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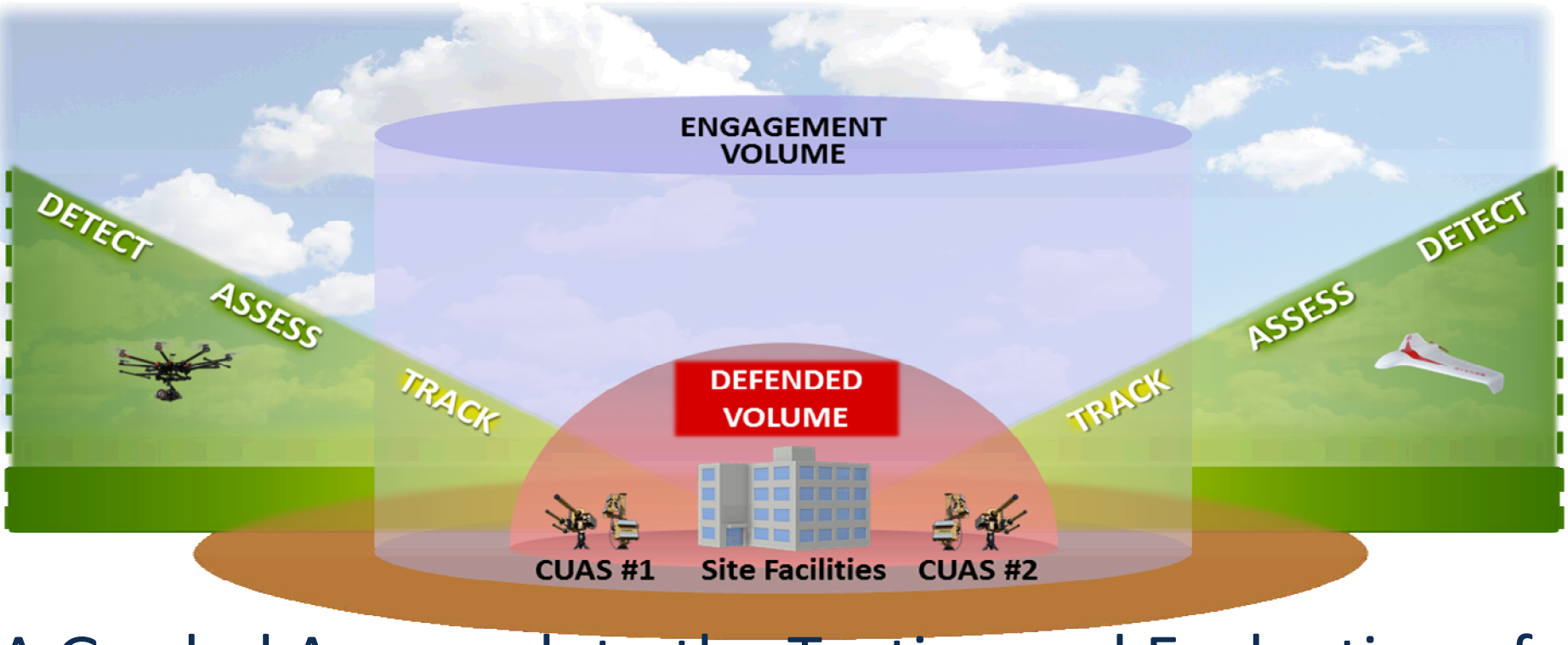

A Graded Approach to the Testing and Evaluation of Counter Unmanned Aerial Systems

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U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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Introduction

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- The potential for using an unmanned aerial system (UAS) as a delivery platform for malicious intent is a security concern.
- As a result, the commercial sector has started to market detection, assessment, and neutralization systems to counter the UAS concern.
- It is important to establish a credible CUAS T&E program such that it provides:
  - Comparative Results
  - Repeatable Results
  - Quantifiable Results
  - Scalability
  - Flexability
- Reason for this proposed graded approach is to establish a credible, consistent, and comparable T&E methodology that can be leveraged by industry, academia, and government agencies

Objectives

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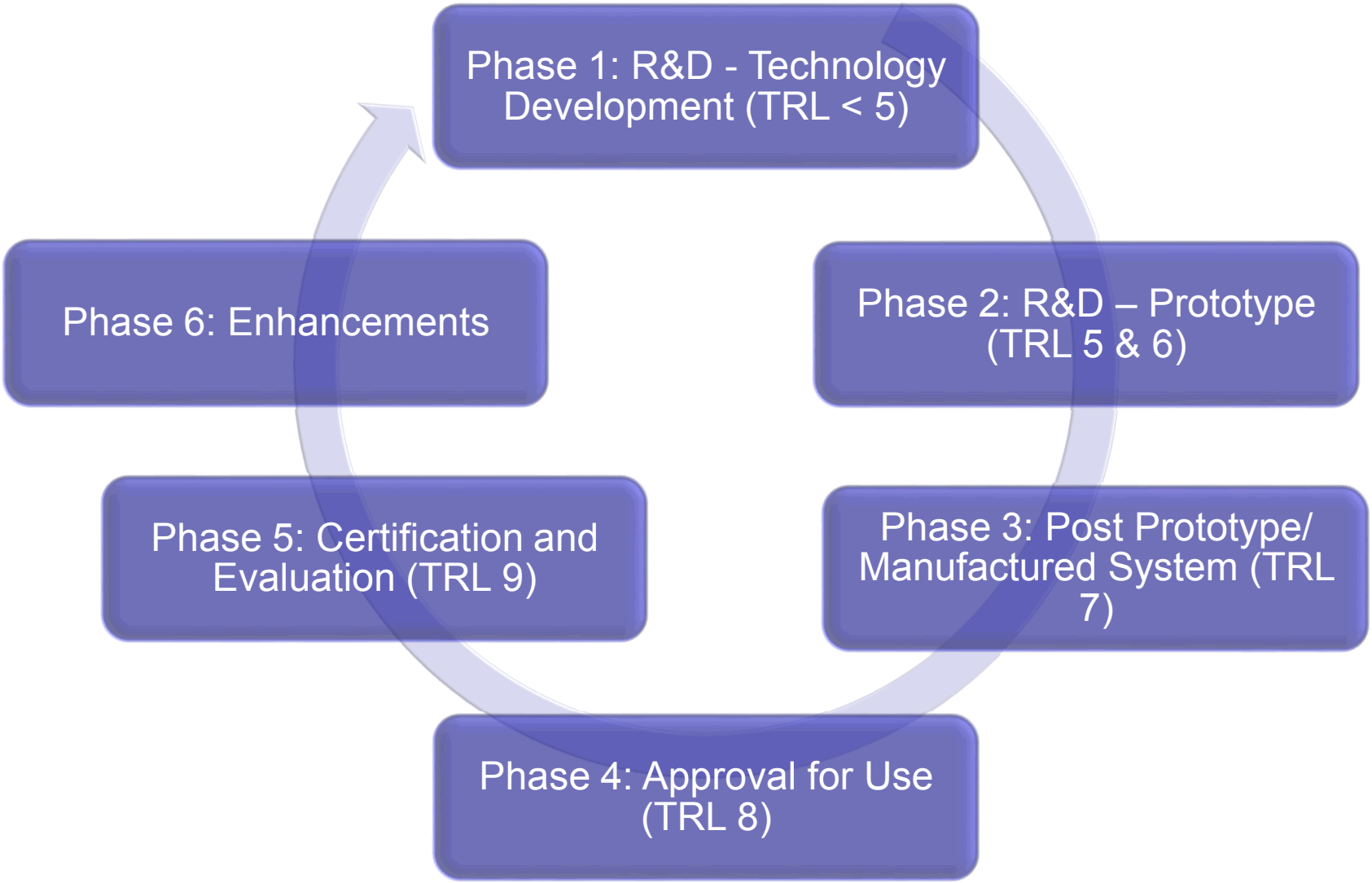
Evaluate the performance characteristics of COTS Counter-Unmanned Aerial Systems (CUAS) in order to inform executive decisions for acquisition, deployment, and operations:

- Establish a test methodology dedicated at providing credible, consistent, and comparable testing
- Identify capability gaps that require further technology development to meet the security needs for critical infrastructure.
- Establish a dedicated test site and test methodology for repeatable quantitative testing and allow other agencies to leverage their technology needs in a collaborative manner.

Lifecycle of Product



Phase 1: R&D - Technology Development (TRL < 5)

- Developmental and Validation T&E
  - Pass/Fail testing on individual subcomponents that validate system requirements
  - Proof of concept validation
  - The CUAS developer is responsible for this level of testing
- Elements may be done by Academia and/or National Laboratories
  - Far leaning Low TRL
  - Aide commercial industry
  - Higher risk/multiple year effort
  - National level resources capabilities, modeling, and expertise
- Industry is developing CUAS technologies that address the current threat. There are elements that are being performed by academia and/or national laboratories that are addressing higher risk, far reaching research that address emerging threats as well as future threats.

Phase 2: R&D – Prototype (TRL 5 & 6)

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- When the CUAS developer has created the R&D prototype T&E will be required in the following categories prior to commercialization:
  - Component
  - Integration
  - Modification
  - System
- There are options for third party testing to further R&D needs and investments, which typically include:
  - Demonstrations
  - Challenges
- This is usually the first “real” demonstration of the device outside of internal developer testing. It represents a big step forward, however, may still be composed of elements that are not optimally organized.

Phase 3: Manufactured System (TRL 7)

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- Once a CUAS developer has completed the T&E prototype phase, the system is now considered a manufactured system and therefore, third party validation testing is required.
- Third party validation T&E
  - Functional
  - Compatibility
  - Component Level
  - Burn-in
  - Performance
  - Environmental (optional)
- It is important that third party validation be performed for the entity utilizing the CUAS technology in order to make a risk based decision.

Phase 4: Approval for Use

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- The pre-requisite for this phase is third party validation T&E in phase 3:
  - Component Level
  - Functional
  - Burn-in
  - Performance
  - Compatibility
- The additional T&E that may be performed in this phase include:
  - Degradation
  - Vulnerability
  - Blackhatting
- Performing the T&E in this phase is important to reduce the risk of deployment, as well as, re-evaluation of significant enhancements prior to deployment

Phase 5: Certification and Evaluation

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- Certification and Evaluation is the penultimate phase and consists of:
  - 100% T&E (level dependent)
  - 72 hour operational test
  - 30 day burn in Evaluation
  - Certification
- Certification and Evaluation is important in order to try to detect any premature failures and latent defects in the equipment as well as assessing the adequacy of logistics support
- Re-evaluation of significant enhancements should also occur in this phase prior to those upgrades being deployed

Phase 6: Enhancements

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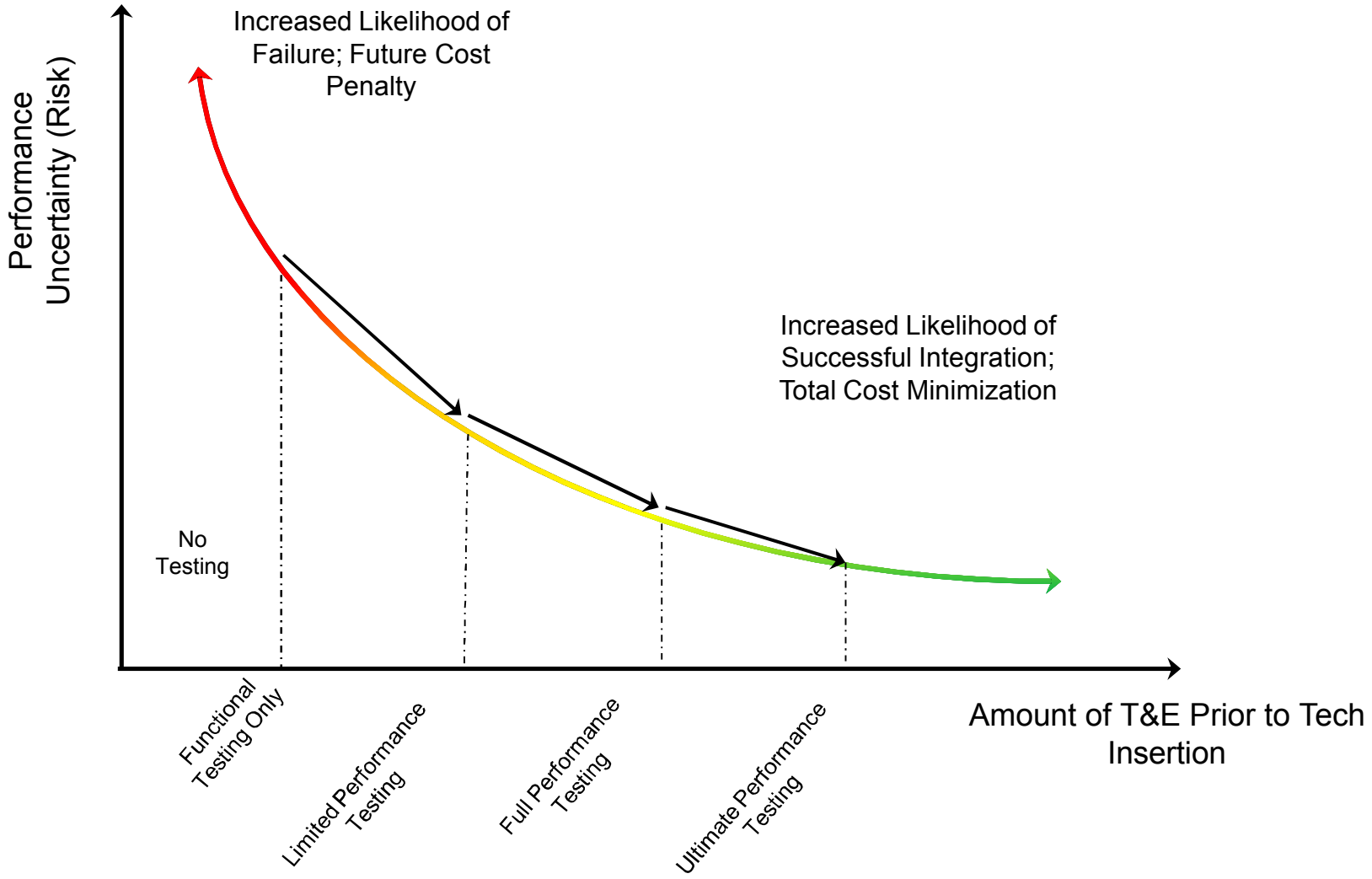
- After the certification and evaluation is completed, the threat will continue to change and new technologies will emerge, which will require enhancements to the existing CUAS technology.
- As these enhancements are introduced, the cycle continues in order to mature, evaluate, and certify those enhancements for deployment. The importance of this phase is to state that once any enhancements are installed on an existing technology, T&E and certification and evaluation is required to reoccur to accept the same risk or lower than before.

Graded Approach to T&E

- Level 1 – Functional T&E
- Level 2 – Compatibility T&E
- Level 3 – Demo and Challenges
- Level 4 – Baseline Performance T&E
- Level 5 – Limited Performance T&E
- Level 6 – Full Performance T&E
- Level 7 – Enhanced Performance T&E
- Level 8 – Penultimate T&E
- Level 9 – Ultimate T&E

* Certification and Evaluation

Risk Acceptance vs Testing and Evaluation



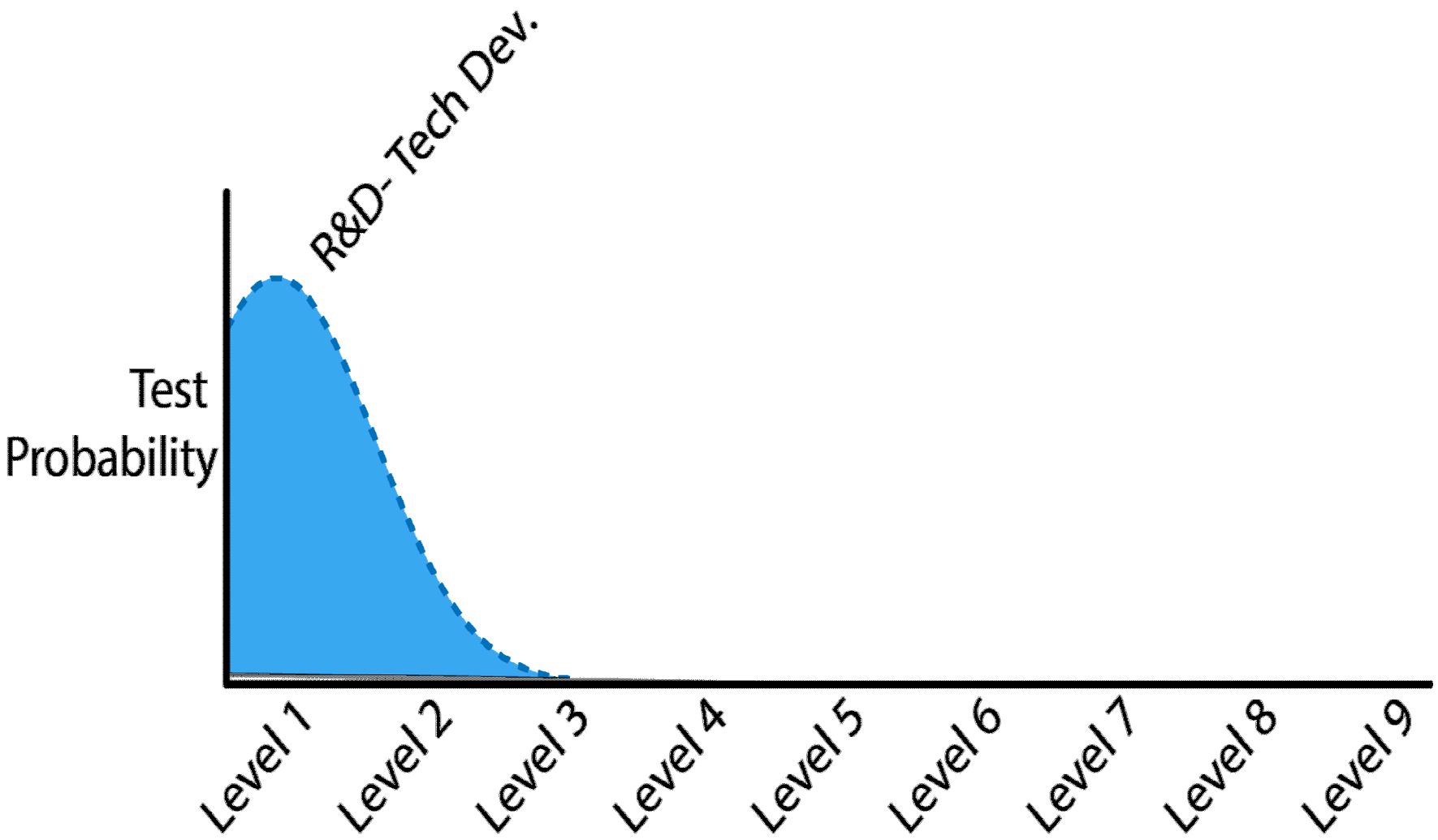
Level 1 – Functional Testing

- Pass/Fail on Functional Requirements
- Scenario Basis Testing
- Modeling and Simulation Testing
- Analogous to bench level testing
- This level of testing will validate the specific scenarios that the CUAS is effective and basic functions
- If this is the only level of testing that is performed prior to deployment, the CUAS owner is accepting a TON of risks
  - Performance of CUAS remains unknown
  - Vulnerabilities of CUAS remains unknown
  - Degradation factors of CUAS remains unknown
  - CUAS nuisance alarm rates and false alarm rates remains unknown
  - Compatibility of CUAS on deployed site remains unknown
  - Etc.

Level 2 - Compatibility

- Temporary limited deployment in a controlled environment to identify impacts to normal operations
  - Local environment impact on CUAS
  - Impact of CUAS on local environment
- Challenges of potential uses and certifications and approvals
  - GPS neutralization
- If this is the only level of testing that is performed prior to deployment, the CUAS owner is accepting a significant amount of risks
  - Performance of CUAS remains unknown
  - Vulnerabilities of CUAS remains unknown
  - Degradation factors of CUAS remains unknown
  - CUAS nuisance alarm rates and false alarm rates remains unknown
  - Etc.

T&E Level versus Deployment Maturity



Level 3 – Demonstrations and Challenges

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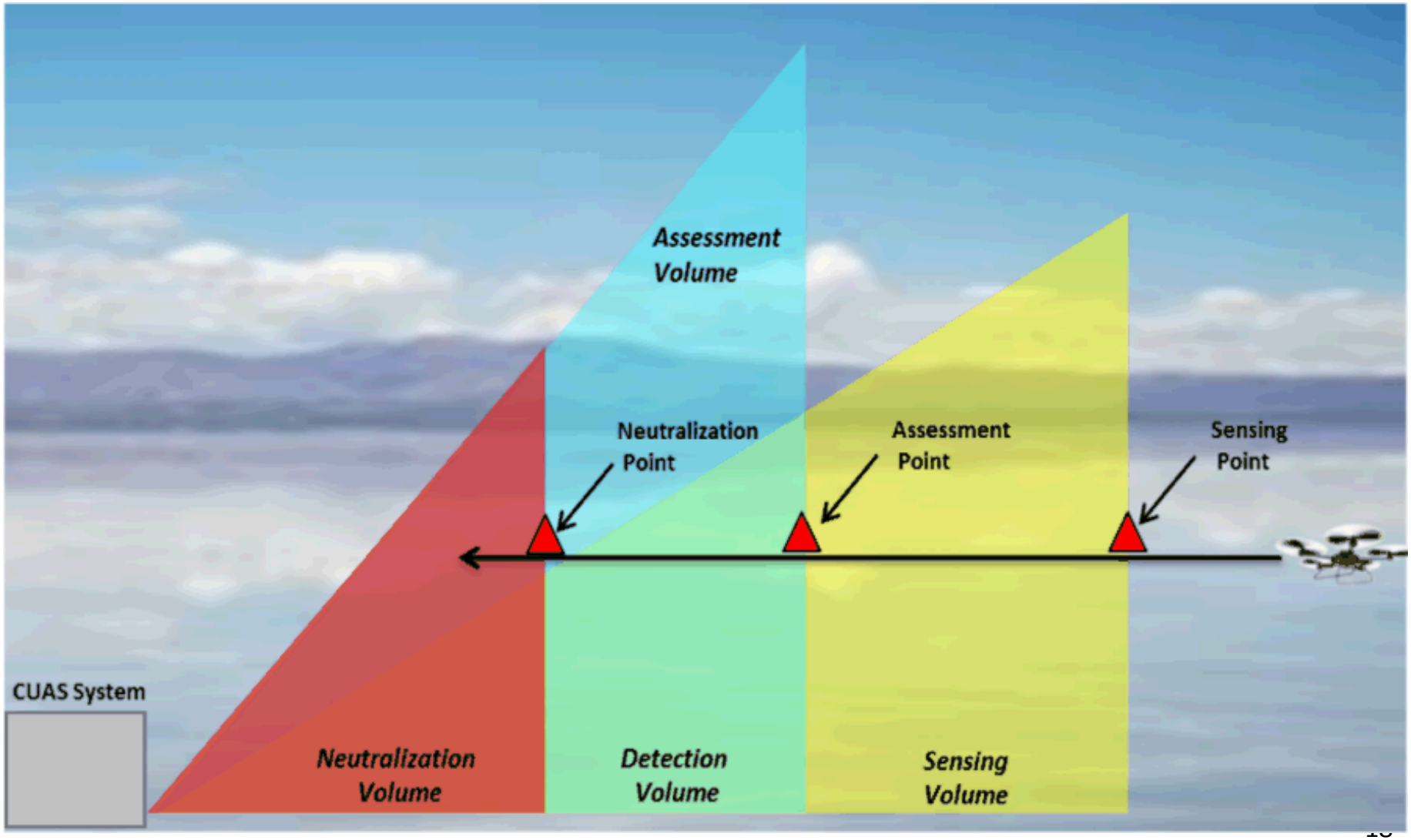
- Demonstrations and Challenges
  - Pass/Fail scenario specific
  - No qualifying performance metrics
- This task reduces risk by identifying the scenarios or conditions that may be effective
- This task does not tell you how the system may perform in more realistic situations
- If this is the only level of testing that is performed prior to deployment, the CUAS owner is accepting risks
  - Performance of CUAS remains unknown
  - Vulnerabilities of CUAS remains unknown
  - Degradation factors of CUAS remains unknown
  - CUAS nuisance alarm rates, false alarm rates, and nuisance alarm sources remains unknown

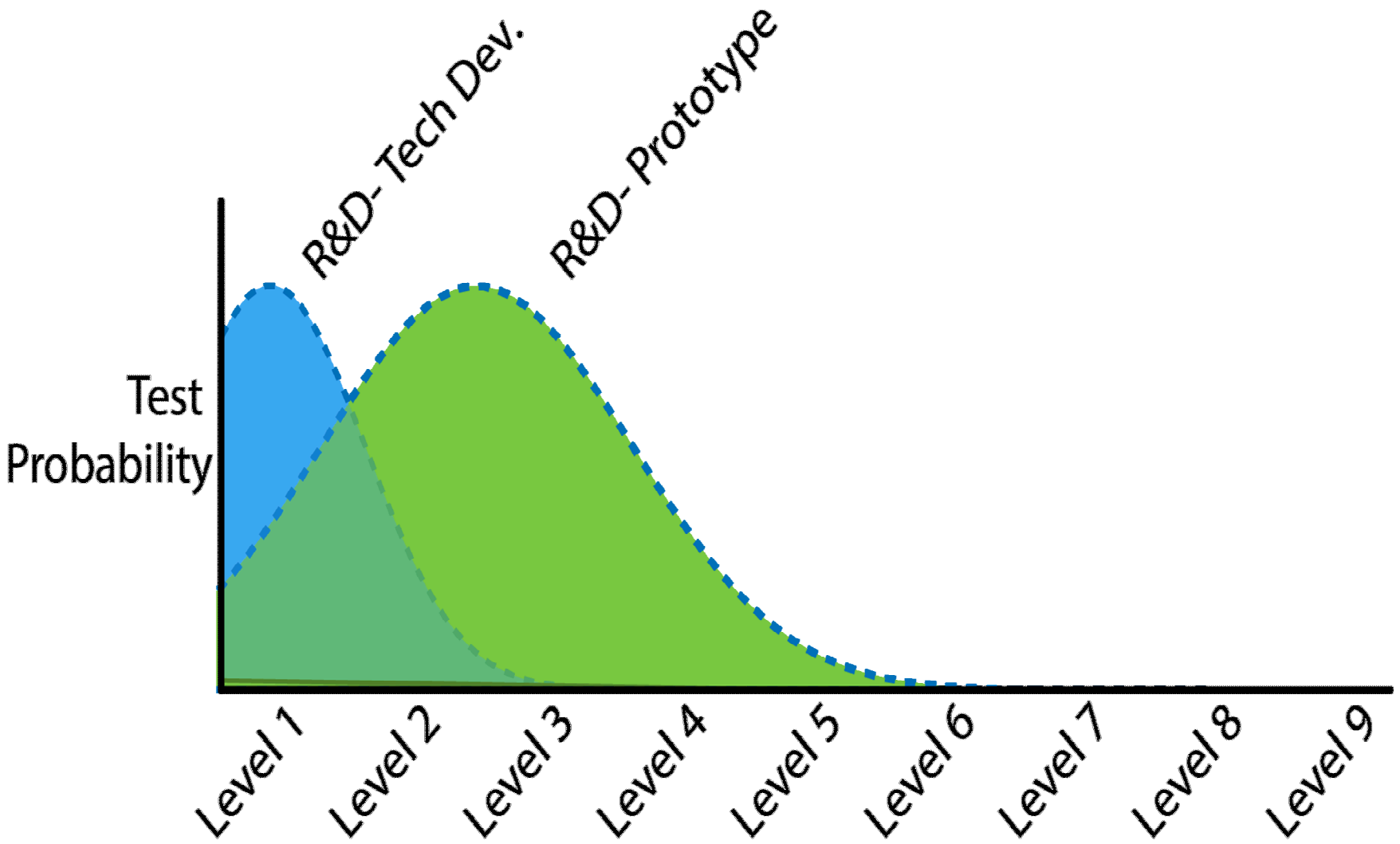
Level 4 – Baseline Performance

- Standard testing
  - Establish baseline performance
    - Sensing Point
    - Assessment Point
    - Neutralization Point
  - Same set of testing across all phenomenologies
- Tests may be occurring at a test site, not where the final deployment site
- With this level of testing you begin to quantify the performance of the CUAS on when sensing, assessment, and neutralization will occur.

Level 4 – Baseline Performance



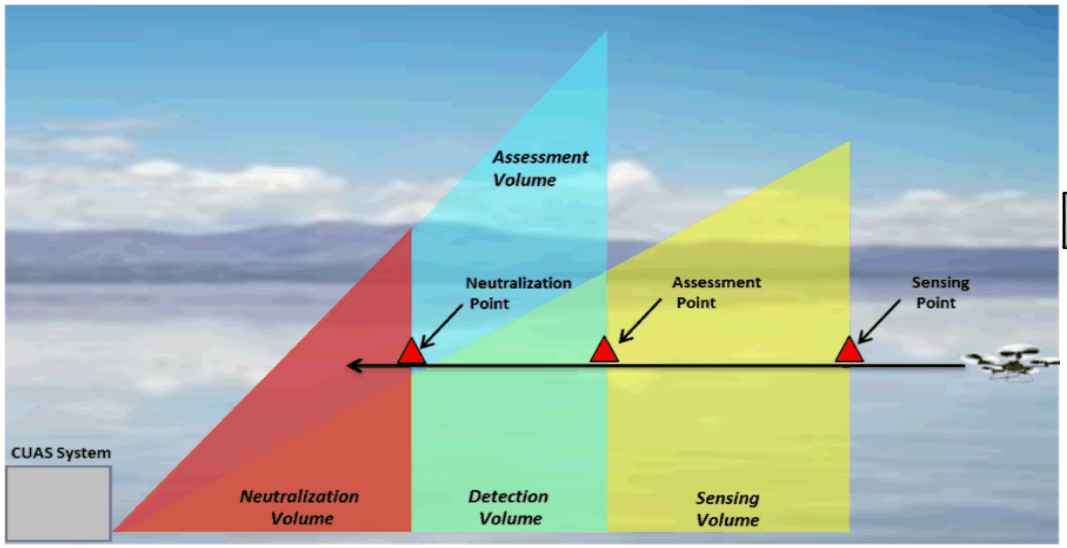
T&E Level versus Deployment Maturity

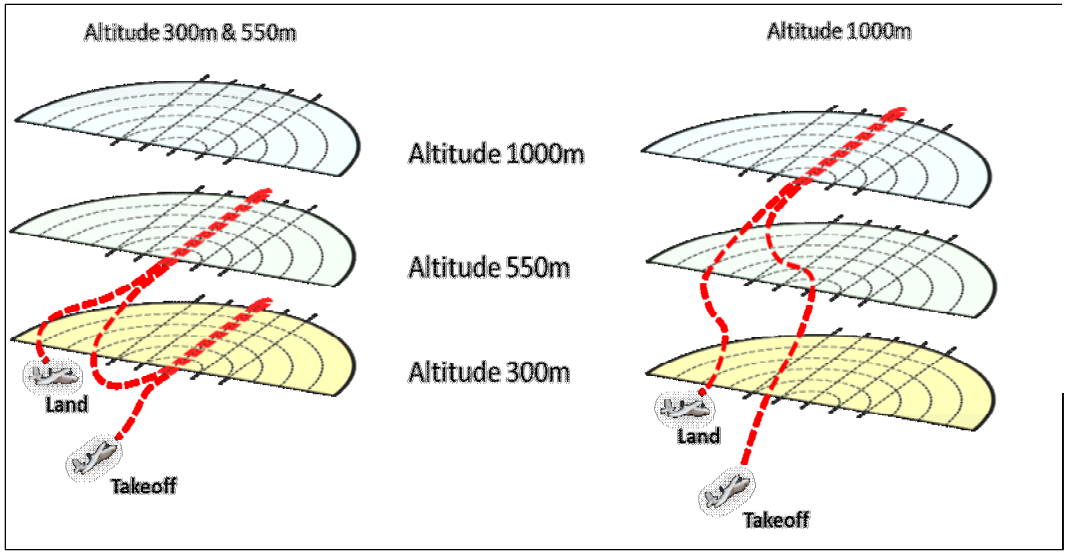


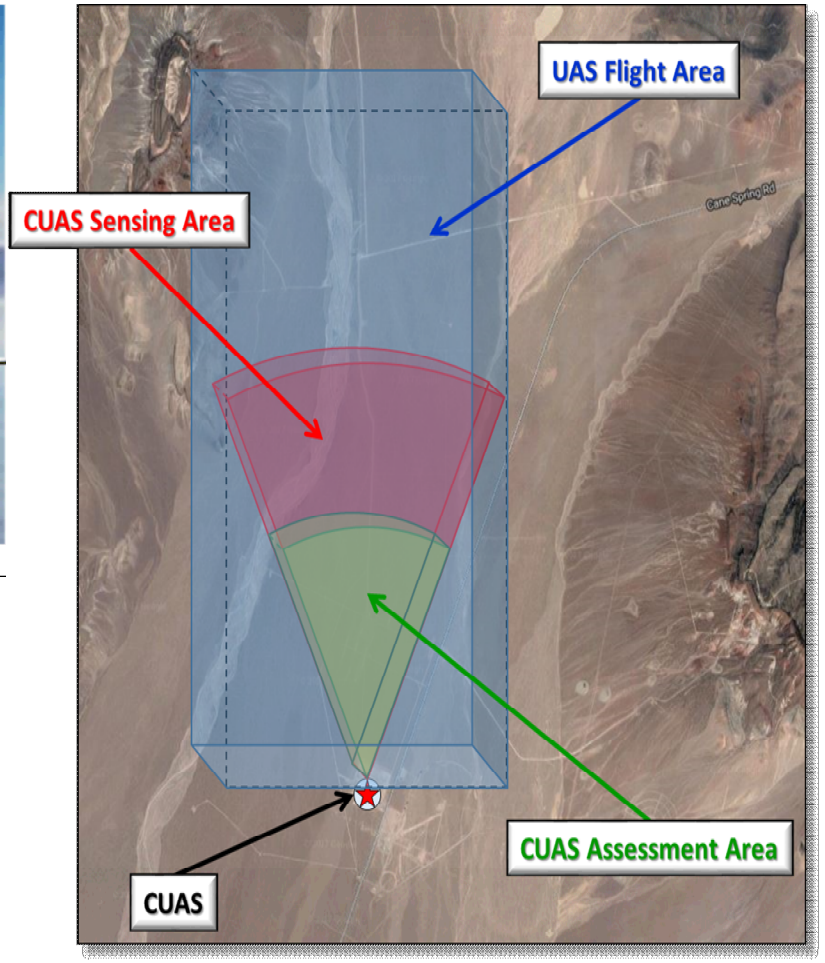
Level 5 – Limited Performance

- Standard testing utilizing a repeatable test methodology
  - Establish baseline performance
    - Sensing Point
    - Assessment Point
    - Neutralization Point
    - Mapping out the Volumes
    - Probability of Sensing, Assessment, Detection, and Neutralization
  - Same set of testing across all phenomenologies
- Limited NAR/FAR testing (<2 months)
- Testing performed at a test site, not where the final deployment site
- This level of testing will identify
  - Performance metrics
  - NAR/FAR
  - Functionality of the CUAS technology.

Test Methodology



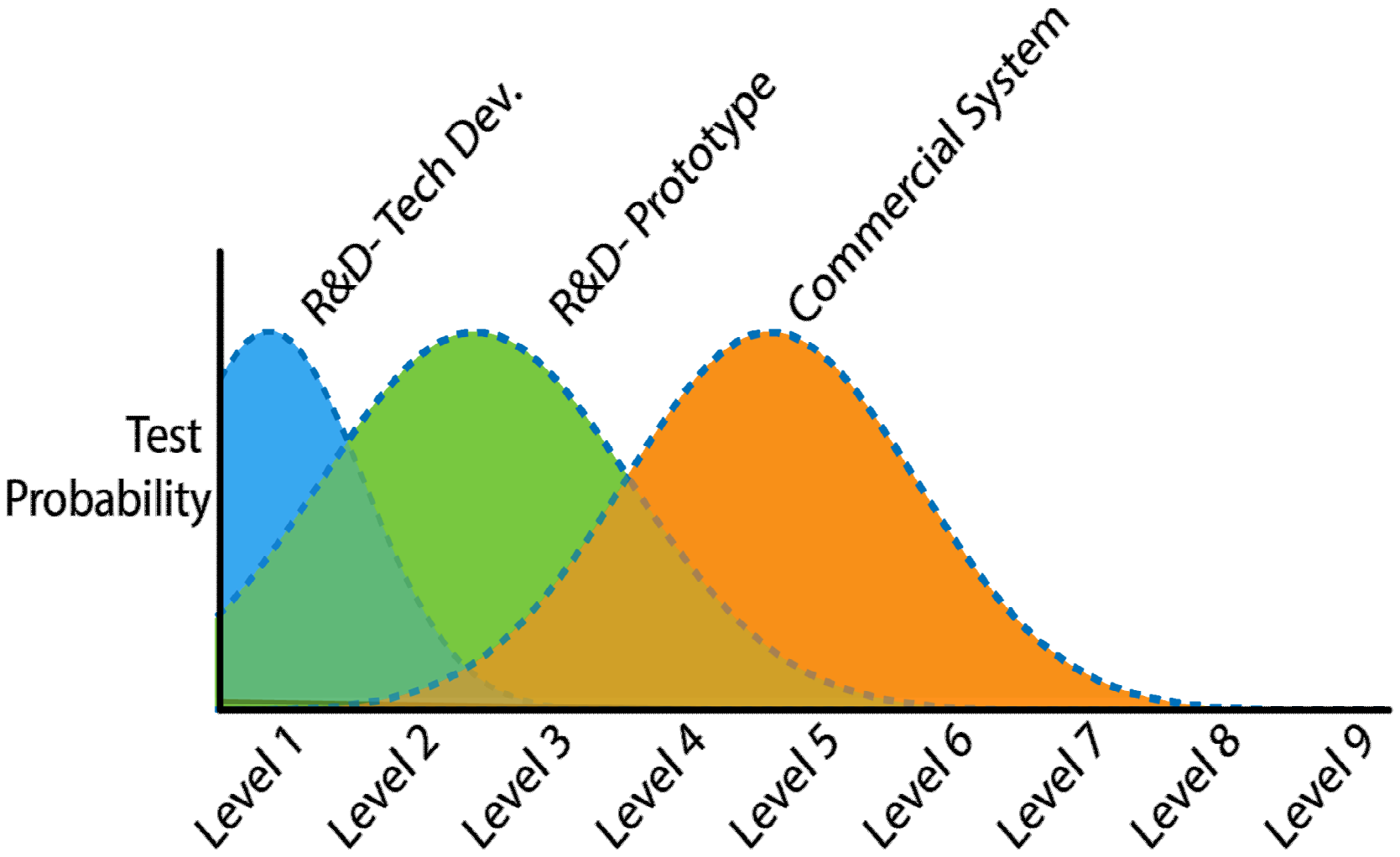




Level 6 – Full Performance

- Standardized Testing
- 6 month NAR/FAR Testing
  - Testing in a relevant environment similar to where system will be deployed
  - Collecting relevant NAR/FAR data (i.e. weather, sources, maybe put chart here?)
- Ensure previous testing performed by vendor is acceptable, otherwise perform testing to satisfy requirements.
- Analysis of CUAS at final deployment site
- This level of T&E will identify:
  - Full performance metrics
  - NAR/FAR levels
  - Environmental effects (if applicable)
  - Functional results
  - Potential technology gaps

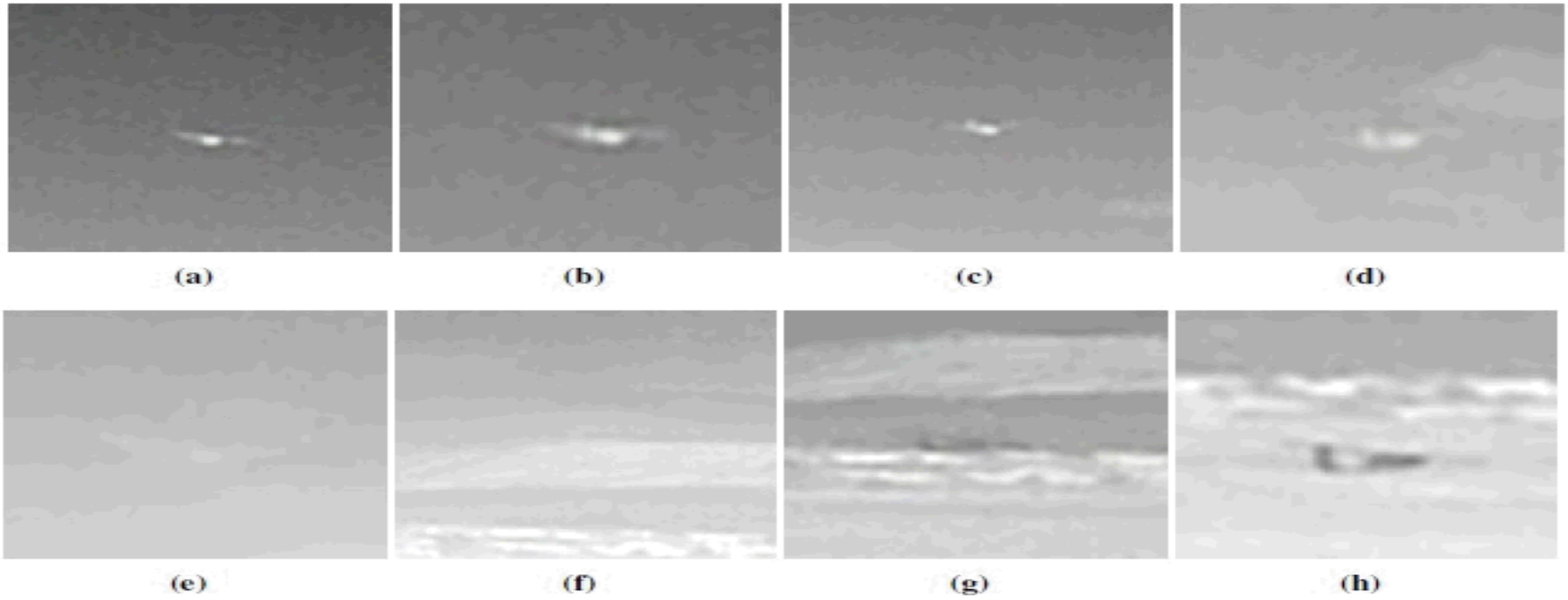
T&E Level versus Deployment Maturity



Level 7 – Enhanced Performance

- Standard testing
  - Establish baseline performance
  - Same set of testing across all phenomenologies
- Vulnerability testing
- Degradation testing
- NAR/FAR testing (> 6 months)
- This level of T&E will identify:
  - Full performance metrics
  - NAR/FAR levels
  - Environmental effects (if applicable)
  - Functional results
  - Potential technology gaps
  - Specific vulnerabilities
  - Specific degradation factors

Test Methodology



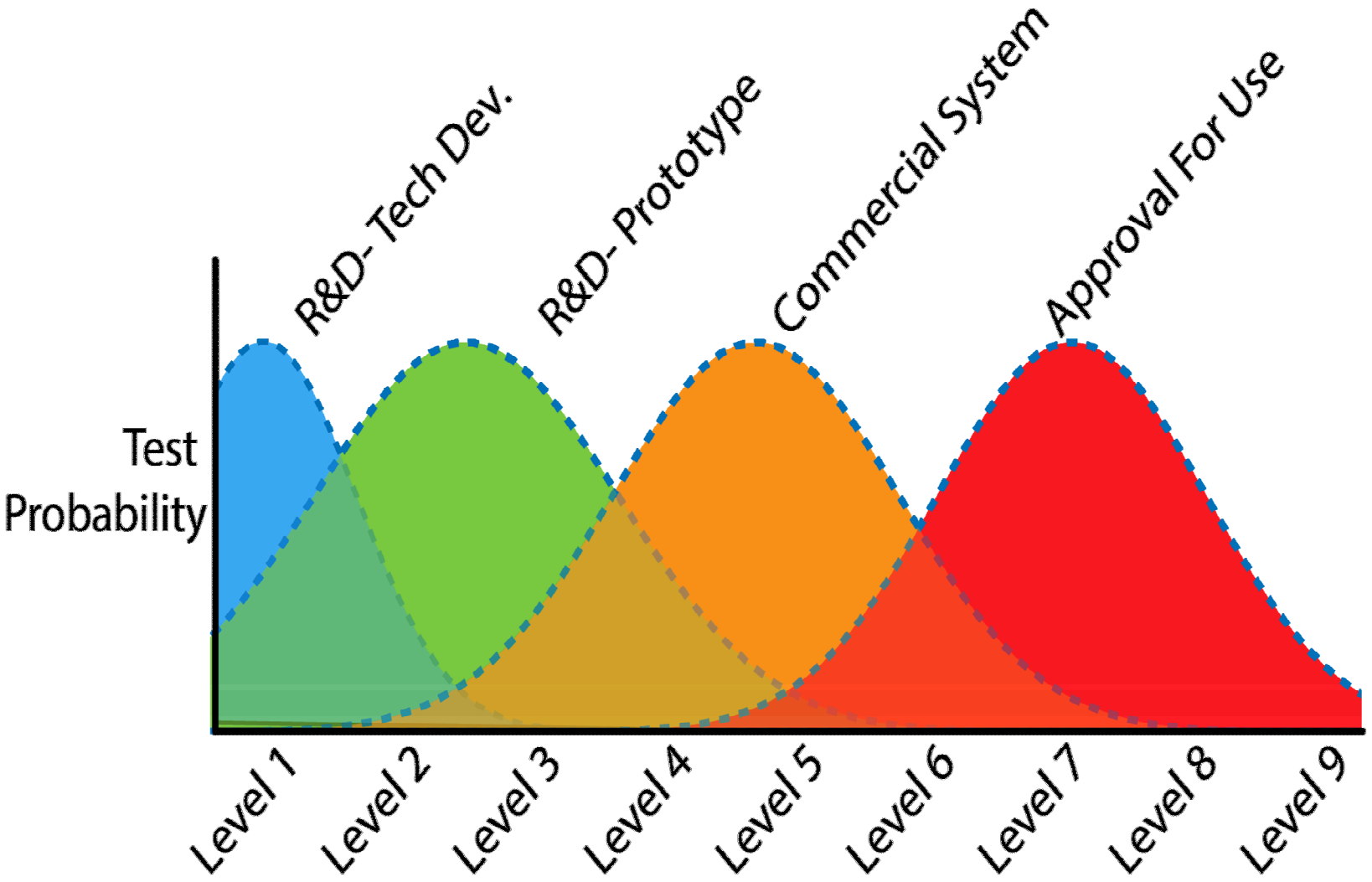
Example:

A fixed wing UAS in the LWIR camera during a landing. The target contrast against background decreases as the UAS moved into an atmospheric region of similar temperature compared to the UAS.

Level 8 – Penultimate Performance

- Standard testing
  - Establish baseline performance
  - Same set of testing across all phenomenologies
- Vulnerability testing
- Degradation testing
- Blackhatting (software, hardware, or cyber)
- NAR/FAR testing (> 6 months)
- This level of T&E will identify:
  - Full performance metrics
  - NAR/FAR levels
  - Potential technology gaps
  - Specific vulnerabilities
  - Specific degradation factors
  - Specific defeat methods to software, hardware, or cyber

T&E Level versus Deployment Maturity



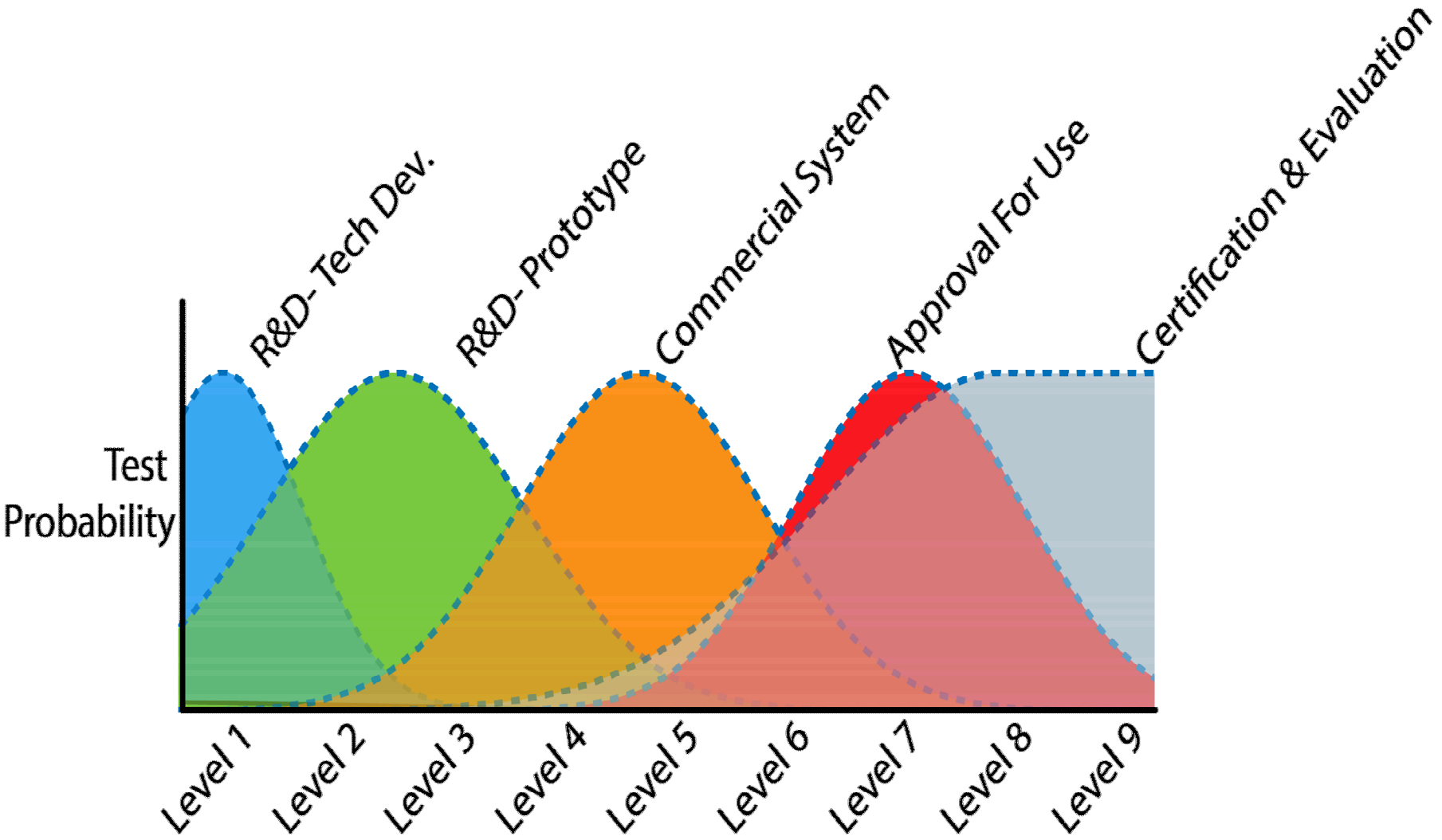
Level 9 – Ultimate Performance

- Extensive Blackhatting Standard testing
  - Establish baseline performance
  - Same set of testing across all phenomenologies
- Vulnerability testing
- Degradation testing
- Blackhatting (software, hardware, and cyber)
- NAR/FAR testing (> 6 months)
- This level of T&E will identify:
  - Full performance metrics
  - NAR/FAR levels
  - Potential technology gaps
  - Specific vulnerabilities
  - Specific degradation factors
  - Specific defeat methods to software, hardware, and cyber

Certification and Evaluation

- Certification and Evaluation is commensurate with the level of testing performed and consists of:
  - 100% T&E (level dependent)
  - 72 hour operational test
  - 30 day burn in Evaluation
  - Certification
- Certification and Evaluation is important in order to try to detect any premature failures and latent defects in the equipment as well as assessing the adequacy of logistics support
- Re-evaluation of significant enhancements should also occur in this phase prior to those upgrades being deployed

T&E Level versus Lifecycle Phase

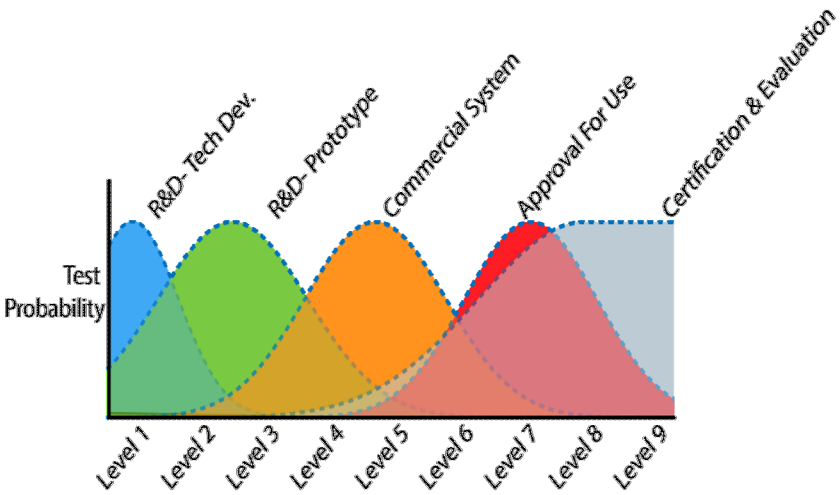


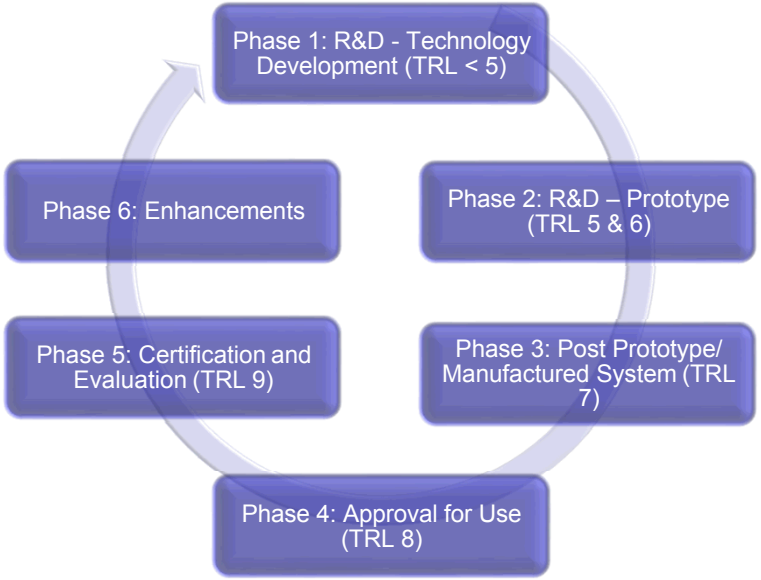
Summary and Conclusions

- This graded approach to T&E provid
  - a consistent CUAS T&E methodology
  - Data to support CUAS selection
  - Information about technology gaps
  - Comparative Results
  - Repeatable Results
  - Quantifiable Results
  - Scalability

Variables of what T&E level is needed:

- Industry/Funding dependent
- Risk acceptance
- Timeline for deployment
- Defined threat





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QUESTIONS?

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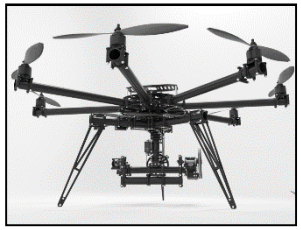
UAS Fleet

Sabre



Octocopter

Phantom 3

Phantom 4

Iris+

Solo

Drak

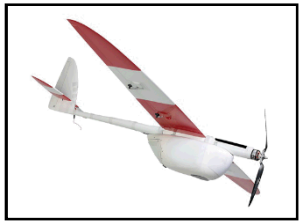
Mighty Mini
Tiny Trainer

Mini Apprentice

Arrow

Quadcopter

Anaconda



Aeromao

UAS Group Definitions

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UAS Group	Max. Weight (lb)	Nominal Operating Altitude (ft)	Speed (kt)	Representative UAS
Group 1	0-20	< 1,200 AGL	100	RQ-11 Raven, WASP
Group 2	21–55	< 3,500 AGL	< 250	ScanEagle
Group 3	<1323	< FL 180	< 250	RQ-7B Shadow
Group 4	>1320	< FL 180	Any	MQ-8B Fire Scout
Group 5	>1320	> FL 180	Any	MQ-9 Reaper

The data contained within the table provides UAS group specifications in accordance with the *Department of Defense Unmanned Aircraft System Airspace Integration Plan*