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Sustainment of the Deployed Navy Munitions Inventory through continuous Quality Evaluation Test and Evaluation

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Naval Ordnance Safety and Security Activity Quality Evaluation Program

- **Provides an independent assessment of the continued safe and reliable performance of in-service weapons through routine and continuous testing**
- **Quality evaluation testing is the method used to predict and therefore prevent munitions failures that are inherent in their design or are the result of aging**
- **Provides a significant contribution in assuring that the Fleet is not the first point of detection of catastrophic failures**
- **Predicting failures and degraded performance is necessary to ensure that Fleet readiness can be assured throughout the reprocurement cycle**

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Quality Evaluation Program Objectives

- **Assess the safety, reliability, & performance of the Navy weapons arsenal**
- **Identify and monitor critical characteristics that change with age and exposure**
- **Detect performance changes related to age and service use**
- **Predict future performance and service life/service limitations**

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Quality Evaluation Program Domain

- All in-service Navy weapons and ordnance programs
- In-service inventory - currently valued at $40B
- Overall age of inventory is 15 – 20 years

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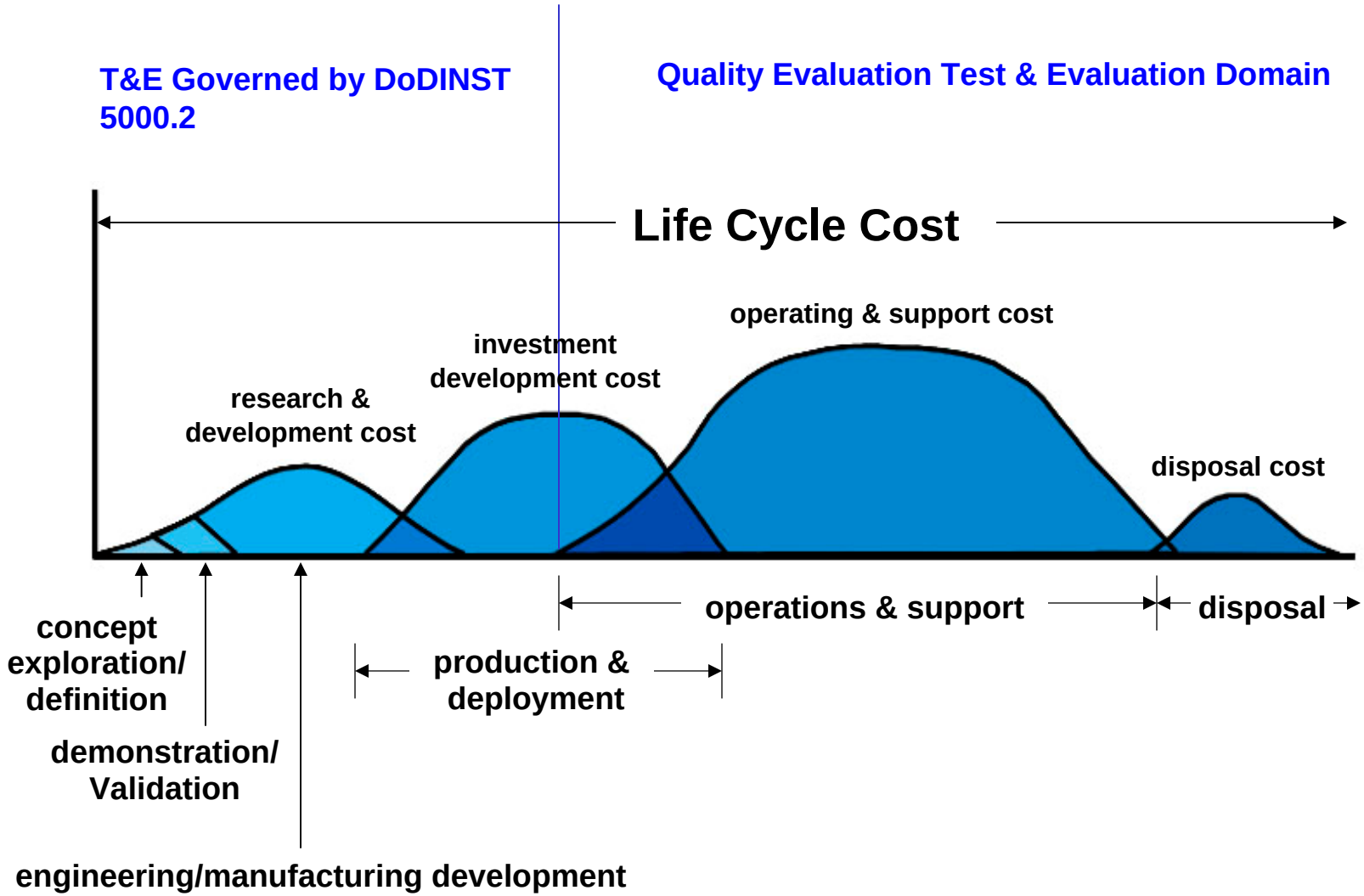
Life Cycle Test & Evaluation vs. Life Cycle Cost



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Quality Evaluation Program Contributions

- **Condition should drive maintenance**
- **Provides objective and independent test and evaluation of deployed munitions**
- **Identifies potential performance degradation during the operational phase**
- **Provides assurance that lethality, reliability and safety is retained in the operational phase**
- **Predicts the effect of system degradation of life cycle readiness and logistics issues**

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Life Cycle Readiness and Logistics Impact of Aging and Exposure

- **Degradation of reliability and performance characteristics critically affect lethality and P_k**
- **Inventory requirements depend on computational methods using as-built P_k without regard for degradation of the deployed inventory**
- **Relying on as-built reliability and performance to determine the quantity of weapons needed to meet mission objectives overlooks the effect of degradation trends understates actual inventory requirements**

Typical War Fighter Concerns

- **Is normal use/consumption still possible without risk to the user after the ammunition is exposed to field conditions?**
- **Does returned ammunition have the same capability as "normal" ammunition?**
- **Are the minimum conditions under which ammunition is currently tested & evaluated during development sufficient for service use in an operational environment?**

Typical War Fighter Concerns (Continued)

- **Will it be necessary to define restrictions for operational use to ensure in-service safety?**
- **Does Ammunition Surveillance ensure unrestricted use, or should special field conditions and mission time be taken into consideration?**
- **Can undesirable changes to the ammunition be avoided by providing special storage conditions (air-conditioned containers or other storage modules)?**

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Traditional Aging Studies and Predictive Analysis

- **Traditional approach relied on destructive testing of meticulously selected test samples**
- **Limited sample sizes creates potential for statistical error**
- **Aging studies discover abnormalities caused by aging factors**
- **Studies provide basis for risk assessment and important retain/discard decisions**

While the confirmation of operational suitability of inventory weapons has traditionally been left solely to real time testing it is likely that greater understanding of the explosive material degradation mechanism through aging studies and predictive analysis, will result in a more accurate and cost effective ability to forecast the limits of continued operational suitability.

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Quality Evaluation Program Technical Desires

- Condition-based maintenance
- Increased availability of life-cycle T & E information
- Health monitoring
- Aging studies and predictive analysis
- Modeling and simulation

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Increased Availability of Life-cycle T & E Information

- **Operational testing and maintenance data**
- **Fleet training results including telemetry data**
- **Improved and integrated data bases and data analysis tools**
- **Zero-age performance data including the results of chemical and physical analysis**

The ability to collect and integrate information from production acceptance, testing, training, environmental exposure, maintenance and handling, and forensic laboratory examination of failures will assure that predictions reflect the most significant and compelling estimates of the continued performance and safety of explosives-based munitions.

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Health Monitoring Approach

- Integrated maintenance and failure-reporting data systems
- Adoption of standardized/adapted best-practices across systems
- Failure and assessment modeling toolbox
- Development and deployment of micro-electro-mechanical (MEMS) sensors
- Remote collection of real-time location data and environmental data
- Labor-free monitoring of environmental conditions
- Determination of failure liability and the applicability of warranty coverage

There is unquestioned degradation of munitions, most specifically explosive and energetic material but also to electrical components, due to chemical changes and the effects of environment. It therefore logical that we have the ability to non-invasively monitor these degradation patterns.

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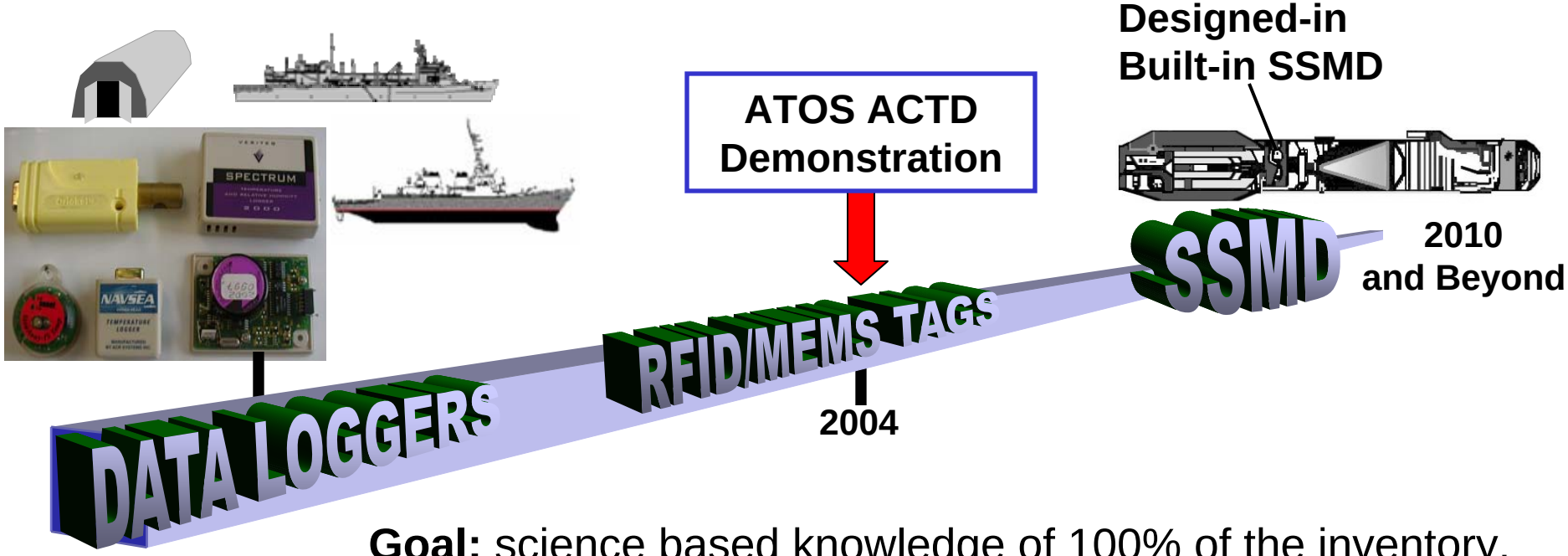
Evolution of Microelectromechanical (MEMS) Sensors



Goal: science based knowledge of 100% of the inventory, 100% of the time, via 100% non-destructive means

Maximized self-sensing and monitoring devices (SSMD)

Increased use of non-destructive technologies and modeling/simulation techniques (100%)

Reduced non Fleet-training destructive testing

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Modeling and Simulation

- **Models are needed to assess reactions to multi-variables such as temperature, humidity, vibration, shock**
- **Simulation of aging effect will permit understanding of resulting changes**
- **Understanding of changes will permit determination of remaining safe and useful service life**

The knowledge needed to assure success include the development of simulation models that will permit the understanding and characterization of the effects of aging and environmental forces that includes environmental variables and combinations of currently used oxidizers, stabilizers, double and single base propellant configurations, particle size, case bonding methods, process variables and grain geometry.

Conclusions

- Objective and independent life cycle test and evaluation of in-service weapons are necessary to assure weapons meet operator needs throughout service
- Maintenance and re-procurement plans should be based on how well the systems meet requirements
- Test-until-failure analysis is giving way to the analysis of degradation forces using aging and environmental exposure simulation models
- Real-time self-sensing monitoring systems will contribute to the quantification of aging effects and the reliable determination of remaining service life
- Standard M & S tools will be relied on for the assessment of the effects of degradation caused by aging and environmental exposure on the continued safety, performance and reliability of in-service munitions

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OUR GOAL: FAILURE PREVENTION