Enabling Success in Combat: An Integrated Approach to Energy and Capability Development

Operational energy is **energy required for training, moving, and sustaining military forces and weapons platforms for military operations**, and includes energy used by ships, aircraft, combat vehicles, and tactical power generators.

Jim Caley
Director for Operational Energy
Department of the Navy
Given at: Naval Post Graduate School
March 2024

Agenda

- Current Operational Energy
- China and Energy
- The SECNAV view
- The Future
- Training and Education – how it effects OE
- How NPS is enabling solutions
- The path forward

Operational energy is energy required for training, moving, and sustaining military forces and weapons platforms for military operations, and includes energy used by ships, aircraft, combat vehicles, and tactical power generators.

Energy: Get it done!









- Increasing logistics tail
- Unnecessary readiness costs
- Overusing equipment ahead of its lifecycle
- Non-deployable capabilities on subs and ships
- Using more power than we need
- Insufficient capability

Are we a credible force?

Historical Perspective

WWII Pacific Theatre

1. Logistics challenges were extreme and played a major factor in multiple key battles
2. WWII was a high casualty conflict. 4,400 allied troops killed in a single day
3. Adversary intentionally avoided targeting logistics chains
4. The U.S. entered the war producing 70% of ships globally
5. The U.S entered the war with 380 ships, and exited the war operating 7,601 ships. In San Francisco alone, shipyards produced 1,400 vessels over a 1,365 day period.

Iraq & Afghanistan

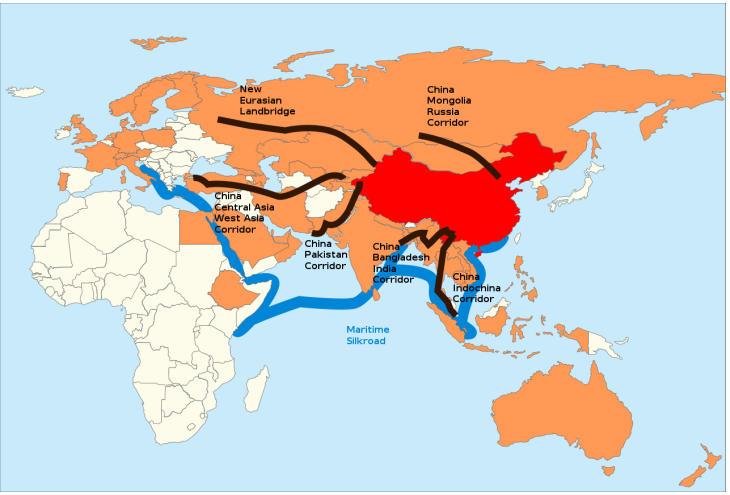
1. Logistics challenges were moderate and U.S superiority on the ground minimized impact
2. Iraq & AFG resulted in 7,054 Americans killed over a 20 year period.
3. Adversary intentionally targeted logistics chains using IEDs

Future Conflict

1. Logistics challenges are projected to be the most challenging in history
2. Two modern military powers clashing may result in extremely high causalities.
3. Adversary intentionally targeting logistics chains using missiles (including hypersonics)
4. The U.S presently has 298 ships, and builds a rate of 3? Navy/CG ships and 5 commercial ships per year (0.36% of global shipbuilding).
5. Asymmetric warfare is going to sea – See Yemen, Ukraine

To produce the number of ships the U.S. built in WWII would take the current U.S. Maritime industrial base 760 years

Two Perspectives
China and Energy



- Belt Road Initiative
  - Expand Chinese Trade
  - Provide Aid without interference
  - China recognizes that it needs energy to be successful
    - Energy infrastructure
    - Naval bases to assure SLOCs

- Competition expanding to Conflict: China Perspective
  - China's territorial claims includes offshore oil
  - 'Attack alliances, then attack logistics.' –Sun Tzu
  - "Fighting the Fight that Fits One's Weapons" and "Making the Weapons to Fit the Fight" - Qiao Liang and Wang Xiangsui

China controls global battery supply chains

Raw Minerals → Processed Materials → Active material/ Components → Cell → Battery Pack → Weapon/ Platform

Stage One: Extraction			
Nickel	8%	0%	31%
Cobalt	0%	0%	1%
Graphite[1]	1%	0%	65%
Lithium	0%	1%	9%
Manganese	0%	0%	6%

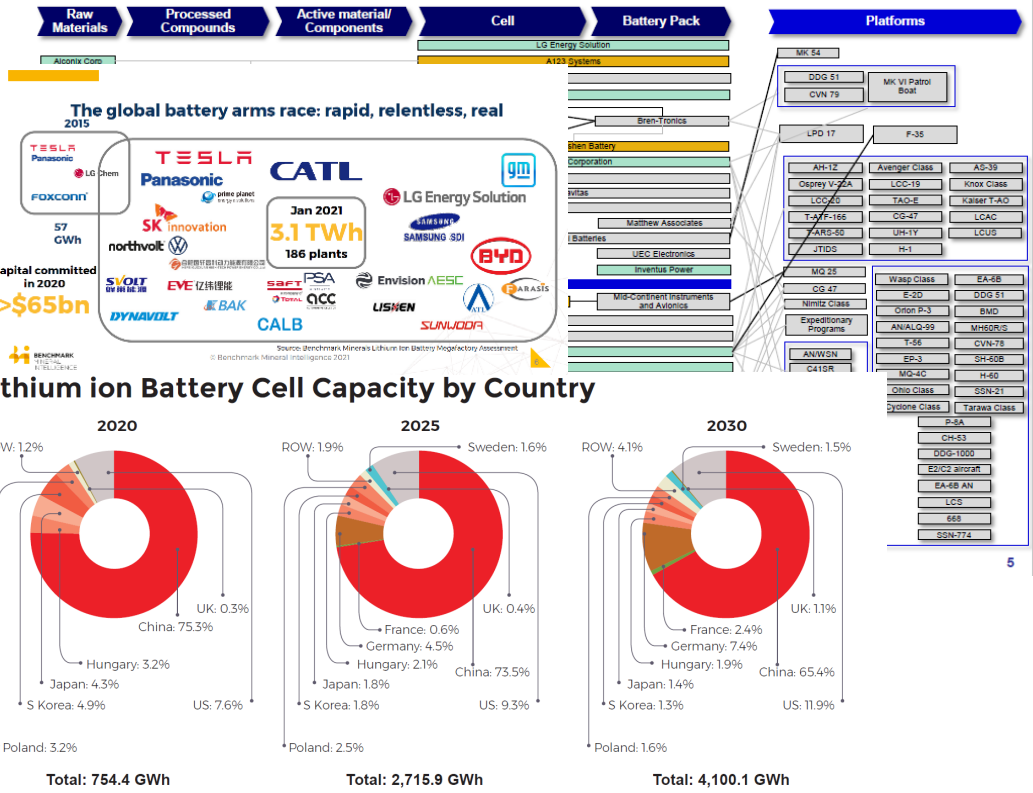
Stage Two: Chemical Processing/Refining			
Nickel	13%	1%	65%
Cobalt	17%	0%	82%
Graphite[1]	0%	0%	100%
Lithium	0%	4%	59%
Manganese	7%	0%	93%

Stage Three: Cathode or Anode Production			
Cathode	0%	0%	61%
Anode[1]	0%	0%	83%

Stage Four: Lithium ion battery cell manufacturing			
Cells	6%	10%	73%

Navy Battery Supply Chain Map and Foreign Dependency – Preliminary Data

As of June 24



Chinese companies are inside the advanced battery supply chain for critical defense systems

Energy Today

Energy: Get it done!

- Increasing logistics ta
- Unnecessary readine
- Overusing equipmen of it's lifecycle
- Non-deployable capa






China and Ene

- **Belt Road Init**
  - *Expand Chin*
  - *Provide Aid w*
  - *China recogn successful*
    - *Energy infr*
    - *Naval bases*
- **Competition e China Perspective**
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  - *'Attack alliances, then attack logistics.' –Sun Tzu*
  - *"Fighting the Fight that Fits One's Weapons" and "Making the Weapons to Fit the Fight" - Qiao Liang and Wang Xiangsui*


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Operational Energy & Logistics Challenges, and DoD Leadership

Future Conflict

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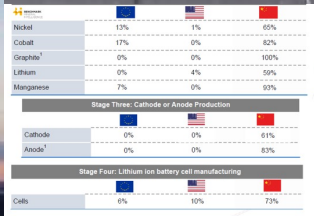
Operational

WWII would take the current 760 years

battery supply



Chinese companies are inside the advanced battery supply chain for critical defense systems

Energy Constrains All Naval Operations

Energy is a combat enabler... and a vulnerability



Operational Realities

- The enemy is not fighting fair – economics, proxy forces…Unrestricted Warfare – READ IT.
- Energy constrains Fleet actions
- Vulnerabilities increase the further you get away from CONUS
- Ground operations are constrained by linear, easily-identified lines of communication (LOC)

The future Navy will face…

- Both Near-Peer and out-matched competitors are actively developing/deploying weapons to target our weaknesses, including the energy supply chain
- High-power weapons systems are coming
- The Navy is expected to function at greater stand off and at greater speed, which requires more power

Energy Vulnerabilities

Enemy and proxy force interdiction

Choke points

Natural and man-made disasters

Near-Peer SOE ownership

Cyber and SCADA system attacks

Price volatility

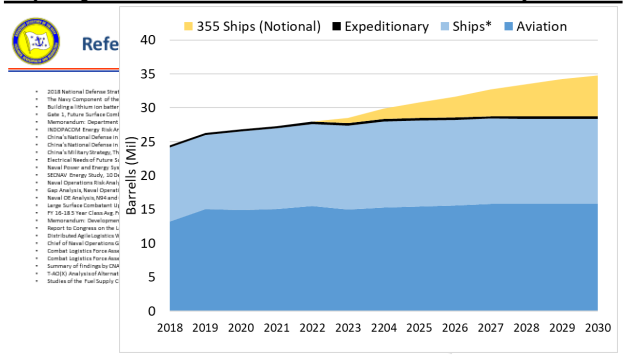
Extended lines-of-communication

Support asset vulnerability

Department of the Navy Operational Energy

Warfighting Impact

- 75% of energy consumption in the Navy is operational.
- Significant Operational Energy **challenges** with *current demand* **constrain** Naval *reach*, *persistence* and *lethality*; limiting our ability in near-peer competition **Fuel demand is going up across the Navy and Marine Corps – 15%**; by 35% considering 355 ships
- Power demand is going up across all platforms; *on ship is projected to more than double by 2030*



- Increased Warfare Sys Energy Availability
- Enhanced Platform Mobility
- Advanced Forces & Platforms
- Advanced Weapon System & Sensor Enablers

Current DON Goals

1. Extend operational reach of current and future weapons systems through more effective use of energy
2. Reduce energy consumption and external energy logistics requirements to forward deployed strike groups
3. Increased energy resilience of forward bases, supply depots, and cooperative security locations – Get more energy to the warfighter
4. Increase the effective use, conversion, storage, distribution, and control of energy to enable integration of future weapons and sensors onto platforms
5. Foster and guide an energy culture in our sailors and marines through policy, training and education

Energy is great power competition is at the base of the kill chain

What do we do?

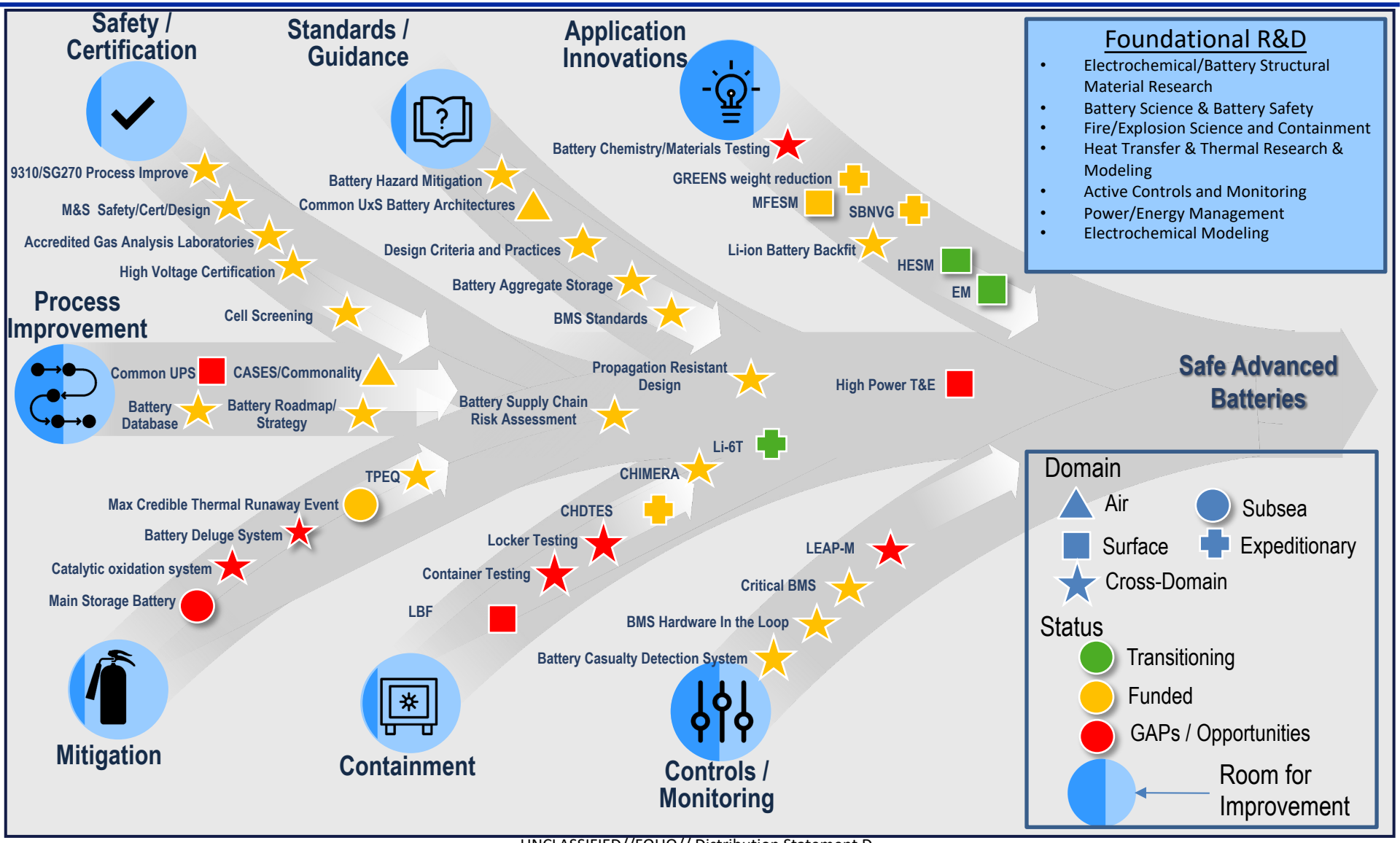
- Solutions we are working on are amazing things
  - Hybrid vehicles
  - Electric small boats
  - Unmanned refuelers (MQ-25)
  - Hydrogen Solutions
  - Directed Energy Weapons Systems
- Waste reduction
  - Inefficient systems
  - Marines and Sailors executing tasks without full consideration – Inspect what you expect
- Do not accept no for an answer from the troglodytes

Remember that your experience is insufficient for you to be correct about most things. Read prolifically.

Top Objectives - System of Systems Solution

- **Inform energy requirements** related to platform design and batteries
- **Establish/modify policy** to guide energy Key Performance Parameters and Energy Supportability Analysis, Energy Metering and Monitoring, Data Management, and Advanced Battery Strategy to include battery acquisition, employment, sustainability, safety and certification
- **Translate** Top Level Requirements, Naval Capability Evolution Plans to a power and energy demand/capacity value to inform decisions; understand dependencies', impacts, and identify risks
- **Establish a protocol/methodology** to aggregate & analyze platform/system power and energy data to facilitate coordination & data accessibility by OPNAV/CNIC requirements/action officers, program offices and technical warrant holders/technical authority to inform their decisions in their respective functional areas.
- **Identify data needs, data sources, data gaps; and collect data** to support the above

Safe Advanced Batteries



Changing the Rules:
Energy and the perception of capability to deliver violence

- Reasonable lessons from the last wars….
  - US unwilling to take casualties
  - Small forces closing the sensor-shooter link aggregating greater fires
  - LOCS are easy to target
  - Missiles beat hardening/armor

- Change the rules
  - Aggregate fires, NOT forces
  - Make isolated forces persistent
  - Overcome external lines of communication
  - Complicate targeting
  - Weapons systems operating at
    - Longer range
    - Longer time on station
    - Reduced Signatures
  - Unman platforms
  - Use risk-worthy logistics fuel platforms
  - Rethink prepositioning

How is energy going to help us do this?

Directed energy weapons
Optical communications
Advanced sensors
Unmanned systems that can spend days over the horizon
Isolated forces that can remain unsupplied for 60 days
Reduced signature / silent or quiet platforms
Low profile

Rethinking the way we generate, distribute, store, and control energy.

Energy is the basis of credible force in combat and the basis of the projection of that force

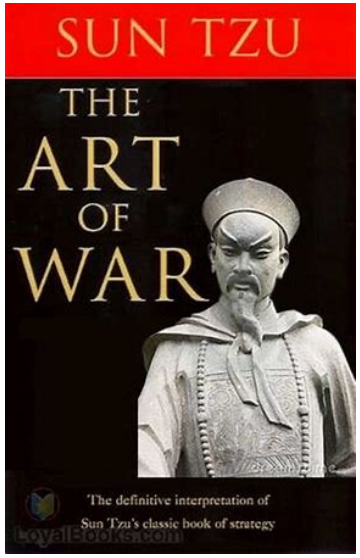
Training, Education and NPS

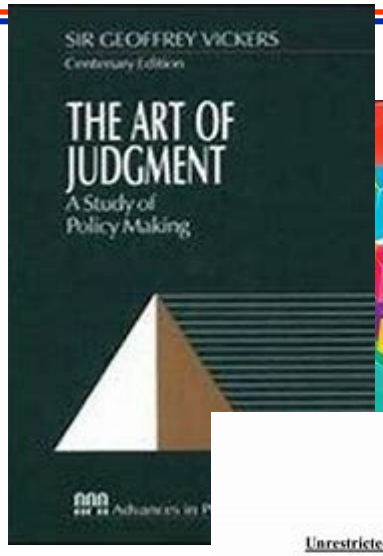
- Education impact on the fleet and fleet Marine forces is fast
- Students at NPS are a huge resource
- Applied curricula
- Experienced professors
- The integration of requirements and development

Naval Post Graduate School Solutions

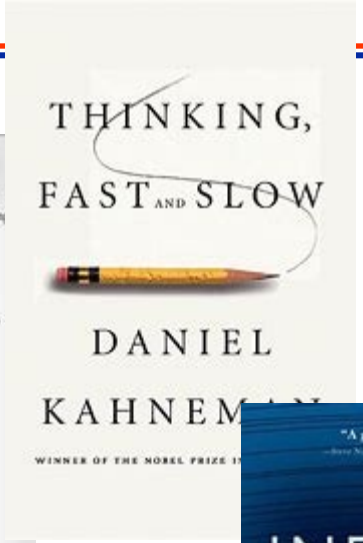
- Applied research by students and facility
  - Unmanned Systems and math behind requirements
  - JLTV optimization with LION batteries
  - Behavioral studies on Marines
  - Competency study on Naval Logisticians
- Curricula development
  - Directed Energy
  - Unmanned System
  - Refuel logistics
- Opportunities
  - Model Based Systems Engineering
  - Conditions based maintenance
  - Power sensing
- Get in front of me

Read

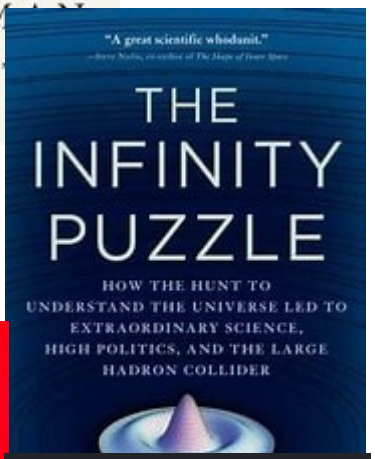

SUN TZU
THE ART OF WAR
The definitive interpretation of Sun Tzu's classic book of strategy

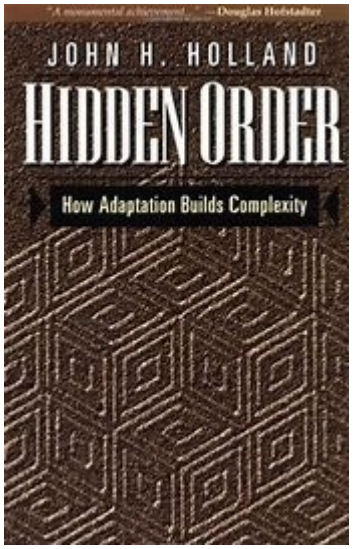

SIR GEOFFREY VICKERS
Centenary Edition
THE ART OF JUDGMENT
A Study of Policy Making

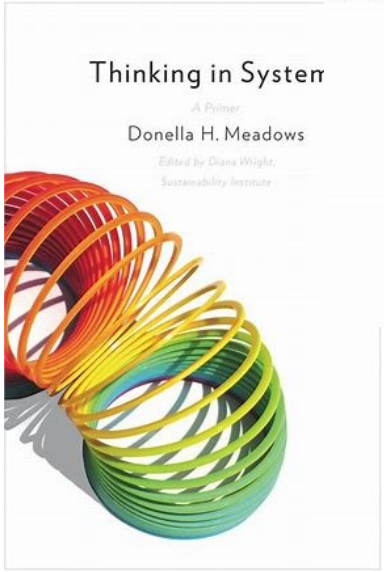

1
There are at least two kinds of games. One could be called finite, the other infinite. A finite game is played for the purpose of winning; an infinite game for the purpose of continuing the play.
2
If a finite game is to be won by someone, it must come to a definite end. It will come to an end when someone has won. . . .
FINITE AND INFINITE GAMES
A Vision of Life as Play and Possibility
JAMES P. CARSE

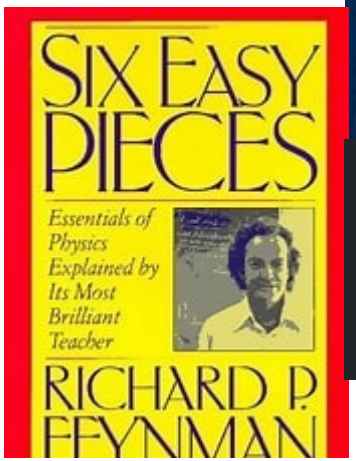

THINKING, FAST AND SLOW
DANIEL


Unrestricted Warfare
Qiao Liang and Wang Xiangsui
(Beijing: PLA Literature and Arts Publishing House, February 1999)


"A great scientific whodunit."
THE INFINITY PUZZLE
HOW THE HUNT TO UNDERSTAND THE UNIVERSE LED TO EXTRAORDINARY SCIENCE, HIGH POLITICS, AND THE LARGE HADRON COLLIDER


JOHN H. HOLLAND
HIDDEN ORDER
How Adaptation Builds Complexity


Thinking in System
Donella H. Meadows


SIX EASY PIECES
Essentials of Physics Explained by Its Most Brilliant Teacher
RICHARD P. FEYNMAN


PHYS ORG

WAIT - READ
The basis of Operational Energy Beyond Tactics and Operations

Predominate basis of
Operational Energy

- National Security Strategy
- Title 10 Acquisition Policy
- Title 10 §2926

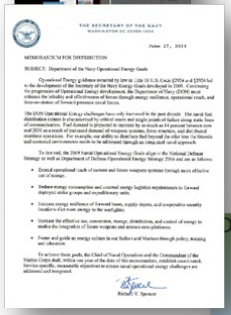
1. Extend operational reach of current and future weapons systems through more effective use of energy
2. Reduce energy consumption and external energy logistics requirements to forward deployed strike groups
3. Increased energy resilience of forward bases, supply depots, and cooperative security locations – Get more energy to the warfighter
4. Increase the effective use, conversion, storage, distribution, and control of energy to enable integration of future weapons and sensors onto platforms
5. Foster and guide an energy culture in our sailors and marines through policy, training and education

MARINE CORPS BUDGET

NAVY BUDGET

DON Energy Goals

US Code
- Title 10 Energy
  - §2911
  - §2912
  - §2924
  - §2925
  - §2926
- Title 10 Acquisition
  - § 1704
  - § 2302
  - § 3103
  - § 3252
  - § 4211
  - § 4820
- Title 42
  - §8254
  - §17143



DoD Policy
- OSD Energy Strategy
- DODI 4180.01
- DODI 4140.25
- DOD 5000 and CJSI 5123

DoN Policy
- DON Operational Energy Goals
- SecNavInst 4101.3
- SecNavInst 5000
- SecNavInst 5430

Back up slides follow

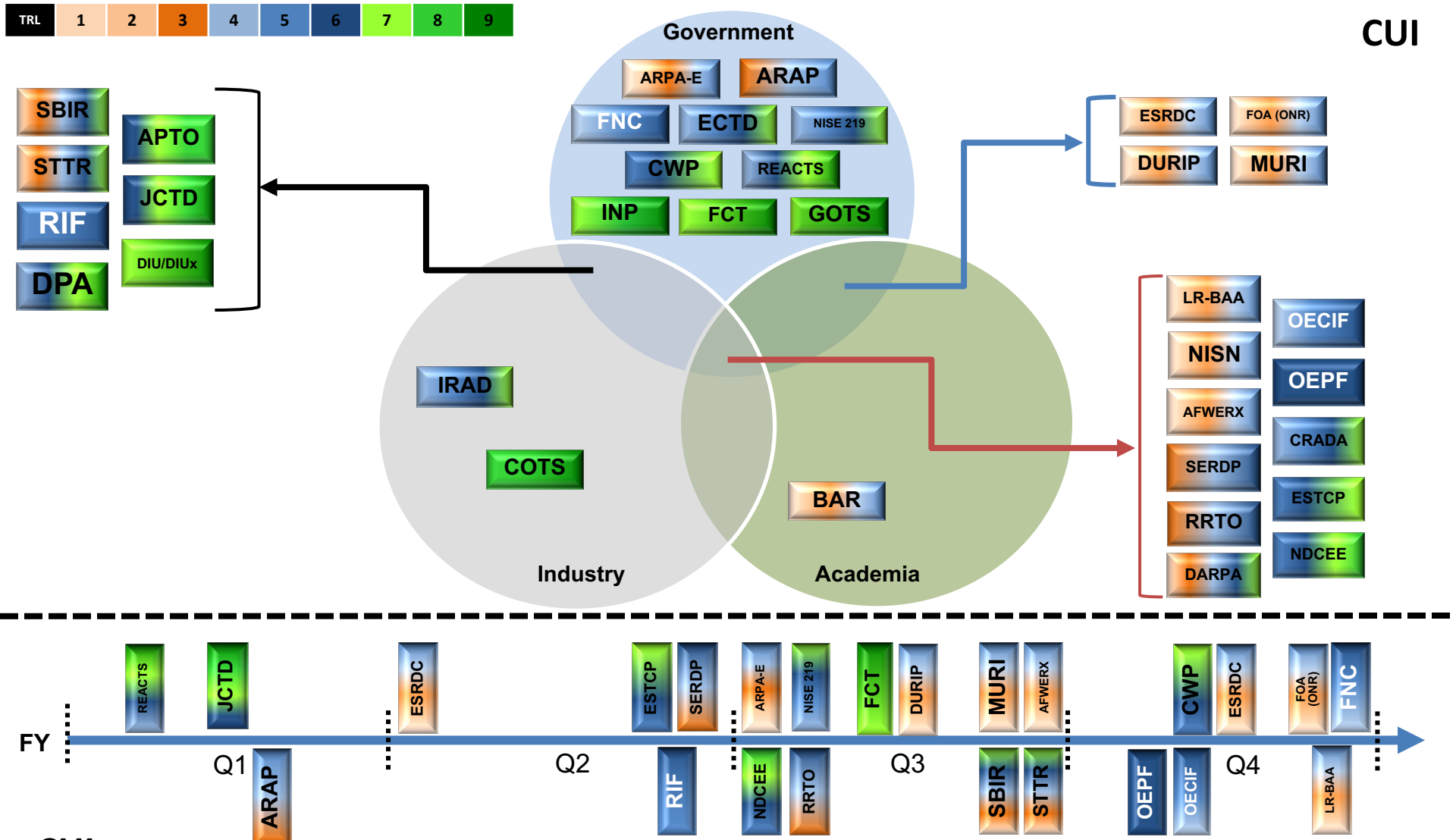
OE Priority Gaps and Opportunities

- Cyber Defense for Control Systems
- Fuel/Energy Distribution Technology for Contested Environments
- Thermal Technology Development
- Power System Development ISO Directed Energy
- Advanced Batteries (mitigation/ shipboard certification)
- Alternatives to Li-ion storage devices
- Hydrogen (generation/storage/safety/logistics/certification)
- UxV Technology Development (ISO endurance, capability, autonomy, integration, and C2)

- Tradespace for platform energy – eKPP – Energy limited capability
  - System M&S / Scenario M&S / SOSAT
  - 10 years/15 years

Alternative Funding Sources

Academia Vs. Industry Vs. Government



CUI

Operational Energy

CUI

*Classified assessment available

Topic	Metric	Status	Comments
Policy/ Authority	Energy Policy Implementation across DON		eKPP and requirements – Policy documents in progress – Est – 1 October Energy metering & monitoring memorandum – Est 1 Sept Advanced Battery Policy – Est 1 October
	Funding authorities leveraged (OECIF, 2912, etc)		PB22 – Additional $25M via CAPE effort focused on Ships OECIF $xxM, $100M available for advanced batteries, BEST office POM-23, CAPE SPR, and climate tasker → Big Navy ask across FYDP
Weapons System Support*	Unmanned Systems		MK-18 Mod 2 - Hybrid Tiger (Group II - w 4 days persistence) Funded UxS Logistics under-resourced
	Ships		LCS Stern Flaps and additional shipboard efficiencies funded in FY22 GENESYS Energy C2 to be installed on 7 DDG 51s (2021) TAO-205 Energy efficient engine funded. MVDC (12kV) Study funded to inform future investment/risk
	Aviation		MQ-25 battery replacement – In progress Common Aviation Li-ion battery (CASES) – Funded – in progress
	Ground		Focus on hybridization & electrification: MTVR 2.0; ULTV; ARV Micropower POM-23 effort in progress Directed Energy and persistent Group II ISR – R&D under-resourced
	Contested Logistics*		Low profile fuel distribution – under-resourced NGLS – under-resourced Spt to MLR included in Naval Rqmts/ Energy C2 included in AWARE
NR&DE - Infrastructure	Operational power, energy, thermal infrastructure		Initial funding identified for advanced battery fire testing and fire fighting Gap between a ship agnostic ITF and a DDG(x) LBTS No plans for thermal testing and integration Thermally Enabled Architectures for Pulsed Power Systems (TEAPPS)
DON OE GOALS	Supporting great power competition.* (See Backup)		Warfighting Capability -40% (improving) Sustainment - Fuel consumption (growing), Battery costs (growing)
Industrial Base Issues	Industry inclusion in DON Safety Certification		Initial industrial base proposals developed – Total requested $410M $20M resourced from 8132 Authority for a prototype

Funding Program Data

Acronym	Description	Common TRL(s)	Group(s)	Prop Due*
AFWERX	Air Force Technology Accelerator	1-6	G-AI	June
APTO	Advanced Power & Technology Office	6-8	G-I	Rolling
ARAP	Applied Research for the Advancement of S&T Priorities	3-5	G	November
ARPA-E	Advanced Research Projects Agency-Energy	1-5	G	April
BAR	Basic and Applied Research	1-5	A	Jan - August
COTS	Commercial off the shelf	8-9	I	Rolling
CRADA	Cooperative Research and Development Agreements	4-7	G-IA	Rolling
CWP	Coalition Warfare Program	5-7	G	August
DARPA	Defense Advanced Research Projects Agency	1-7	G-AI	Rolling
DIU/DIUx	Defense Innovation Unit	7-9	G-I	Rolling
DPA	Defense Production Act	4-9	G-I	Rolling
DURIP	Defense University Research Instrumentation Program	1-4	G-A	May
ECTD	Emerging Capabilities Technology Development	4-7	G	Rolling
ESRDC	Electric Ship Research & Development Consortium	1-4	G-A	Academic Schedule
ESTCP	Environmental Security Technology Certification Program	5-7	G-AI	March
FCT	Foreign Comparative Testing	7-9	G	May
FNC	Future Naval Capabilities	4-6	G	September
FOA (ONR)	Funding Opportunity Announcement	1-4	G-A	September
GOTS	Government off the shelf	8-9	G	Rolling

Acronym	Description	Common TRL(s)	Group(s)	Prop Due*
INP	Innovative Naval Prototype	7-9	G	Rolling
IRAD	Independent Research and Development	4-7	I	Academic Schedule
JCTD	Joint Capability Technology Demonstration	6-9	G - I	October, Novemeber
LR-BAA	Long Range Broad Agency Announcements	1-4	G-AI	September
MURI	Multidisciplinary Research Program of the University Research Initiative	1-4	G-A	June
NDCEE	National Defense Center for Energy & Environment	5-8	G-AI	April
NISE 219	Naval Innovative Science & Engineering	4-7	G	April
NSIN	National Security Innovation Network	1-6	G-AI	Varied
OECIF	Operational Energy Capability Improvement Fund	4-6	G-AI	August
OEPF	Operational Energy Prototyping Fund	6	G	August
REACTS	Energy Resilience, Efficiency, mission Assurance, energy Conservation, Training and education, energy Security	4-9	G	October
RIF	Rapid Innovation Fund	5-6	G-I	March
RRTO	Rapid Reaction Technology Office	3-6	G - AI	April
SBIR	Small Business Innovation Research	1-7	G-I	June
SERDP	Strategic Environmental Research and Development Program	3-6	G-AI	March
STTR	Small Business Technology Transfer	1-7	G-I	June

* Proposal due dates subject to change based on program funding or call duration

Energy REACTS Project Selection Criteria

Proposals will be evaluated and selected for funding based on the following factors. Non-compliance with any single factor is sufficient for a proposal to be eliminated.

1. **Focus Area for Generating OE Savings** – Proposed project must realize savings or demonstrate a benefit through operational energy resilience, efficiency, mission assurance, conservation, training and education, and security for improved readiness, lethality and combat capability.

2. **Alignment with Overarching OE Goals** - Energy REACTS projects will fill technical, operational, and industrial base gaps that aligns with SECNAV Goals, DON OE Goals; and addresses a gap(s) in one of the listed energy categories and domains. A project alignment designator will be provided using the format shown in Figure C-4.

3. **Transition** – Proposed projects must have a direct transition path or demonstrated impact to item (1) or (2) above. A transition partner, path and timeline must be identified.

4. **Auditable ROI or Benefit** - Project must show a clear benefit or return on investment after successful transition of the project. The project must define the process by which the benefit or savings realized after project completion will be measured and tracked. This benefit or measure can be expressed in energy cost savings or in terms of value added. The energy savings calculation process, database, and baseline information must be provided.

5. **Project purpose** – Energy REACTS funds should not augment appropriated programs of record. 10 U.S.C. § 2214 prohibits the use of Energy REACTS funds for any item for which Congress has denied funds. Energy REACTS funds shall not be used in lieu of, or as a replacement for, existing or anticipated future programming and budgeting shortfalls, nor should it be used in any future budgetary planning.

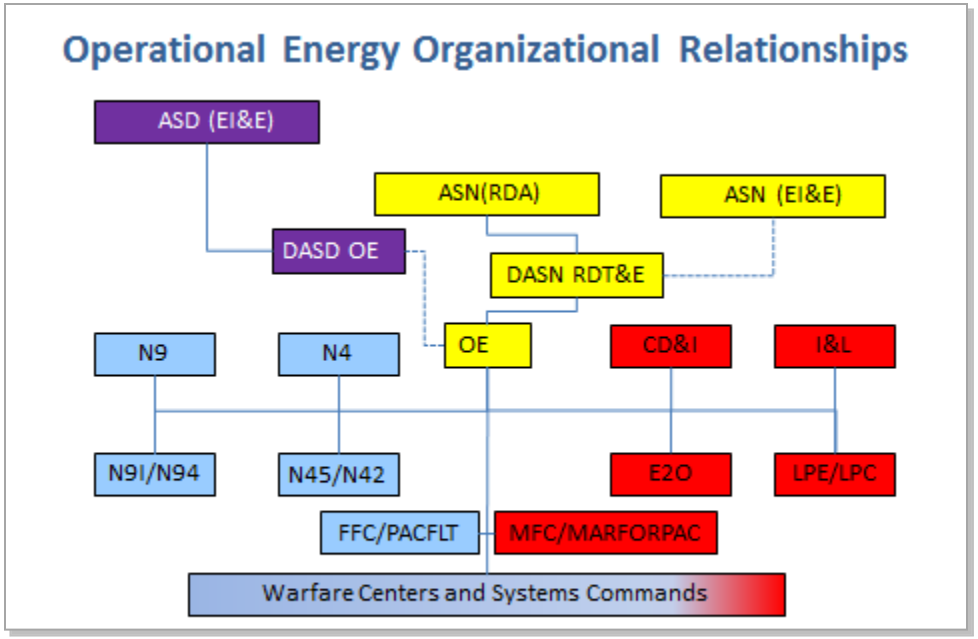
6. **Project Plan** – The proposed project must meet the fiscal and legal requirements of appropriation type. Recipient BSOs and NOEEB/NOESB Stakeholders will ensure projects meet the fiscal and legal purposes pursuant to references 10 USC § 2912, FMR Vol 12 Chapter 12, and FMR Volume 2A (Chapters 1-3)

7. **Project milestones, deliverables and spend plan** should be clearly identified and completed to support an identified fleet/field need timeframe (such as Initial Operational Capability, maintenance depot timeframe, etc...), inform a Capability Requirement, inform a policy, or any other identified transition pathway.

Backups

OE Roles & Responsibilities

- Work with DON Systems Commands, PEOs, and PMs to ensure major acquisitions appropriately consider the benefits of energy efficiency to combat capability, system supportability, and life cycle costs.
- Work with Type and Fleet Commanders to ensure operational commanders assess and mitigate energy-related risks to operations.
- Develop DoN-level policy and guidance for operational energy policy and programs.
- Inform the development of wargames, future force requirements, acquisition programs and influence tactics, techniques, and procedures in operational maneuver with modelling and simulation.
- Coordinate with ONR on ongoing research and emerging energy technologies.
- Collaborate with DOE, DLA, and other federal agencies on new fuel sources, including advanced biofuels.
- Understand the energy impact of DON acquisitions, research and development, including advanced weapons systems.
- Review and validate energy service budgets.
- Lead energy related behavior change and incentivization efforts across DON operational commands.



Staffing Risk:
Mitigated Risk
Managing Risk
Unmitigated Risk

OE FY22 Goals

Identify Problems
- Integrated Battery Study
- FSCF UAS Power Study
- FSCF/UXS Modelling
- CNA UxS
- USN OESA (x3)
- USMC LOCE
- MVDC Study
- FFG-62 Laser Eng Study
- Navy Battery Supply Chain study
- Battery Safety Factor Study

Inform Policy
- Navy OE Policy
- USMC OE Policy
- SECNAV 4101
- SECNAV 5430.7
- DODI 4180.01

Training and Education Policy
- Establish T&E Program
- Establish Fleet Energy Manager Program (USMC + USN)
- Doctrine
- METLS

Naval Integration
- Naval OE Forum
- Tech Connect/Industry
- Battery Forum
- Power and Energy Tech and Transition Forum
- Support DOD EPCOI
- FCAB
- Fuel Distribution
- BEST integration

Inform Systems of Solutions
- UxV Spiral Dev
- Hydrogen
- Secure Power
- Thermal

Acq Policy
- eKPP TTP/SOPs
- OE Metering + Monitoring Policy
- Acquisition MCO
- Advanced Battery Pol.
- Battery Contracting Policy
- Energy REACTS Policy
- NOEEB Charter

Integrate Resources
- Energy REACTS OMN
- Energy REACTS Other
- OECIF / OEFP
- SBIR
- ESRDC influence
- ARPA-E

Inform Capability

Inform Requirements
- DDG(X)
- FSCF
- FFG62 Batteries
- F-18 Power Gen and Distro
- LAW
- CVN
- NGLS
- LPDS*

Close Gaps

Hybridization/ Electrification
- Ship UPS Consolidation Demos
- Tactical Vehicles
- Small Water Craft
- Tactical Gp 2/3 UAS

Fuel – Enhance Tactical Distribution
- NGLS – POM
- LAW – POM
- LPDS – POM RQMTS
- EFDS
- JPOTS

Advanced Batteries
- Li-ion Offset Strategy
- Industry in Inspections
- Safety Mitigation Strategy
- BEST
- MIL-PRF dev timeline

Energy C2
- GENESYS – DDG 51
- GENISYS – LPD/FFGx
- FARS
- Secure POWER

P&E ISO DE
- EM - Lg Energy Storage
- Thermal Architecture
- Thermal ITF
- ITF/BES
- Integrated Power System

International
- Transition AUS 6T effort to USMC
- PECOI for TTCP (FVEY)
- Bi-Lats (UK, FN, AUS)
- Industrial base counsel Bi-Lats (Batteries)
- Int-Strat supply chain

DON OE informs policy, capability, and requirements