Invest Early, Smart & Effectively (E-S-E)

Richard Carlin
Department Head, Sea Warfare & Weapons
Office of Naval Research

Acquisition Research Symposium, Monterey, CA 26-27 April 2017

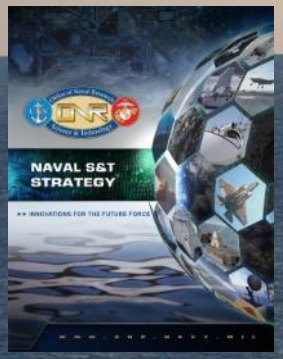
Invest Early, Smart & Effectively

- ***Early*: Long-Term & Stable Investments**
- ***Smart*: Relevant & Sound Technical Investments**
- ***Effectively*: Impactful & Enduring Investments**

The Office of Naval Research

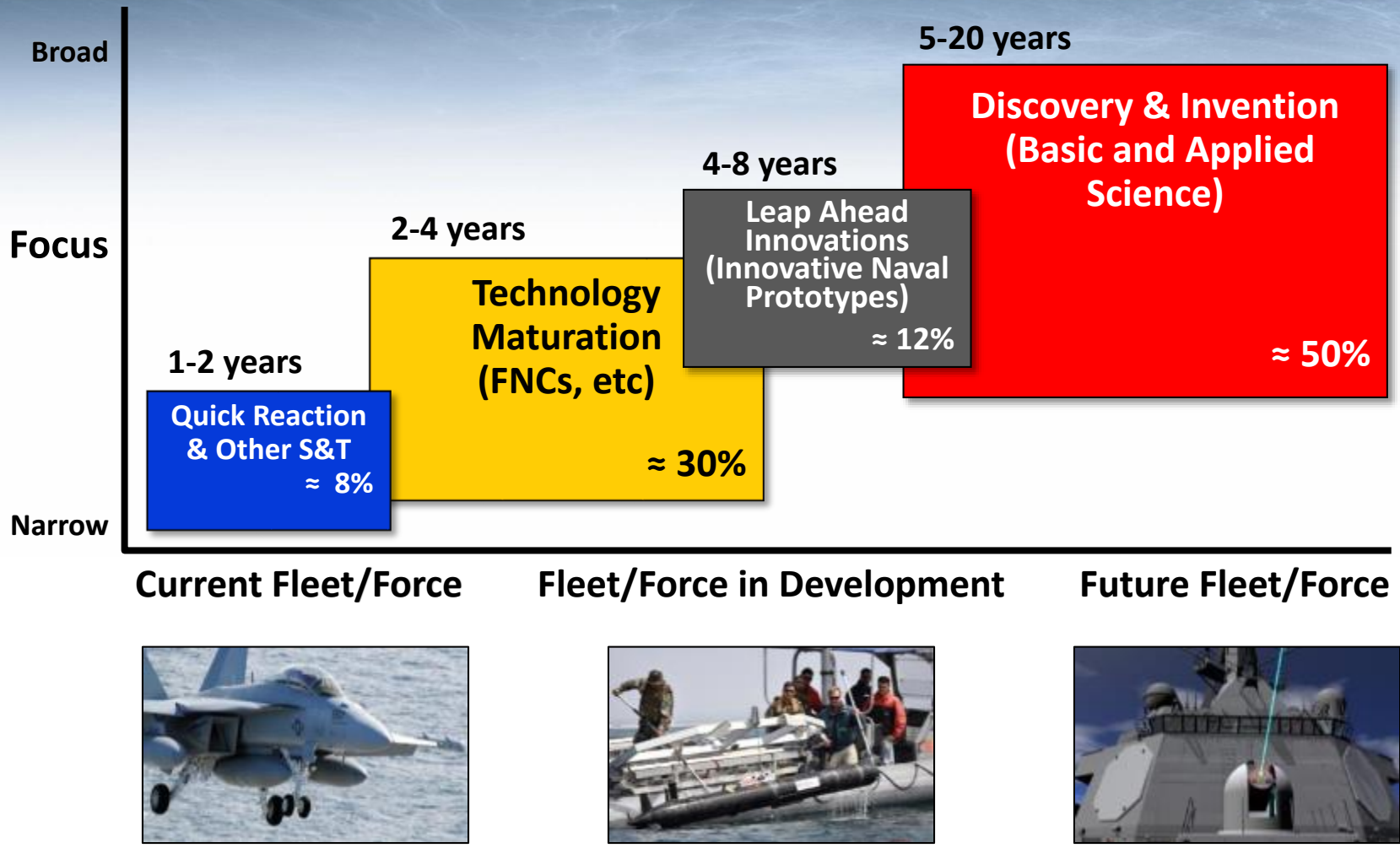
The S&T Provider for the Navy *and* Marine Corps

- 4,000+ People
- 23 Locations
- $2.1B / year
- >1,000 Partners



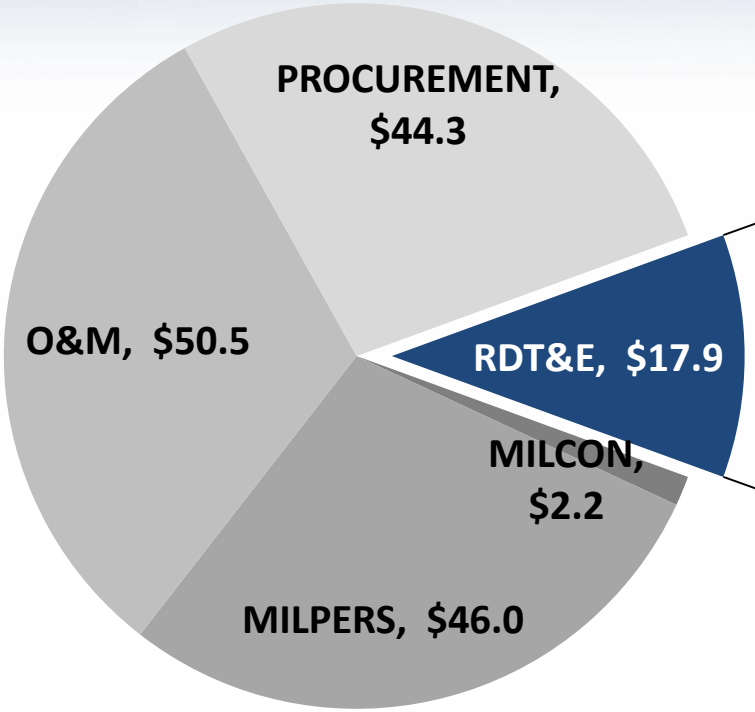
Discover → Develop → Deliver → Technological Advantage

Warfighting Capabilities Enabled by S&T Investments

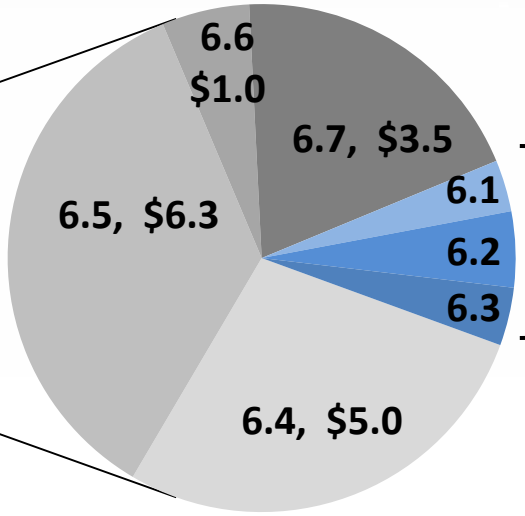


DoN FY16 Budget

FY16 DON Budget ($160.9B)



RDT&E Budget ($17.9B)



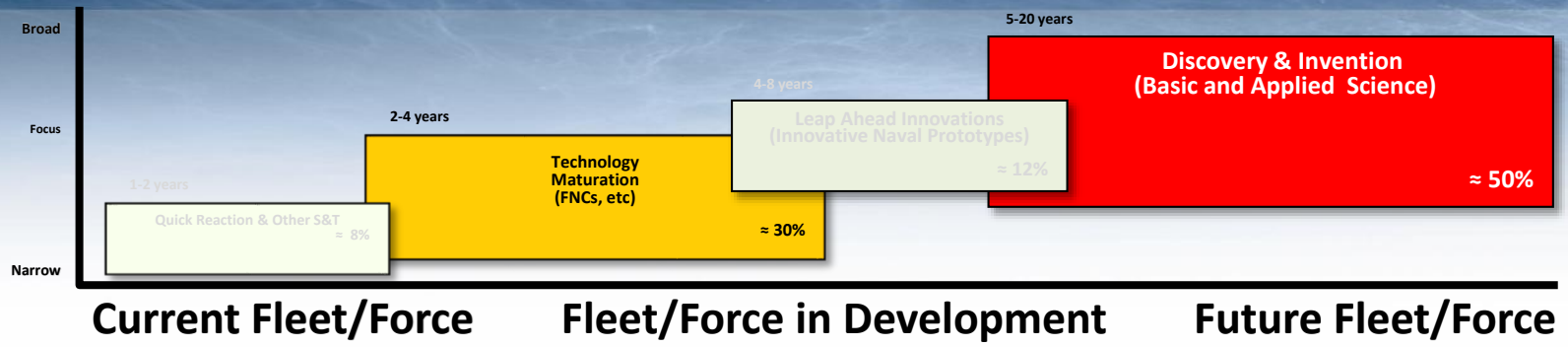
ONR S&T, $2.1B

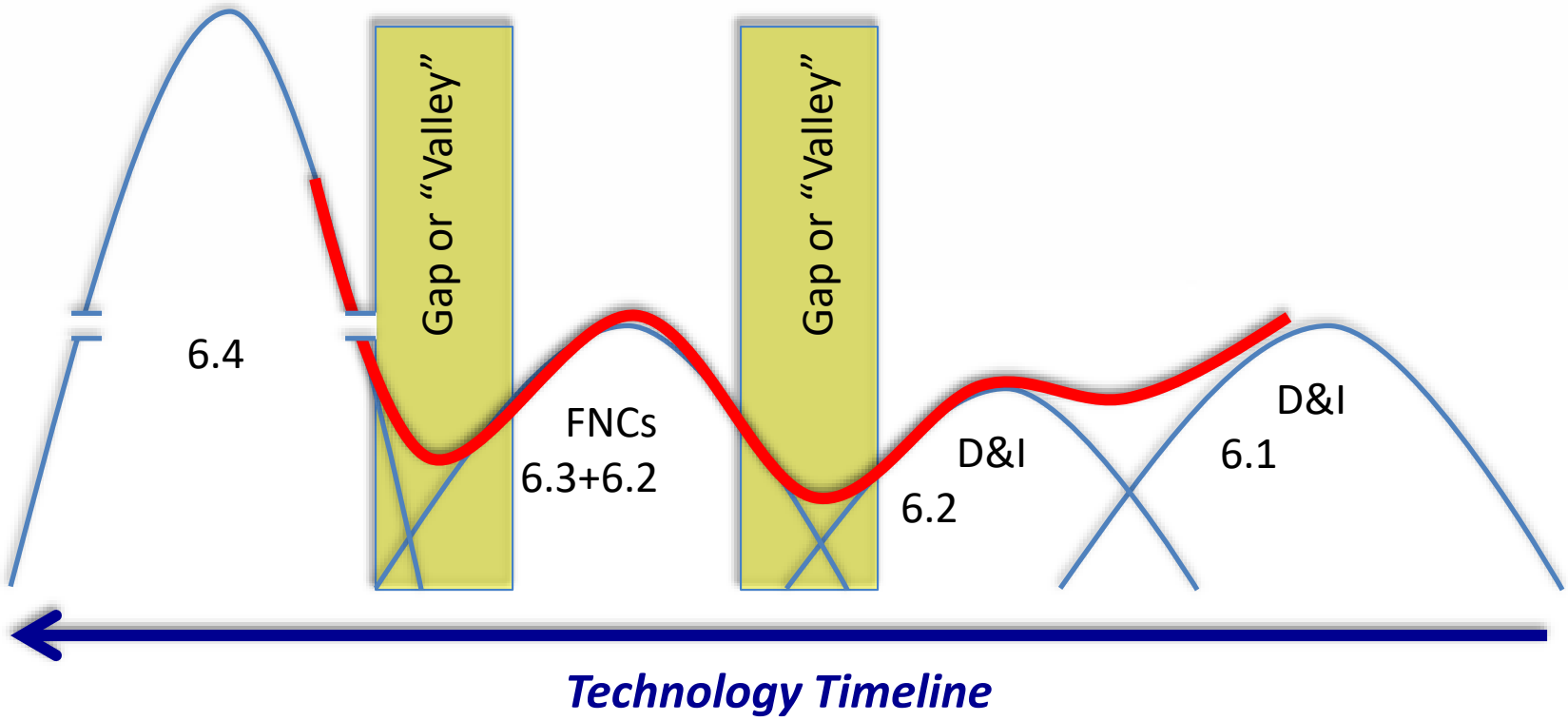
Basic Research	BA1	586,928
Applied Research	BA2	864,570
Advanced Technology Development	BA3	662,864
Advanced Component Development & Prototypes	BA4	5,024,626
System Development & Demonstration (SDD)	BA5	6,308,800

Source: DoN FY16 Presidential Budget

Warfighting Capabilities Enabled by S&T Investments

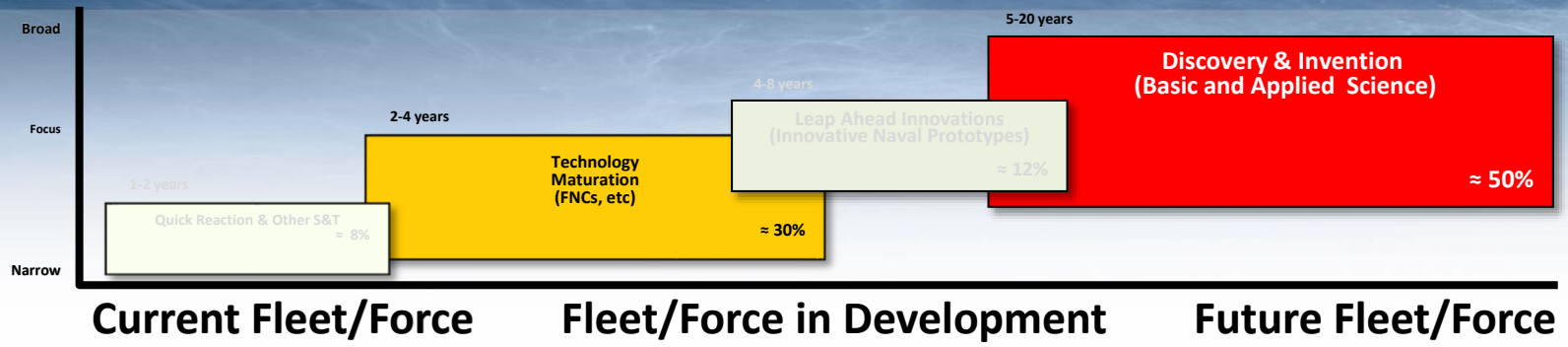
E-S-E

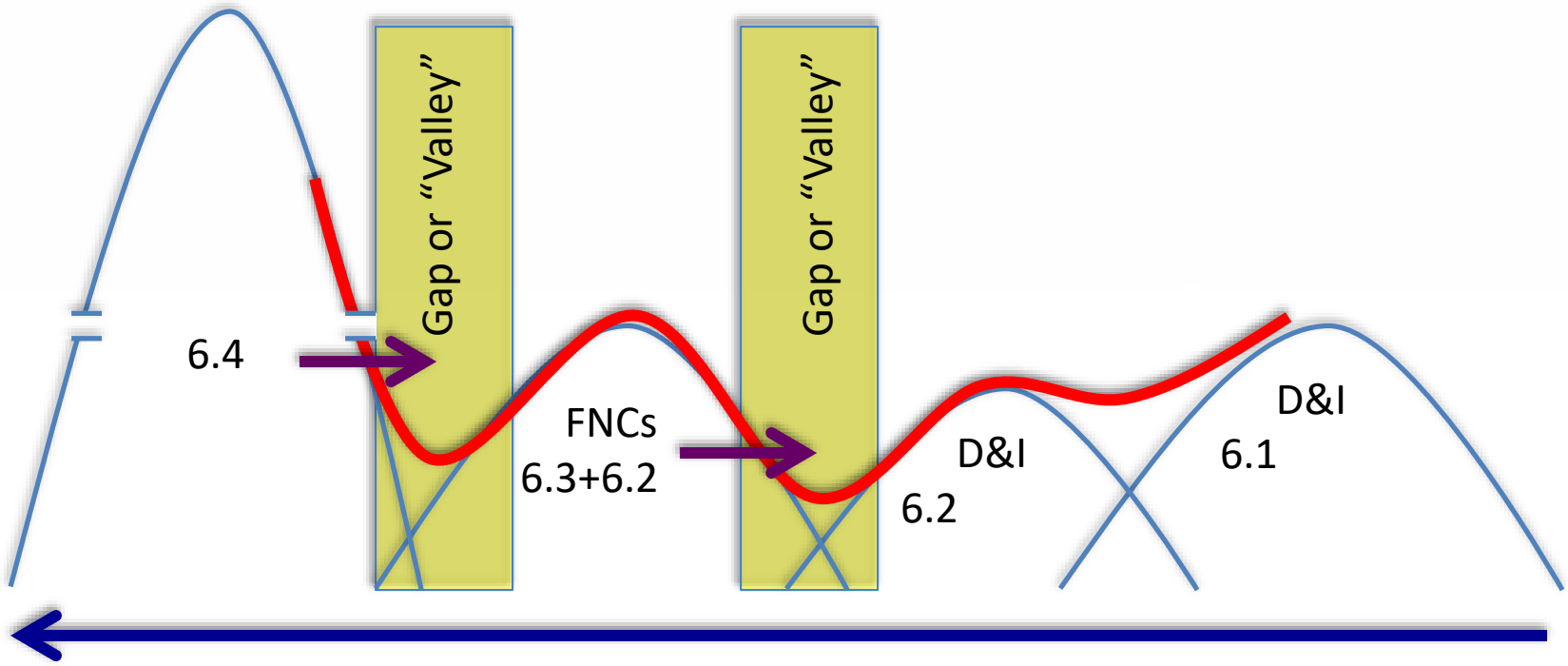




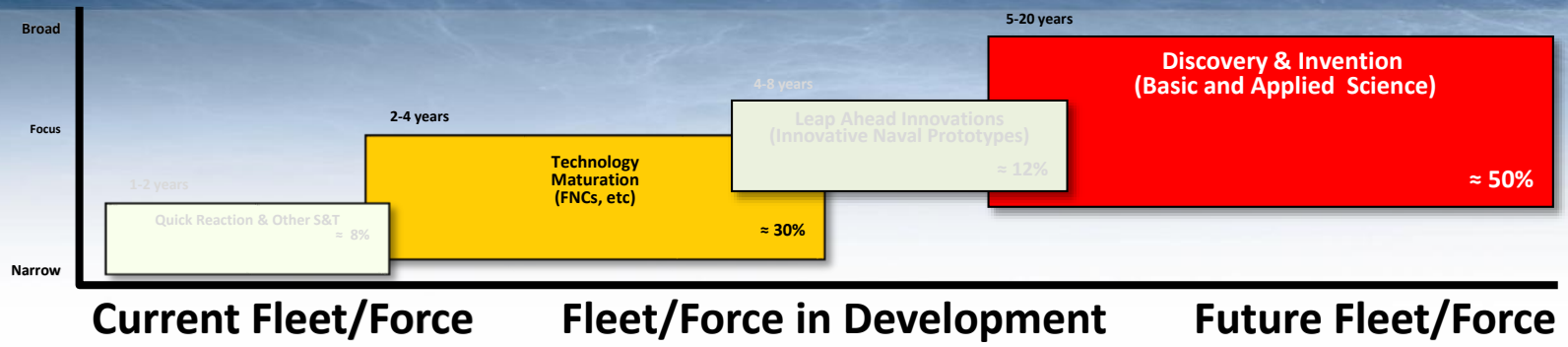
Warfighting Capabilities Enabled by S&T Investments

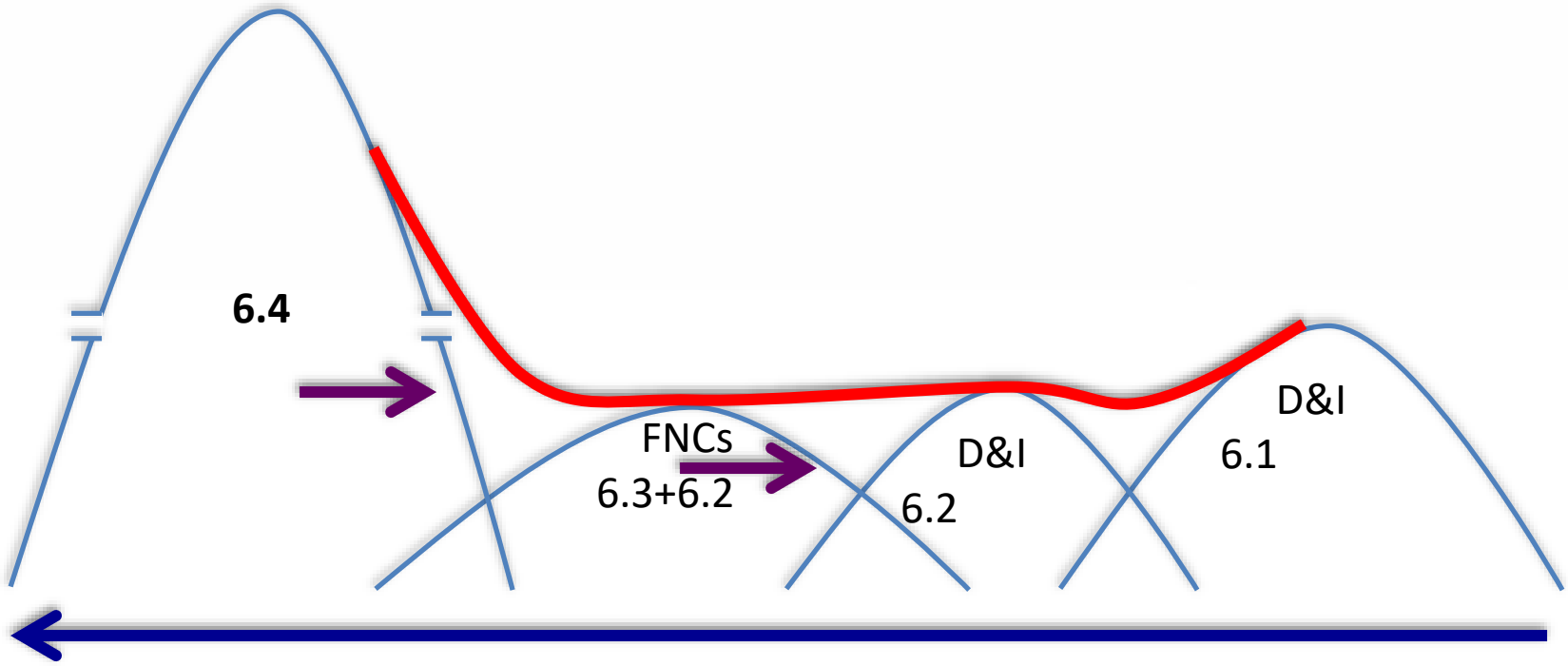
E-S-E





Warfighting Capabilities Enabled by S&T Investments E-S-E





Secretary of the Navy Advisory Panel (SNAP)
Time and Responsibilities Table
(2011)

E-S-E

Responsibility	Action	Date
Sharon	Met with Steve Ramberg (NDU)	31-Aug
Rich	Met with STEM/Culture Performers in California	2-Sep
Sharon/Rich	Met with Scott Shimp/Todd Bowie Task Force Energy (TFE)	20-Sep
Sharon/Rich	Met with John Amy (ASN RD&A)	21-Sep
Sharon/Rich	Visited Center for Naval Analysis (CNA)	22-Sep
Sharon	Met with Mary Lacey (ASN RD&A)	4-Oct
Rich	Met with Tom Hicks (DASN Energy)	4-Oct
Sharon	Visited NPS - Energy Curriculum	6-Oct
Sharon/Rich	Visited Caltech – Energy Professors	7-Oct
Sharon/Rich	Visited Marine Corp	11-Oct
Sharon/Rich	Visited NCCA	11-Oct
Sharon/Rich	Visit additional Universities	On-going
Sharon/Rich	Sent SNAP update reports	Approx. Biweekly as Appropriate
SNAP	Provided Feedback	Following Biweekly Report
Sharon/Rich	Provided Draft ROI Assessment to SNAP	14-Oct
All	Briefed SNAP Naval Energy Process	19-Oct
All	Briefed SNAP on Draft Final Report	8-Dec

Energy ROI Investment Strategy

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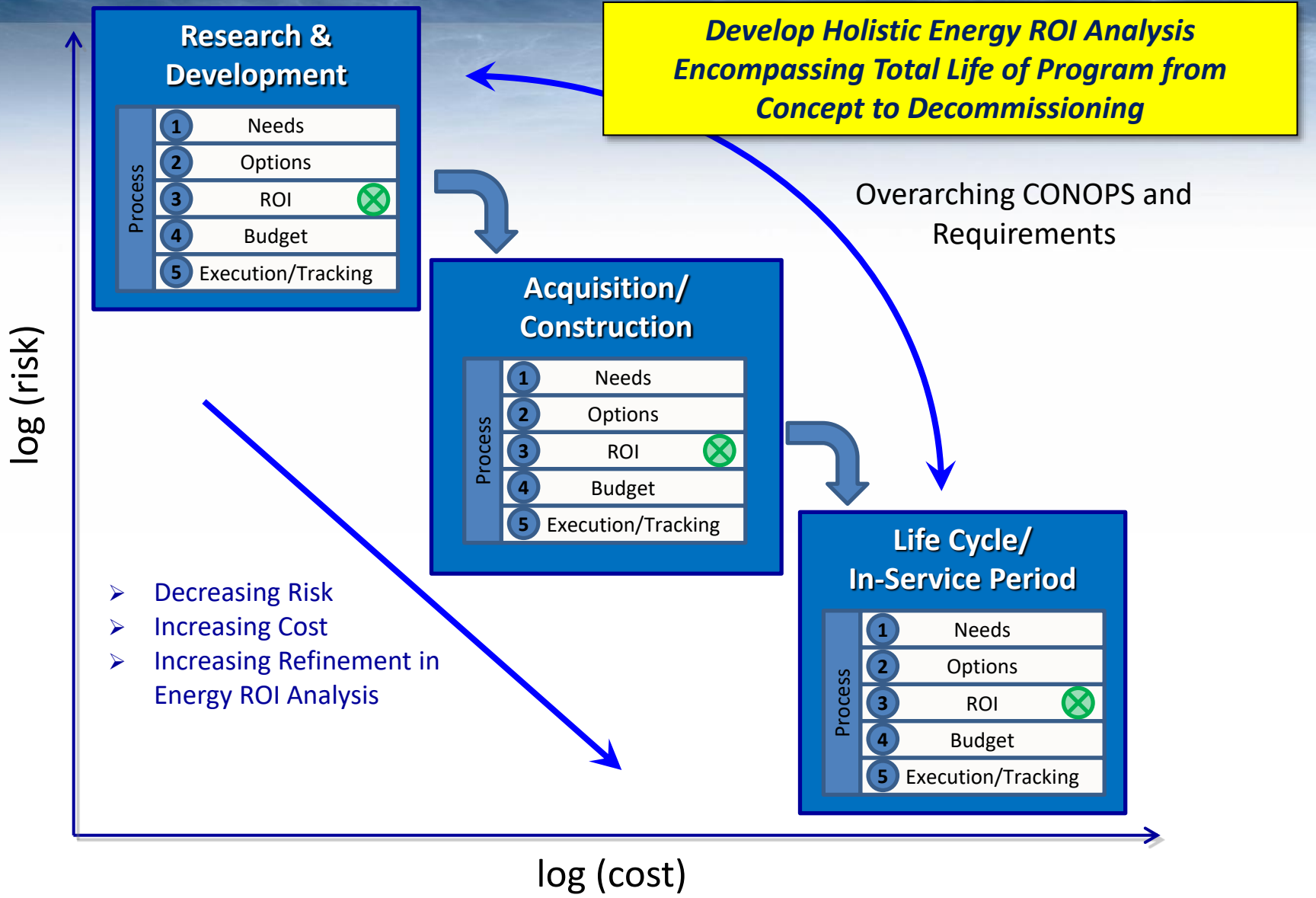
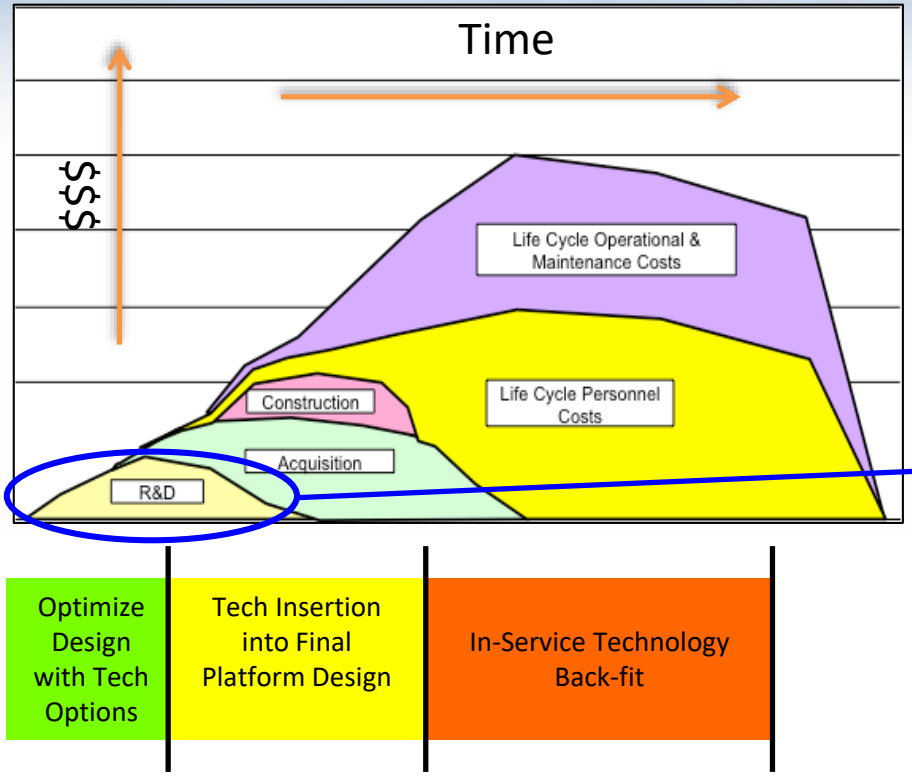


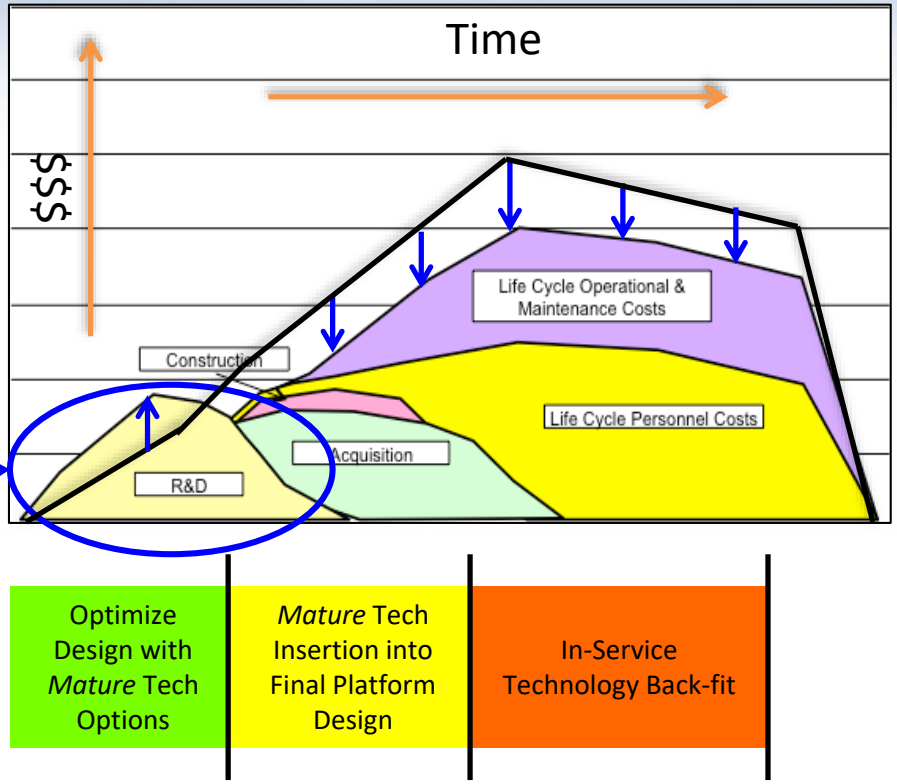
Total Program Life Investment

E-S-E

Typical Investment Profile



Improved Investment Profile with Increased R&D



Increase Early R&D Investment to Optimize Platform Design & Technology Maturity

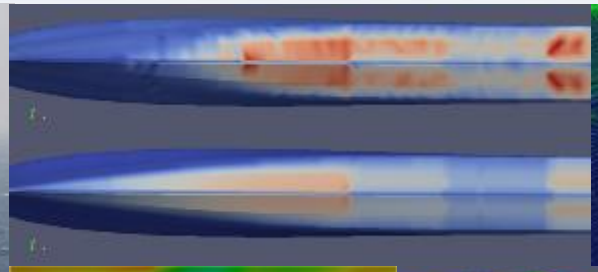
=

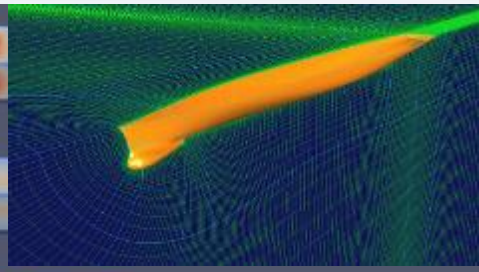
Reduced Total Program Life Costs & Enhanced Warfighting Capability

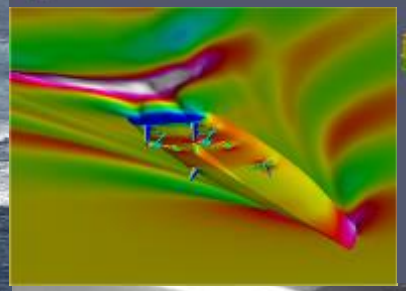
Navy Digital Twin (NDT)
The Basis for a Digital Fleet

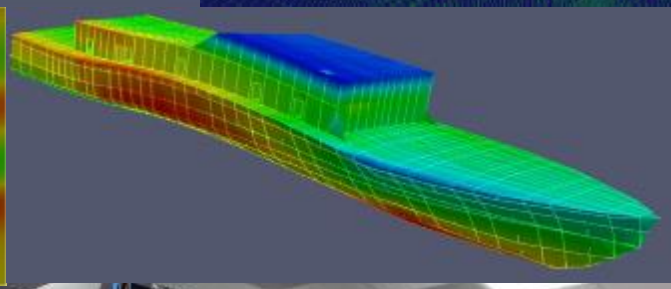
E-S-E

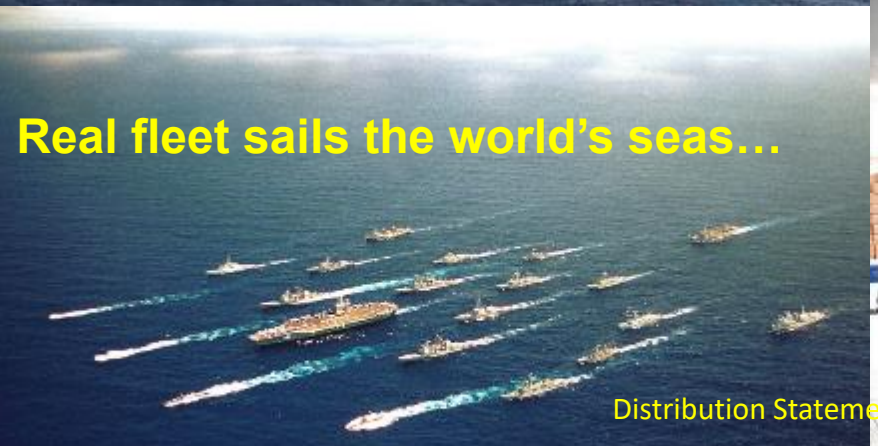
Starting with design, and progressing through fabrication and fitting out, the NDT is “built” alongside the real world vessel. Installed sensors permit model calibration during sea trials, and in service. NDT furnishes a virtual fleet: enhanced readiness for emerging and future threats.











Real fleet sails the world’s seas…

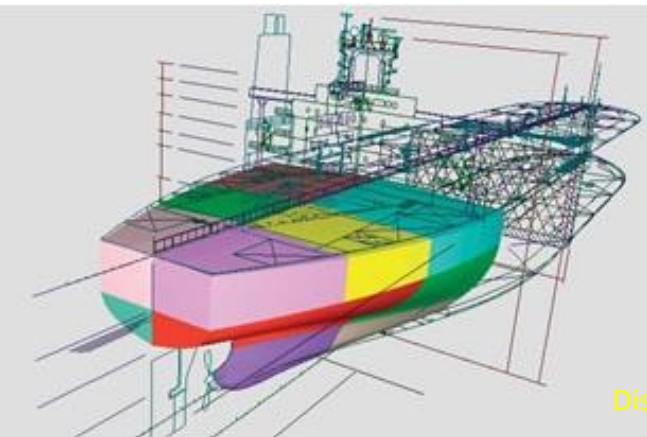
…NDT fleet sails the virtual seas

Motivation

E-S-E

- Resource constraints put vessels in the field past the end of their design lives;
- Evolving mission requirements are forcing vessels to operate outside of their envisioned design envelopes;
- New hull designs and materials are being fielded with little prior experience regarding long term performance;
- Need for evaluating existing vessel susceptibility to emerging and novel future threats;
- Need for gauging future capabilities and readiness in a quantifiable manner.

The NDT follows its counterpart from design, through trials, into service…
…mirroring everything that happens in the real world, maximizing predictive capacity…there are in effect two ships: one with a real hull number, and the other with the same hull number followed by a “V” for virtual.



Power & Energy
Electric Ship Research & Development Consortium (ESRDC)

E-S-E

Objective / Goal

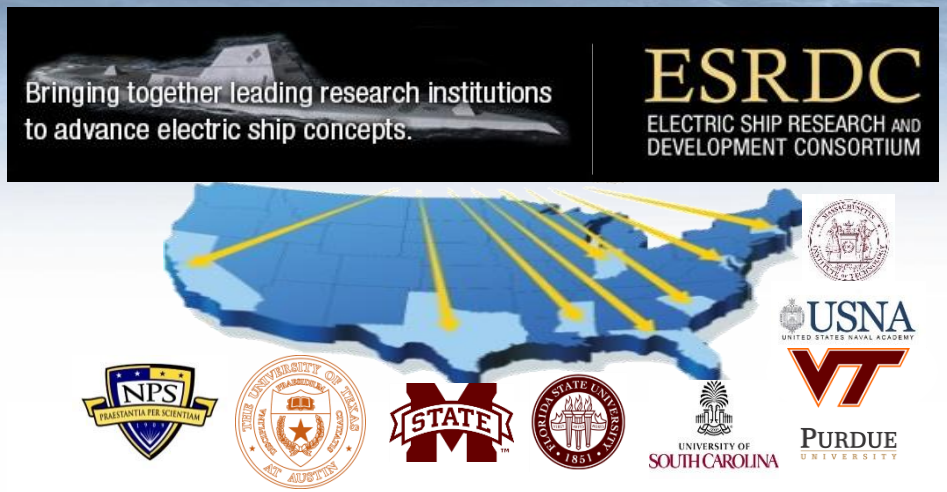
- Brings combined programs and resources of leading electric power research institutions to advance near to mid-term electric ship concepts.

Technical Summary of Research

- The five major thrusts are:
  - Combat Power and Energy Systems (CPES) Design Methodologies
  - High Power Dense Component Development and Characterization
  - System Management and Control Technologies
  - Developing New Design Functionalities
  - System Level Experimentation

Major Participants

- USNA, NPS, MIT, Purdue, Univ of South Carolina, UT Austin, FSU, Mississippi State, VT



Recent Accomplishments

- S3D transition to Navy use
- Control hardware in the loop testing for equipment behavior model development
- Power hardware in the loop testing for equipment behavior model development

Key Milestones / Projected Transition

- Continue development, testing, and performance characterization of future components to enable MVDC shipboard energy networks

Smart Ship System Design (S3D) Capabilities/Technologies

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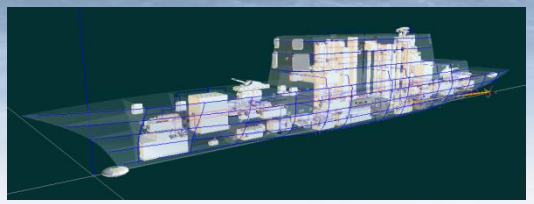
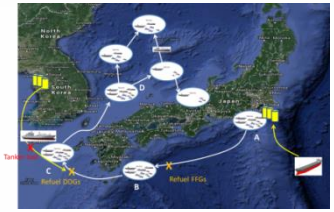
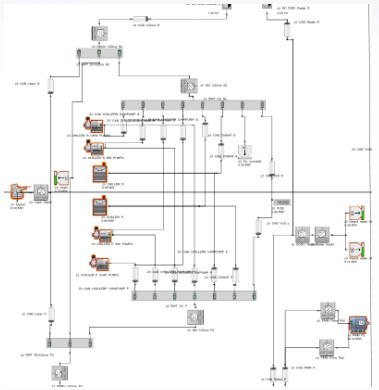
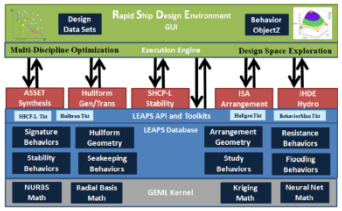
New Insights and Analyses Produce Better Ships

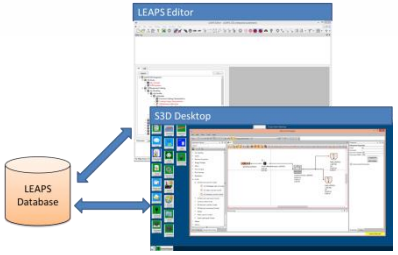


- Compute power and energy flows across all domains and systems
- Meet mission system requirements (impacts of energy storage, operational strategies, energy routing, pulsed load management, etc.)
- Quantify how well a system concept will fulfill its intended purposes across a full range of prospective missions
- Integrate with existing Navy design tools via LEAPS
- Component scaling – "what if" for new hardware
- Automatic cable/pipe routing speeds assessments
- Aggregation/disaggregation of components facilitates moving to greater levels of detail as the design progresses (future)
- Time domain simulation permits analyses at higher level of detail (future)
- Automated system configuration and controls speeds mission analyses (future)



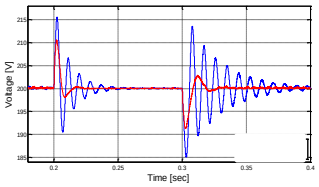


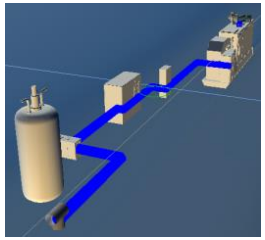




Bringing New Technologies to Ship Design

- Templates to support Set Based Design and RSDE processing
- Collaborative concurrent design to foster interdisciplinary cooperation
- Intelligent design guidance to provide designers with technical knowledge when needed
- Cloud based simulation to speed simulation





Additive Manufacturing Materials & Processes Overview

E-S-E

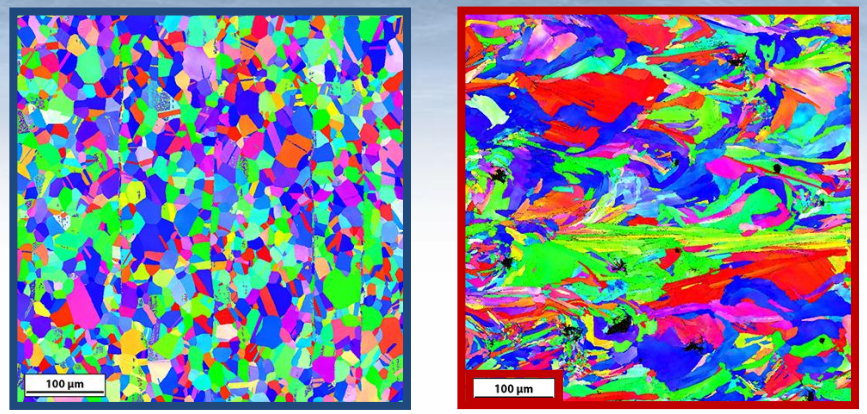
Objectives / Goals

- Develop predictive models for AM materials and processes for engineering applications
- Create and develop additive manufacturing materials and processes for Naval applications
- Enable broad implementation of AM

Technical Approach

- Investigate the highly coupled and complex design, structure, process, and performance relationships for AM fabricated parts through computational modeling and materials characterization
- Verification and validation of robust computational models to enable an accelerated qualification framework for AM parts
- Develop computational approaches for new and tailored AM materials and processes

Microstructural Differences in AM



Wrought 316 Stainless Steel

Additive DMLS 316 Stainless Steel

Naval Relevance / Impact

- Develops the capability to rapidly qualify and certify AM components to supports Naval AM goal to increase readiness/sustainment of long lead time items
- Enhanced capabilities through broader design space in AM fabrication, including tailored design and materials performance

Recent Accomplishments

- Large scale AM for molds and tooling applications; including development of a full scale optionally manned technology demonstration
- Flight critical AM part demonstration

Building Capacity from Classroom to Operational Capabilities

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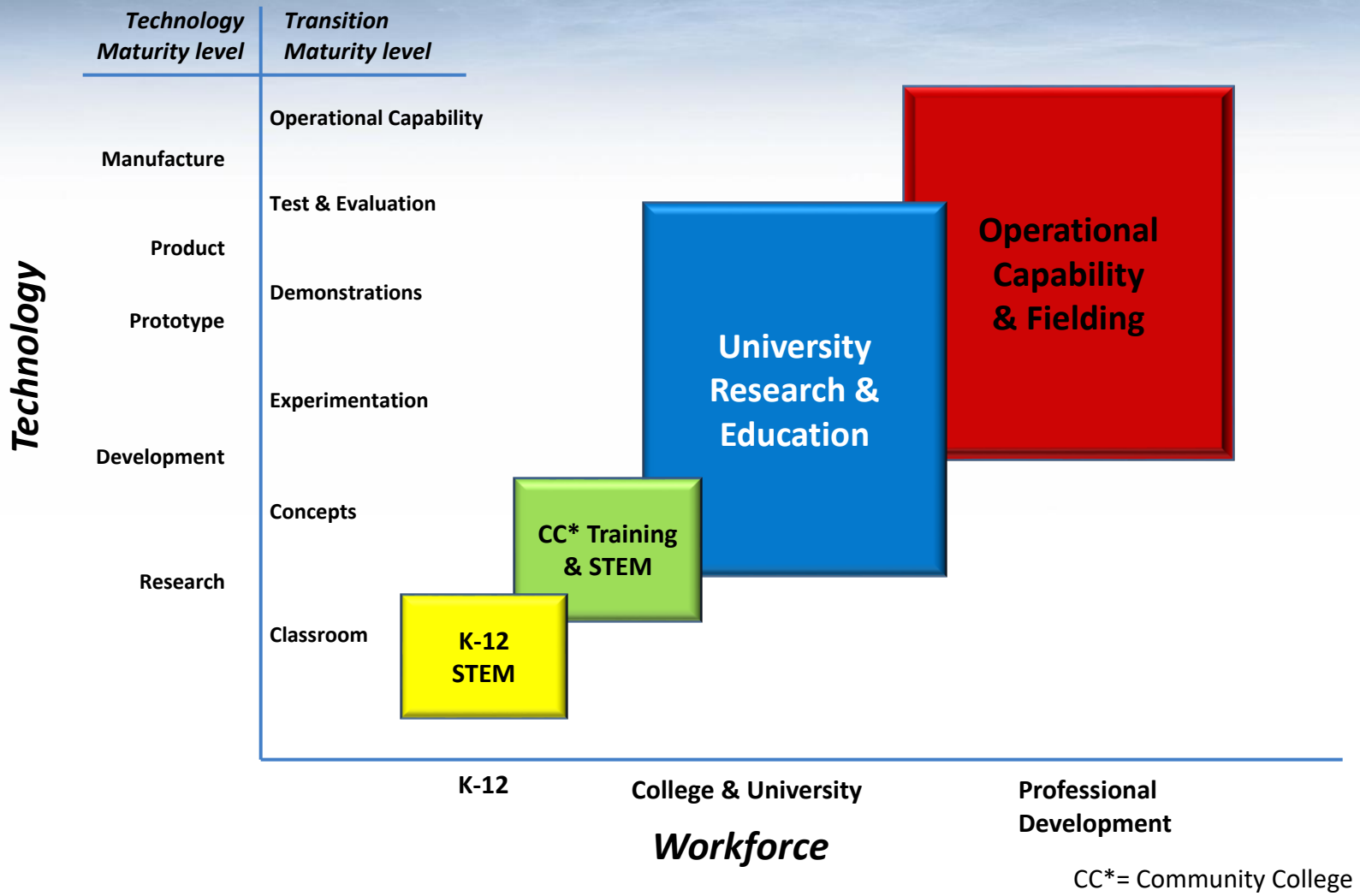


CC*= Community College

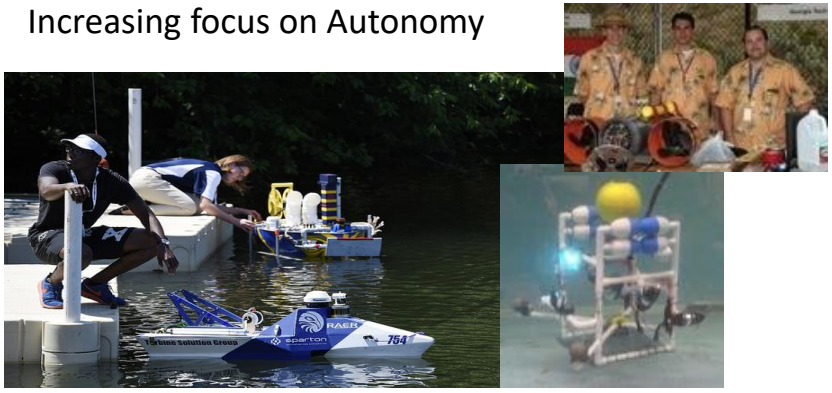
Science, Technology, Engineering & Math (STEM)
SeaPerch, RoboBoat, RobotX

Objective / Goal

- SeaPerch creates awareness of, develops interest in, and encourages pursuit of degrees and career fields in STEM through hands-on experiential learning activities.
- RoboBoat competition is to enhance the community of innovators capable of substantive contributions to the domain of autonomous unmanned surface vessels (USVs).
- RobotX expands RoboBoat and RoboSub to multiple vehicles performing cooperatively in all domains.

Technical Summary of Research

- SeaPerch K-12 Basic introduction to Remotely Operated Vehicles (ROVs)
- RoboBoat – combines systems engineering thinking through sensor/platform integration
- Increasing focus on Autonomy



Recent Accomplishments

- 10th RoboBoat June 2017 Daytona Beach, FL will include Unmanned Aerial Vehicles
- Annual SeaPerch Challenge May 19-20 at Georgia Tech
- RobotX 2016 – Keeho Lagoon, Sand Island, Oahu, December (held biennieally)

Key Milestones / Projected Transition

- SeaPerch becoming a self-sustaining program
- SeaSense adds data collection to SeaPerch
- RobotX 2017 – Sydney Australia will include virtual simulation environment for testing algorithms and provide a venue for publication of research utilizing the WAM-V

Electrical & Power Engineering Education

Objective / Goal

- Revive and Enhance Education - Prepare next generation of Navy electrical & power engineers
- Meet increasing demands in power-related fields in the Navy and elsewhere
- Educate naval officers to maintain, operate, & sustain naval power systems

Summary of Effort

- Develop 19 courses in Electric Power & Energy Systems
- Disseminate widely by offering course materials free online to all U.S. universities for classroom and distance learning

Major Participants

- Ned Mohan – University of Minnesota
- Consortium of Universities for Sustainable Power (CUSP) – 224 universities participating as of Feb 2017

Recent Accomplishments

- 13 courses completed
- 2 courses in development
- 4 courses not yet started but in planning
- Adopted by USNA and Naval Postgraduate School for core and distance learning curriculum
- Over 100 universities are using these materials

Key Milestones / Projected Transition

- **Near:** Publication of all 19 courses in FY18
- **Mid/Far:** Educate/Train Navy Electrical Engineering Workforce with emerging technologies (COMNAVSEA 05Z and NSWC PD technical work force benefiting now!)

Naval Enterprise Partnership Teaming with Universities for National Excellence (NEPTUNE)

E-S-E

People, Power and Partnerships

Advance Department of Navy personnel and energy objectives by supporting university research activities that directly incorporate participation and education of naval personnel across active & reserve duty military, ROTC and veterans.

PURDUE UNIVERSITY

ASU ARIZONA STATE UNIVERSITY

UCDAVIS

MIT Massachusetts Institute of Technology

NPS PRAESTANTIA PER SCIENTIAM

U.S. Naval Academy

Centers for Innovation in Naval Technology (CINTs)

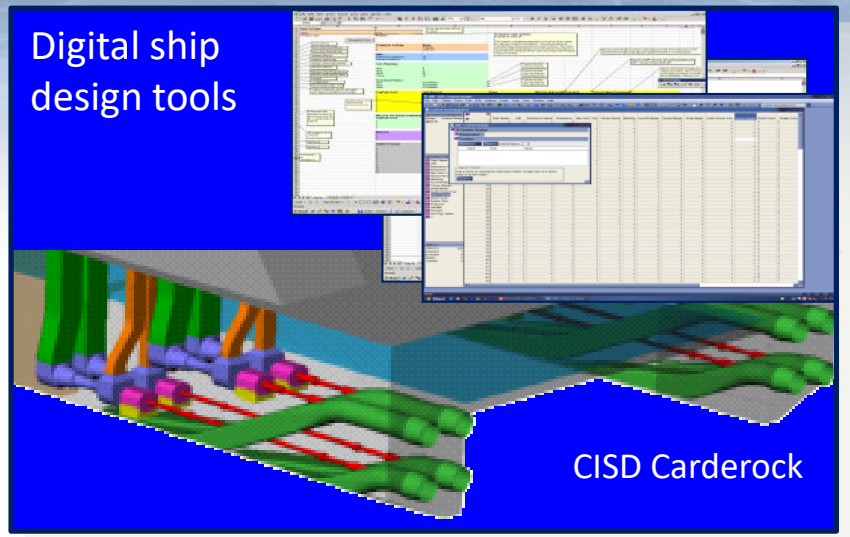
E-S-E

Objectives

- **To sustain the capability i.e., people, tools, and knowledge, to develop future innovative naval technologies**
- **To maintain a pipeline of people capable of substantive research contributions to the naval research enterprise**
- **To reinvigorate interest in Navy unique research and technology development through topical, short term innovation cell activities**
  - Information Warfare: SPAWAR San Diego
  - Center for Innovation in Ship Design: NSWC Carderock
  - Littoral Warfare Innovation Center: NSWC Panama City
  - Center for Innovative Machinery Design and Integration: NSWC Philadelphia
  - Warfare Innovation Cell Knowledge for Educational Development: NSWC Dahlgren

Approach

- **Annually, each CINT selects topics from many sources; PEO Ships, OSD, NAVSEA, Warfare Centers.**
- **NREIP students, interns, summer faculty and new employees investigate, act, and report back.**



Recent Accomplishments

CINT	FY15-17 # of Students	FY15-17 # of hires
CIMDI	46	6
CISD	54	7
LWIC	24	1
WICKED	66	3
IW - SPAWAR	32	0
Totals	222	17

Energy Systems Technology Evaluation Program (ESTEP)

E-S-E

Education & Training Opportunities for Current & Future Naval Energy Workforce

- *Command Personnel*
- *Naval Postgraduate School (NPS) Energy Students*
- *California State University San Marcos (CSUSM) Student Veterans*

SPAWAR

Program Management
Info/Network Security Expertise
Technical & Business Training

Technology Demonstrations at Naval Facilities to Reduce Energy Costs & Increase Energy Security

ONR Oversight & Funding

NPS

Energy ROI Research
Student Project Participation
Technical & Business Education

NAVFAC

Project Management
Facility Expertise
Technical & Business Training

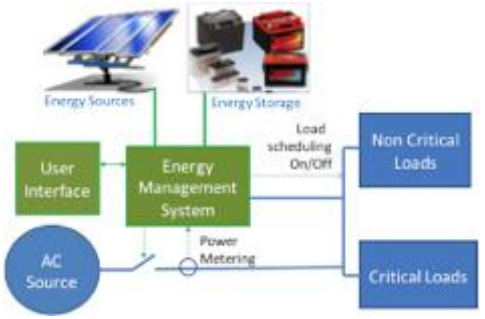
ESTEP
MISSION • PEOPLE • TECHNOLOGY

http://www.aptep.net/partners/estep/
http://www.csusm.edu/veterans/estep/
https://youtu.be/Ck-xjlC0NF8

ESTEP Microgrid Related Projects

E-S-E

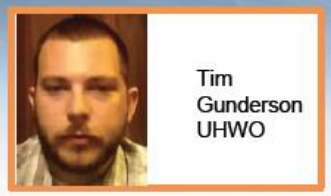
- Cyber-SCADA Energy Capability (C-SEC): Develop Cyber SCADA metrics and new Cyber SCADA integrated capability
- Virtual Smart Grids for Achieving Regional Net-Zero Energy Goals: Develop & demonstrate virtual smart grid to manage/achieve net-zero energy goals at the regional scale
- Marine Corps Base Hawaii Energy Management Evaluation: *Evaluate cost-effective energy management for MCBH. Determine ROI, ease of integration and ease of use*
- Optimization Tool for Hybrid Energy Systems: Develop an effective tool to analyze and optimize the performance of hybrid energy systems composed of renewable power generation (e.g. PV and wind) and energy storage
- Seamless Integration of GIS and Electrical Architecture Models for Smart Grids and Net-Zero Energy Goals: Develop a technical approach to integrate one-line electrical models into Naval GIS programs in support of virtual smart grids and net-zero energy goals at the regional scale
- Modular Microgrid with Energy Storage: Demonstrate mobile microgrid with existing PV at 30kW scale and at 100kW scales at two locations
- Mobile EMS Prototype for Field Studies: Design and build an energy management system (EMS) packaged so that it can be moved to different locations for practical demonstrations and microgrid studies.



Personnel Overview

E-S-E

California State University SAN MARCOS


Tim Gunderson UHWO


David Bright CSUSM


Jason Sneddon CSUSM


Tim Jordan SDSU


Christopher Hardy CSUSM

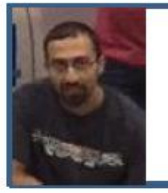

Ryan Fatchett SDSU


Glen Geiser SJSU


Bashar Ameen SDSU


Michael Souza SJSU


Christian Gilmartin CSUN


Ammar Ameen SDSU


Christopher Phelps CSUN


Adrian Marquez SBCC


Brian Pierce CSUSM

Success

E-S-E

California State University SAN MARCOS

- **Supplement Education**
  - Provides real world application of theory
  - Introduces new concepts
  - New software
  - Cross train into different areas and majors
  - Provides opportunity for student to discover their interests
- **Professional Development**
- **Mentors**
- **Networking**

Past ESTEP students

- 59 Total Veteran Student Interns 2013-2016
- 23 Hired into full-time Jobs: SPAWAR, Helix Electrical, Northrop Grumman, SD Composites, NAVAIR etc.
- 24 Current ESTEP Students
- 4 Ended internship focus on school at SDSU

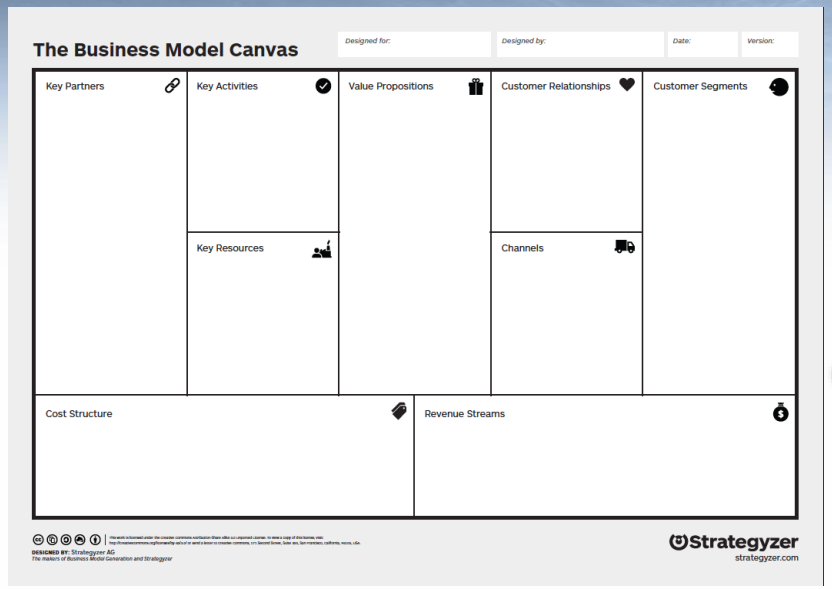
Adrian Marquez
Hydrogen Fuel Cell Vehicles
Summer 2016

Hacking For Defense (H4D)

"Hacking for Defense™ is a university-sponsored class that allows students to develop a deep understanding of the problems and needs of government sponsors in the Department of Defense and the Intelligence Community. In a short time, students rapidly iterate prototypes and produce solutions to sponsors' needs."
http://www.h4di.org/about.html

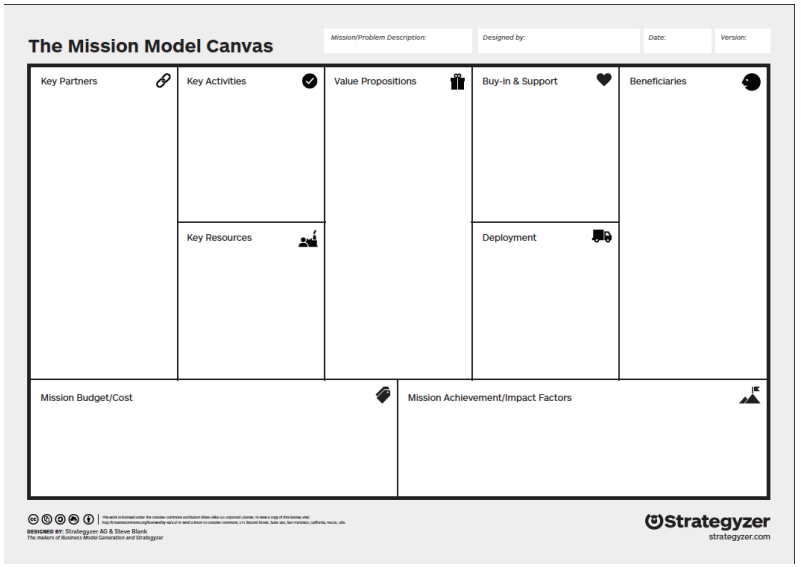
https://www.md5.net/bootcamp

Business Model → Mission Model



Business Model
"Revenue Streams"

Mission Model
"Mission Achievement/Impact factors"



Adoption Readiness Level (ARL)

E-S-E

Table 1. Summary of Adoption Readiness Levels

ARL		Component Technology TRL	Systems-Level Technology Integration	Stakeholders	Processes
1	Application Identified	5	Potential to satisfy an existing or anticipated need more effectively than alternatives.	N/A	N/A
2	Demonstration Planning	5	Research plan developed, necessary facilities identified.	Stakeholders identified. Need verified.	Funding budgeted for demonstration phase. Approvals required for demonstration identified.
3	Representative Prototype	6	Demonstrated at representative research site. Performance documented.	Pilot performance validated by stakeholders.	Technical approvals required for operational use identified and documented. Testing or modification requirements documented.
4	Representative Demonstration	7	O&S requirements and any training requirements for O&S documented.	O&S funding levels and personnel requirements for sustainable support in operation estimated.	Process for getting technical approvals for operational use has been documented.
5	Fully Adoptable	8	Operating at representative research site or operational site for relevant time period. Performance requirements satisfied and documented.	Validated and accepted by stakeholders, including budget for procurement and ongoing O&S.	All required technical approvals have been received. Any required updates to Unified Facilities Criteria or Guide Specifications have been made or in process of being updated.
6	Adopted	8	In operational use at multiple installations.	Training and communication programs in place.	Technology installed and in operational use.

E. Regnier, R. W. Barron, D. A. Nussbaum, K. Macias, *Defense AT&L*, January–February 2017, pp. 9-12.

Lean Methods for Defense Energy Innovation

Lean Methods for Defense Energy Innovation: Process & Component Matrix

Concept-to-Adoption Steps in Pathway (C2D & D2D)

Component Activities & Funding Opportunities

	Create/Identify Concepts & Startups	*Advance Technologies & Startups*	*Adopt Technologies & Products*
Educational Classes & Events and Related Outreach Activities	MD5 (Boot Camp & Hackathon); H4Di; NPS; NDU; STEM	MD5 (Accelerate); NPS	NPS (Adoption Readiness Levels)
Navy/ONR Funding Opportunities	SBIR/STTR (Phase I); NEPTUNE	EEx (Go-to-Market); Launch Alaska; ESTEP; SBIR/STTR (Phase I/II); NSETTI	EEx (Demonstration); Launch Alaska; SBIR/STTR (Phase III); NSETTI
Partner Funding Opportunities	OECIF; OSD SBIR/STTR (Phase I)	OECIF; OSD SBIR/STTR (Phase I/II); SERDP; AF-OEA; AF-REDI, DIUx	ESTCP; OSD SBIR/STTR (Phase III); AF-OEA; AF-REDI; DIUx
Military Community Professional Development	NEPTUNE (veterans, active & reserve duty, ROTC)	ESTEP (veterans & installation personnel); NEPTUNE	ESTEP (veterans & installation personnel)
FY18 Topic & Proposal Calls, Due Date	OECIF (Topic Call, ?)	OECIF (Topic Call, ?)	ESTCP (Pre-proposal call, 6 Apr 17)

Energy Excelerator

E-S-E

Who We Are

Strategically located in Honolulu, HI, Energy Excelerator (EEx) is an ONR-supported technology commercialization program under the Asia-Pacific Technology and Education Program (APTEP) focusing on commercializing clean energy technology, research and development that can later be utilized at Naval installations and civil society once it is proven and the cost has been reduced through commercialization activities.

We focus on two different areas:

1. *Helping our **companies succeed**; and*
2. *Helping transform a place, the **Asia-Pacific**, through innovation, and research and development*

Asia Pacific Regional Engagement

Energy Excelerator is building research and development partnerships in the Asia-Pacific through ongoing meeting and discussions with:

- Korea Electric Power Co (KEPCO) and Korean Energy Technology Evaluation and Planning Dept (DETEP)
- First Philippine Holding Co
- Enetech and the Okinawa Prefectural Govt Ministry of International Trade and Industry
- New Energy & Industrial Technology Development Org (NEDO)

Energy Excelerator New Industry Partners

Federal support is core to this effort. Additionally, as part of the commercialization mission of EEx under APTEP, EEx engages industry partners to assist and inform technology innovation and research and development. New industry partners include:

Hawai'i Community Foundation — **Support for new water track focused on conserva7on and energy savings technologies.**

Vector — **Vector is the largest electric distributor in New Zealand.**

TEPCO — **Tokyo Electric Power Company is the largest electric utility in Japan and the 4th largest electric utility in the world.**

New Companies Accepted into the Program to Advance their Research, Development and Commercialization

2016 Cohort

Energy Efficiency	Finance	Generation	Grid	Water	Cybersecurity
carbonlighthouse	T REX	AUTOWATTS	Blue Pillar	GOmeter	lastwall
plotwatt		Edisun	Geli	WaterSmart	

It Works!!

$15M Federal → $350M Private Investments

http://energyexcelerator.com