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For the best of reasons

Sustainability Analysis: Capturing Life Cycle Impacts and Costs in Defense

Short Course 3B

November 29, 2018

Washington, DC

SERDP ◆ ESTCP SYMPOSIUM

2018 | Enhancing DoD's Mission Effectiveness

Sustainability Analysis: Capturing Life Cycle Impacts and Costs in Defense

- Course overview:
  - Demonstrating that a chemical, process, or product is more sustainable or greener than the original requires data, tools, and interpretation. DoD's Sustainability Analysis method provides researchers and program officers with a way to collect and produce the evidence needed to support decisions that promote sound environmental stewardship.
- This short course will:
  - Describe Life Cycle Thinking / Sustainability Analysis (SA) at DoD
  - Show how results of SA were useful to analysts/program managers/etc.
    - For communicating with peers and management
    - For informing design (from Defense Acquisition Guidebook)
    - For improving analyses (and meeting SON/BAA requirements)
  - Identify data, software, and other resources for SA
- Instructors:
  - Kelly Scanlon, DrPH, CIH
  - Andrew Henderson, PhD

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Item	Length
Introduction	**10 minutes**
• Objectives, agenda, welcome • Getting to know one another	
Life Cycle Thinking in DoD	**20 minutes**
• Sustainability in SERDP and DAG • LC / SA method overview • Examples	
Break	
Responding to SON, BAA, etc.	**45 minutes**
• Resources to conduct SA • Technical examples	
Conclusion	**15 minutes**
• Concluding remarks • Question and answer	

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Getting To Know One Another

- What is your affiliation and role?
  - R&D Firm, Entrepreneur, OEM, Venture Capitalist, University, DoD Program Manager, DoD System Engineer
- Have you responded to a SON or BAA before?
- Do you have experience doing LCA or SA?
- What do you want to get out of this course?
- Other questions?

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Life Cycle Thinking at DoD

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Life Cycle Thinking in SERDP Statements of Need
Example: Development of Advanced Coating System (WPSON-20-C1)

- Objective: New, innovative advanced protective coatings and systems
  - Improved protective properties
  - Require few resources
  - Easier to use
  - Environmentally sustainability
- The “new” system must be able to meet performance requirements …
  - Operational protective properties
  - Less complex application techniques
  - Ability to selectively strip or apply coatings
- … and, it must be more sustainable …
  - Reduced life cycle costs and impacts associated with human health and the environment
  - Energy efficient
  - Improved chemistry
- … when compared with current and legacy systems.

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Life Cycle Thinking in SERDP SEED Proof of Concept
Example: Reduction of Hazardous Waste Streams from Composite Manufacturing and Repair (WPSEED-20-S1)

- Objective: Enable reuse or recycle of composite material
  - Reduce waste
  - Reduce environmental and worker exposures to chemicals and particulates
  - Reduce impact of composite material waste (millions of pounds of hazardous waste)
- The “new” system must perform …
  - Manage shelf-life and expiring materials
  - Identify scrap uses
  - Change the way composite materials are produced
- … and, it must be more sustainable …
  - Reduced life cycle costs and impacts associated with human health and the environment
- … when compared with current and legacy systems.

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Life Cycle Thinking in the Acquisition Process
Example: Defense Acquisition Guidebook (Ch 3 – 2.4.3)

- Objective: Assist System Engineer to design more sustainable systems
  - Use fewer resources across life cycle
  - Create fewer impacts on human health, environment
  - Generate lower life cycle costs, total cost of ownership
  - Make systems more affordable
  - Improve accuracy of life cycle cost estimates
- Use Sustainability Analysis to make data-driven decisions
  - Preliminary design
  - Analysis of alternatives
  - Trade Space Analysis
  - Business Case Analysis
  - Hazard Analysis
  - Energy Analysis

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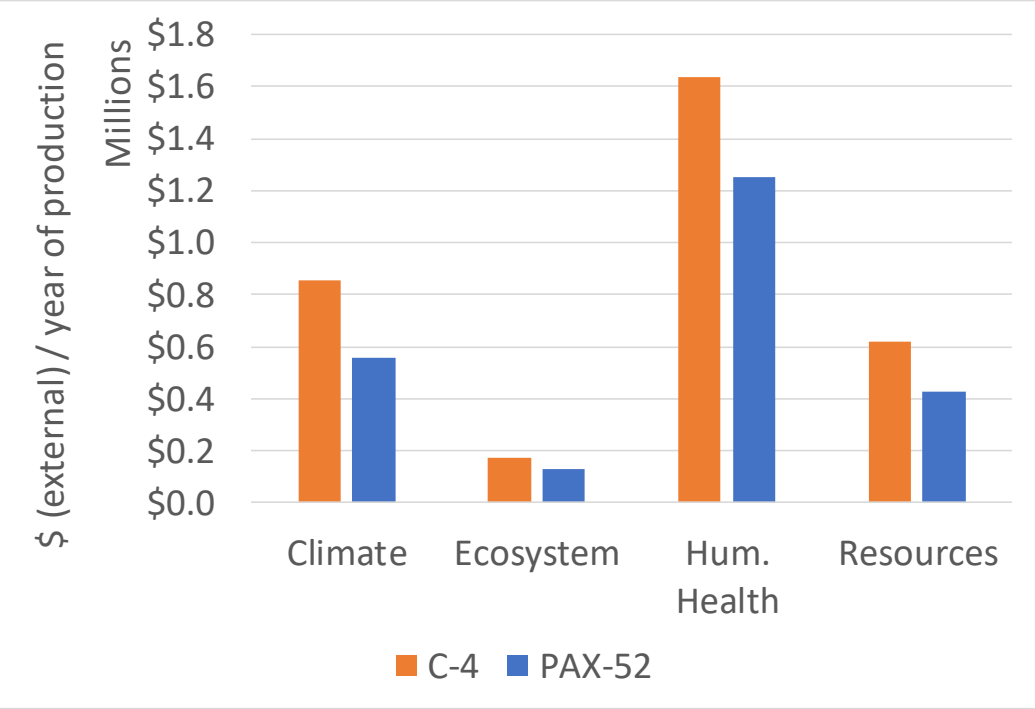
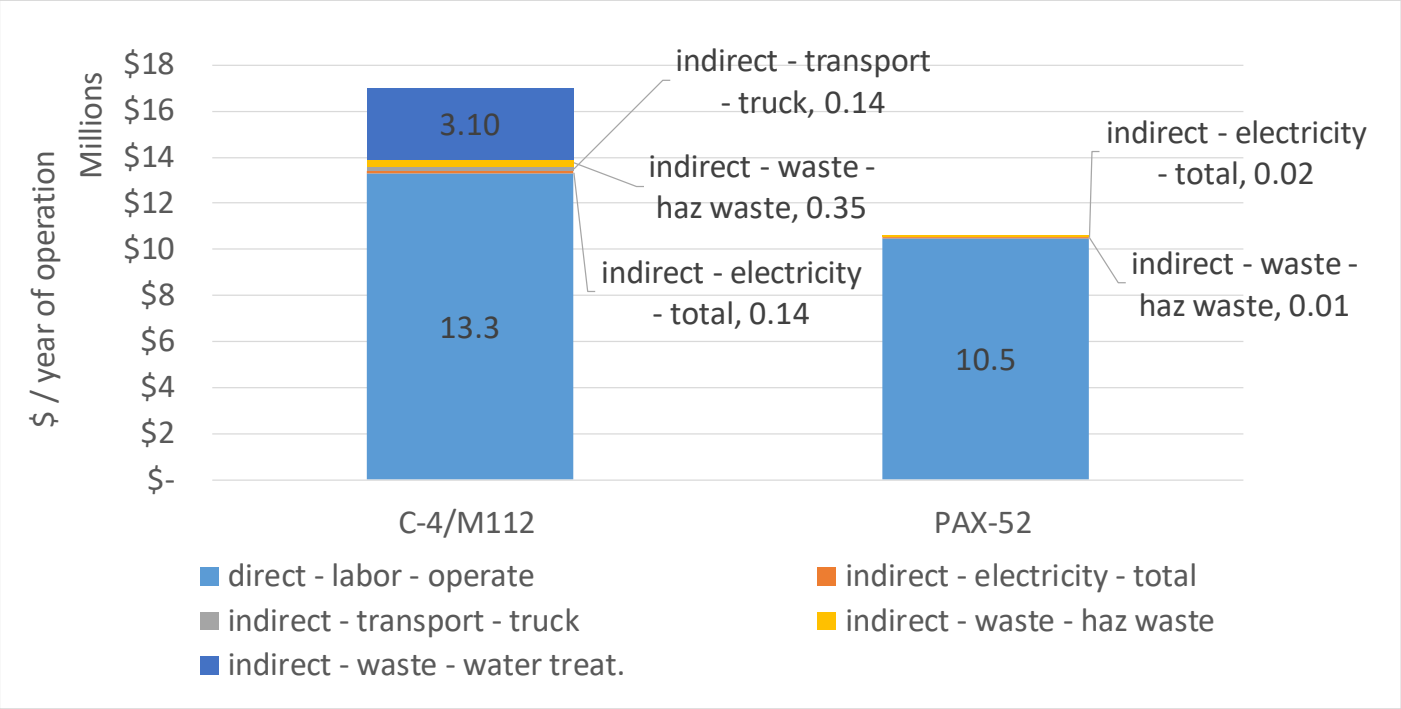
Life Cycle Thinking / Sustainability Analysis Can Provide You With Evidence to Support Claims of Sustainability





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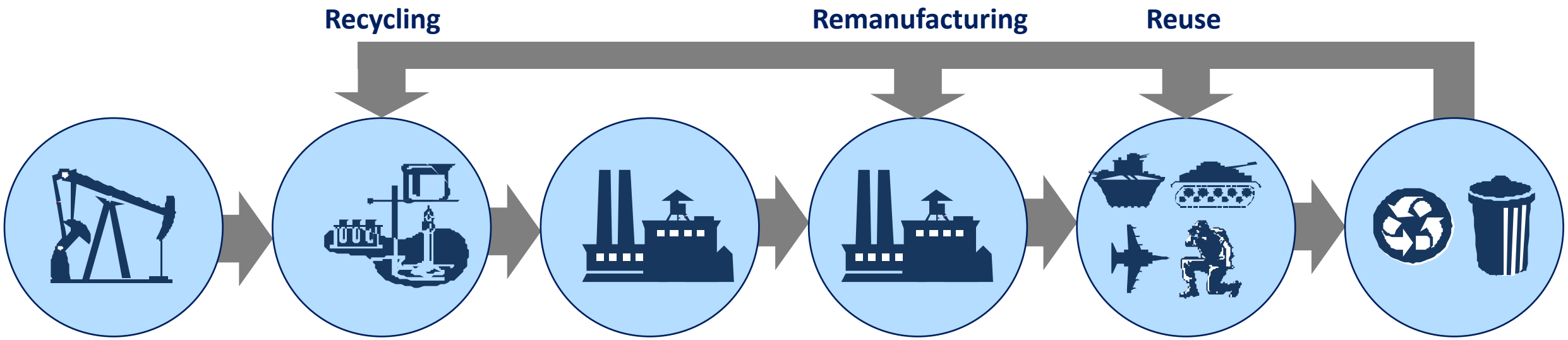
What Do We Mean By a Life Cycle? What Is Life Cycle Thinking?



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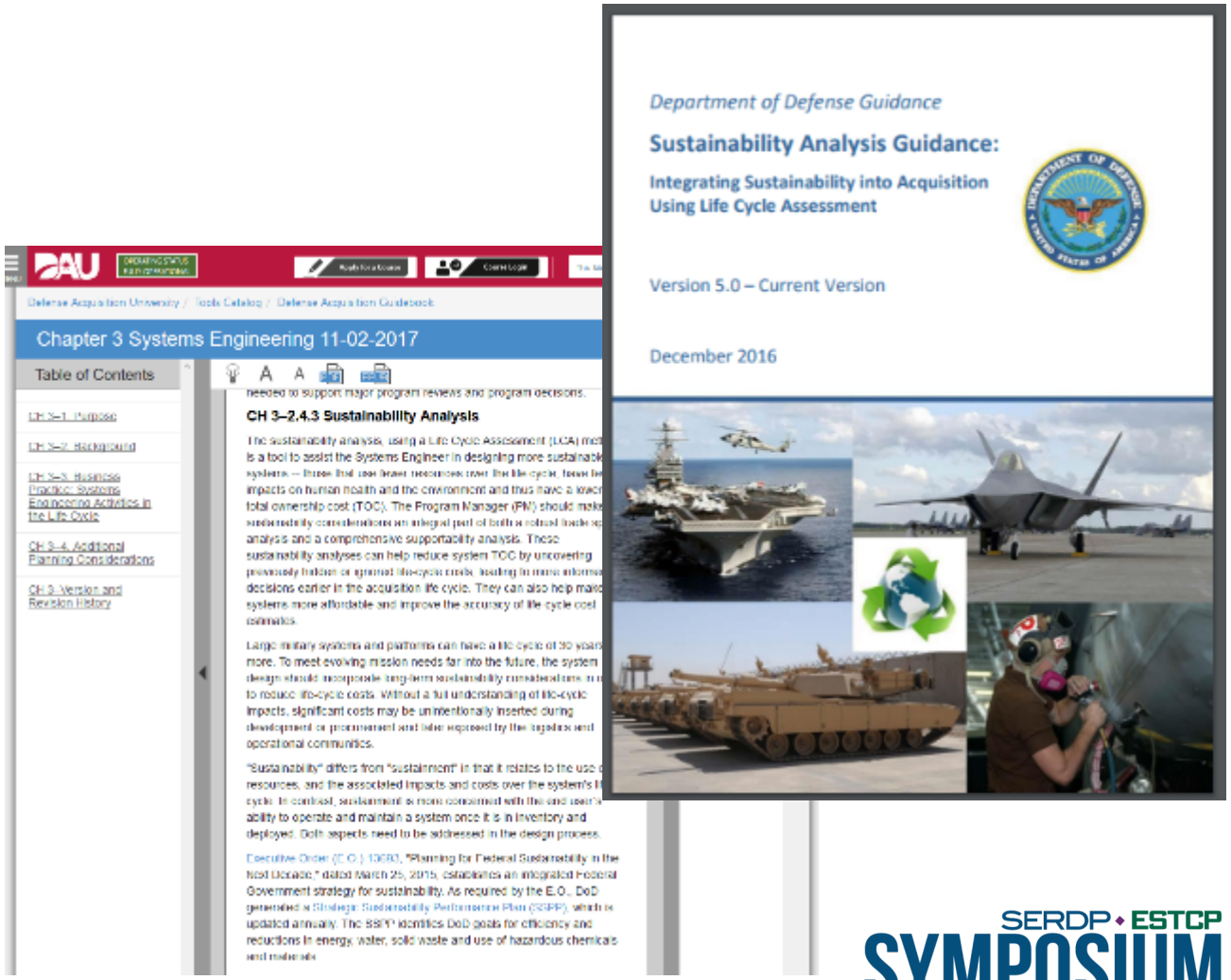
Sustainability Analysis at the DoD

- The Defense Acquisition Guidebook requires performance of a Sustainability Analysis (SA) for all systems.
- The Sustainability Analysis Guidance describes the process for performing an SA



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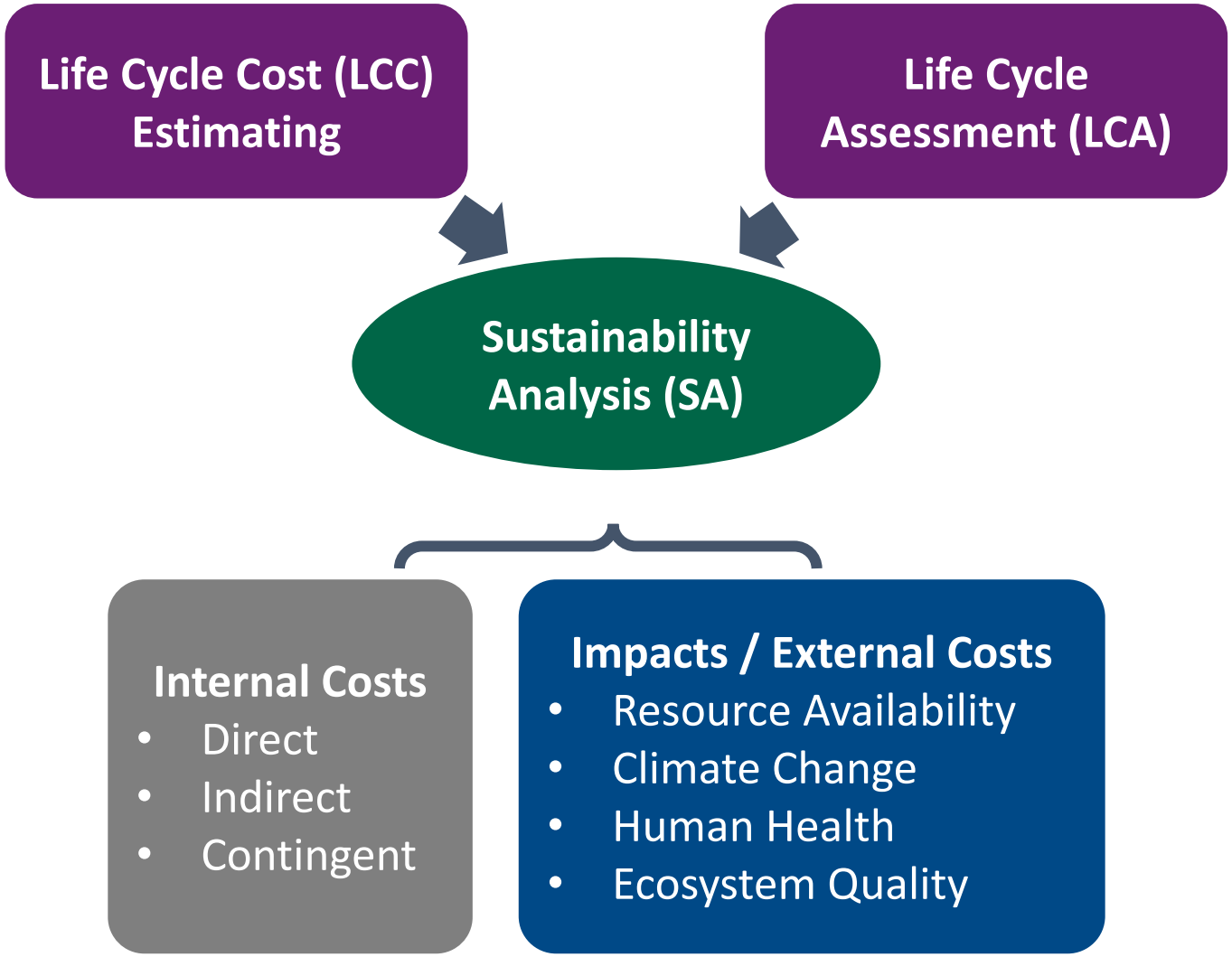
Sustainability Analysis Framework



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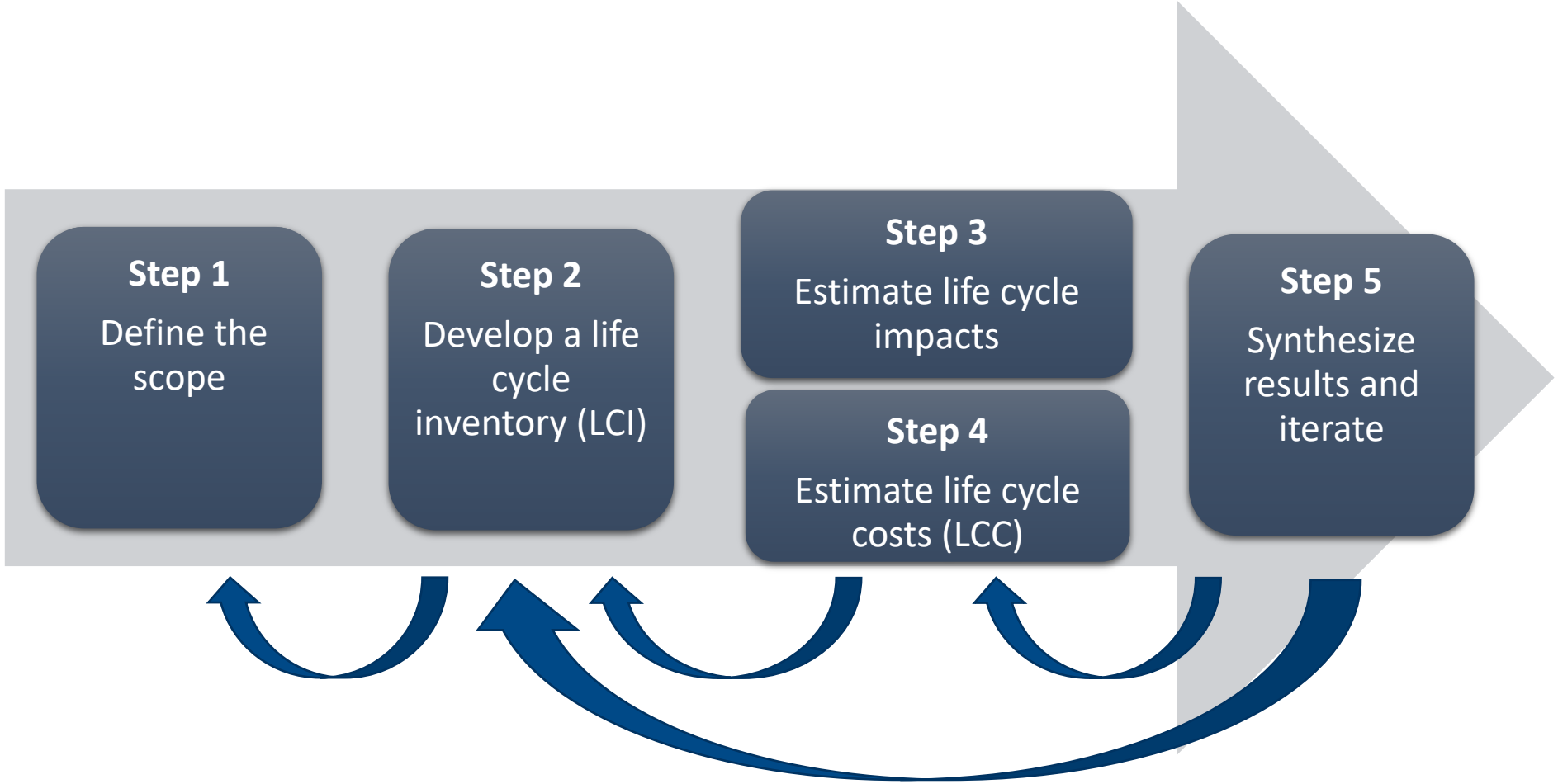
Sustainability Analysis is a 5-step, Semi-iterative Process



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Sustainability Analysis is Informed by Standard Practices

LCC Estimating

- 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.

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.

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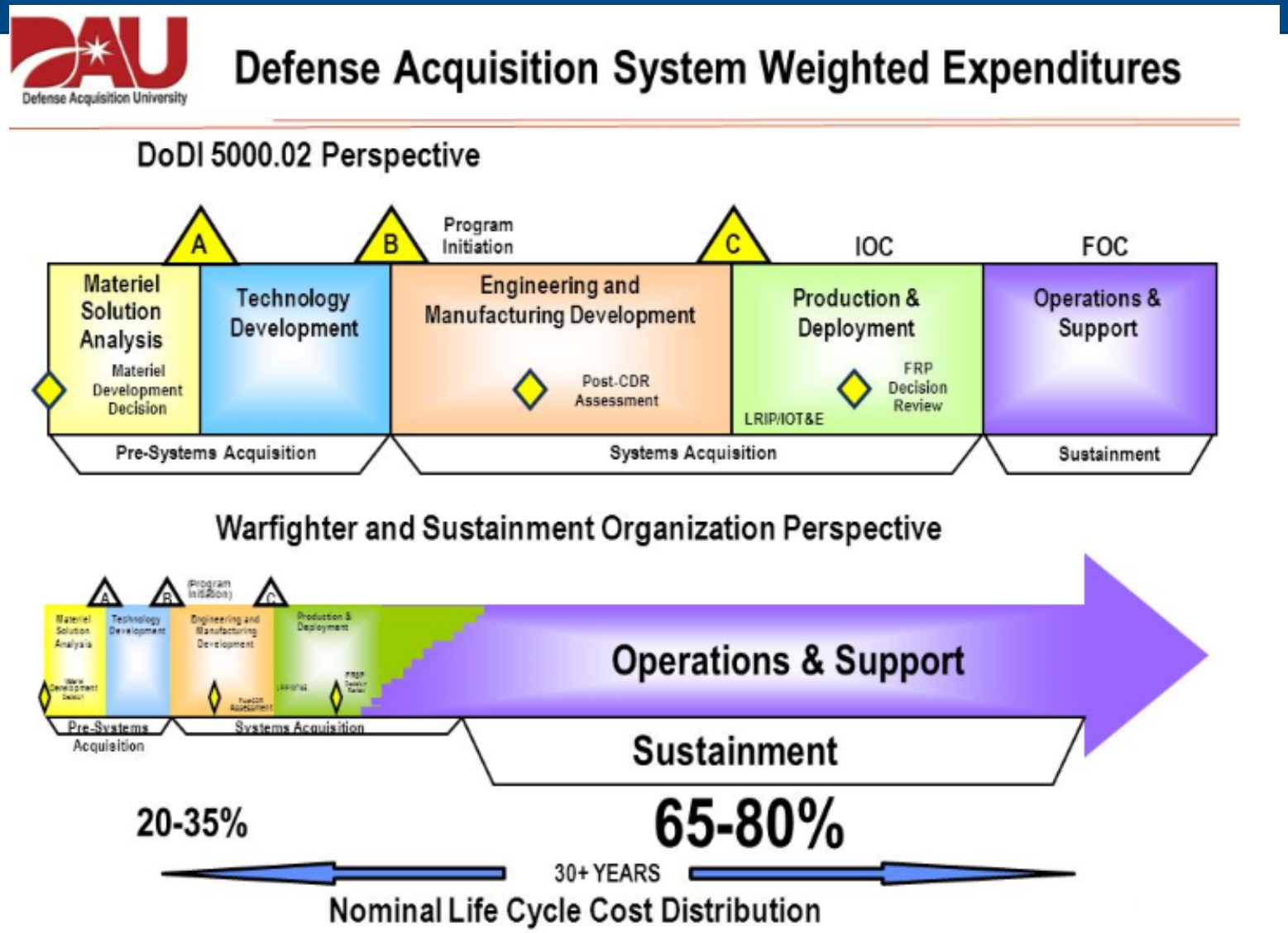
What is the DoD Acquisition Process?



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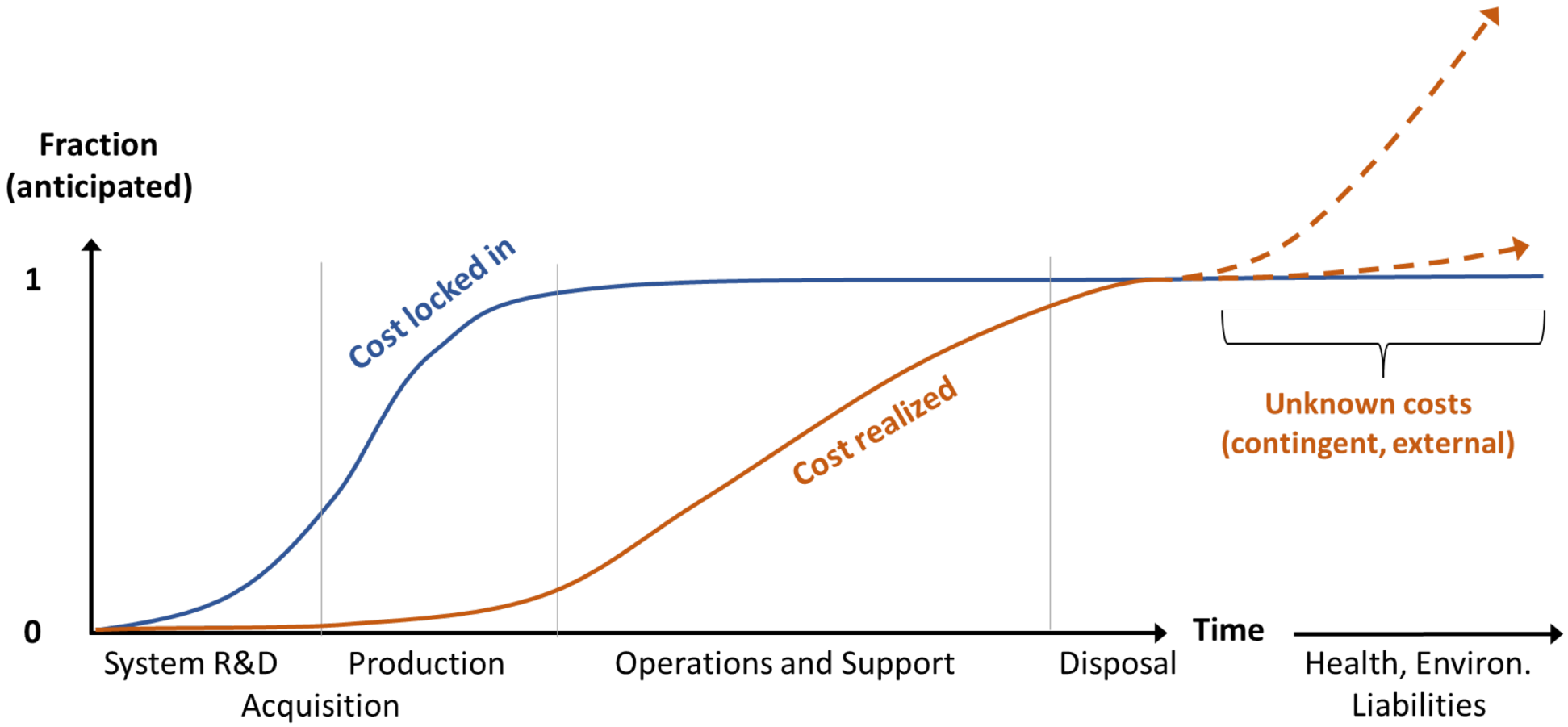
There is a Need to Capture LCC Comprehensively



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Types of Costs Considered

Direct Internal Cost	Indirect Internal Cost	Contingent Internal Cost	External Cost (social cost)
• Procurement cost of material • System manufacturing	• Procurement cost of PPE • Hazardous waste management	• Clean up of pollution • Medical cost for DoD personnel • Substitute development and testing	• Damage to human health • Damage to ecosystem quality

Revealed and quantified using LCC estimating

More fully revealed through LCA

Revealed and quantified through LCA

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Examples of Life Cycle Thinking and Sustainability Analysis

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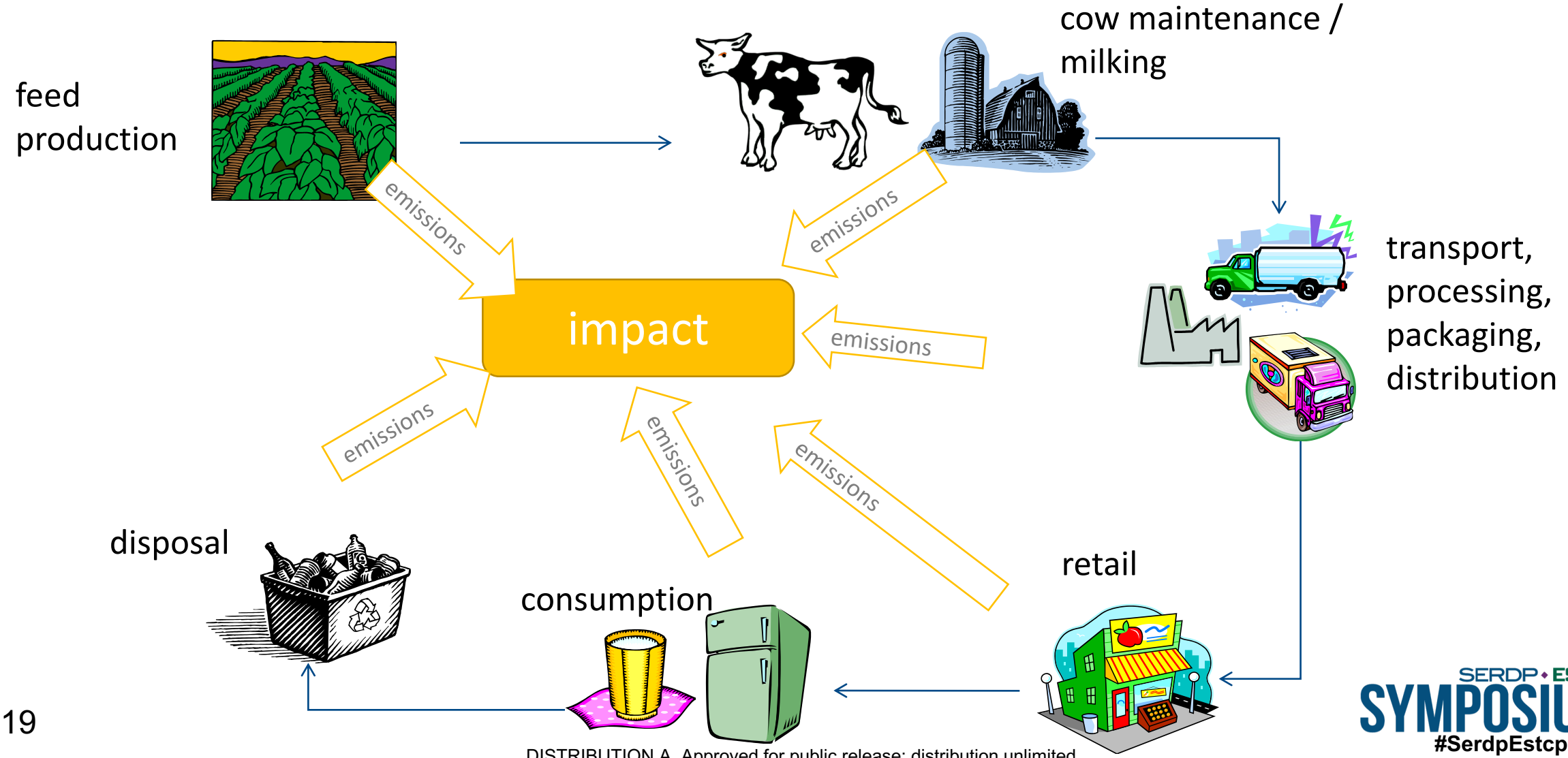
Life Cycle of Milk



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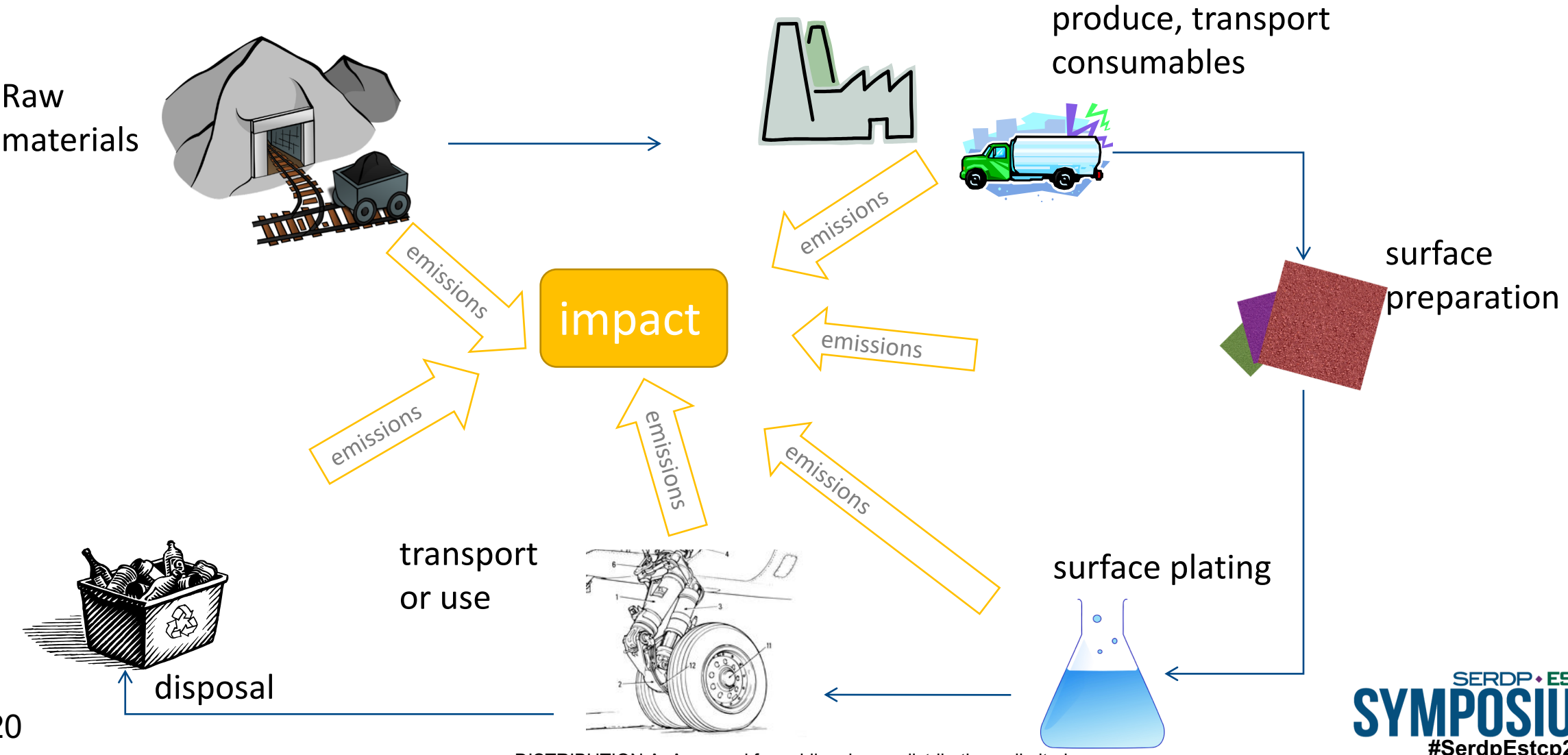
Life Cycle of a Surface Coating



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How You Can Support Claims of Sustainability

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How You Can Support Claims of Sustainability

Scenario 1

Baseline

Use baseline fluorescent fixtures with NiCd battery backup units

Scenario 2

Drop-in Replacement

Replace fluorescent fixtures with equivalent LED fixtures and use NiMH backup units

Scenario 3

Optimal Design

Use appropriate number and type of LED fixtures for optimal lighting with NiMH back up units

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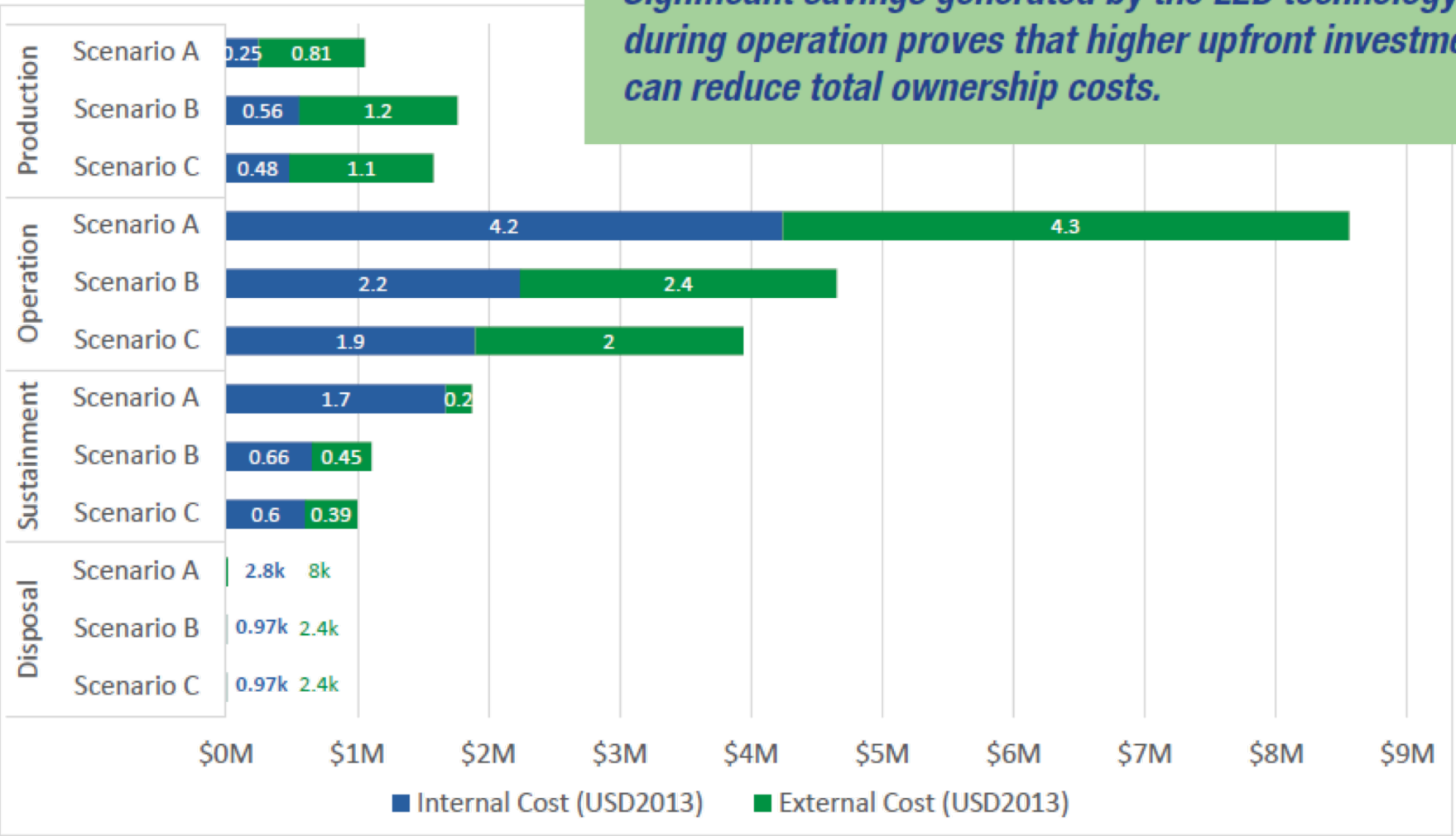
How You Can Support Claims of Sustainability

Significant savings generated by the LED technology during operation proves that higher upfront investments can reduce total ownership costs.



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Value of This Approach

	Milk	Ship Lighting	Coating	Explosive
(Unexpected) Results	• Human health issues are from the dairy farm – NH3 from manure and PM from tractors	• Save energy AND reduce accidents by reducing maintenance	• Improved performance of Zn-Ni leads to labor, wastewater, etc. savings • Quantify Cr reductions	• Labor: cost savings in manuf. process with fewer steps; also improved worker conditions • Scale-up of reagent production important for cost predictions
Added value for communication	• Identify specific processes to improve • Advertising claims grounded in research	• Multiple arguments for switching lighting: cost, environment, and employees	• Quantify reduced cost AND reduced potential environmental liability	• With *current* cost, current system is preferable, but this changes with full labor costs. • Quantified benefits of reduced liability of compounds in alternative.

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Break

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Responding to Statements of Need, Broad Agency Announcements, etc.

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The DoD Portfolio for Sustainability Analysis …

- Builds awareness with policy makers and practitioners
- Provides guidance and support to enable success
- Delivers tools and resources that make it "easier" to do

… readies you to respond to SONs and BAAs which ask you to …

- Develop a baseline life cycle framework
- Identify elements of a life cycle inventory
- Conduct a preliminary LCA to assess cost, health, and environmental impacts of proposed approach
- Perform an initial assessment of human health and environmental impacts of proposed ingredients, formulations, byproducts

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Building Awareness

We are engaging with experts …

- DoD RDT&E stakeholders
- DoD community of practitioners
- DoD acquisition community
- Federal LCA Commons
- Professional societies for LCA

… so that we have a cadre of DoD personnel and outside experts who

- Are familiar with life cycle thinking and the Sustainability Analysis methodology
- Can help us to “make the case” for this type of approach
  - Evidence and data to support claims of “sustainability,” “green,” “safe,” “better”

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Expertise

- DoD
  - OSD Chemical & Material Risk Management Program
  - USACE Engineer Research and Development Center
  - And more
- Academia
- Industry
- Professional Organizations
  - SETAC
  - ACLCA

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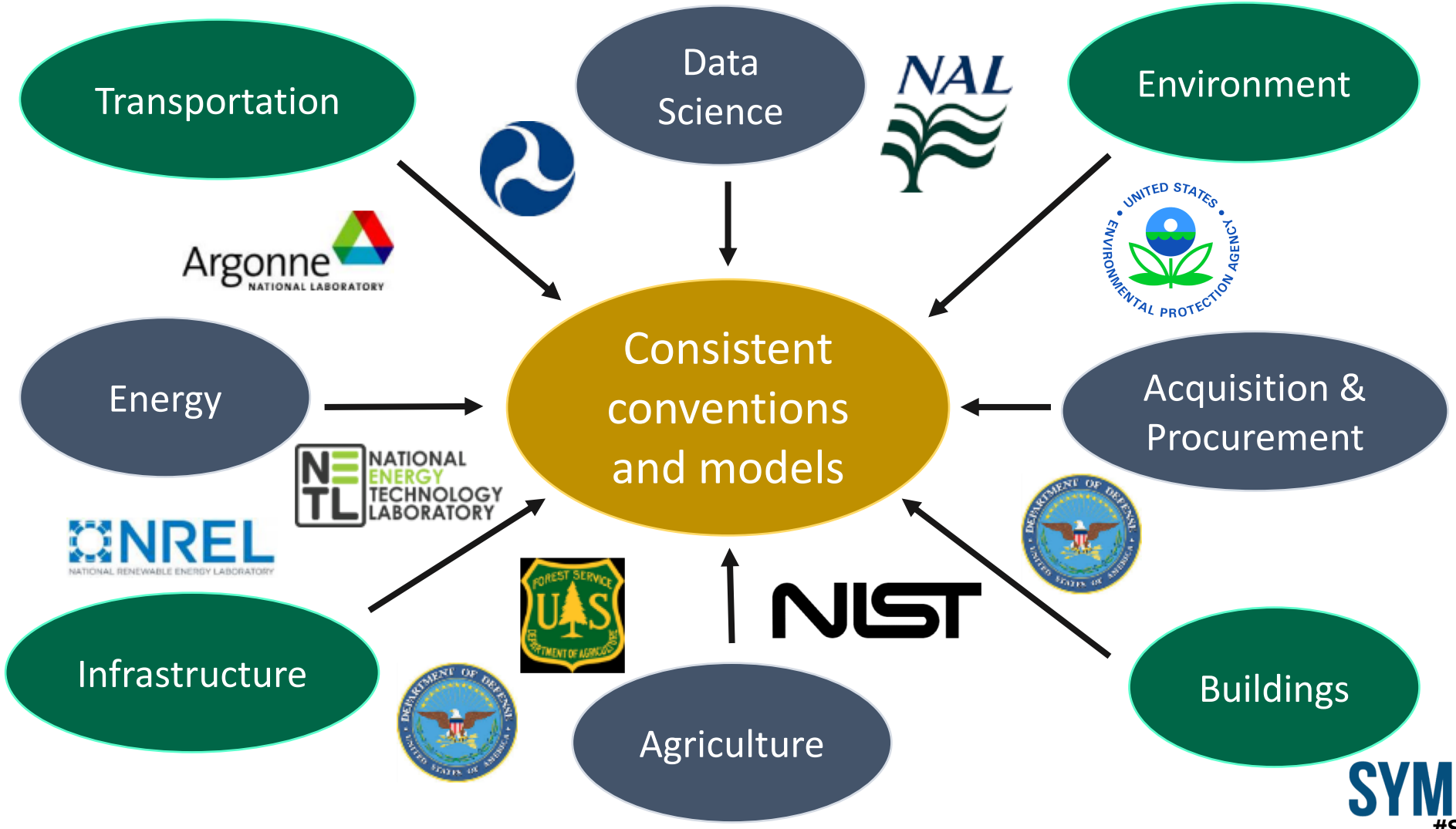
Federal LCA Commons



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Guidance and Support

We have Sustainability Analysis guidance and can offer technical support so that you …

- Consistently apply data, models, and methods
- Communicate results and recommendations suitable for various audiences

… can make efficient and effective analyses; resources available to you:

- Sustainability Analysis Guidance document and DENIX site
- Stepwise methodology
- Data Requirements listing
- Repository of pilot projects

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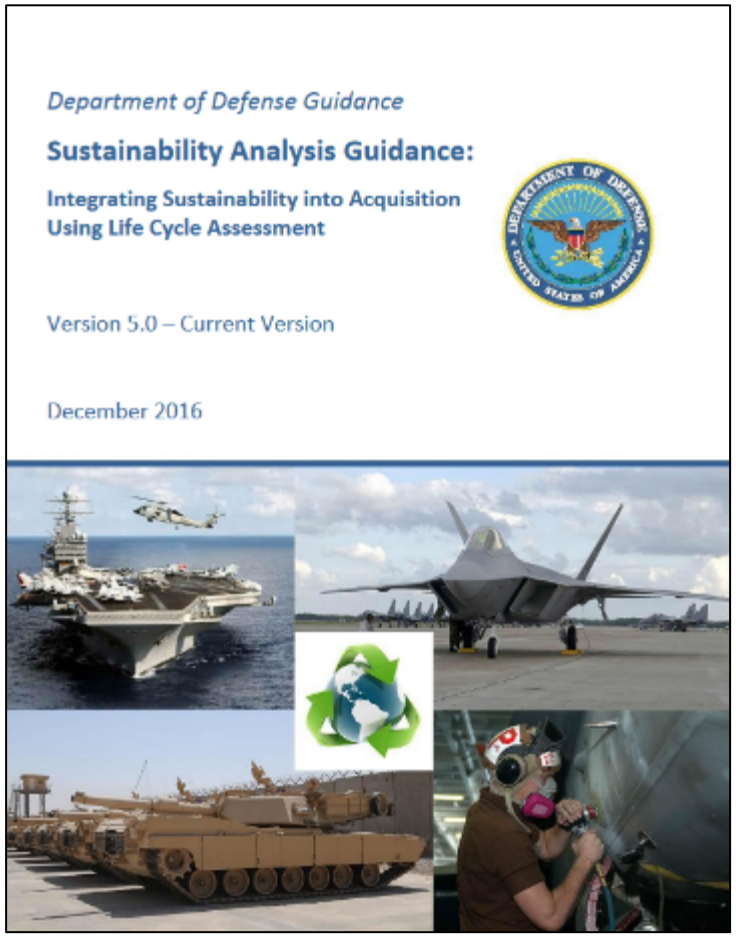
Sustainability Analysis Guidance Document

- Offers a consistent, practical, flexible methodology
- Can be used to develop the scope, inventory, impact assessment, cost assessment
- Uncovers previously hidden human health and environmental impacts and their associated life cycle costs
- Can be used to identify the most sustainable alternative among those that meet performance requirements

- Available at http://www.denix.osd.mil/esohacq/home/



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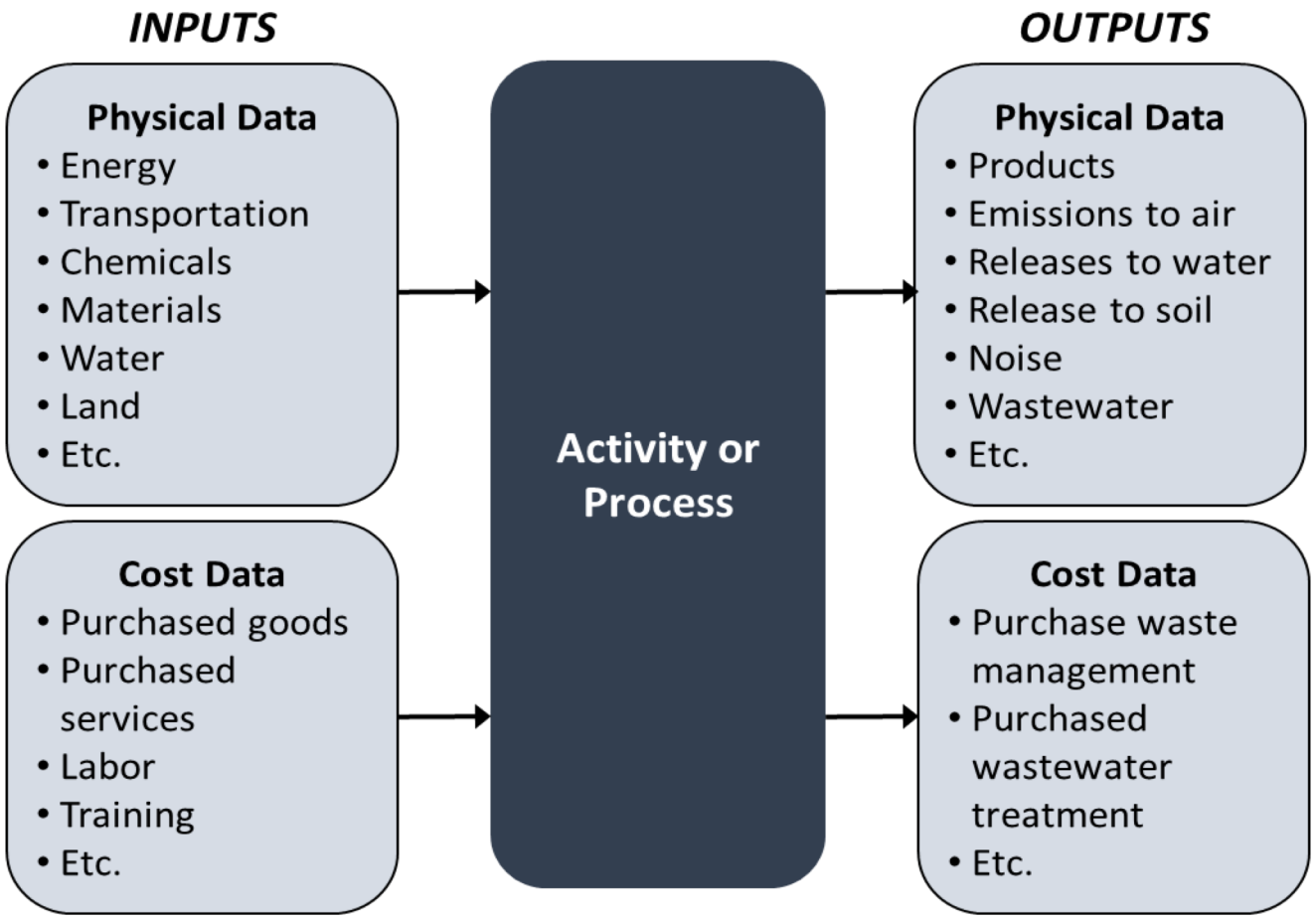
General Data Requirements for an Inventory



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Examples of Pilot Projects

- Boeing P-8 Poseidon Aircraft (2013): exterior coatings with and without CrVI
- Sikorsky MH-60R Seahawk Helicopter (2013): exterior coatings with and without CrVI
- Superstructure Non-combat Ship (2015), notional example: steel and composite superstructure materials
- GE fuel nozzle for aircraft engine (2016): traditional and additive manufacturing
- AF brush plating for repair operations (2017): eliminate or reduce cadmium in repair process
- Navy anodizing for repair operations (2017): eliminate or reduce CrVI in coatings process
- AF paint removal from military components (planned 2018): eliminate or reduce methylene chloride, waste

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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.

Examples:

- Defense-based environmentally extended input output model
- Characterization factors, including DoD Scoring Factors

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Examples of Publicly Available Data

- Scoring Factors – DoD
- US Environmental Protection Agency, US Environmentally Extended Input-Output (USEEIO) Model
- USDA LCA Commons, Life Cycle Inventory database with agriculture focus
- US Life Cycle Inventory database, providing US based LCI data, polymers and more! available at https://uslci.lcacommons.gov/uslci/search
- NETL, Unit Process Library at www.netl.doe.gov/LCA
- NREL, Feedstock Production Emissions to Air Model (FPEAM) quantifying air emissions inventory for biofuels production system.
- ANL, GREET LCA model (with GREET1—fuel cycle model; GREET2—vehicle cycle model; CCLUB—land use change model for biofuels)
- Berkeley Lab, Lifecycle Industry GHgas Technology Energy through the Use Phase (LIGHTnUP) analysis tool available at https://eaei.lbl.gov/tool/LIGHTEnUP
- NIST, BIRDS and BEES for building sustainability associated with energy, environment, and costs

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Scoring Factors

Factor Class.	Factor Type	Inventory Element	Inventory Item	Inventory Item Unit	Resource Avail.	Climate Change	Human Health	Environ. Quality	External Cost
					MJ extra	*kg CO2-eq*	*DALY*	*PDF*m2*y*	USD2014
Input	Supply Chain	Chemicals & Materials	Oilseed farming (1111A0)	USD2014	2.0E+00	7.1E-01	3.2E-07	2.1E+00	1.9E-01
Input	Supply Chain	Chemicals & Materials	Synthetic dye and pigment manufacturing (325130)	USD2014	7.2E+00	9.5E-01	6.1E-07	5.8E-02	2.4E-01
Input	Supply Chain	Chemicals & Materials	Other basic inorganic chemical manufacturing (325180)	USD2014	4.7E+00	1.0E+00	9.6E-07	2.8E-02	2.5E-01
Input	Supply Chain	Chemicals & Materials	Other basic organic chemical manufacturing (325190)	USD2014	9.1E+00	1.2E+00	3.2E-07	4.8E-01	1.8E-01
Input	Supply Chain	Chemicals & Materials	Plastics material and resin manufacturing (325211)	USD2014	8.0E+00	9.3E-01	2.6E-07	1.7E-01	1.4E-01
Input	Activity (energy use)	Energy	No. 5 fuel oil combustion in ship	L	1.6E+01	3.6E+00	2.3E-06	7.1E-03	6.2E-01
Input	Activity (energy use)	Energy	Jet kerosene combustion in twin engine light bomber (ex. A-10A)	flight-h	2.1E+01	6.0E+03	4.9E-04	9.2E-03	3.2E+02
Input	Activity (transportation)	Other Costs	Truck transport, class 8, heavy heavy-duty (HHD), diesel, long-haul, load factor 0.75	t-km	7.8E-01	1.2E-01	2.1E-08	3.5E-04	1.3E-02

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Technical Examples

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SA examples

	Milk	Ship Lighting	Coating	Explosive
Goal and Scope	• Full life cycle; how can dairy improve?	• Compare fluorescent with LED fixtures; compare NiCd and NiMH batteries	• Compare Cd and Zn-Ni plating, include performance	• Compare C-4 and alternative explosive
Inventory	• Interview experts (dairy farmers, retailers, etc.) • Private-sector database	• Company data	• Interview experts (artisans, PMs) • Public databases • Company websites	• Interview experts (PM, SMEs) • Public databases • Journal articles
Impacts	• Scoring factors	• Scoring Factors	• Scoring factors	• Scoring factors
Cost	• Not considered	• 25 years • Consider optimization	• 15 years of operation	• 1 year of operation • Consider scale-up
Interpret and Communicate	• Stakeholder workshops • Conferences	• Stakeholder meetings	• Symposium	• Symposium

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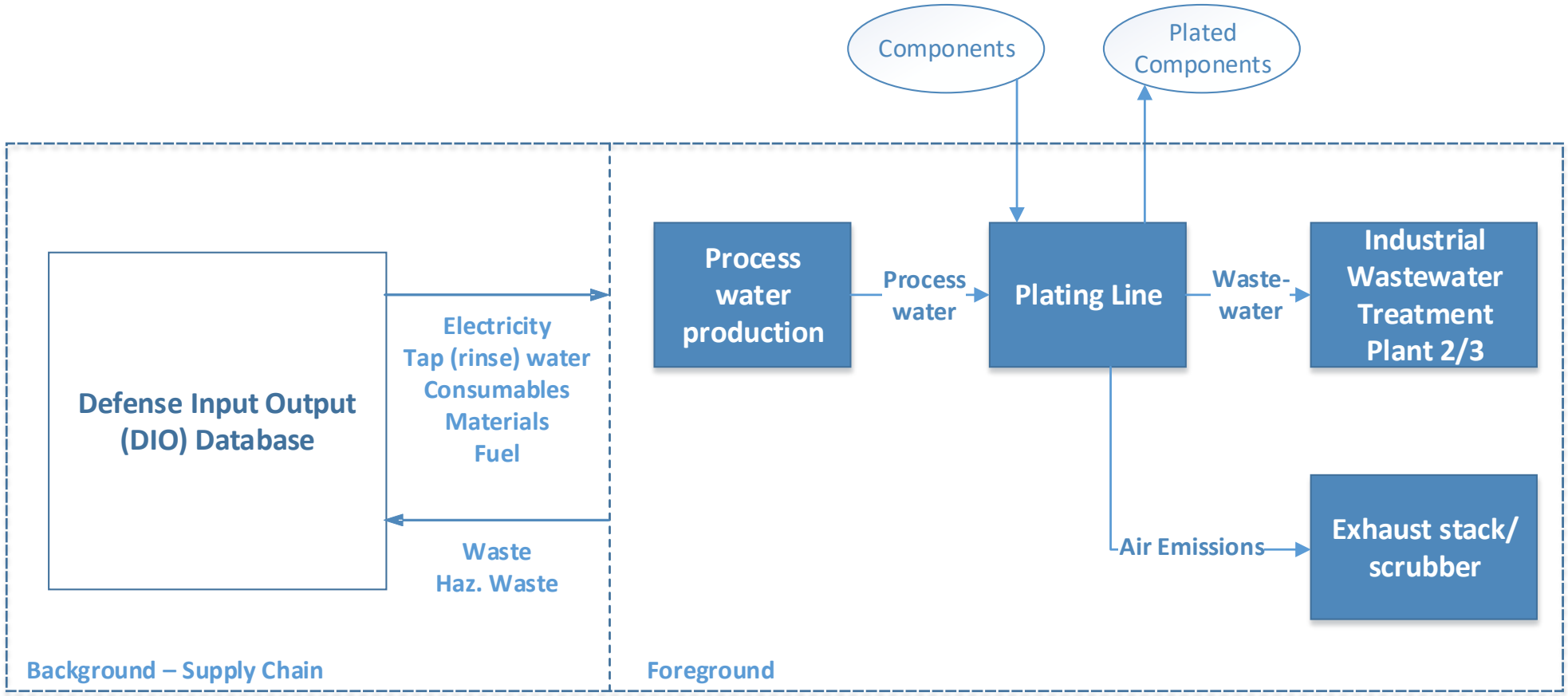
Goal and Scope: Coating



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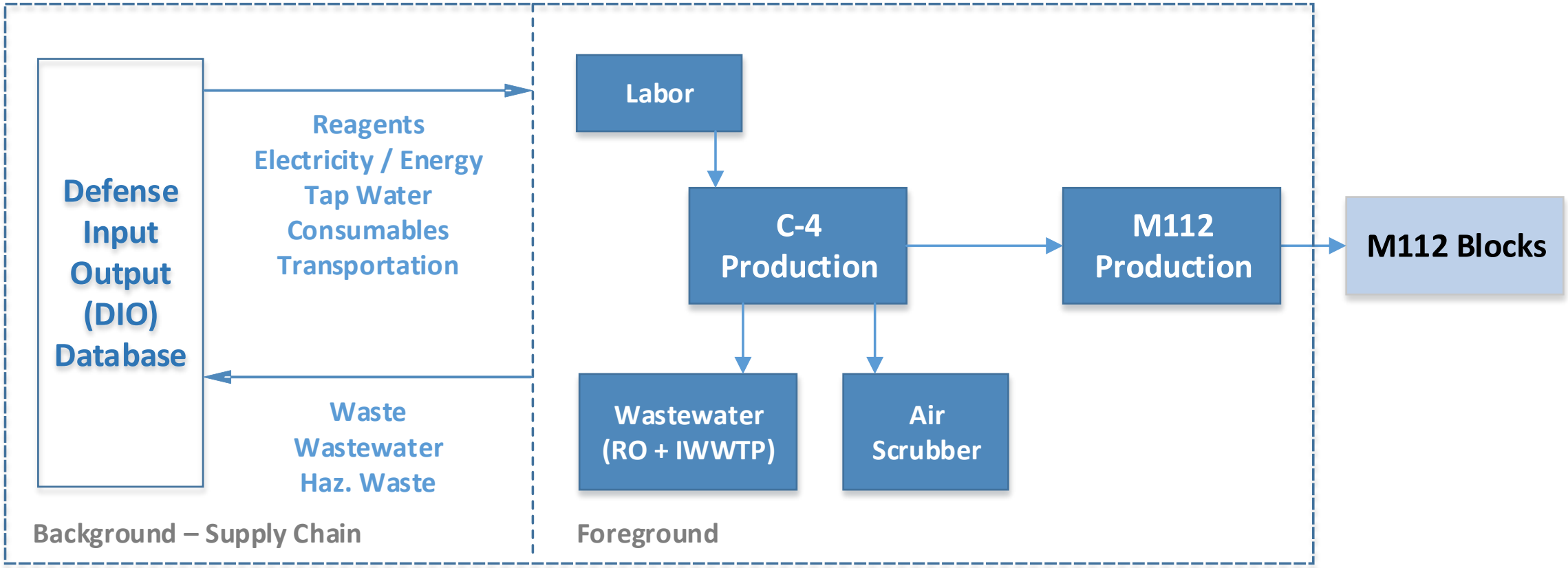
Goal and Scope: Explosive



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Inventory Example

Description	Use	Units	Annual Quantity	Unit	NAICS activity, process activity, elementary flow
Polyisobutylene (PIB)	314	lbs/two batches	77229.8	lb	325180 Other Basic Inorganic Chemical Manufacturing
dioctyladipate (DOA)	742	lbs/two batches	182498.5	lb	325180 Other Basic Inorganic Chemical Manufacturing
Process Oil	202	lbs/two batches	49682.9	lb	424720 Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals)
Energy to heat single Batch	144.63	kwh/two batches	35571.8	kwh/yr	Electricity use, average generation mix - Tennessee, U.S.

Each modeled activity captures inputs, outputs, cost, and link to supply chain

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Scoring Factors

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Input	Activity (transportation)	Other Costs	Truck transport, class 8, heavy heavy-duty (HHD), diesel, long-haul, load factor 0.75	t-km	7.8E-01	1.2E-01	2.1E-08	3.5E-04	1.3E-02

- Provides final and valuation (and intermediate) results for 1 unit of all: Sectors, Activities, Flows
- Can be used in parallel with LCC estimating
- Available at http://www.denix.osd.mil/esohacq/home/

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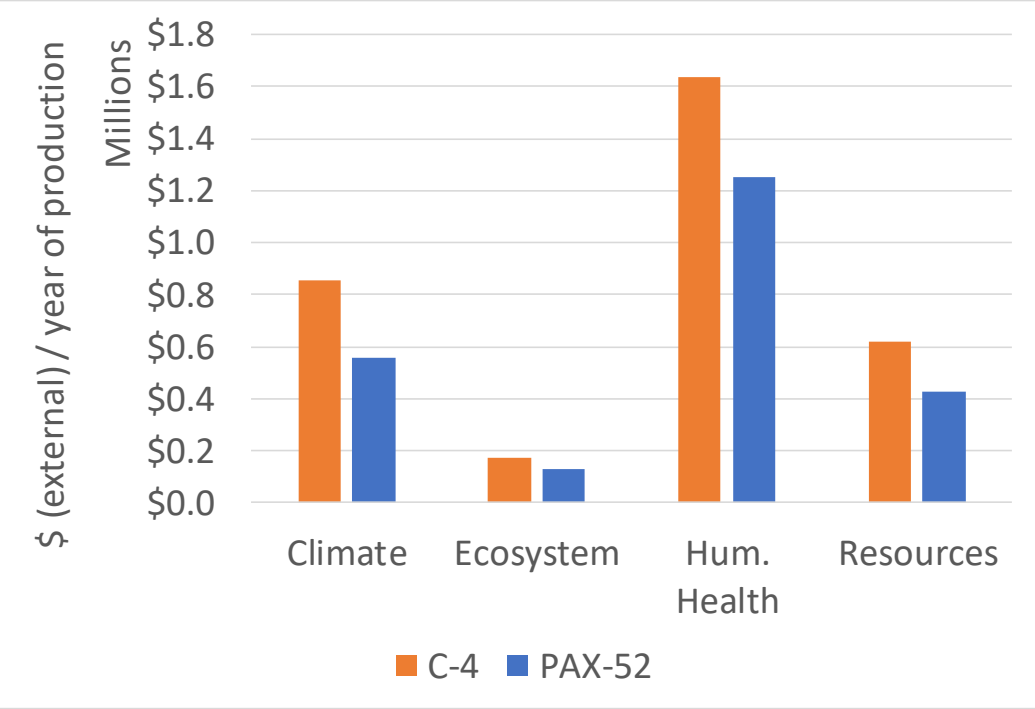
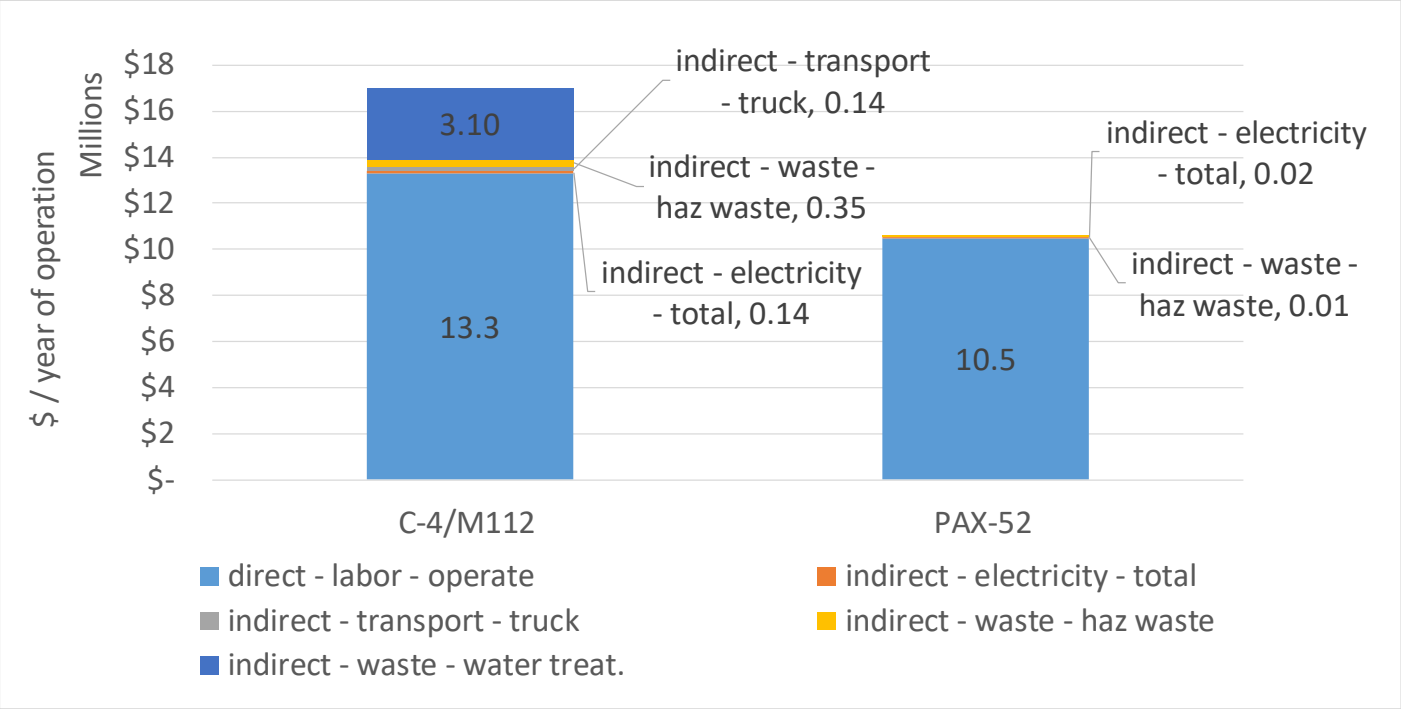
Impacts and Costs





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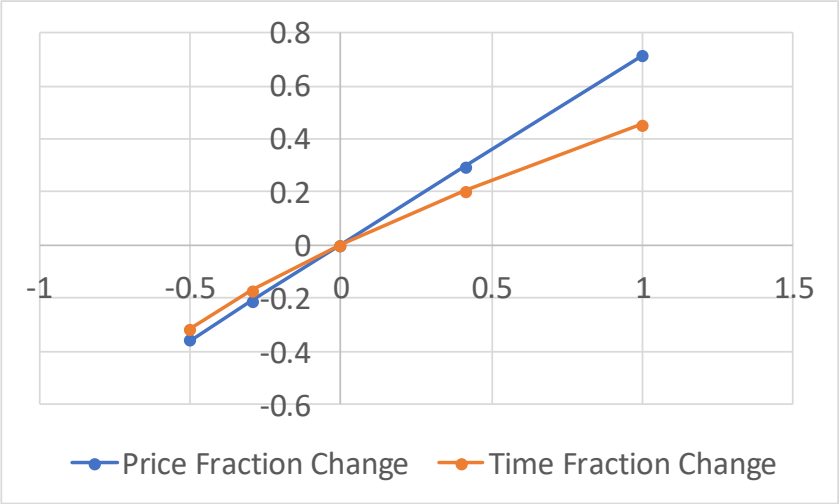
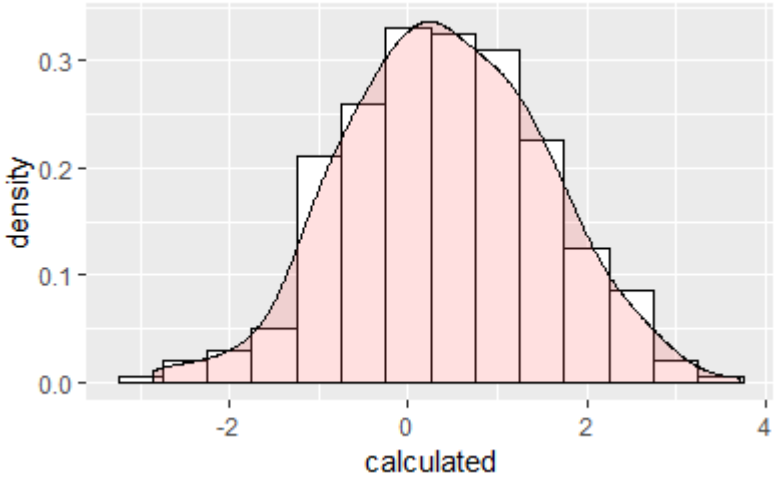
Uncertainty and Sensitivity

- Engineering judgments, ranges with bounds are okay. Keep track of these estimates, and decide if you need to revisit.
  - As research matures, your data matures!
- Various approaches
  - Low – Best – High estimates
  - Back of envelope sensitivity
  - Excel add-ins (@Risk, Crystal Ball)
  - “Homemade” tools in Matlab, Python, R, Excel





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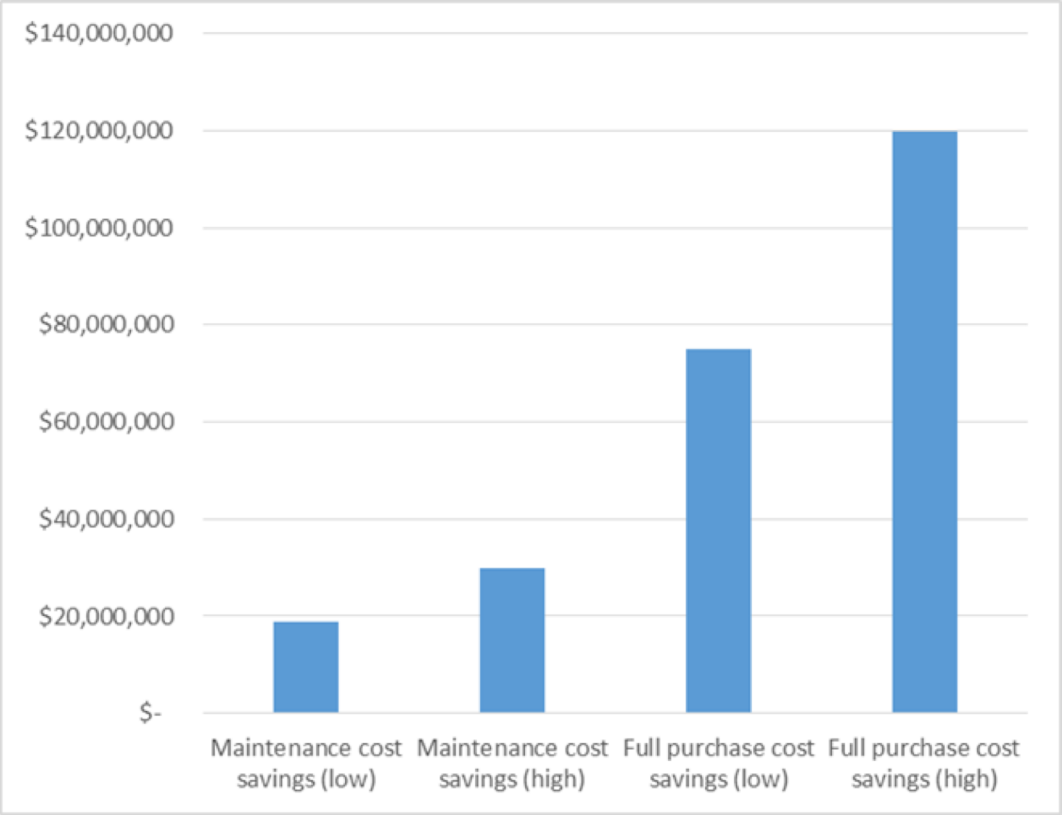
Life Cycle Thinking – Communicating Potential Savings

- Multiple scenarios for alternative coating effects on purchase and maintenance cycles
- 33% - 67% maintenance cycle increase could result in 25-40% reduction in costs



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Wrapping up

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Recommendations for Investigators

Proposal

- If SON or BAA calls for SA, then include how you would address the five-step SA methodology
- Discuss expected results, possible data uncertainty, limitations
- Include references to data that can be used to build the inventory unique to your project; estimate what data you are likely to have at this stage of RDT&E
- Estimate time to conduct SA appropriate to the maturity of the project

Project

- Use the methodology to complete an SA appropriate to the maturity of the project; gather information on inputs, outputs, and costs corresponding to the life cycle stages of your project
- Document, to the extent possible, the Goal & Scope, Inventory, Impacts, and Life Cycle Costs
- Document data limitations and discuss data uncertainty

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Closing Remarks

- Action items and takeaways
- Question and answer
- Thank you
  - Kelly Scanlon, kelly.a.scanlon4.civ@mail.mil
  - Andrew Henderson, andrew.henderson@noblis.org

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Supplemental slides

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Further reading

- Sustainability Analysis
  - OASD 2016
- LCA Overview
  - Jolliet et al. 2004; Matthews et al. 2015; US EPA ORD et al. 2006; US EPA 2014
- Impact Assessment
  - Jolliet et al., 2003; Huijbregts et al. 2017
- Monetization
  - Weidema 2009

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- Weidema, B.P. 2009. “Using the Budget Constraint to Monetarise Impact Assessment Results.” *Ecological Economics*, Eco-efficiency: From technical optimisation to reflective sustainability analysis, 68 (6): 1591–98.

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Why Monetize Social Costs?

- Used in regulatory impact analysis, value of statistical life
- Used to value damages, Social Cost of Carbon
- Indication of future government intervention
- An ounce of prevention is worth a pound of cure
- How else can we evaluate environmental and social sustainability?

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