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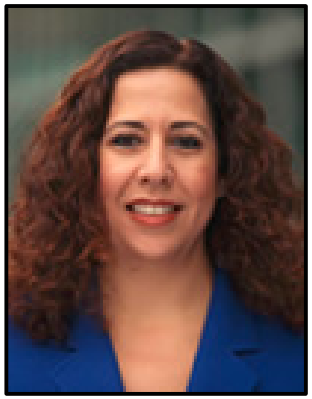
Life Cycle Assessment and Developmental Environment Safety and Occupational Health Evaluation: Tools for Sustainment and Health

September 19, 2019

SERDP DOD • EPA • DOE | ESTCP

Welcome and Introductions



Rula A. Deeb, Ph.D.
Webinar Coordinator

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Mr. Timothy Tetreault, SERDP and ESTCP
- **Environmental, Safety and Occupational Health (ESOH) Analyses in Acquisition** (25 minutes + Q&A)
  Mr. Brian Hubbard, JPEO Armaments & Ammunition
- **Approaches and New Tools for Incorporating Life Cycle Thinking into Acquisition: Making Sustainability Decisions More Robust** (25 minutes + Q&A)
  Dr. Andrew Henderson, Noblis
- **Final Q&A session**

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- If material is not showing on your screen or if screen freezes
  - Key in Ctrl + F5 to do a hard refresh of your browser
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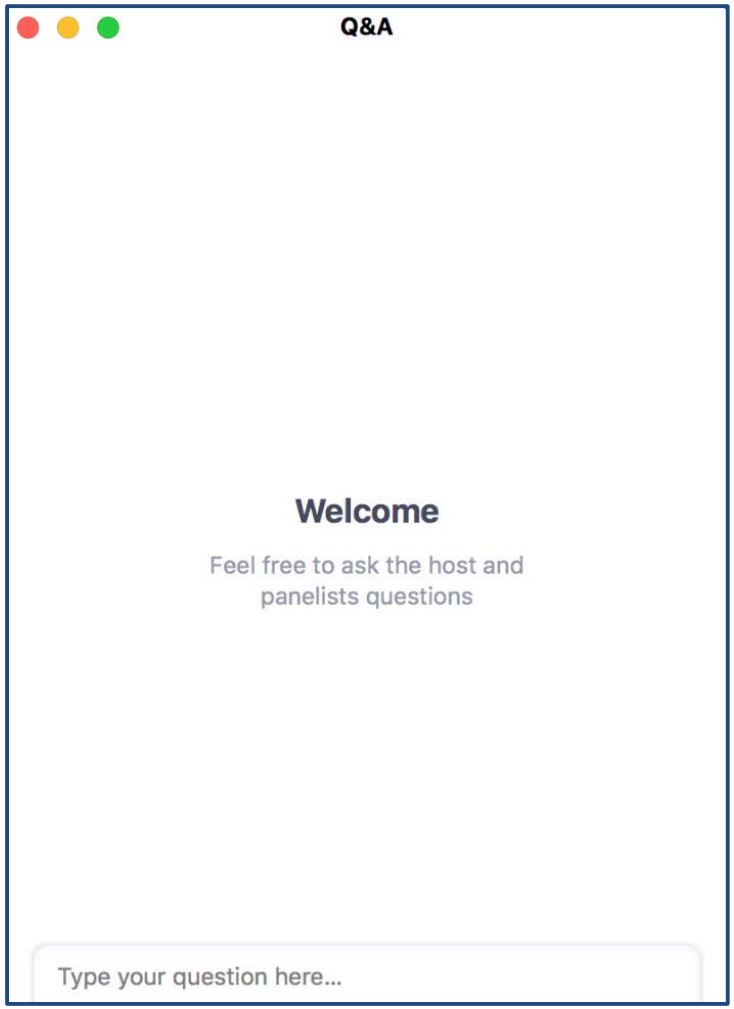
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview

Timothy Tetreault
SERDP and ESTCP

SERDP

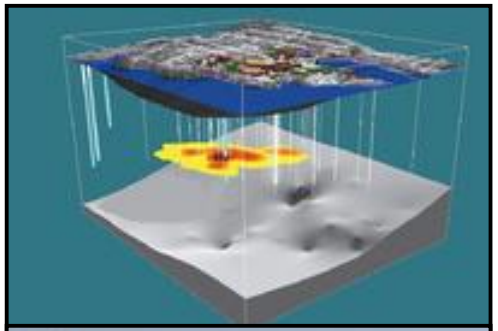
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas

1. Environmental Restoration
2. Installation Energy and Water
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



Weapons Systems and Platforms

- Major focus areas
  - Surface engineering and structural materials
  - Energetic materials and munitions
  - Noise and emissions
  - Waste reduction and treatment in DoD operations
  - Lead free electronics

SERDP and ESTCP Webinar Series

Date	Topic
October 3, 2019	Variation in Phenological Shifts: How do Annual Cycles and Genetic Diversity Constrain or Enable Responses to Climate Change?
October 17, 2019	Managing Aqueous Film Forming Foam (AFFF) Impacts to Subsurface Environments and Assessment of Commercially Available Fluorine-Free Foams
October 24, 2019	Advances in Managing Contaminated Groundwater Using High Resolution Site Characterization and Contaminant Mass Flux Reduction
October 31, 2019	Developing and Demonstrating Non-Toxic and Sustainable Coating Systems for Military Platforms
November 7, 2019	Overview of SERDP and ESTCP Efforts on Developing and Demonstrating PFAS Treatment Technologies

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Save the Date!

SERDP • ESTCP
SYMPOSIUM

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

December 3-5, 2019

Washington Marriott Wardman Park

Registration is open!

Environmental, Safety and Occupational Health Analyses in Acquisition

Brian Hubbard
Joint Program Executive Office
Armaments and Ammunition, U.S. Army

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Agenda

- Joint Program Executive Office Armaments and Ammunition (JPEO A&A) Overview
- Phased Environment, Safety and Occupational Health (ESOH) - Technology development
- ESOH analyses in acquisition
- DoD benefits
- Conclusions

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JPEO A&A Overview

- Mission
  - Lead the development, procurement, and delivery of lethal armaments and ammunition to provide joint warfighters with overmatch capabilities to defeat current and future threats
- Priorities
  - Lean forward to provide overmatched capabilities to the warfighters
  - Develop people, teams and future acquisition leaders
  - Innovate and operate effectively and efficiently
  - Optimize the ammunition enterprise
  - Prepare the organization for the future

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JPEO A&A Overview

PM Combat Ammunition Systems	PM Close Combat Systems	PM Maneuver Ammunition Systems	PM Towed Artillery Systems	PD Joint Services	PM Joint Bombs
Indirect Fire Munitions and Mortar Weapon Systems • Excalibur • Guided Precision Munitions and Mortar Systems • Conventional Ammunition	**Networked Munitions, Force Application Systems, Explosive Hazard, and Countermine** • Counter Explosive Hazard • Area Denial • Combat Munitions • Support Munitions	**Direct Fire Munitions** • Large Caliber • Small Caliber • Medium Caliber • Non-Standard Ammo	**Towed Artillery Fires for Army and USMC** • M777A2 Lightweight Howitzer • M119A2/A3 Digitization	**Integrates the SMCA Mission** • Demilitarization • Ammunition Industrial Base • Ammunition Logistics • Technology and Prototyping	**Air Force and Navy Unique Items** •Bombs •Navy Deck Gun Ammo •Energetics •CAD PAD

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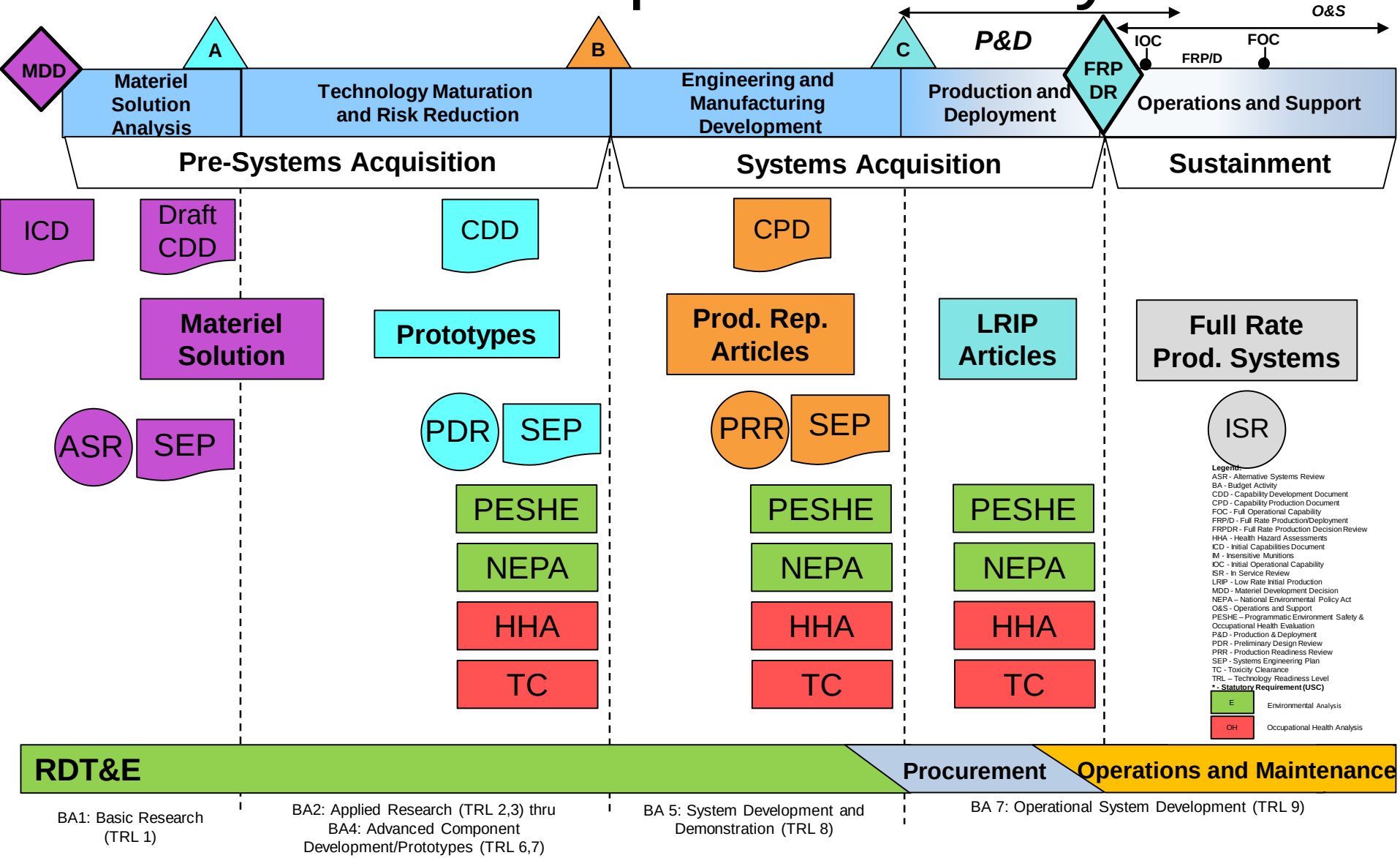
ESOH in Acquisition Lifecycle



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ESOH in Acquisition Lifecycle

Materiel Solution Analysis (MSA) Phase

- Phase objectives
  - Team identifies a materiel solution to address capability gap – partly determined through an Analysis of Alternatives (AoA)
  - Convert validated capability gaps into system specific requirements – Key Performance Parameters (KPPs), Key System Attributes
- ESOH activities during MSA
  - ESOH Subject Matter Experts (SMEs) participate in the AoA
  - Ensure ESOH planning included in the Systems Engineering Plan (SEP), draft Capability Development Document (CDD), Request for Proposal (RFP)

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ESOH in Acquisition Lifecycle:

Technology Maturation and Risk Reduction (TMMR)

- Phase objectives
  - Reduce technical risks, gain understanding of materiel solutions to support investment decisions at pre-Engineering and Manufacturing Development (EMD) Review, and Milestone B
- ESOH activities during TMMR
  - Prepare initial PESHE, NEPA Compliance Schedule
  - Integrated Product Team (IPT) membership, participate in design activities, prototyping – identify and mitigate ESOH risk for next phase
  - Include early ESOH risk in the Preliminary Design Review (PDR)
  - Provide input to SEP, Life Cycle Sustainment Plan (LCSP), draft RFP

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ESOH in Acquisition Lifecycle

Engineering and Manufacturing Development (EMD)

- Phase objective
  - Develop, build and test prototypes, verifying all operational requirements achieved
  - Prepare for production, deployment
- ESOH activities during EMD
  - Through IPT, participate in trade-off, design development activities
  - Evaluate Test & Evaluation (T&E) results, in context ESOH risk mitigation
  - Update NEPA Compliance Schedule, PESHE for Milestone C
  - ESOH risk acceptance
  - Obtain ESOH approvals, endorsements, Capability Production Document, draft RFP
  - Health Hazard Assessment (HHA), Toxicity Clearance (TC) updated for Milestone C

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ESOH in Acquisition Lifecycle

Production & Deployment (P&D)

- Phase objective
  - Produce, deliver products to end user that comply with requirements
  - Product produced and fielded for use by operational units
- ESOH activities during P&D
  - Evaluate Test & Evaluation (T&E) results, in context ESOH risk mitigation
  - Update NEPA Compliance Schedule, PESHE, HHA, TC for Full Rate Production/Decision Review (FRP/DR)
  - ESOH risk acceptance
  - Obtain ESOH approvals, endorsements, Capability Production Document, draft RFP

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ESOH in Acquisition Lifecycle

Operations & Support (O&S)

- Phase objective
  - Execute product support strategy, sustain system throughout its lifecycle
  - Product produced and fielded for use by operational units
  - Eventual disposal, at end of service life
- ESOH activities during O&S
  - As developed, assess hazard reports, regulatory violations, etc., develop courses of action to mitigate ESOH issue
  - Update, maintain the PESHE as necessary
  - Support NEPA analysis, compliance schedule
  - Updated HHA and TC

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ESOH in Acquisition

- AR 70-1: Army Acquisition Policy
  - National Environmental Policy Act (NEPA) (32 CFR Part 651)
  - Programmatic Environment, Safety and Occupational Health Evaluation (PESHE)
- MIL-STD-882E: DoD Standard Practice System Safety
  - ESOH risk management for engineering activities throughout life cycle
  - ESOH planning in System Engineering Plan
  - Planning results in PESHE, NEPA Compliance Schedule
- DODI 5000.02: Operation of the Defense Acquisition System

Table 2. Milestone and Phase Information Requirements, Continued

INFORMATION REQUIREMENT	PROGRAM TYPE[1]				LIFE-CYCLE EVENT[1,2,3]								SOURCE	APPROVAL AUTHORITY
	MDAP	MAIS	ACAT II	ACAT ≤ III	MDD	MS A	CDD Val	Dev RFP Rel	MS B[5]	MS C	FRP/FD Dec	OTHER		
PESHE AND NEPA/E.O. 12114 COMPLIANCE SCHEDULE	•	•	•	•					•	✓	✓		42 U.S.C. 4321-4347 (Ref. (ag)) E.O. 12114 (Ref. (ah))	CAE or as delegated
STATUTORY. The Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) and National Environmental Policy Act (NEPA) / Executive Order (E.O.) 12114 Compliance Schedule is approved by the CAE. Related design considerations must be included in the SEP; related operations or sustainment considerations after Milestone C will be included in the LCSP. Not required for software programs with no hardware component.														

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Phased ESOH Approach

Why?

- Program managers depend on data developed during RDT&E to support a Program's Full Rate Production Decision Review
- Absence of ESOH data does not equal "no risk"
- New chemicals entering Army Supply System may be subject to the Toxic Substances Control Act (TSCA)
  - USEPA may require evaluation through Consent Orders
  - Cost and schedule impacts likely
- Minimum dataset reduces uncertainty in planning
  - Allows transition partners to budget for additional testing required before fielding

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Phased ESOH Approach

Delivering Capability

- U.S. Army Public Health Center (PHC)
  - American Society for Testing and Materials (ASTM) E2552-16: Standard Guide for Assessing the Environmental and Human Health Impacts of New Compounds for Military Use (2016)
- U.S. Army Research, Development and Engineering Command (RDECOM)
  - Developmental Environment, Safety and Occupational Health Evaluation (DESHE) (2017)
- The Technical Cooperation Program (TTCP)
  - Assessing the Potential Environmental and Human Health Impact of Energetic Materials: A Phased Approach (2014)

Each document recommends a phased data collection approach, consistent with corresponding Technology Readiness Level (TRL)

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Developmental Environment Safety and Health Evaluation (DESHE)

- Created by US Army RDECOM's Environmental Technology Acquisition Program (ETAP), 2017
- DESHE is not a risk assessment tool
  - Phased approach collects ESOH data throughout RDT&E
- As material/technology, matures data collection methods align with TRL, Budget Activity (BA)
- Results support the following:
  - PESHE
  - NEPA
  - Health Hazard Assessment (HHA)
  - Environmental permits

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Notional DESHE Process

BA2

- **Chemical/physical:** Experimental data for fate and transport
- **Human health:** *In-vitro* tox screen (mutagenicity, acute tox)
- **Ecotox:** *In vitro* screen (aquatic)
- Professional judgment

BA3

- **Chemical/Physical:** Environmental persistence, experimental data for fate and transport
- **Human health:** *In vivo* tox (acute), *in vitro* irritation/sensitization
- **Ecotox:** *In vivo* aquatic, terrestrial invertebrate (acute), *in vitro* screening
- Professional judgment

BA4

- **Fate/transport:** Biodegradation in various media
- **Human health:** *In vivo* tox (sub-chronic)
- **Ecotox:** *In vivo* aquatic (chronic, multiple species), terrestrial (chronic, invertebrates, plants, single species)
- Professional judgment

Acquisition Requirements

- PESHE
- NEPA
- HHA
- Toxicity Clearance

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DESHE Data

- At each BA/TRL, DESHE collects:
  - Physicochemical properties
  - Fate and transport
  - Human health
  - Ecotoxicity

- Pertinent data collected in accordance with prescribed methods and good laboratory practices

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DESHE Advantages

- Links the RDT&E and acquisition communities
- Opportunity to identify potential risks prior to transition
- Data collected by multiple government, industry and academic laboratories
  - Per EPA, Organization for Economic Cooperation and Development (OECD) and ASTM procedures
- Supports industrial base sustainment and army readiness
  - Robust assessment of new materials before Full Rate Production/Decision Review

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ESOH in Acquisition

PESHE

- Statutory requirement; AR 70-1 Army Acquisition Policy; DODI 5000.02: Operation of Defense Acquisition System; MIL-STD-882E: DoD Standard Practice System Safety
- Required at Milestone (MS) B, MS C and Full Rate Production Decision Review; regardless of acquisition category (ACAT) level
- Examples of data required:
  - ESOH risks and status
  - Corresponding environmental impact – infrastructure, training lands
  - Minimize environmental impact, plan safe disposal
- Living document

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ESOH in Acquisition

NEPA

- Compliance schedule statutory requirement for Army actions, per 32 CFR Part 651
- Consider environmental impacts of proposed actions, within acquisition programs, before they are executed
- Actions requiring NEPA analyses:
  - Test and evaluation
  - Materiel fielding
  - Major system modifications
  - Demilitarization/disposal

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ESOH in Acquisition

MIL-STD-882E DoD Standard Practice System Safety

- System engineering tool for identifying, classifying and mitigating hazards
- Hazard Materials Management Plan (Task 108):
  - Processes to identify, assess, and control hazardous material risks
  - Anticipated quantities generated throughout life cycle
- Environmental Hazard Analysis (Task 210):
  - Impact design decisions early
  - Failure to consider may adversely impact cost, schedule, performance
  - Address entire life cycle

RISK ASSESSMENT MATRIX

SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

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Conclusions

- PESHE, NEPA are required at each Milestone Decision, as well as at the FRP/DR
- Opportunities to address ESOH risks decrease significantly as Program matures
  - Cost and schedule impacts
- DESHE provides guidance to collect the relevant data, at the proper time, via standard methods
- Absence/lack of ESOH data does not equate to minimal risk

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DoD Benefits

- Understanding ESOH impacts of new materials prior to transition is critical - enables PMs to plan for production impacts, associated Industrial Base modernization, corresponding permit requirements as well as sustainment considerations
- Assessing ESOH attributes early, enables risk mitigation opportunities and resource allocation
- Executing the phased approach leads to robust PESHE, HHA, NEPA assessments, which are required to achieve Materiel Release

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For additional information, please visit

https://www.pica.army.mil

Speaker Contact Information

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Q&A Session 1

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Approaches and New Tools for Incorporating Life Cycle Thinking into Acquisition: Making Sustainability Decisions More Robust

Andrew Henderson, Ph.D.
Noblis

SERDP DOD • EPA • DOE | ESTCP

Agenda

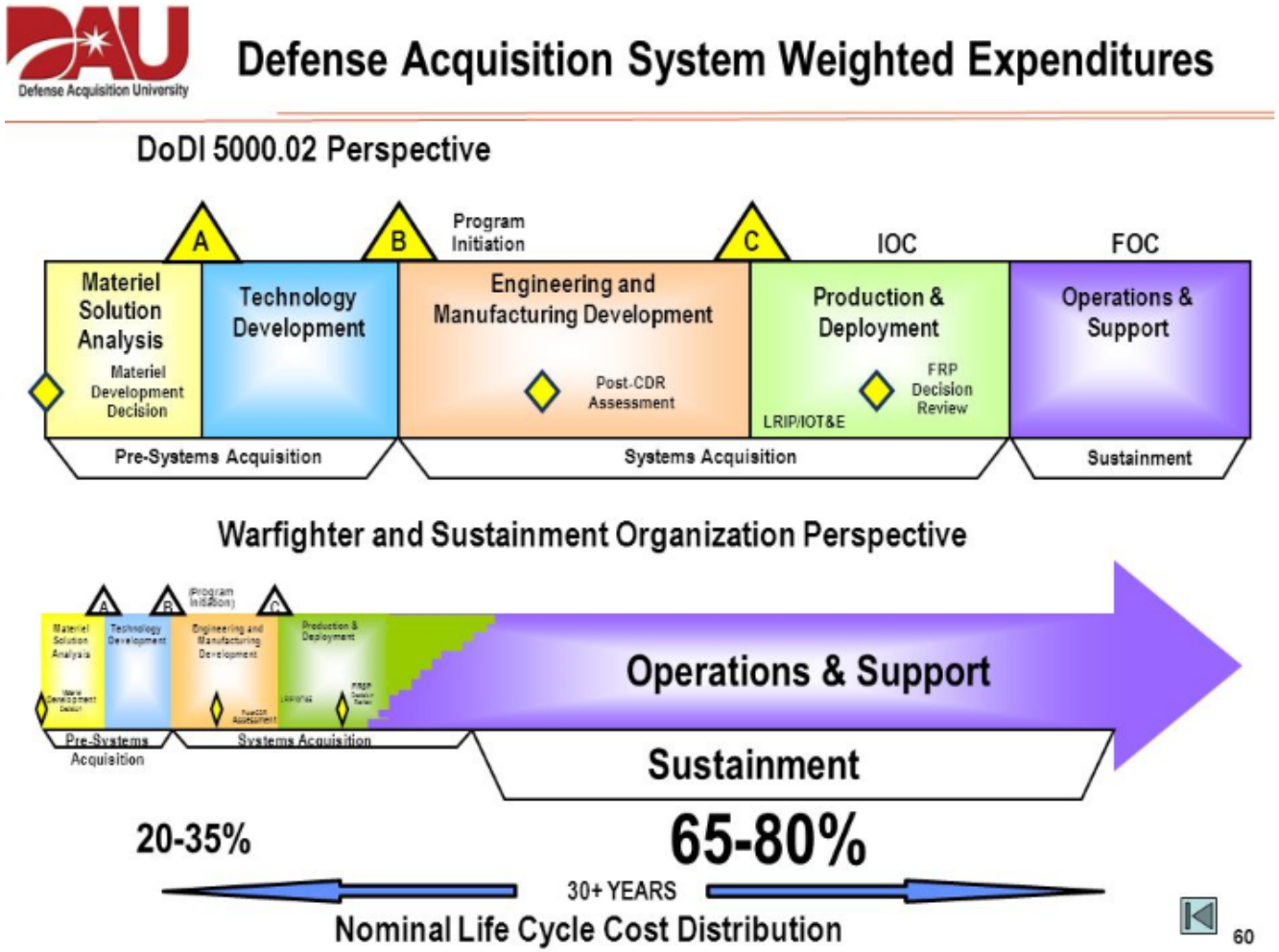
- Requirements and financial drivers for sustainability analysis
- Case study: Electroplating alternatives at maintenance depot
- Tools and resources available
- Conclusions
- Benefits to DoD

National Defense Strategy 2018

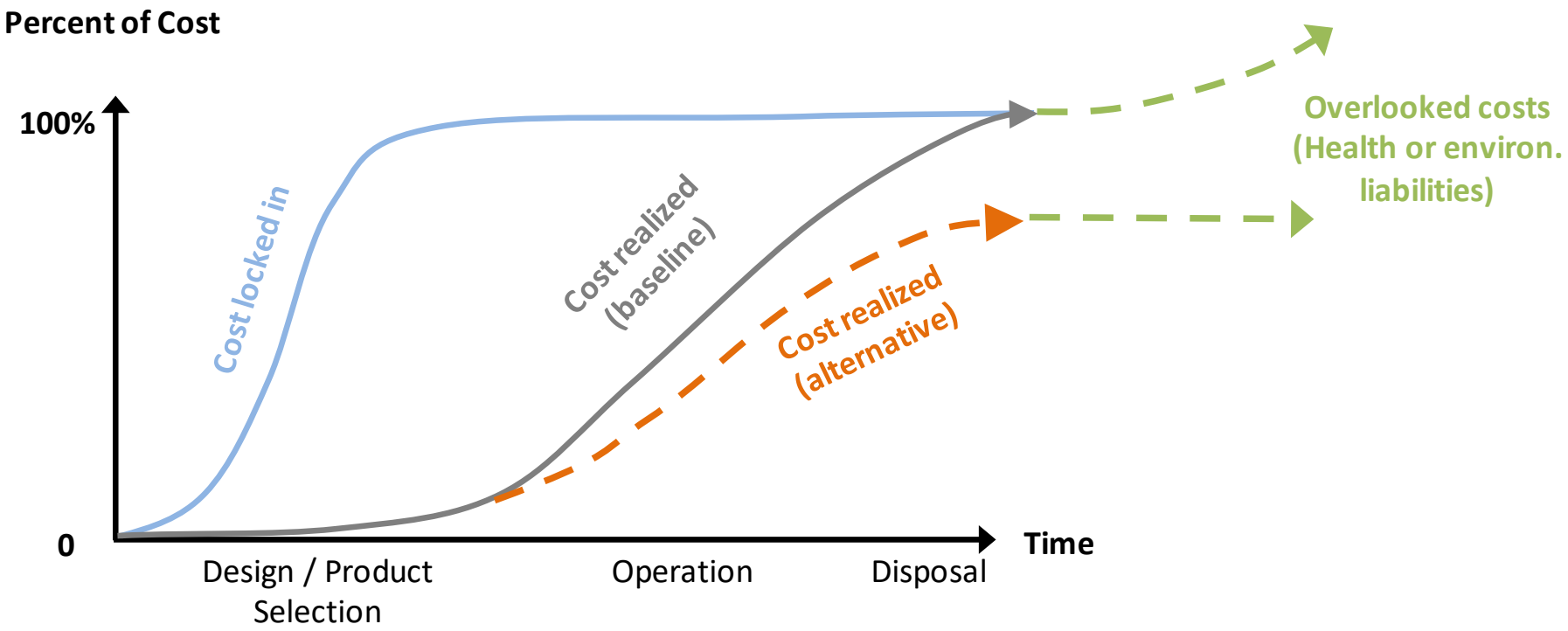
Includes Costing

- NDS goals
  - Increase lethality
  - Strengthen and build alliances
  - Improve performance and affordability
- Already plenty of guidance to address affordability
  - DoD 5000.04-M, Product Support Business Case Analysis Guidebook
- But…

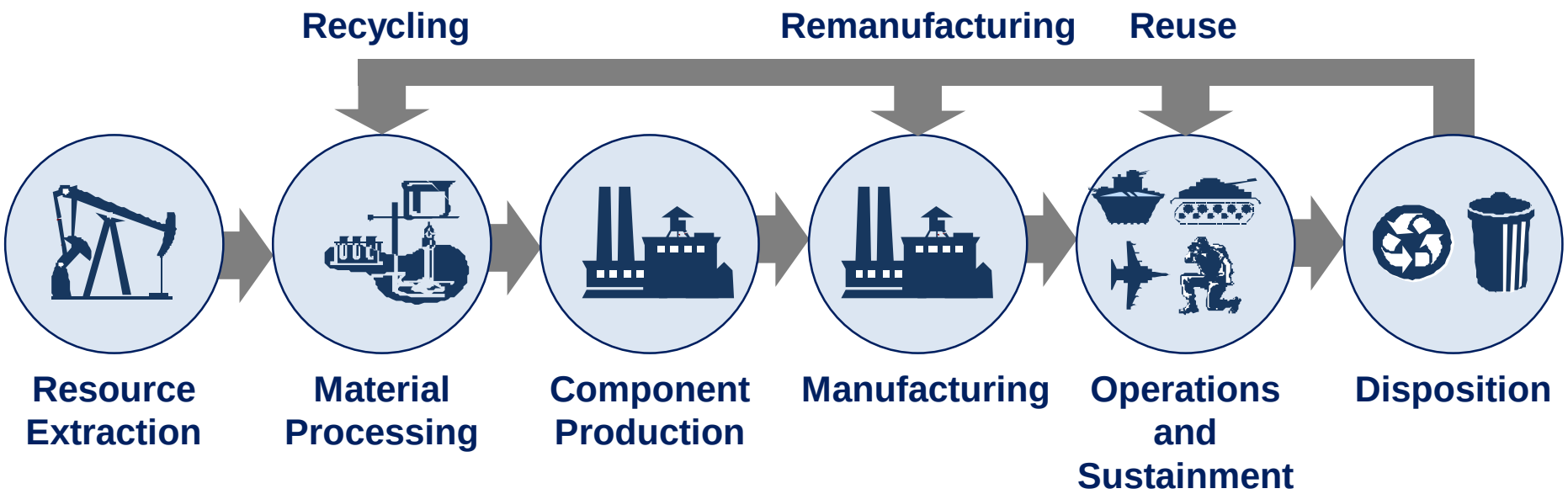
Operations Are (Often) Costly



We Need to Anticipate Holistically to Compare Alternatives Comprehensively



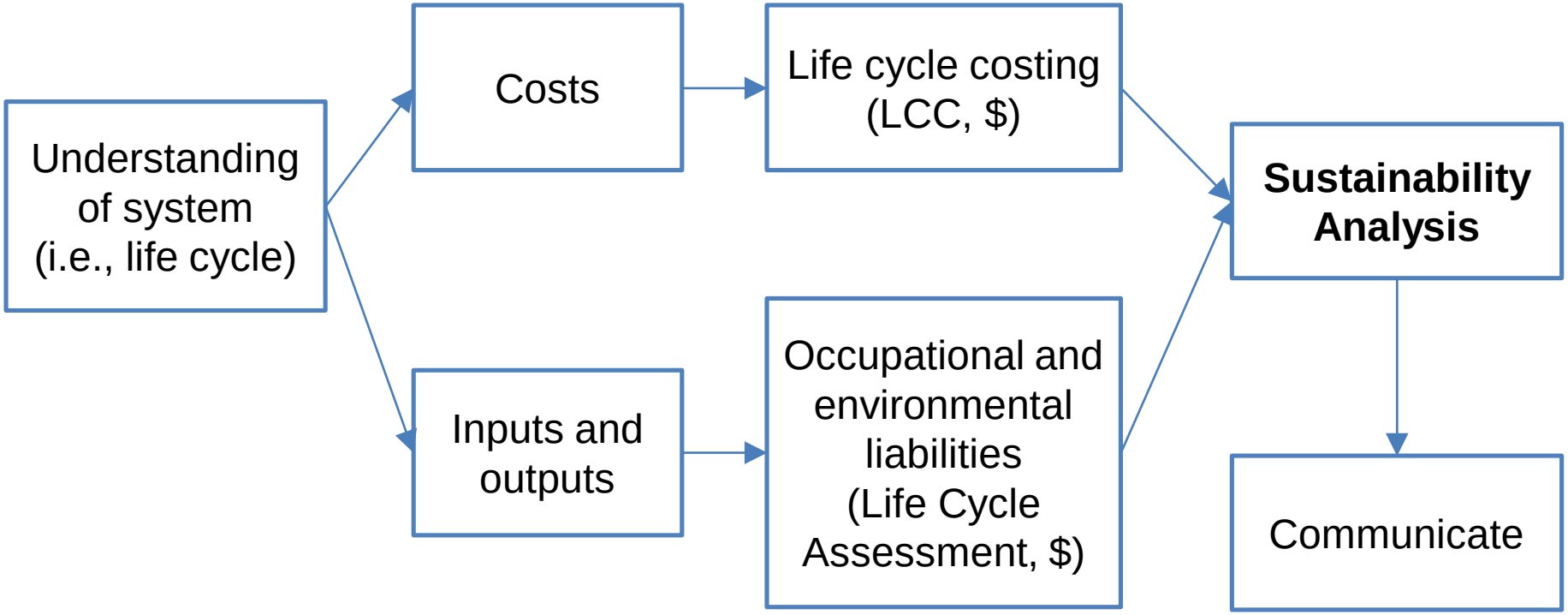
What is Life Cycle Thinking?



Types of Questions for Life Cycle Thinking

- Would on-site water treatment require more energy than available supply?
- How much would a new explosives production line save in terms of long-term medical costs for workers?
- How much would a cadmium-free plating line save in haz waste costs?
- i.e., "**Is the cost / health / environment tradeoff acceptable?**"

What is the DoD Sustainability Analysis Framework?



Sustainability Analysis

Informed by Standard Practices

Life Cycle Costing (LCC)

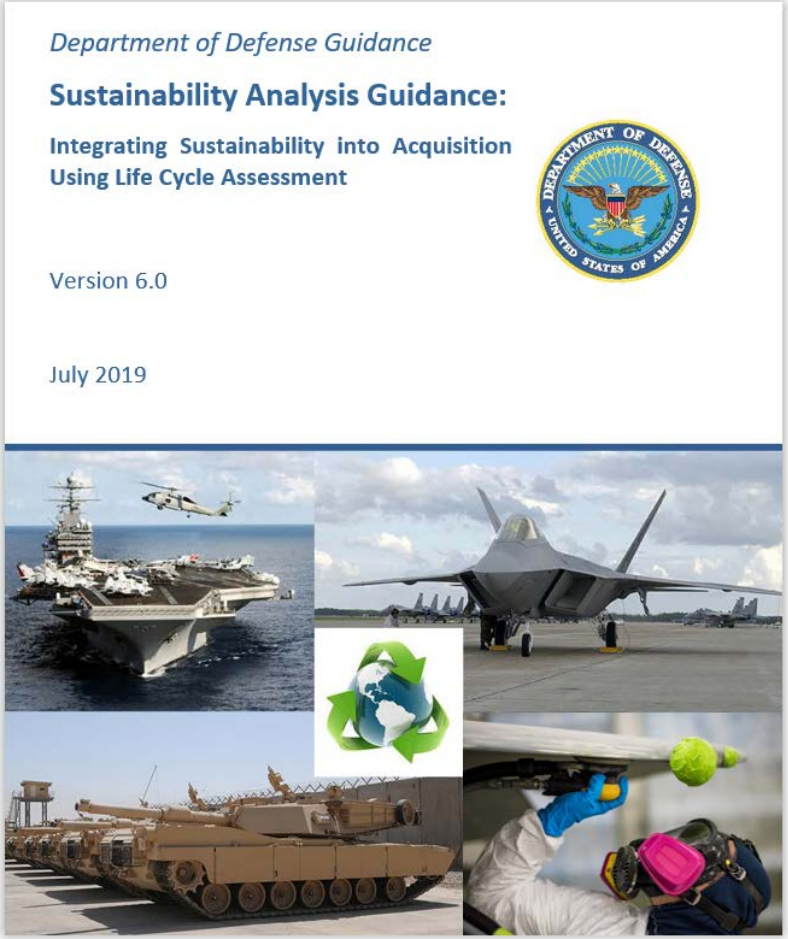
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- Operating and Support Cost-Estimating Guide
- DoD 5000.04-M-1, Cost and Software Data Reporting (CSDR) Manual
- DoD Instruction 7041.04, Estimating the Full Costs of Civilian and Active Duty Manpower and Contract Support
- DoD Instruction 7041.3, Economic Analysis for Decision-making
- DoD Product Support BCA Guidebook
- etc.

Life Cycle Assessment (LCA)

- ISO 14040:2006, Principles and framework
- ISO 14044:2006, Requirements and guidelines
- ISO 14047:2012, Illustrative examples on how to apply ISO 14044 to impact assessment situations
- ISO 14048:2002, Data documentation format
- ISO 14049:2012, Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis
- ISO 14071:2014, Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006
- etc.

Sustainability Analysis Execution

- The Defense Acquisition Guidebook
  - Requires performance of a Sustainability Analysis (SA) for all systems
- The Sustainability Analysis Guidance
  - Describes the SA process

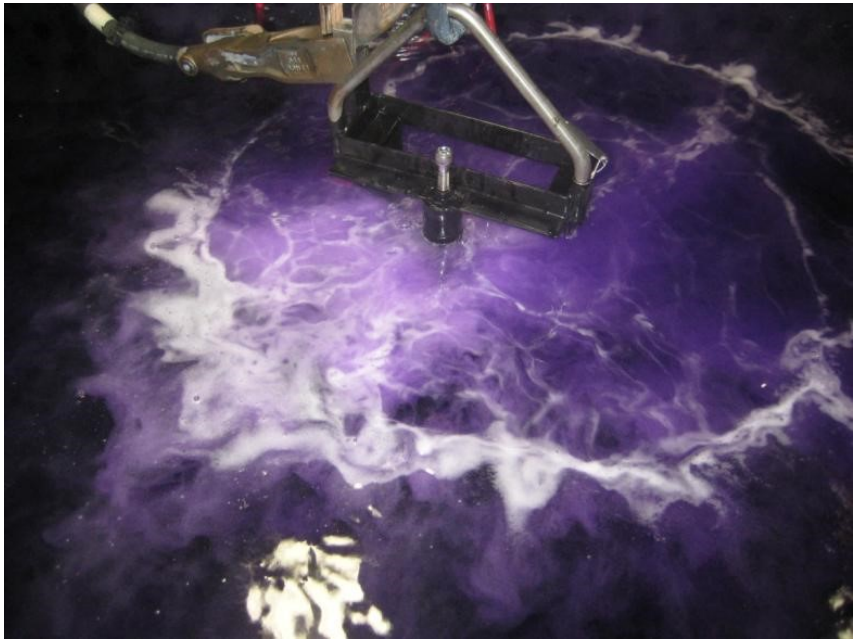


https://www.denix.osd.mil/esohacq/home/

Case Study

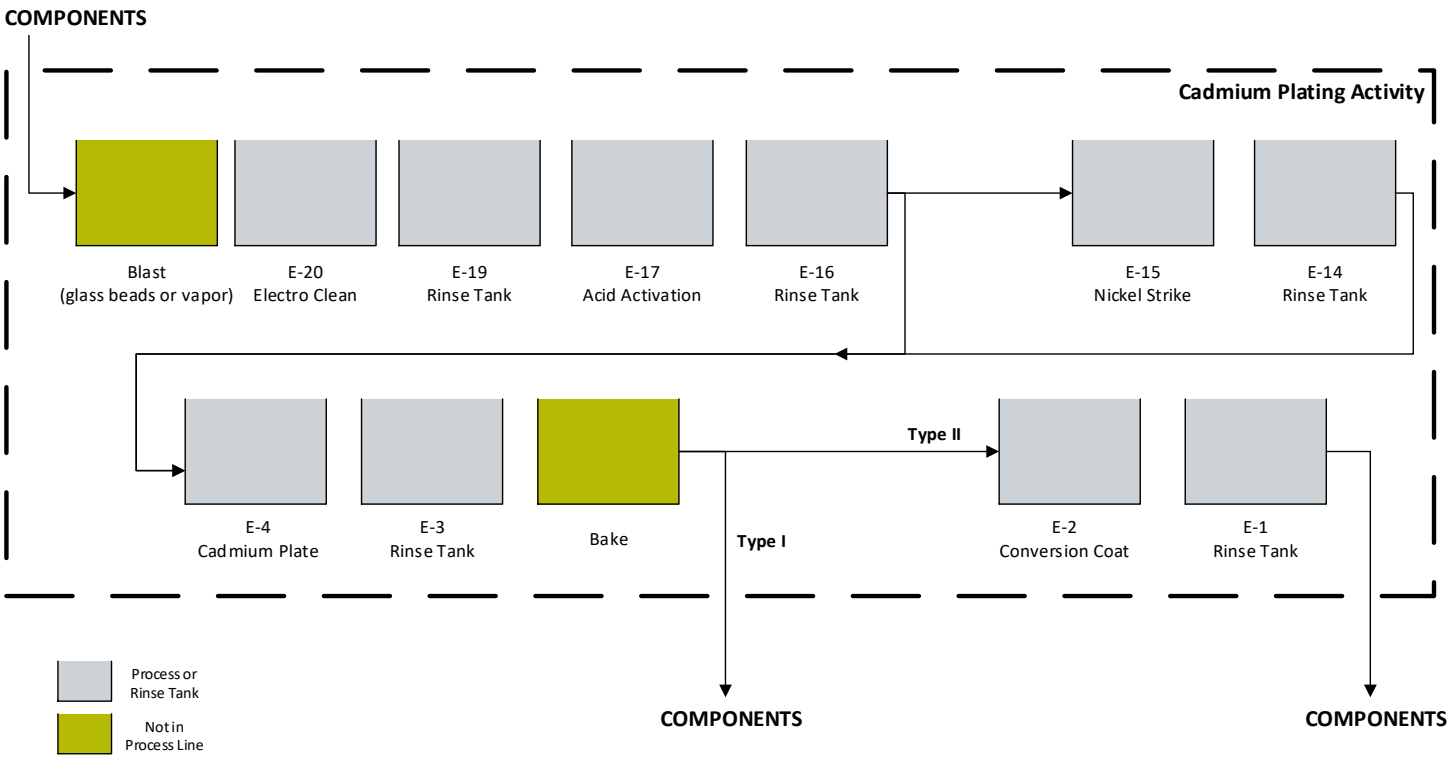
Switch to Zinc-Nickel (Zn-Ni) from Cadmium (Cd) Electroplating

- Objectives
  - Understand cost over life cycle
  - Understand environment, occupational health impacts
  - Office Assistant Secretary of Defense (OASD): Avoid burden-shifting throughout portfolio
  - Fleet Readiness Center Southeast (FRCSE): Communicate results up the command chain (e.g., build business case)



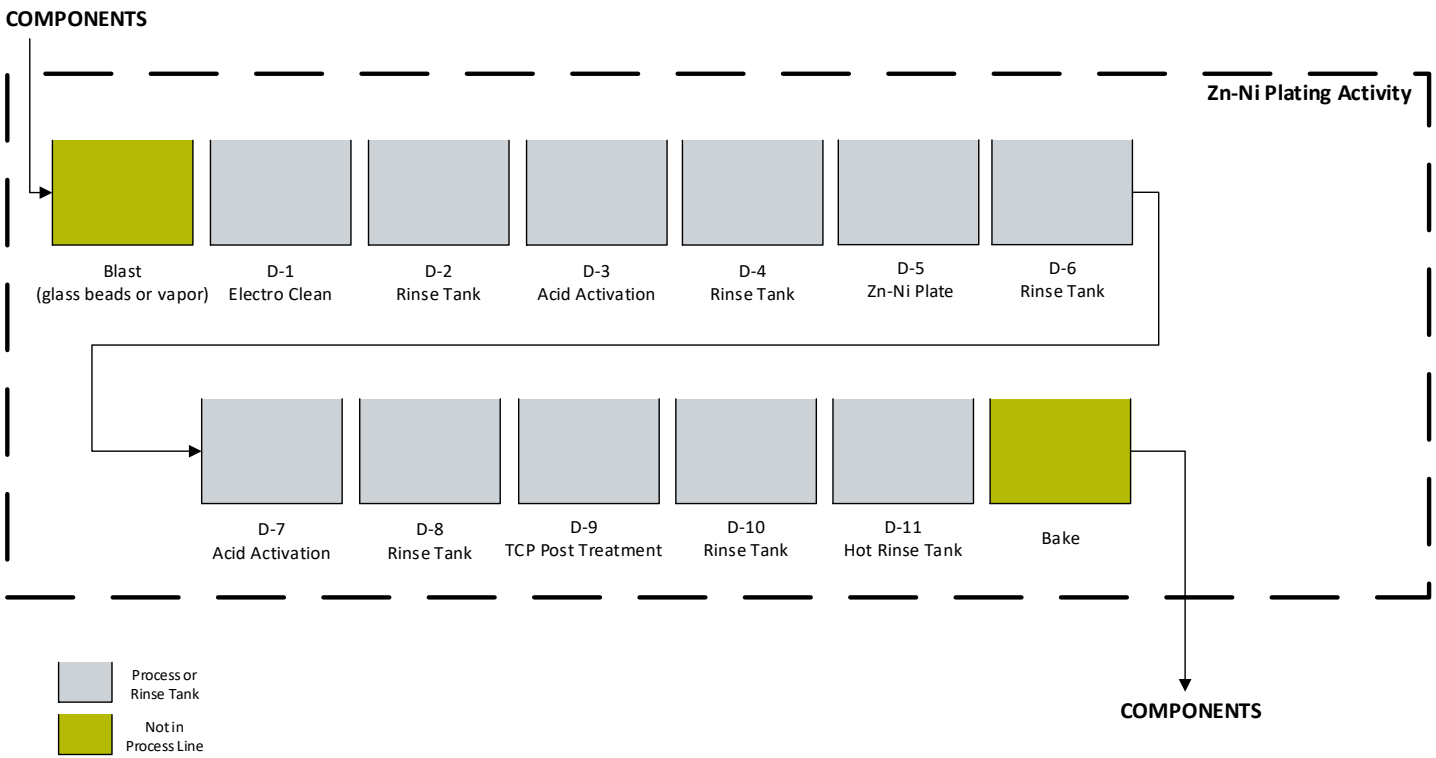
Low Hydrogen Embrittlement Zn-Ni Plating at Hill AFB
(ESTCP Project WP-201107)

Plating Line: Cd Baseline



- 15-year lifespan
- Capital costs associated with line installation are sunk
- Inputs and outputs for components with and without post-treatment are included

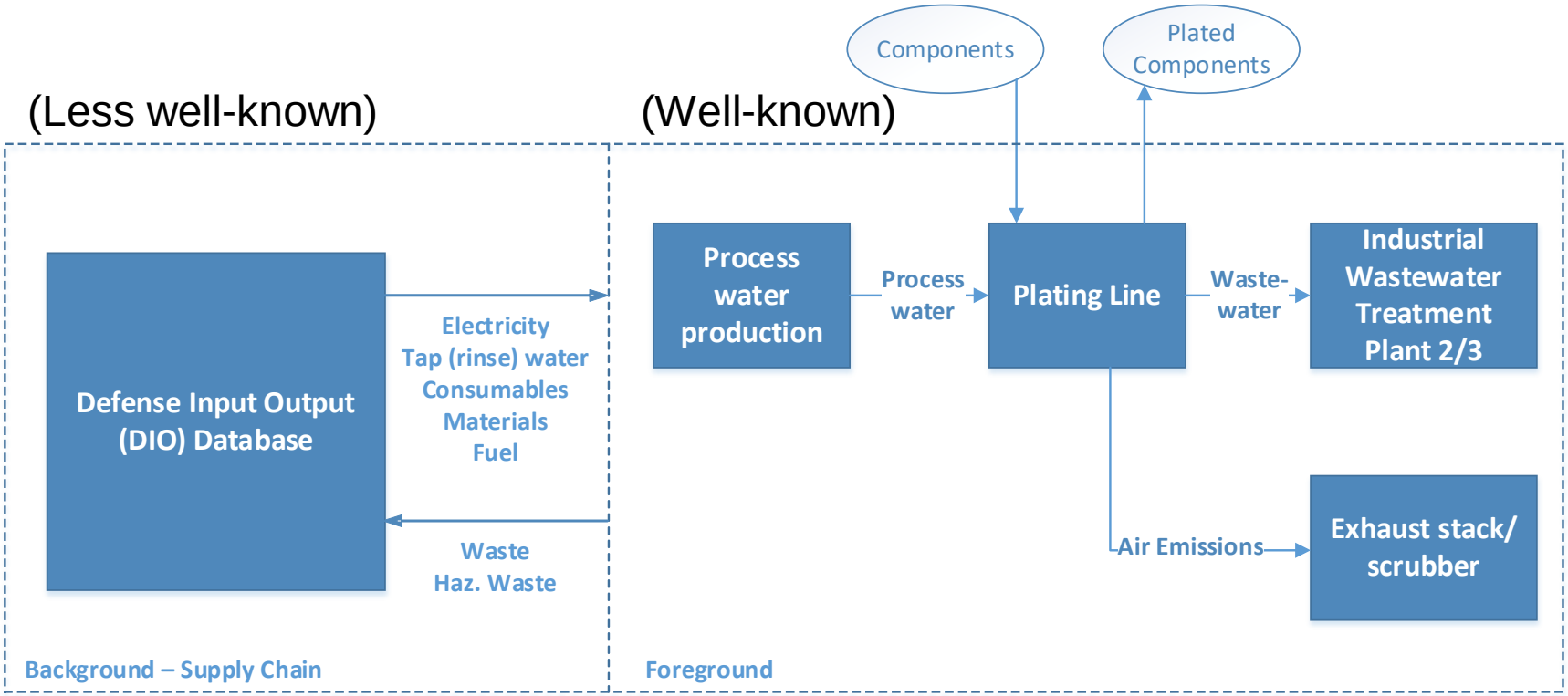
Plating Line: Zn-Ni Alternative



- 15-year lifespan
- Capital costs associated with line installation included
- High and low labor estimate scenarios

Scope of Comparison

Tiered Approach

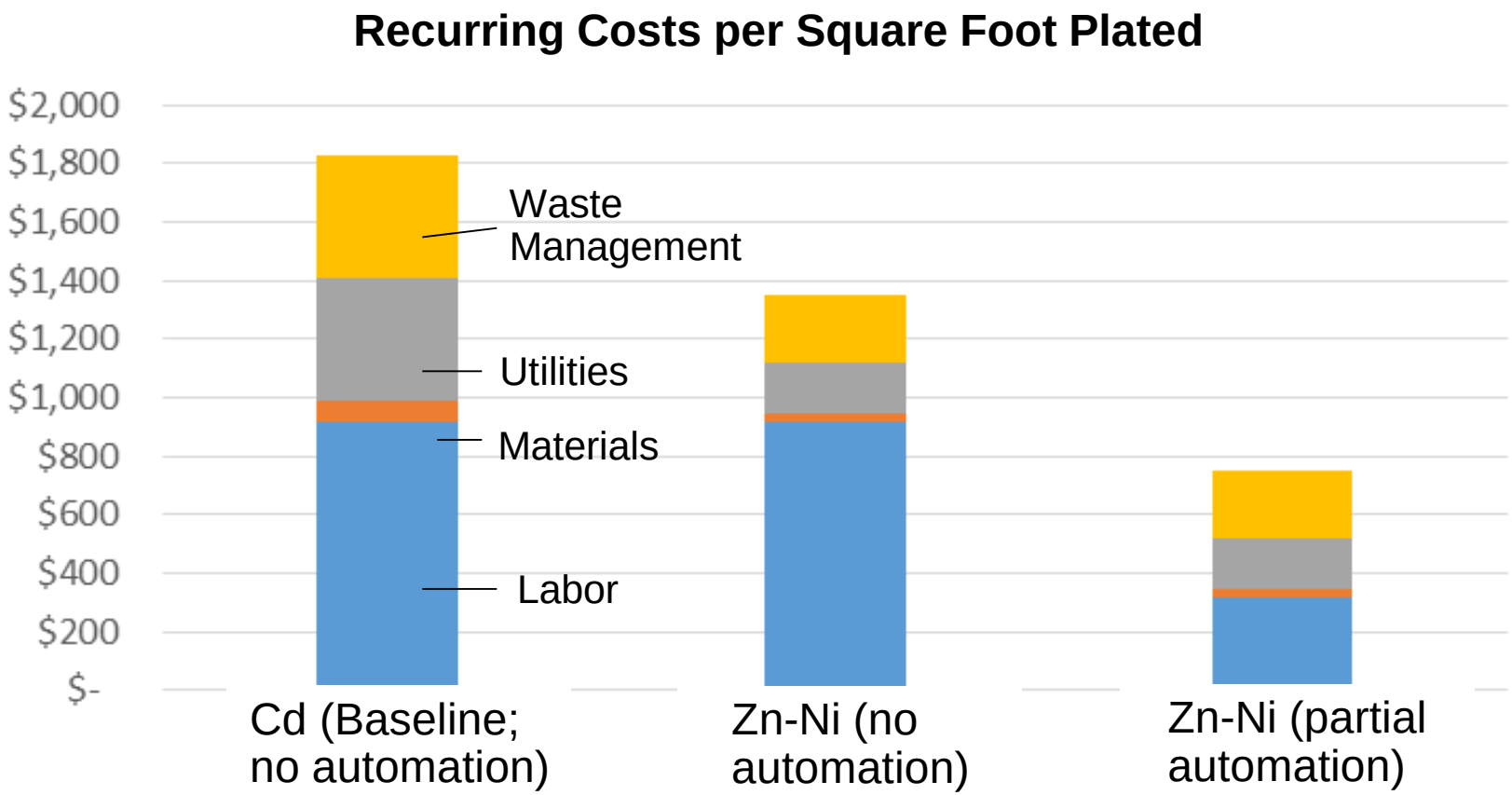


- Costs and environmental impacts are compared per ft^2 of plating over a 15-year line life span
- The system boundary includes the plating line, support infrastructure, and the supply chain

Life Cycle Costs (LCC)

Cost Category	Cd (Baseline; No Automation)	Zn-Ni (No Automation)	Zn-Ni (Partial Automation)
Labor	36%	36%	13%
Materials	3%	1%	1%
Utilities	17%	7%	7%
Waste Management	16%	9%	9%
Total Investment	0%	46%	46%

Life Cycle Costs (LCC)



Labor and capital investment are cost drivers

LCCs and O&M Costs

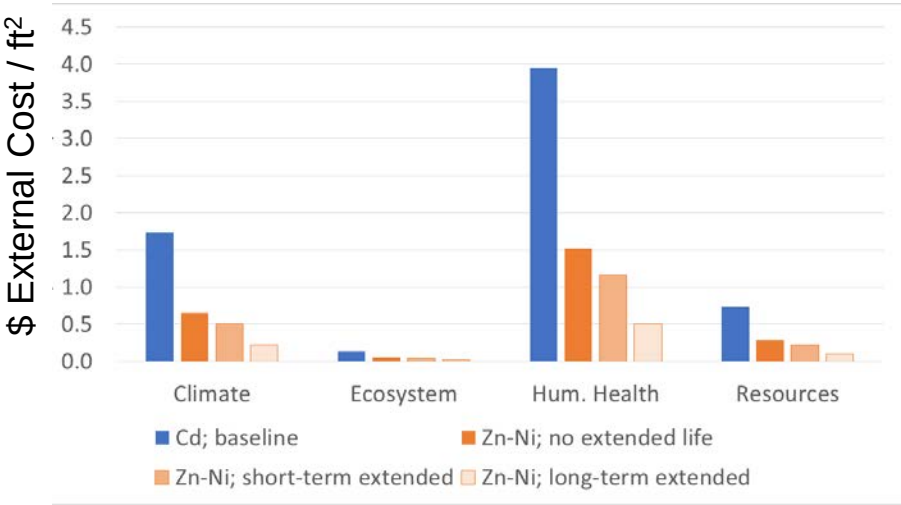
- Cd plating operations ~ \$1,830 / ft^2
- Zn-Ni plating operations between:
  - \$1,350 / ft^2 (worst case)
  - \$750 / ft^2 (best case)

Total Present Value (PV) of Annual Costs	Cd (Baseline; No Automation)	Zn-Ni (No Automation)	Zn-Ni (Partial Automation)
Labor	\$ 1,593,000	\$ 1,593,000	\$ 550,000
Materials	\$ 129,000	\$ 46,000	\$46,000
Utilities	\$ 730,000	\$ 309,000	\$ 309,000
Waste Management	\$ 723,000	\$ 403,000	\$ 403,000
Total Recurring	\$ 3,175,000	\$ 2,352,000	\$ 1,309,000

Life cycle operating and maintenance costs are lower for Zn-Ni than Cd plating

Life Cycle Impacts and External Costs

- Three scenarios were modeled to incorporate the impact of potential corrosion protection performance
  - "No extended life" – assumes identical performance between Cd and Zn-Ni
  - "Short-term extended" – assumes 30% improvement in performance
  - "Long-term extended" – assumes 200% improvement in performance



Life cycle impacts increasingly improve the more corrosion data impact the maintenance cycle

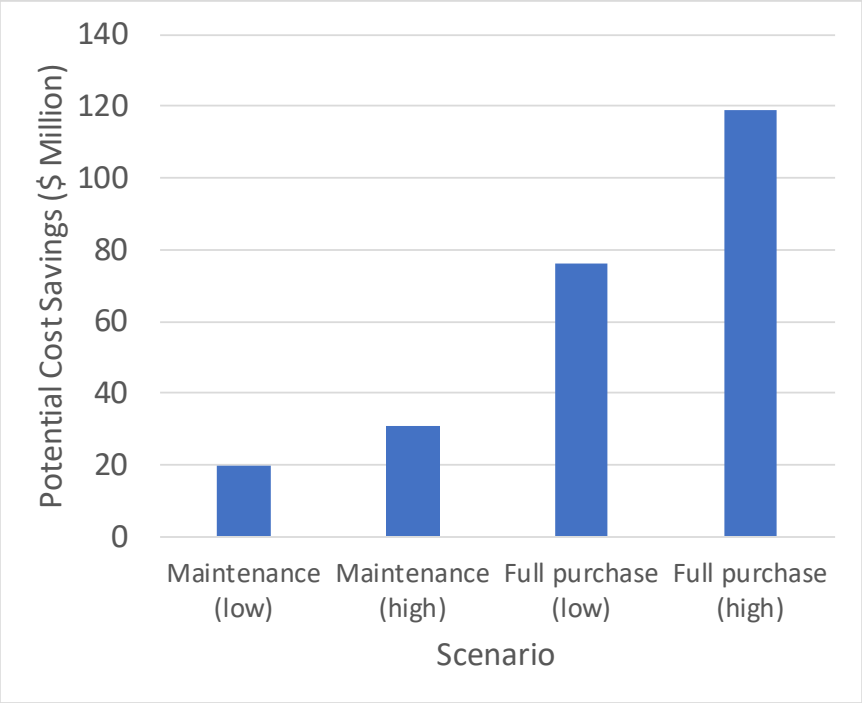
Comparison and Communication

Data

Item (Annual, Assuming Equivalent Coating Area)	Cd	Zn-Ni
Pounds of Cd used at FRCSE	45	0
Process chemical cost (normalized)	1	0.36
Labor hours (normalized)	1	0.64 - 1

Communication: Potential Savings for the Navy

- Multiple scenarios modeled
  - Full purchase scenarios assume 6-year life and new landing gear (LG) procured always
  - Maintenance scenarios assume LG life infinite and thus no procurement needed
  - Low scenarios estimate programmed depot maintenance (PDM) cycle extended by 2 years
  - High scenarios estimate PDM cycle extended by 4 years



An eight or ten-year maintenance cycle could result in 25-40% reduction in costs

Case Study Conclusions

- Opportunities for improvement
  - Corrosion testing may indicate longer life of components or less frequent repair plating
  - Parameters of higher importance could be explored further (e.g., labor, investment costs)
- How can results be used?
  - Can communicate results up the command chain (e.g., build business case)
  - High level picture of benefits and drawbacks (cost, quantitative, and qualitative) for alternative

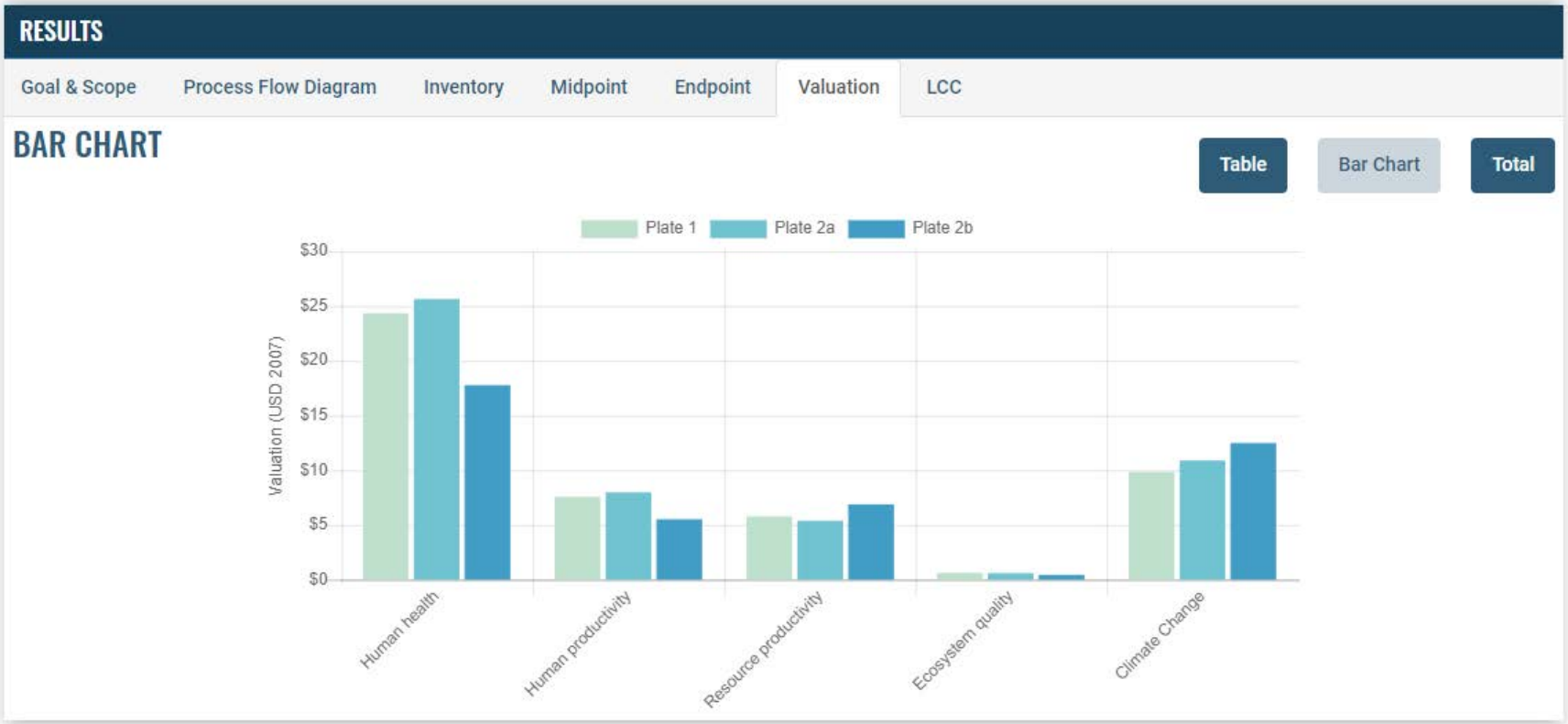
Tools and Resources

- There are databases, models and software tools available to help you to do a life cycle-based assessment or a Sustainability Analysis
  - Defense-based environmentally extended input output model
  - Characterization factors, including DoD Scoring Factors
  - Spreadsheets or open-source software (learning curve)
  - SparkLC web tool available to SERDP-ESTCP PIs (easier to get started quickly; based on DoD requirements)

Example: Notional Plating

Process	Plate 1	Plate 2a	Plate 2b
DI Water (user-defined process)	Low	High	Med
Other basic inorganic chemical manufacturing (based on North American Industry Classification System code 325180)	High	Med	Low
Water, sewage and other systems (221300)	High	High	Low
Electricity use, average generation mix, Florida	Med	High	Low
Coating, engraving, heat treating and allied activities (332800)	Yes		
Natural gas combustion, small conventional low NOx burner (<100 MMBtu/hr)			Yes
Nonferrous metal (except copper and aluminum) (331490)			Yes
Truck transportation (484000)			Yes

Example With Web Tool: External Costs Show Tradeoffs and Possible Liability



Conclusions

- Costs for weapons systems are driven by O&S and liabilities (supply chain and ESOH)
- Costs need to be part of research and design (per DoD guidelines)
- Systematic and holistic cost assessment requires Sustainability Analysis
- Tools are available to facilitate these assessments
  - DoD Sustainability Analysis Guide
  - DoD Scoring Factors
  - SparkLC web tool
  - Open-source and paid software and databases

Benefits to DoD

- The Sustainability Analysis approach, along with associated tools, aims to accomplish the following
  - Improve affordability of weapons systems and platforms
  - Help researchers identify potential cost, supply chain and ESOH issues

For additional information, please visit

https://noblis.org/

https://www.denix.osd.mil/esohacq/home/

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Q&A Session 2

SERDP DOD • EPA • DOE | ESTCP

The next webinar is on October 3, 2019

Variation in Phenological Shifts: How do Annual Cycles and Genetic Diversity Constrain or Enable Responses to Climate Change?

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Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends

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