Benefit-to-Cost Studies of Laboratory Research Investments at

Naval Undersea Warfare Center (NUWC)
&
National Institute of Standards & Technology (NIST)

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FLC Southeast – Midwest Joint Regional Conference

Benefit to Cost Studies and the FLC Charter ?

1999 FLC Strategic Plan includes following goals and objectives:

- Provide federal agencies an analysis of key performance measurement elements and assessment options

- Publicize best practices, solutions, and success stories (S&T & TT)

- Expand communication among agencies and laboratories

Will summarize results and methodology for the assessment of

- 3 Navy research initiatives at NUWC – Success = "Fleet Transition"
- 3 Research initiatives by NIST – Success = Commercialization

Central Role for Technology Transfer

Benefit-to-Cost Studies of Laboratory Research Investments at

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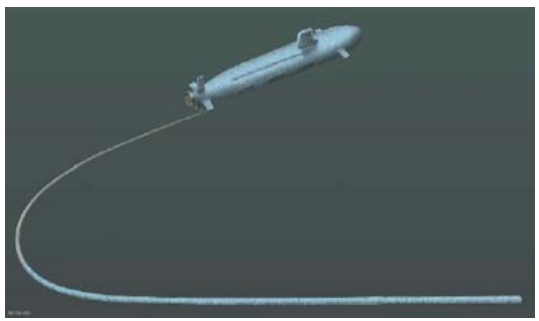


Objective

What benefits has the Navy realized from warfare center laboratory research? What future benefits will the Navy realize ?

In 2005, Office of Naval Research commissioned a BtC study of 6.1 / 6.2 research conducted at NUWC

- Not practical to evaluate every research initiative over 30+ year period.
- Instead tasked to identify and document benefits from several successful research initiatives

Selected Research Initiatives at NUWC
Directed S&T in Response to Fleet Requirements

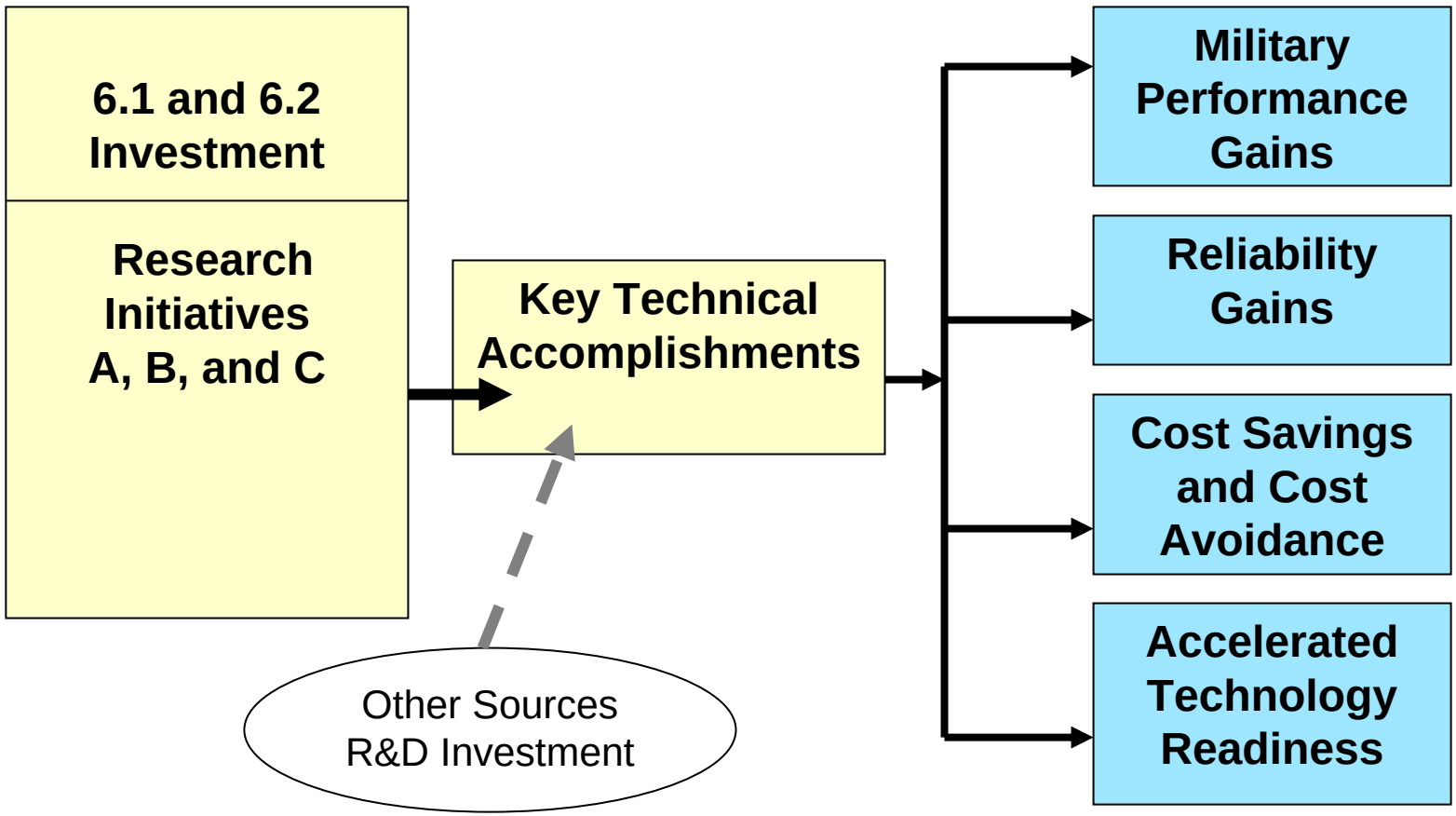
	Research Initiative A	Research Initiative B	Research Initiative C
Projects	21	74	1
PIs	9	39	1
Research Investment ($2005)	**$4.2 million**	**$13.1 million**	**$330,000**
Initial Operational Capability	1995	1995 (A1) 2009 E (A2)	2012 E

What Does the Navy Get in Return for $18 Million Research Investment?

Note: Then-year dollars inflation adjusted, using April 2005 Release of Naval Cost Analysis Division (NCAD) Inflation Indices

FRAMEWORK for BENEFIT to COST STUDIES

"Going Beyond Technical Accomplishments"



Research Initiative A

Research Motivated by Fleet requirements: Mission Oriented Basic Research – per D. Stokes “Pasteur’s Quadrant”

Realized substantial performance gains relative to technology being replaced - defender technology

Realized $1.1 billion avoided costs relative to alternative or competitor technology

$1.1 B realized benefits vs. research investment → 260 : 1

$1.1 B realized benefits also > 9 times entire research investment at NUWC over 30+ year period

Force Is More Lethal,
Sailors Safer, at Lower Cost

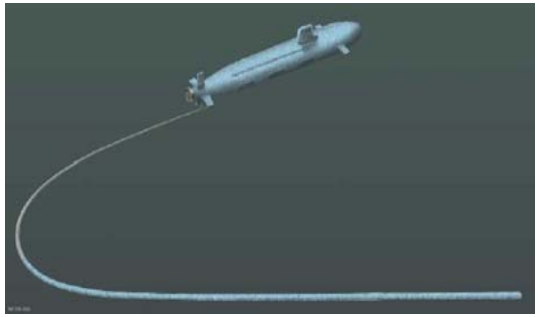
Cost Avoidance: Weapon System Enabled by Research Initiative A vs. the "Runner Up" Alternative Weapon System

		1991 Estimate	Crediting 6.3, 6.4….	Actual		
A	Development	178	123	55		
	Acquisition	135	69		66	
	Total Cost	313	**193**			**120**
		1991 Estimate	**Crediting 6.3, 6.4….**	**"Squeezed Down" Estimates**		
Competitor Technology	Development	863	216	647		
	Acquisition	956	127		829	
	Total Cost	1,819	**343**			**1,476**

1.356 B Cost Avoidance

80% or $1.1 billion Attributed NUWC research
260 :1 Benefit to Cost

Research Initiative B:
Acoustic Performance Relative to Defender Technology



Substantial Improvements in Acoustic Sensor Performance		Force More Lethal and Sailors Safer
However	Reduced System Reliability	Neg
	Increased Life Cycle Costs	Neg

Risk Adjusted Cost Savings - B1 to B2

B1 Life Cycle Cost	$28.5 million (2005 dollars)
B2 Life Cycle Cost	$7.2 million (2005 dollars)
Expected Cost Savings	$21.3 million
Extended by 98 Units	(Preliminary Acquisition Plan)
Total Savings	$2,087 million

Posit 60% Probability of Technical Completion / Fleet Deployment
Expected Value $1,252 million

Attribute 50% of Savings or $626 million to NUWC Warfare Center Research. Balance attributed to NRL and Others

$626 million Savings / $13.1 Million Research Investment

Expected Value of Benefits (Savings) to Costs: 48 to 1

Expected Value Estimates & Treatment of "Failure"

EV = 60% ($2.087 billion) + 40% ($ 0) = $1.252 billion

Valuing "research failure" @ zero

Objection: Lessons learned from "failure" can lead to key future innovations

Yet, if unable to Identify, Document, Quantify, and Validate associated benefits of failure (in the interest of conservatism), "failure" is valued at zero.

And even then, EV of Savings : Investment 48 : 1

Summary of BtC Study Results at NUWC

Force Is More Lethal, Sailors Are Safer and at Lower Cost

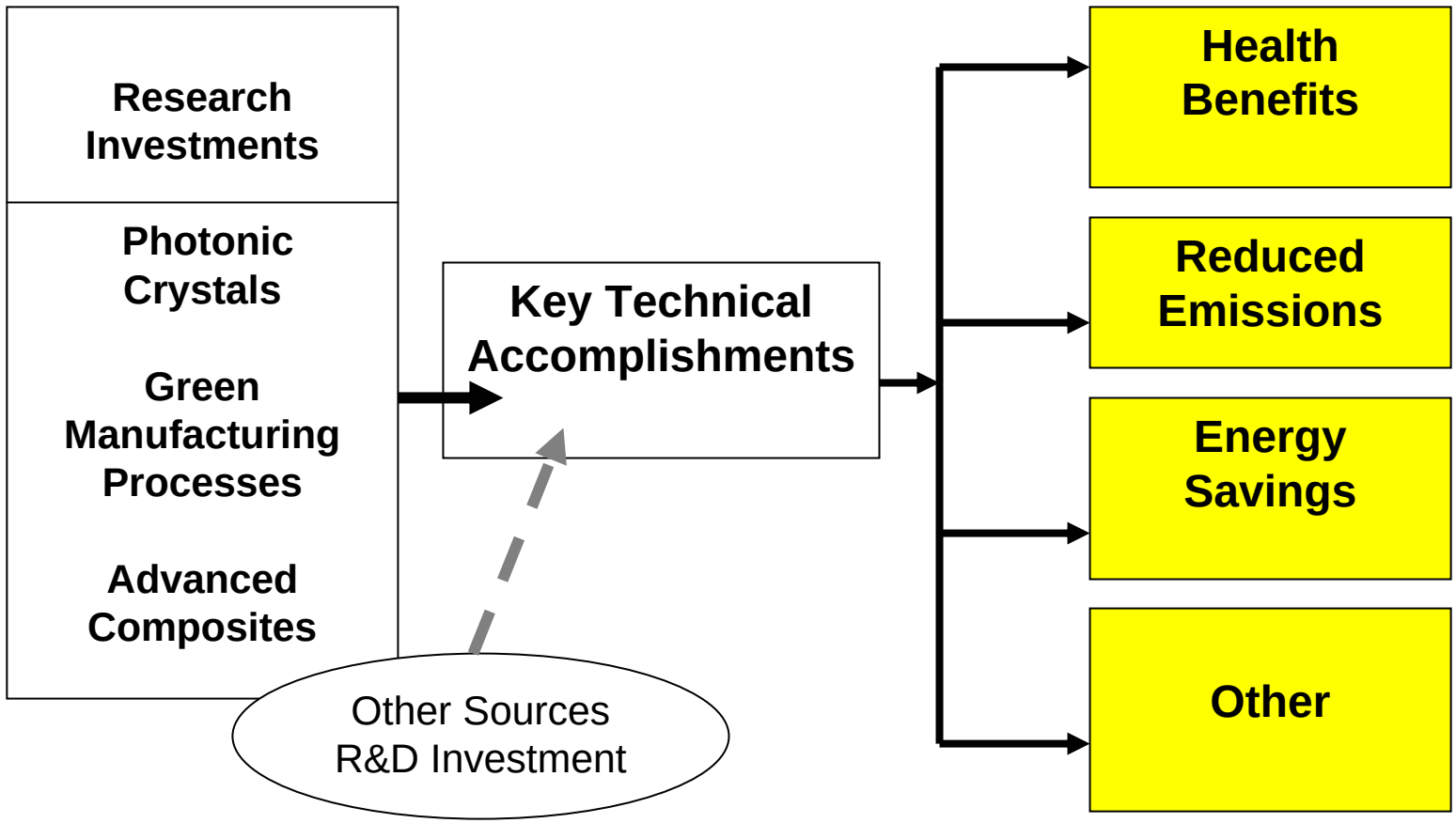
	Realized Benefits Attributed to NUWC	Risk-Adjusted Expected Values Attributed to NUWC
A	Open ocean & littoral performance gains plus $1.1 billion in avoided costs	
B1 and B2	Acoustic performance gains (defender technology to B1)	Reliability gains and $626 million cost savings (B1 to B2)
C		New military capability + $31 million savings

Benefit-to-Cost Studies of Laboratory Research Investments at National Institute of Standards & Technology (NIST)

Lives Saved and
Health Care Treatment Costs
Reduced

FRAMEWORK for BENEFIT to COST STUDIES

"Going Beyond Technical Accomplishments"



NIST-Funded New Photonics Technology: CO_2 Sensor for Emergency Medicine

To stabilize critically ill patients on their way to ER, paramedics may place tube into patients' trachea to maintain unobstructed airway. 18% of time, tube is misplaced into esophagus and 57% of these patients die on their way to ER.

NIST-funded sensor measures CO_2 content in patient's exhaled breath to identify and eliminate "mis-intubations", resulting in

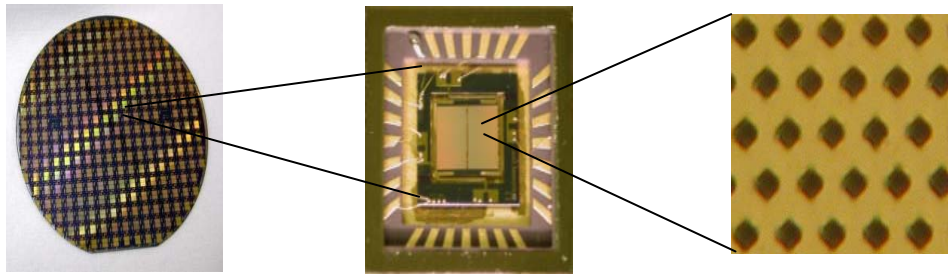
- Fewer deaths in-transit to ER (Not yet "lives saved" as injury and illness are yet be addressed in ER).

- Avoidance of corrective hospital treatment and mechanical ventilation for those who survive mis-intubation.

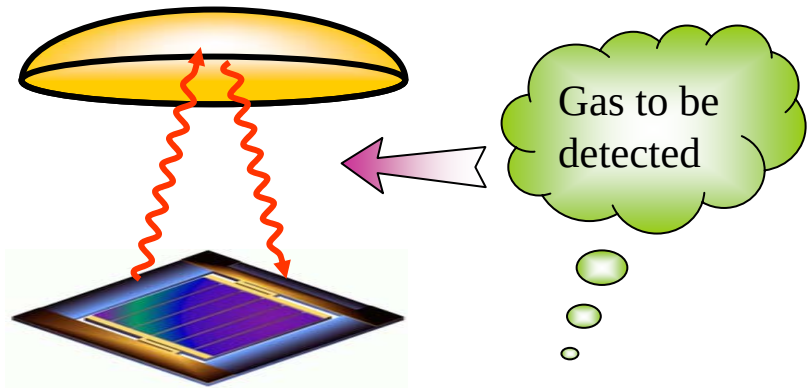
Photonic Crystal CO_2 Sensor: How Does It Work?

What does it look like?

Tuning crystal structure to target gas wavelength



How does it work?



Benefits of Photonic Crystal CO_2 Sensors

- 2007 sensor sales projected at 40,000 units, each sale corresponding to one intubation.
- 3,800 avoided mortalities in-transit to ER.
- $367 in avoided treatment costs per intubation ($14.7 Mil).
- Positing 65% probability, expect 2,470 avoided mortalities
- Positing 65% probability, $9.56 million EV dollar benefits
- Offsetting $28,000 lost profits (defender technologies)
- 50% of EV net benefits or $4.77 million attributed to NIST and 50% to NSF.

Over the 2006 to 2015 Period, Benefits Attributable to NIST are Projected as:

- Reduced Mortality In-transit to ER - 113,000 avoided deaths, in-transit.
- Health Care Cost Savings: $201 million in net present value or $244 in benefits for every $ of NIST investment.

NIST - Funded Green Manufacturing Process Technology

Old Paradigm: **Zero Sum Game**

Polluter pays. Costs of environmental remediation and emission reduction constitute net drag on industrial competitiveness.

Evolving Green Paradigm:

Through green design principles and use of green process technologies it becomes possible to “have your cake and eat it too”. Reduce emissions, reduce petroleum use, reduce waste, and at the same time, improve cost structures and competitiveness.

Elements of “Green Chemistry”

- Use renewable feedstock in the original process design and minimize the use of finite depleting resources
- Design safer chemicals with fewer toxic components
- Design for energy efficiency
- Design to reduce industrial waste
- Recycle industrial waste
- Design products that degrade after their use

“In the past we created a mess and then come up with bandages to make it less bad” Paul Anastas, Green Chemistry Institute of American Chemical Society

“ Chemical manufacturers are now understanding that part of their costs – which are subtracted from their bottom line – are the avoidable costs of waste and environmental disposal” Mary Ellen Weber, U.S. EPA

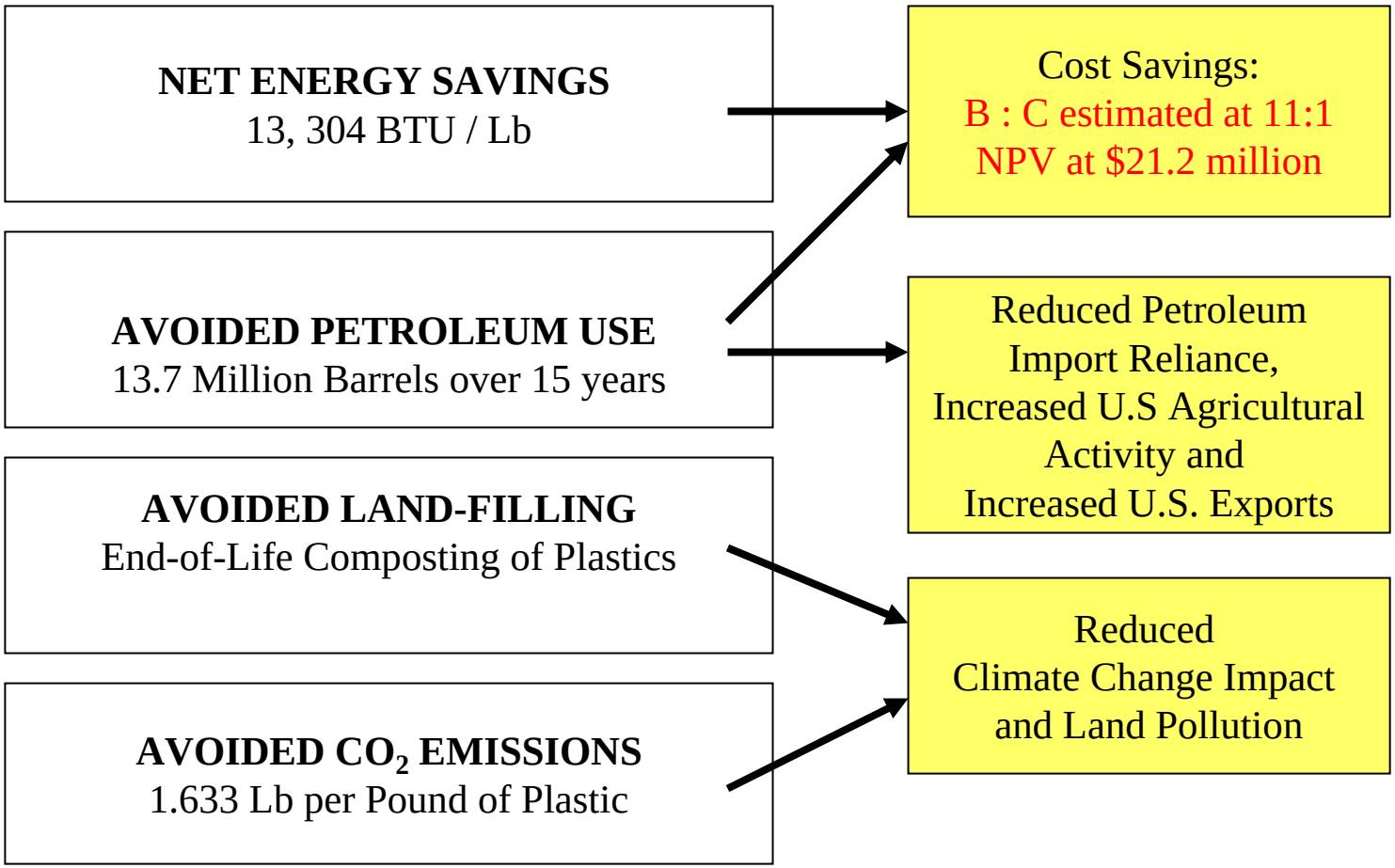
Fossil Energy Savings (BTU / Pound of Polymer)

	PLA-Based Product		Petroleum-Based (PET) Product		PLA Energy Savings
	All BTU	Petroleum Component	All BTU	Petroleum Component	All BTU
Feedstock Production	914	914	1,015	1,015	101
Feedstock Fossil Energy Content	0		16,132	16,132	16,132
Feed to Pellet Operations	17,419		13,811	13,811	- 3,608
Packing	450		450		
Transportation	276	276	276	276	
End Product Operations	4,253		4,932		679
Fossil Energy Budget	23,312	1,190	36,166	31,234	

Saved 13,304 BTU / Lb of Polymer

Reduced Petroleum Use: 30,044 BTU / Lb of Polymer

Green Benefits and Economic Impact: PLA-Based Plastics



Methodology for Benefit : Cost Studies

Benefit Cost Study Methodology:
Identify, Document, Quantify, and Validate **I-D-Q-V** Claimed Benefits

Benefits are always relative to baselines. Often two baselines

Defender Technology to

Gauge performance and reliability gains

Competitor / Proxy Competitor Technology to

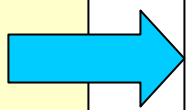
Gauge cost savings for equivalent performance

How Are Benefits Identified, Documented, Quantified, & Validated?

Screen Project Clusters

Against Benefit to Cost Criteria:

- Technical Completion
- Prospects for Transition or Commercialization
- Access to People and Information



For Each Case Study

Detailed Review Selected Projects & Costs

Document Scientific & Technical Advances

Document Performance Gains for Alternative Mission Scenarios & Continued Relevance

Identify + Inflation Adjust Cost Savings

Risk Adjusted Cost Savings = Expected Value

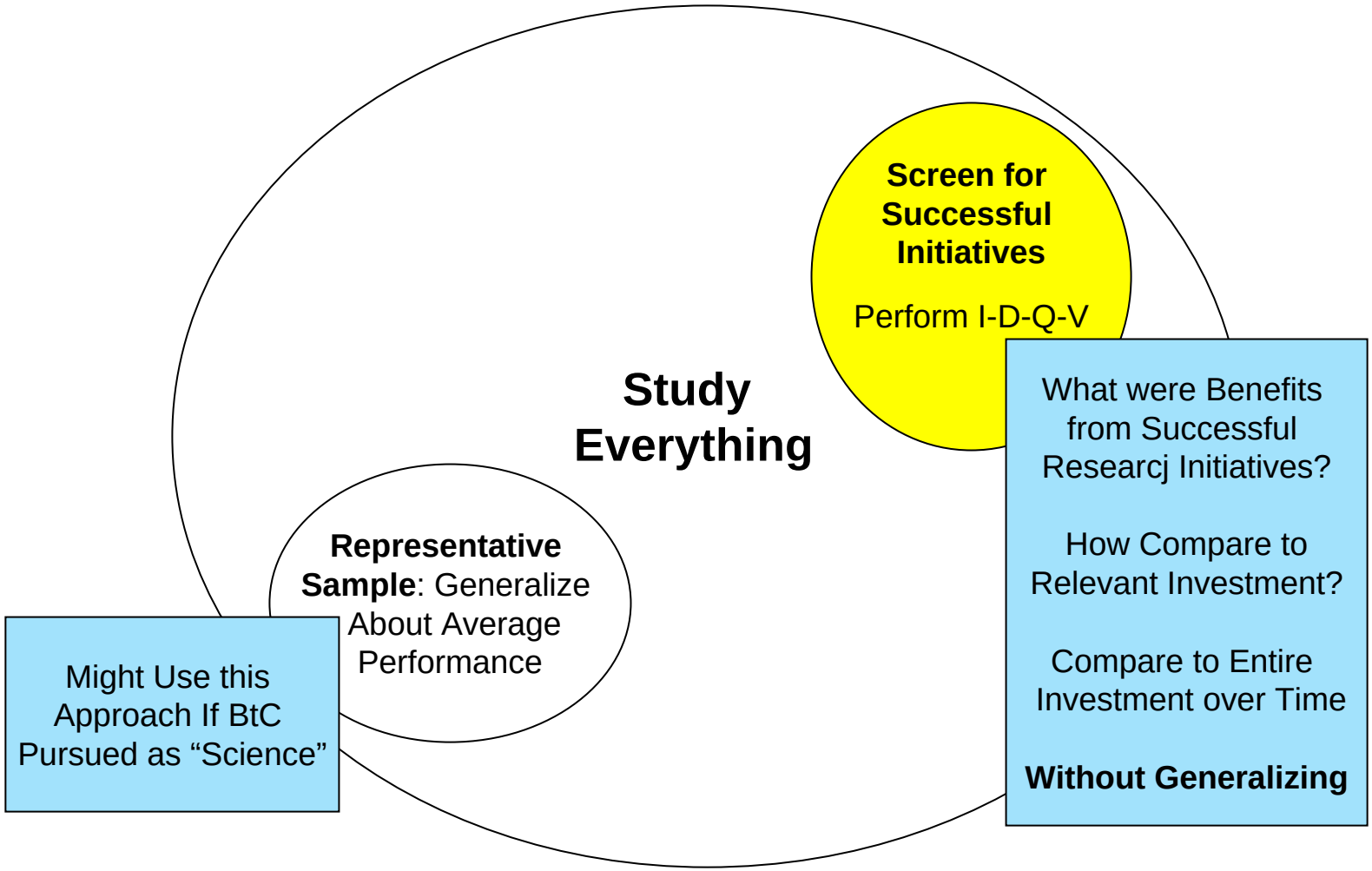
% Attribution to B : C Sponsor

Sensitivity Analysis

Other Sources of Research Funding?

Benefits to Costs

BtC Evaluation Space: Cherry - picking or Balanced Analysis?



Methods: Overview

S&T is a complex, uncertain enterprise.

Case studies indicate that realized and expected benefits from S&T initiatives can often be **I**dentified, **D**ocumented, **Q**uantified, and **V**alidated.

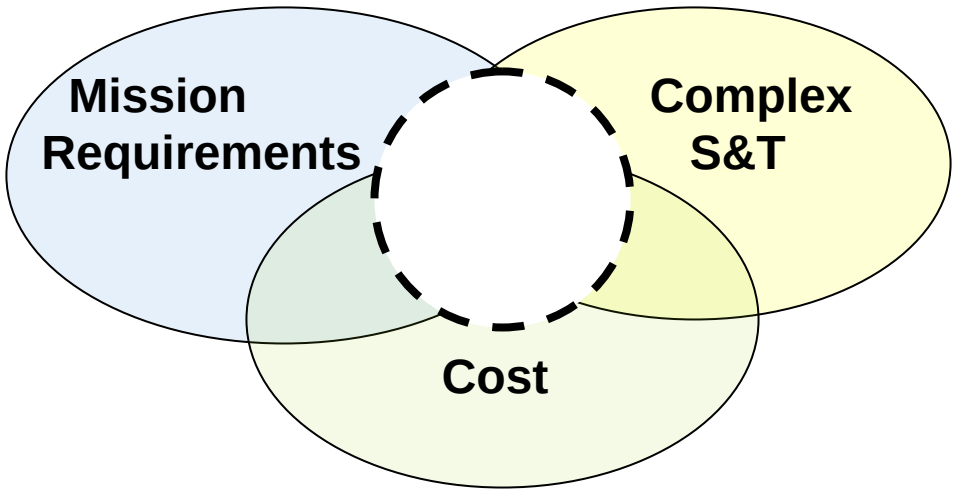
Tracing benefits from S&T investments is not science.

Rather a management discipline, where yardsticks are conservatism, transparency, and integrity of the process. Not technical perfection.

If R&D managers unable to demonstrate value of research in credible and pragmatic manner, who else can?

How can Agency leadership defend S&T budgets that Feed TT Efforts?

What Does It Take to Develop S&T Performance Metrics?



Operate outside normal professional comfort levels

Accurate Observation and Analysis at Complex Interface:
S&T issues, Mission requirements, and Financial analysis.

Delta Research Co.(DRC)

Since 1991, DRC completed S&T Benefit to Cost studies for

- National Institute of Standards & Technology (NIST)
- National Oceanographic and Atmospheric Administration (NOAA)
- U.S. Department of Energy (DOE)
- U.S. Geological Survey (Geospatial Information)
- U.S. Department of State
- Winthrop Rockefeller Foundation (Winrock)
- Woods Hole Oceanographic Institution (Marine Policy Center) & Others

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