger samples on their system**

- Potentially less risk, depending upon how stringent the simulant validation criteria are
- Reduced risk with respect to producing and handling sensitive materials
- Potentially utilized in certification