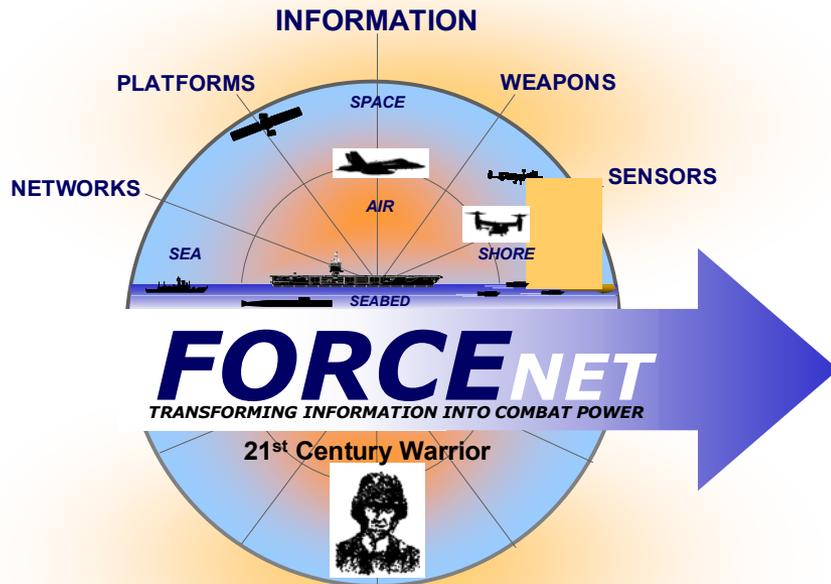


Analysis for Network Centric Warfare in the Navy



Mr. Edgar Bates
Dr. Michael Bell

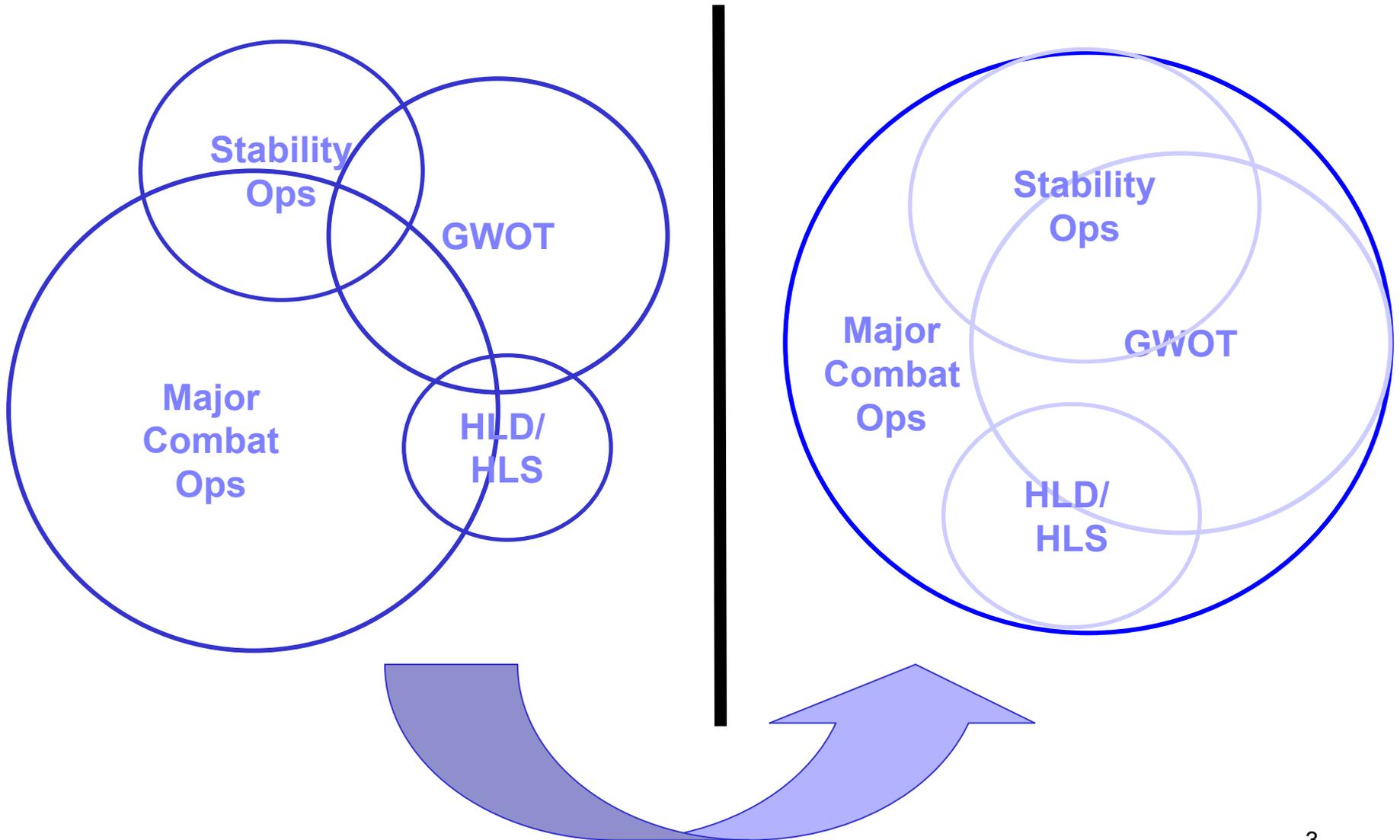
Chief of Naval Operations (N71F)

10th ICCRTS
13 June 2005

Outline

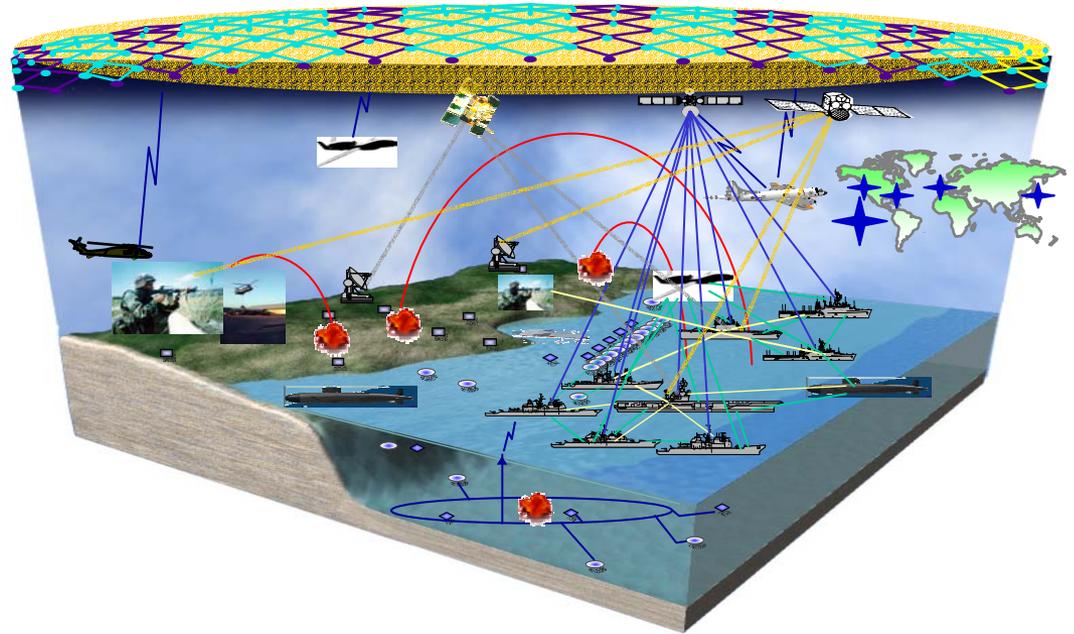
- FORCEnet analysis framework
- Examples
 - M&S and Campaign Analysis
 - Experimentation
 - Science and technology
- Conclusions

Naval Transformation



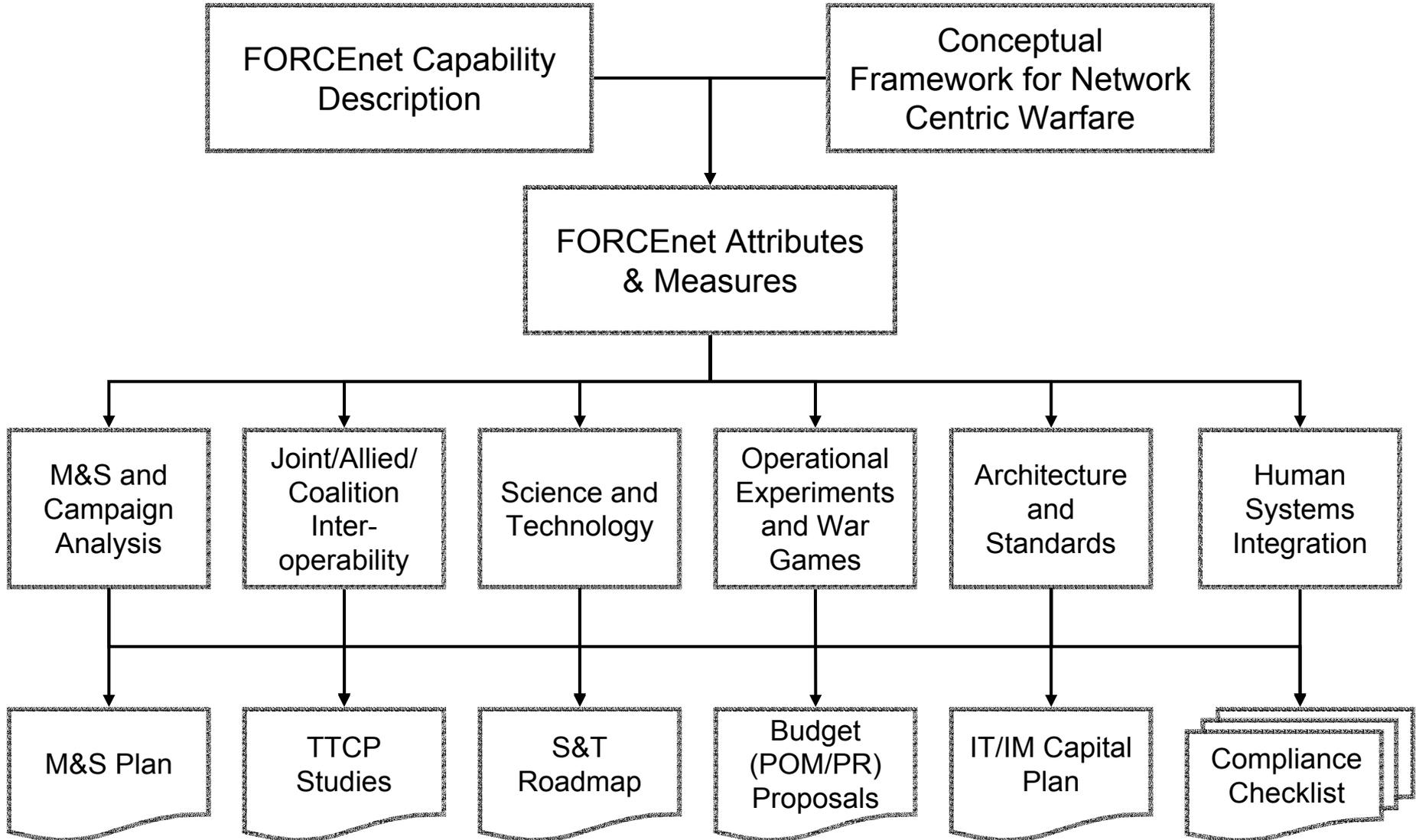
FORCEnet Definition

“FORCEnet is the operational construct and architectural framework for Naval Warfare in the Information Age which integrates Warriors, sensors, networks, command and control, platforms and weapons into a networked, distributed combat force, scalable across the spectrum of conflict from seabed to space and sea to land.”



Source: CNO Strategic Study Group XXI, definition from 22 July 02 CNO Briefing

FORCEnet Analysis Framework



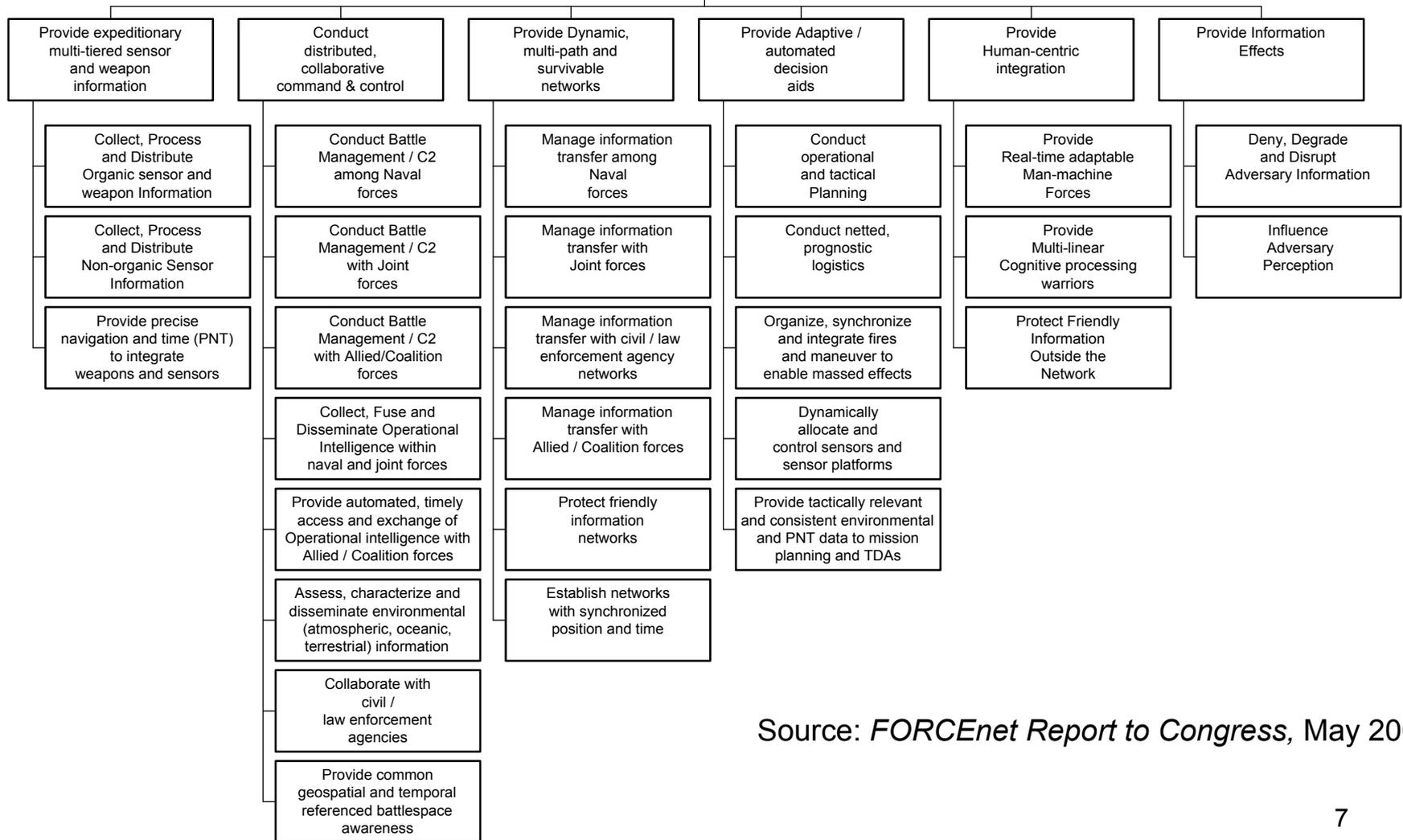
FORCEnet Capabilities

1. Provide expeditionary, multi-tiered sensor and weapon information
2. Conduct distributed, collaborative command and control
3. Provide dynamic, multi-path and survivable networks
4. Provide adaptive/automated decision aids
5. Provide human-centric integration
6. Provide information effects

Source: *Sea Power 21 and Naval Transformation Roadmap*

Capability Hierarchy

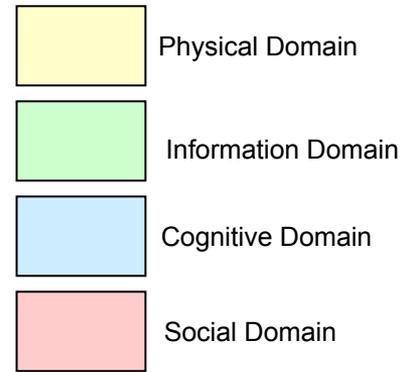
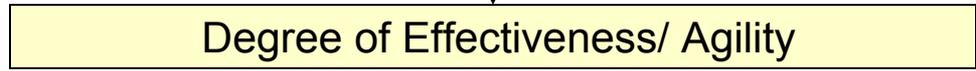
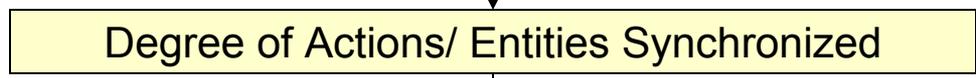
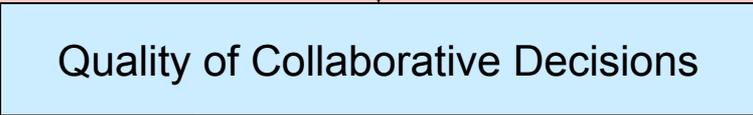
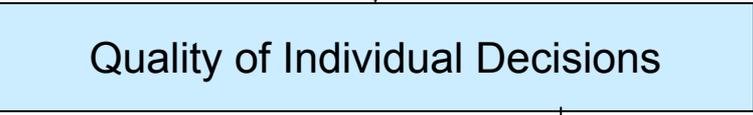
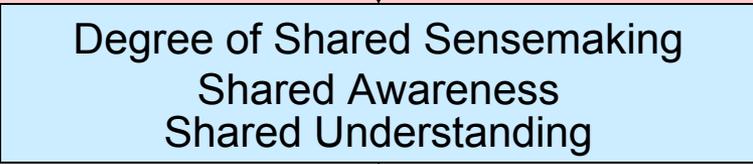
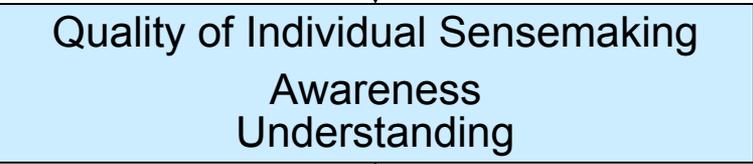
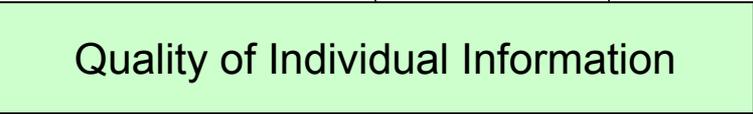
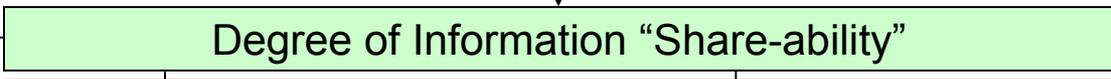
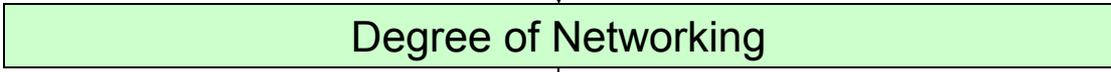
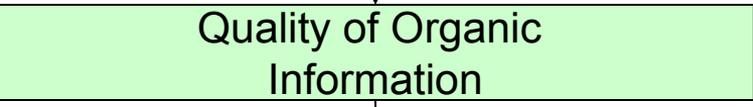
FORCEnet



Source: *FORCEnet Report to Congress*, May 2003



NCW Conceptual Framework



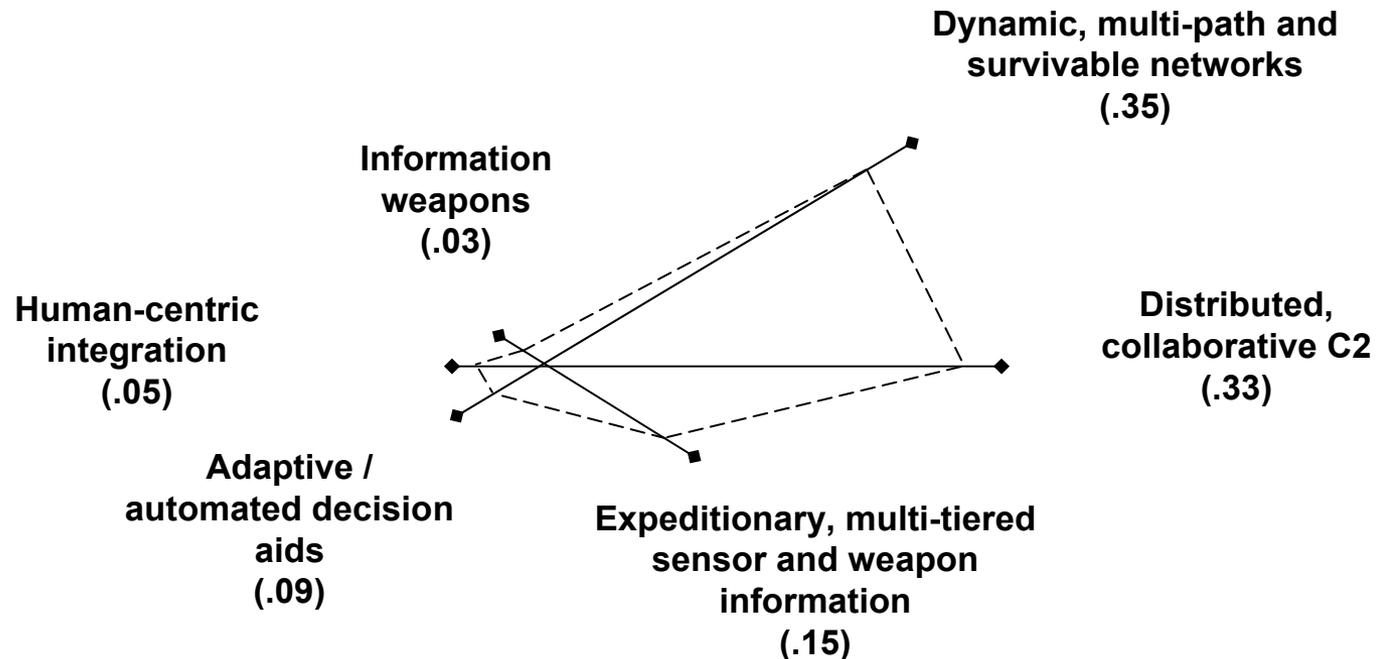
Attributes, Measures, and Metrics

- Terminology based on
 - OASD(NII)/OFT Framework for NCW
 - CCRP and NATO Codes of Best Practice (C2 Assessment & Experimentation)
- Attribute: some aspect of an event, situation, person, or object considered important to understanding the subject under study
- Measure: a standard by which some attribute of interest is recorded
- Metric: the application of a measure to two or more cases or situations

Sample Attributes and Measures

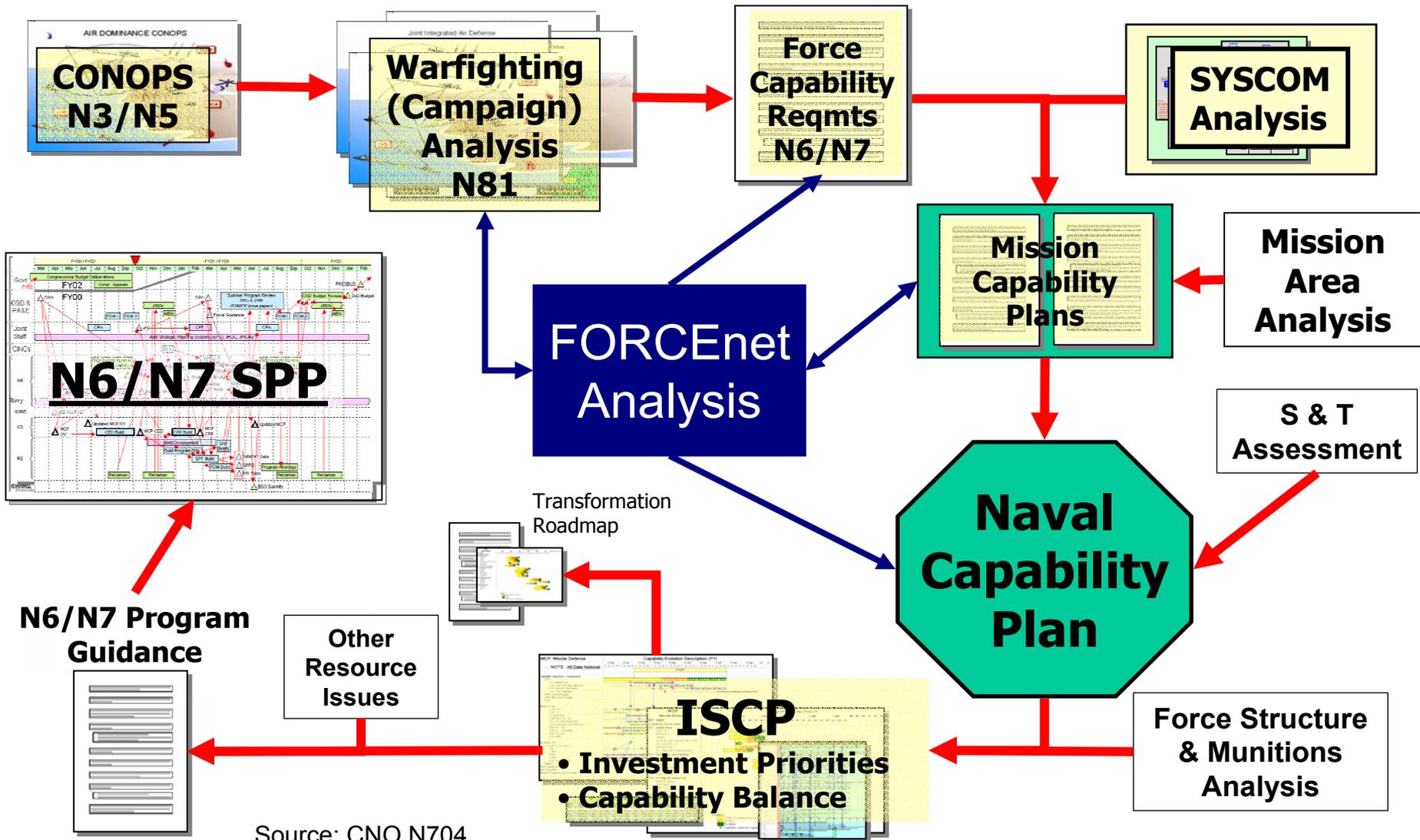
Capability: provide expeditionary, multi-tiered sensor and weapon information	
Attribute	Notional Measure
Accuracy	Correspondence with ground truth-correlation coefficient (0 = no correspondence with ground truth, 1 = full correspondence with ground truth). Data matrix comprised of relevant information items estimates (for instance: detection, ID, velocity, location, heading, etc.)
Consistency	Degree of lack of ambiguity with previous information
Completeness	Percentage of ground truth relevant and necessary for ongoing task
Precision	Error and confidence level for time and position information compared to a standard reference
Timeliness	Degree to which currency matches what is needed (0 = no match, 1 = high degree of matching between currency level needed and available)

FORCEnet Capability Growth



- ◆ = Desired “end state” for each capability
- (value) = Weight in warfighting outcomes (N6/N7 PR-05 scenarios)
- = notional status of capability

Naval Capability Development Process

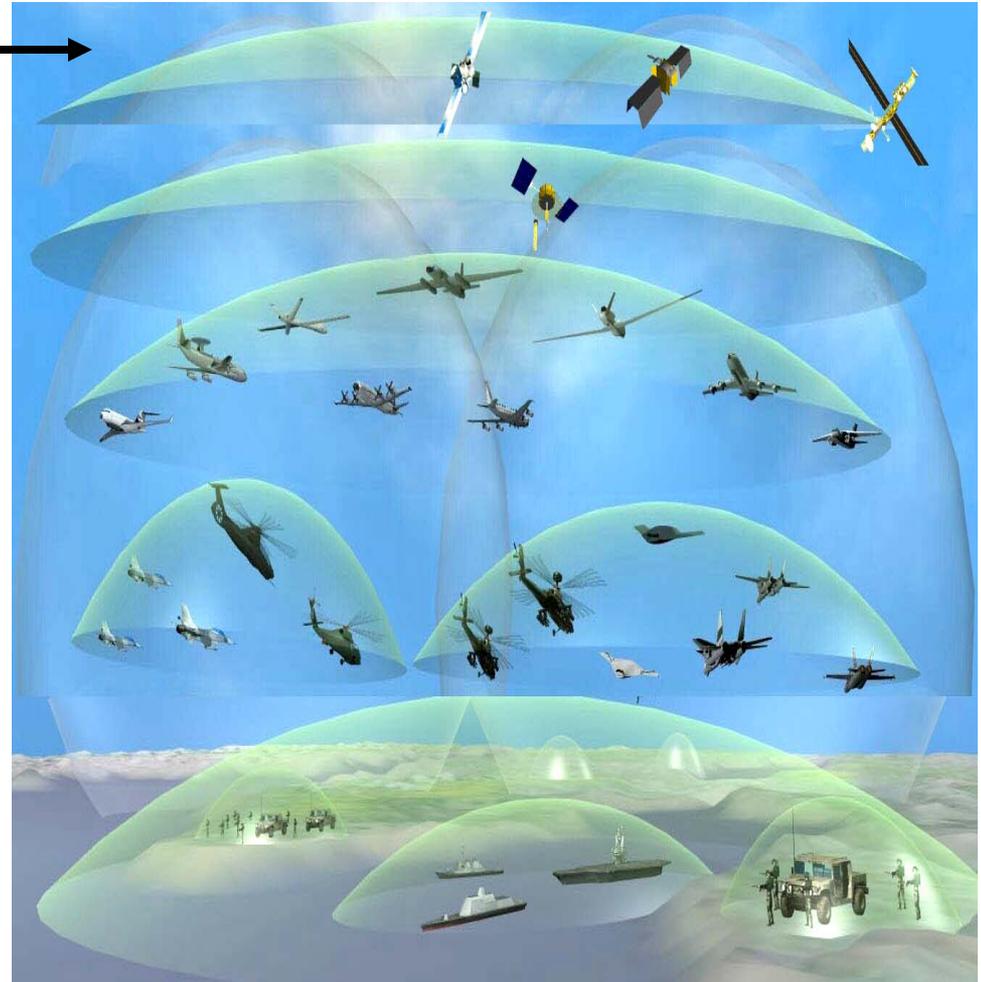


Campaign Analysis Questions

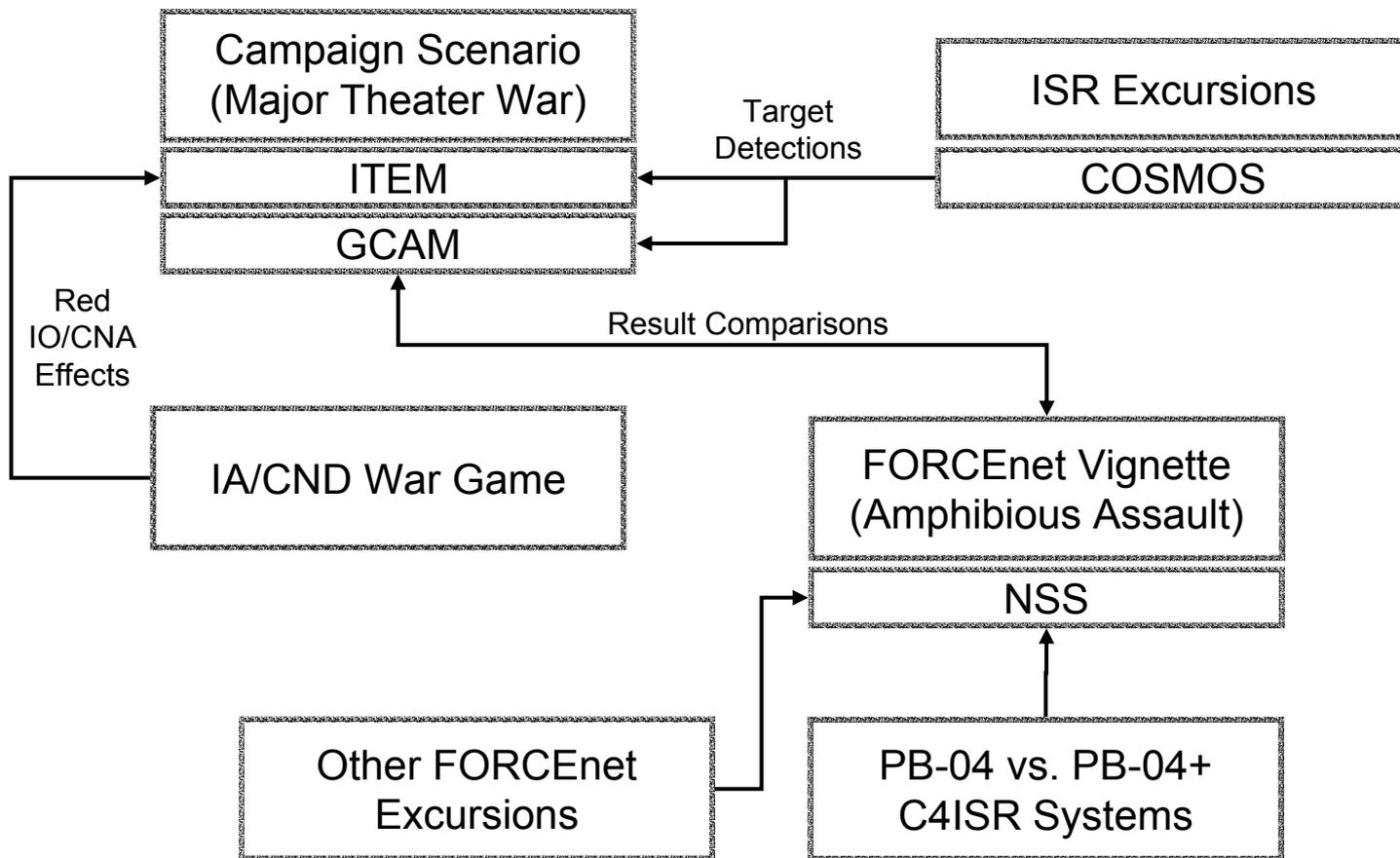
- Template:
 - “What is the impact of [selected capability] on the outcome of the campaign”
- Chief of Naval Operations :
 - What is the impact of Joint and Navy unmanned and/or autonomous systems (sub/surface/air) on the number and type of naval forces needed to provide levels of ISR required to achieve a successful warfighting outcome?
 - How much bandwidth, and over what transmission modes (e.g. single channel, multi-channel terrestrial and SATCOM), will U.S forces require to support combat operations, and how does this compare to available bandwidth? What operations would not be conducted within bandwidth constraints?
 - What is the impact of varying levels of network attacks on the successful outcome of combat operations? What types of redundancy, backups, and alternative paths are necessary to ensure successful warfighting outcomes?
- Sea Strike:
 - Are planned ISR assets sufficient to support the required rate of strike missions? If not, would additional assets mitigate the shortfall, and how many would be needed?

Measuring a “Pound of C4ISR”

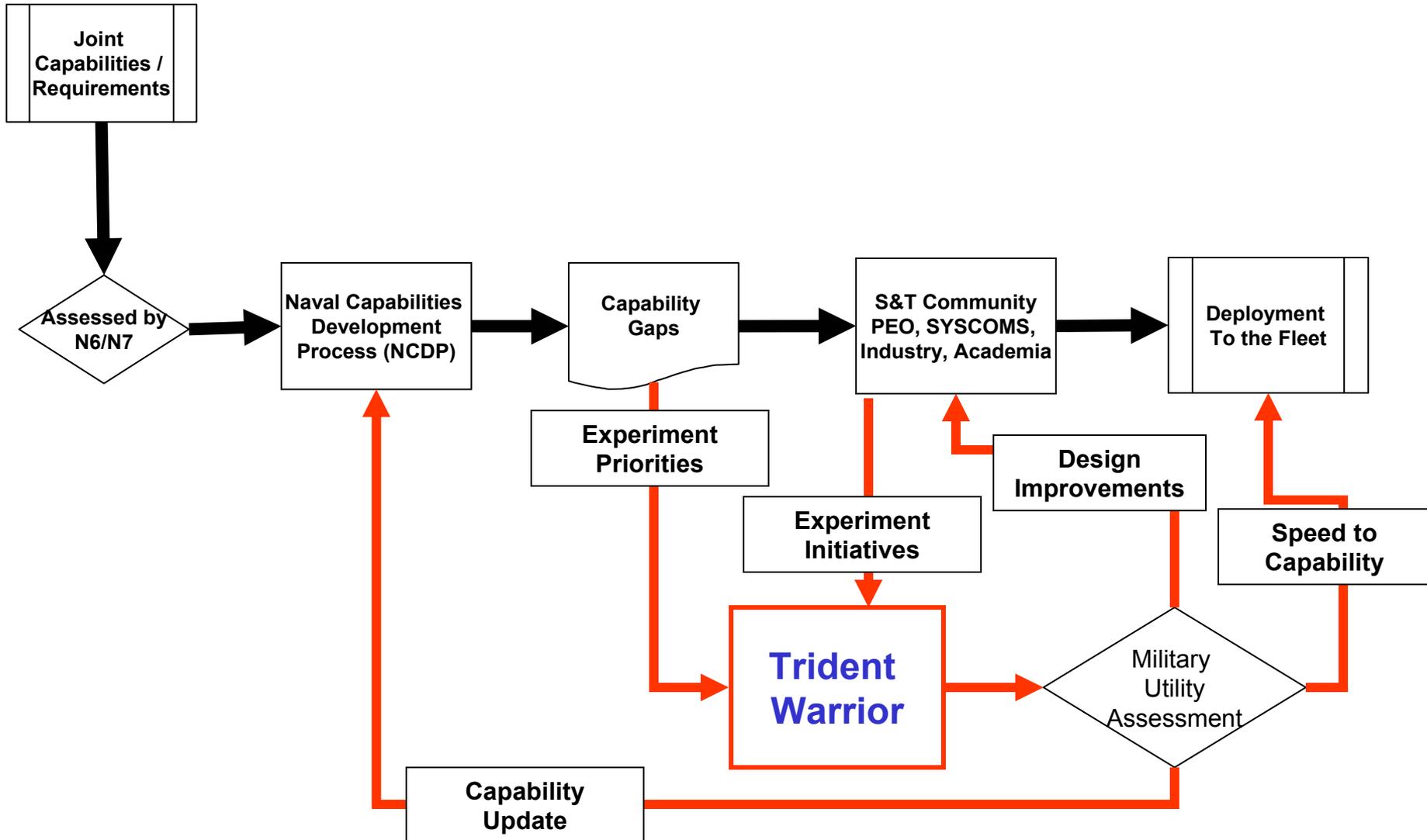
- Previous work assumed “perfect” C4ISR →
- Models should provide a more realistic assessment of:
 - System capabilities
 - Performance limitations and bottlenecks
 - Impact of new systems
- Integrated multiple mission-level models:
 - C4ISR Space and Missile Operations Simulator (COSMOS) – ISR
 - Naval Simulation System (NSS) – C4I
- These feed our campaign models:
 - General Campaign Analysis Model (GCAM) – maritime campaign
 - Integrated Theater Engagement Model (ITEM) – air land battle
- Models federated by “sneaker net”
- Combat outcomes determined by campaign level models



Campaign Analysis Process



Trident Warrior Intake / Exhaust





Giant Shadow Objectives

- Technology demonstration for new SSGN class
 - 4 SSBNs to be converted to support TLAMs by 2007
 - Advanced Payload Capability would allow support of SOFs (ASDS) & uninhabited vehicles (UUVs, UAVs)
- FORCEnet experiment to examine layered C2ISR network requirements to support SSGN/SOF ops
 - Clandestine clarification of ambiguous HUMINT
 - Persistent comms & ISR for time-critical activities

FORCEnet Metrics

Provide dynamic, multi-path and survivable networks

Current Metrics

- **Capacity:** Throughput (1) effective systems capacity = maximum data rate - system overhead rate (2)
bandwidth utilization = available data rate / effective systems capacity
 - ↑↑ **Approximations of capacity of a channel can be inferred from the sniffer logs**
 - ↑↑ **Max data rate required during the experiment**
 - ↔ Not all of the links were sniffed => difficult to get an indication of capacity across channels
 - ↓ **Non-operational setting => non-realistic usage of tactical systems**
- **Connectivity:** Percentage of time that all required nodes are connected to the network
 - ↑↑ **Can extrapolate from packet traffic between MS and HB**
 - ↔ Only available on days when significant traffic
 - ↔ Not all nodes were sniffed => cannot get timed connection info. on all nodes

↑↑ Quantitative ↑ Qualitative ↔ Not collected ↓ Could not be collected ↓↓ Difficult to address

Trident Warrior

- Major annual FORCEnet Sea Trial Experiment (NETWARCOM sponsored)
- Goals:
 - Rapid fielding of improved capability to the Fleet, with full supportability and maintainability.
 - Supporting Tactics/Techniques/ Procedures (TTP) and concept of operations (CONOPS)
- Trident Warrior 03
 - 25-30 Sept 03, USS ESSEX with the FDNF Expeditionary Strike Group (CTF 76) off Okinawa
- Trident Warrior 04
 - Fall 2004, TARAWA ESG off SoCal (COMTHIRDFLT host)
- Trident Warrior 05
 - Fall 2005, CSG (TBD) off East Coast (COMSECONDFLT host)



TW03 Metrics

USS Ft. McHenry Network Improvements

		Before (satcom only)	After (satcom and IBGWN)	Percent Improvement
Throughput	Inbound	20.0 kbps	25.8 kbps	29%
	Outbound	59.0 kbps	67.1 kbps	14%
Availability	Inbound	87.7%	99.4%	13%
	Outbound	86.0%	99.2%	15%
Total Outage Time per Day	Inbound	2 hrs 57 min	9 min	95% reduction
	Outbound	3 hrs 22 min	12 min	94% reduction
# of Outages		23	2	91% reduction
Time to Reconnect	Mean	12 min 16 sec	3 min 12 sec	74% reduction
	Max	2 hrs 19 min	6 min	96% reduction

99+% Network Availability; 91% Reduction in Outages;
74% Reduction in Average Network Outage Times

FORCEnet Focus Areas

1. Common, Persistent Maritime picture - improving shared situational awareness across the force
2. Computer Network Defense and Information Assurance - assured info
3. Ubiquitous communications and network infrastructure - bandwidth management, IPv6, etc.
4. Data link management & architecture - improving data link throughput
5. Joint Combat ID - IFF and Blue Force Tracking
6. Persistent and pervasive ISR

Trident Warrior 04

- Continues “speed to capability” via LOE to *Trident Warrior* series
- Builds upon *Trident Warrior 03* baseline
 - Improve traffic management and efficient use of bandwidth
 - Increase shared situational awareness
 - Contribution of mature TTP to both
 - Processing and exploitation of imagery ashore, in a networked environment and product pushed to Expeditionary Strike Group
- Alignment of *Silent Hammer* and *Trident Warrior* provides efficient use of Fleet assets, enhances both experiments
 - *Silent Hammer* demonstrates how a *network of forces* consisting of Ground Forces Sea Based on an SSGN can fill Joint Gaps (*ISR and Time Sensitive Strike*) by conducting a *large scale clandestine* operation, aided by advanced unmanned systems to reduce risk and increase capabilities.

Undersea Dominance FORCEnet Analysis Thrusts

UD04 ASW Concepts

Battlespace Prep (BSP)

Hold at Risk

Maritime Shield

FORCEnet Enabling Capabilities

Comm & Networks

ISR

COTP

UD04 Mission Analysis

- Mission Capability Analysis
- Campaign Analysis
- FORCEnet aspects:
 - Battlespace Preparation
 - Situational Awareness
 - ASW Timeline Reduction
 - Cueing (Deployed Sensors)
 - C4I (Sub Comms, USW-DSS)

UD04 Systems Analysis

- System Assessment
- Technical Analysis
- FORCEnet aspects:
 - Comms & Networks
 - Latency, Data Rate, Range, Availability, Covertness
 - C2
 - Effectiveness & coherency of Plan
 - Uniformity of situational awareness
 - Improved utilization of multi-sensor types
 - HSI attributes
 - ISR
 - Improved BSP through bottom mapping

N61F UD04 FORCEnet Analysis

- Goal
 - Provide analysis of Fn capabilities employed in UD04
- Approach
 - **Network Thrust & C2 Thrust**
 - Leverage UD04 Mission & Systems analysis
 - Identify C4 capabilities necessary for new ASW technologies

System	UFn IWG Systems	U/D
USW-DSS (CUP)	X	X
T-USWC	X	X
WebCOP	X	X
Composable Fn	X	X
SEAWEB	X	X
ACOMMS	X	X
BLOOM	X	X
Special Radio	X	X
HAIL	X	X
LFACOMMS	X	X
U/K ACOMMS	X	
Deep Siren	X	

USW Fn Implementation Working Group (IWG)

- Requirements
- Arch & Standards
- Implementation Plan
- Technologies / System Comparison

FORCEnet MCP/NCP

- Requirements Validation
- Assessment of Technologies
- Budget Recommendations

Rigorous C4 analysis to feed USW development efforts, IWG & MCP/NCP

FORCEnet Innovation & Research Enterprise (FIRE)



FORCEnet F.I.R.E.
FORCEnet Innovation & Research Enterprise



Trident Warrior 05



Password



Home

Welcome

Initiatives

Plan Status

Data Planning

Fn Measures

FORCEnet Measures

This section contains information to help form basis for analysis of the initiatives. The MOP MOE definitions are drawn from the SPAWAR final report. The attributes and notational measures are drawn from N71.

MOE/MOP

Fn1: Expeditionary

Fn2: Distr C2

Fn3: Dynamic Nets

Fn4: Decision Aids

Fn5: HCI

Fn6: Info Weapons

Fn 1. Provide expeditionary, multi-tiered sensor and weapon information

The expeditionary, multi-tiered sensor and weapons grid capability uses a full spectrum of manned and unmanned vehicles, platforms, sensors and weapons to provide the Force Commander with what is needed to locate targets and attack them across the depth and breadth of a theater-sized battlespace. Sensors must determine their position, time and movement at the precise time they are reporting their target or other intelligence information. The time and position information of the track provided by sensors in the grid must be properly attributed (e.g., linked to a standard reference frame with uncertainty (error) and confidence level) for it to be accurately understood, represented and fused with other data / information. Many modern weapons are also dependent on precise time and position (including uncertainty) for effective operation.

MOE or MOP (Attributes)	Metrics or Data (Notional Measures)
Accuracy	Correspondence with ground truth-correlation coefficient (0 = no correspondence with ground truth, 1 = full correspondence with ground truth). Data matrix comprised of relevant information items estimates (for instance: detection, ID, velocity, location, heading, etc.)
Consistency	Degree of lack of ambiguity with previous information
Completeness	Percentage of ground truth relevant and necessary for ongoing task
Precision	Error and confidence level for time and position information compared to a standard reference
Timeliness	Degree to which currency matches what is needed (0 = no match, 1 = high degree of matching between currency level needed and available)

Source: N71

F.I.R.E.
Home

MUA

TW04

TW05

Experimentation
Calendar

FORCEnet
Repository

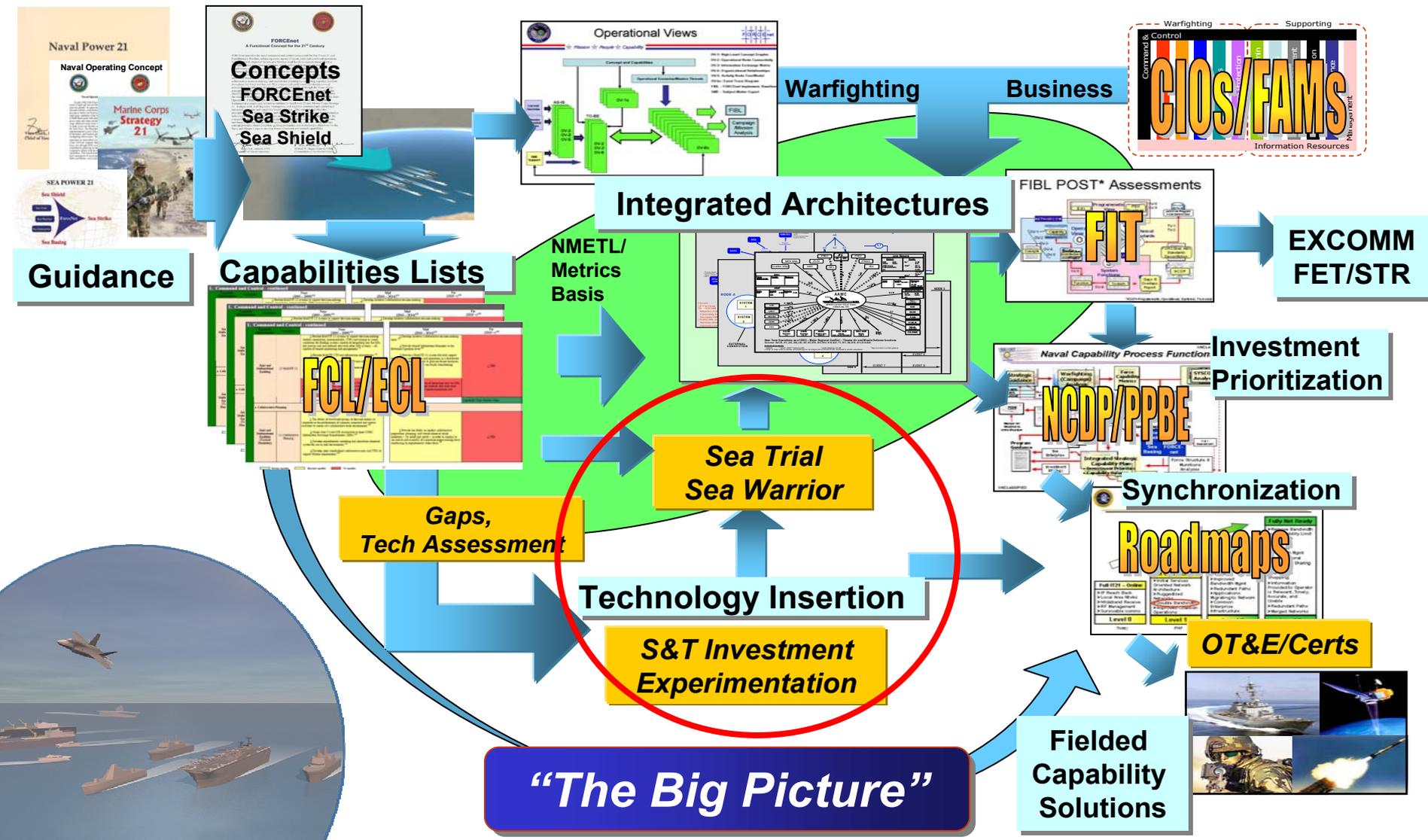
EDISON

Lessons
Learned

S & T

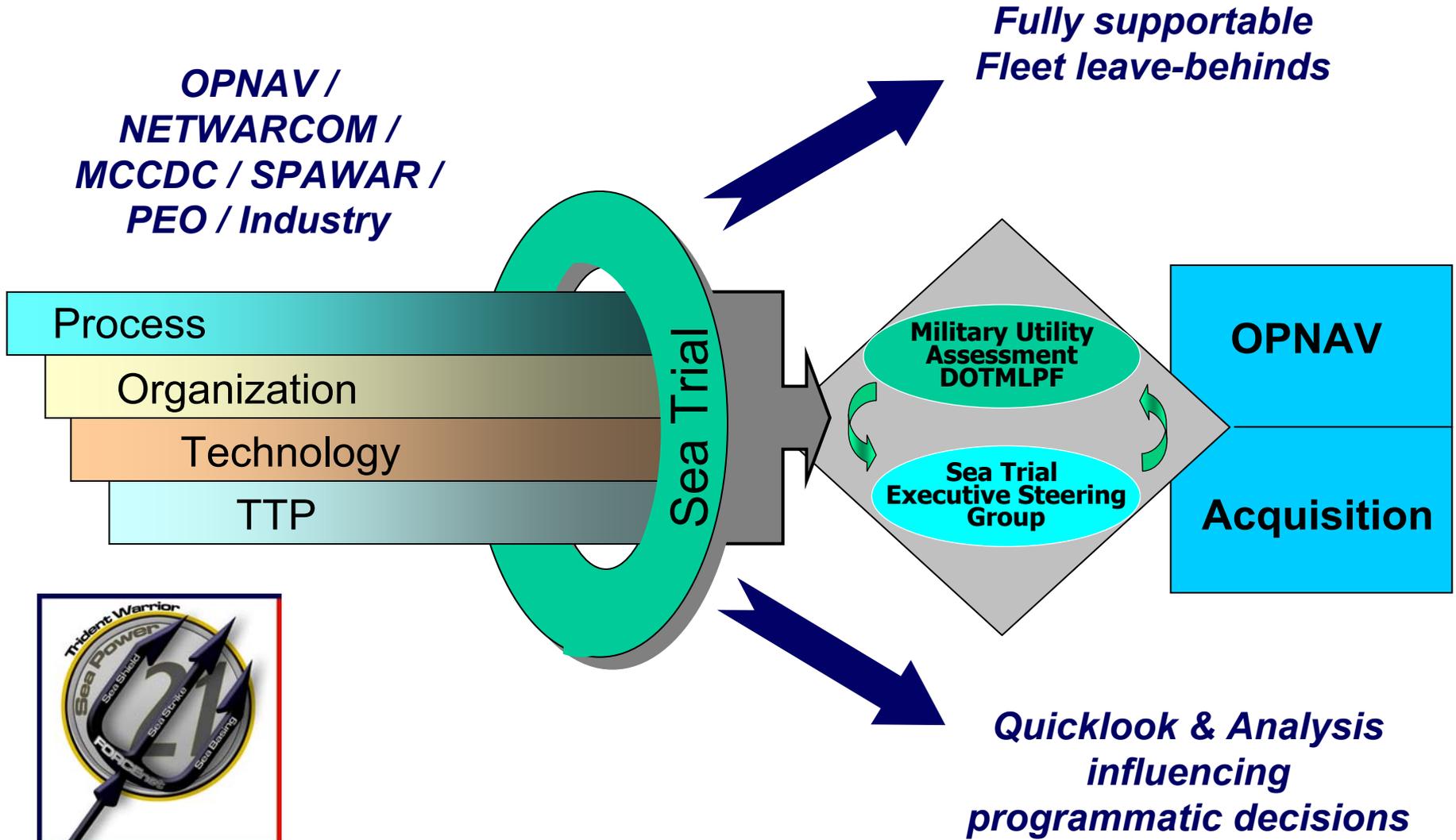
Collaboration

Concept Based Strategy Development



Trident Warrior

Goal: Fleet Driven Speed to Capability



Trident Warrior Evolution



TW 03
Essex ESG

Oct 2003

- Fn Integrated Prototype Demonstration, ESG LOE & JTF WARNET PDX

5 Focus Areas
17 Specific Initiatives
7 Rapid Acquisition Recommendations

- Bandwidth Management (ADNS)
- Integrated Supporting Arms Control Center – Automated (SACC-A)
- Intra BG Wireless Network



TW 04
Tarawa ESG

Nov 2004

- End-to-end process established
- Objectives mapped into NCDP capability gaps

9 Focus Areas
28 Specific Initiatives
16 Rapid Acquisition Recommendations

- EHF TIP
- Dynamic Bandwidth Process (ADNS II)
- Bandwidth Managed Voice
- Doctrinal support to Fires
- Afloat Electromagnetic Spectrum Operations Program (AESOP)



TW 05
Iwo Jima ESG

Dec 2005

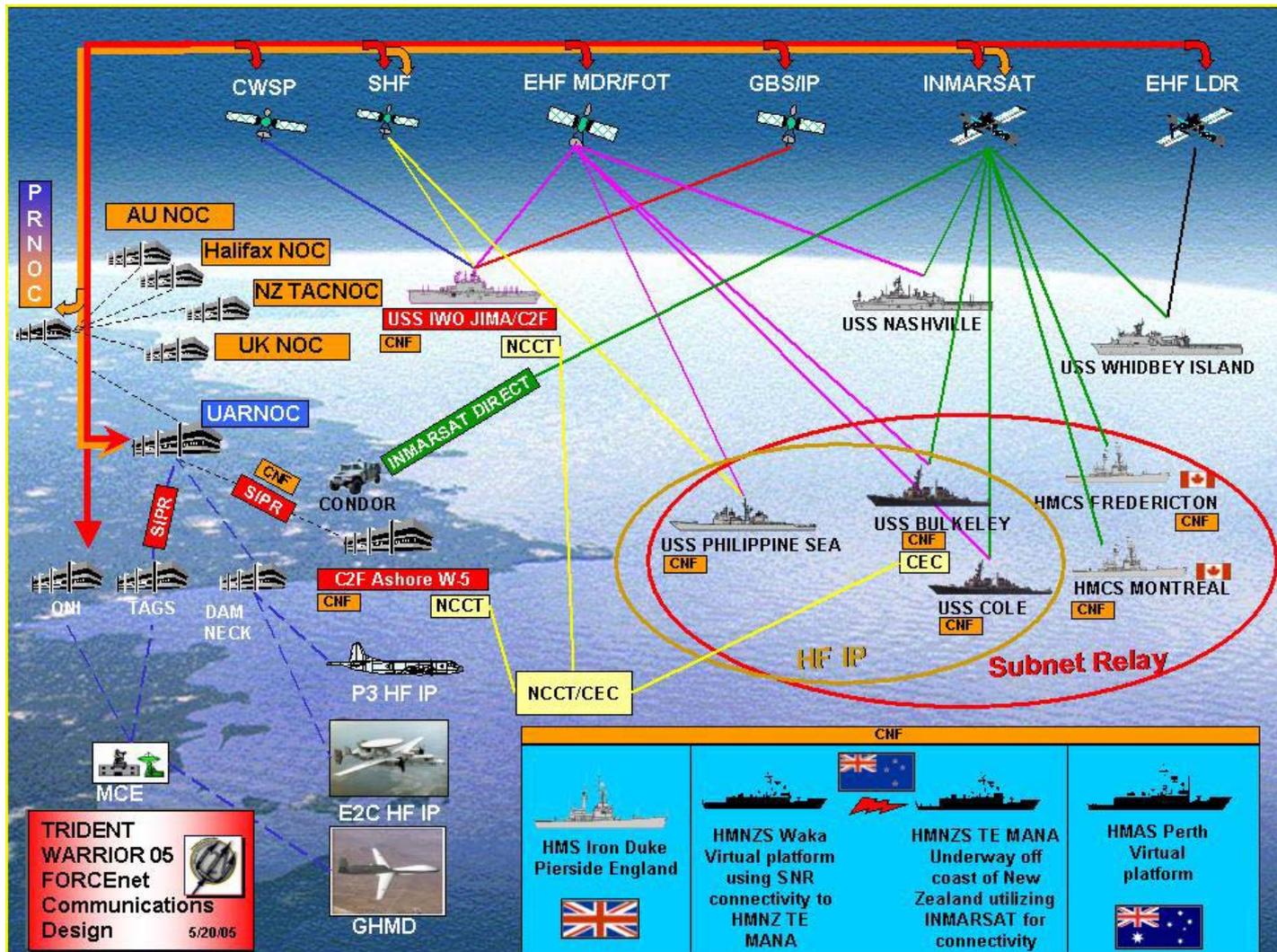
- CFMCC focus, GWOT scenario, extensive Coalition, Joint and Industry participation

11 Focus Areas
108 Measurable Objectives

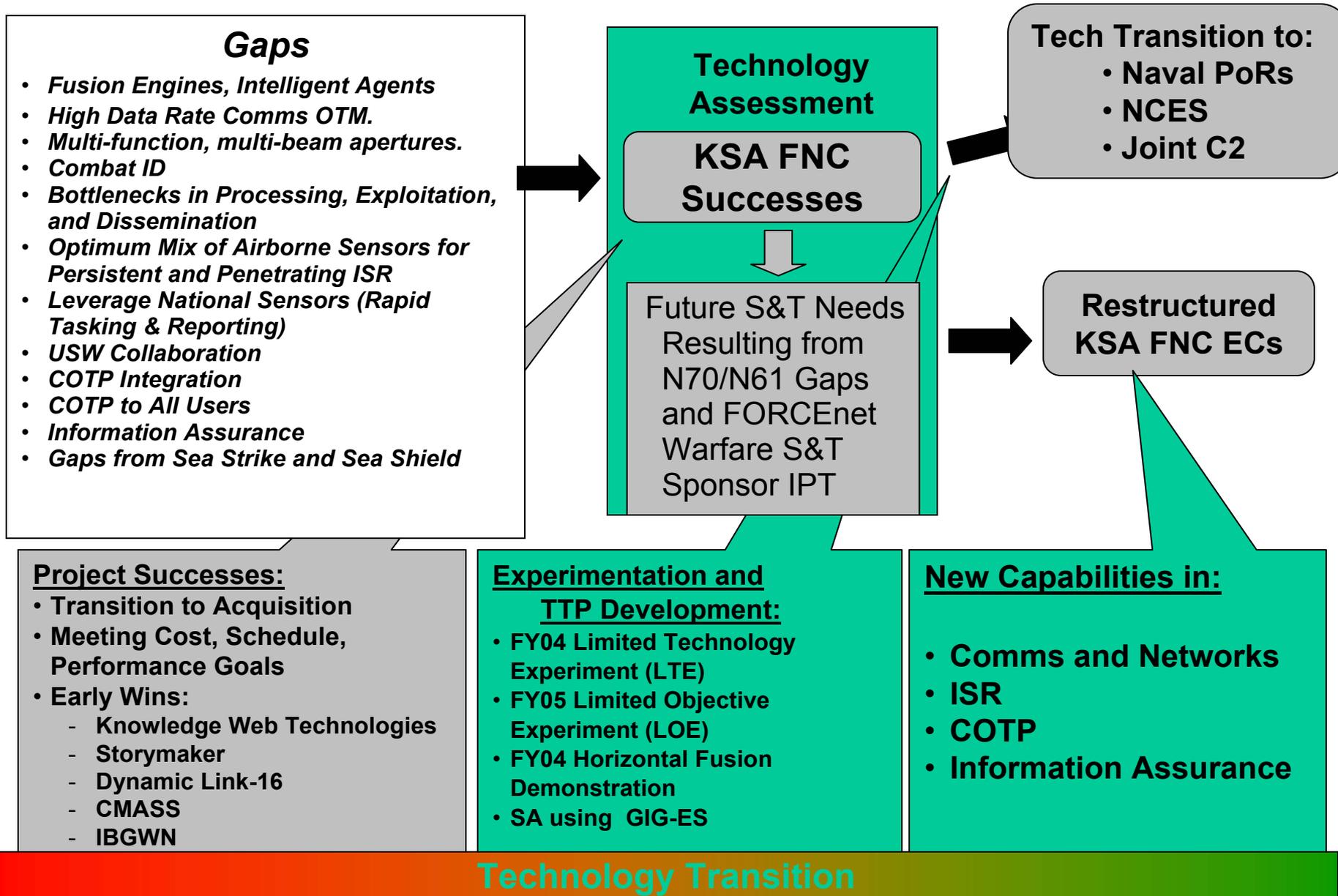
- CFMCC C2
- Cross Domain Solutions
- Five-Eyes Coalition Network
- Information Management Plan
- GHMD CONOPS
- Human Systems Integration
- ADNS II with ECP

Trident Warrior 05

- CFMCC C2 Focus
- Exercise Distributed Staff With C2F
- Joint, Coalition & Industry Participation
- GHMD CONOPS Development
- Netted ISR Sensors
- Coalition Naval Forces (CNF) Network
- Laboratory Testing to Minimize Risk
- Wargame to Refine CONOPS & TTP's



S&T (Future Naval Capabilities)



S&T (Discovery and Invention)

- Information Integration is primary focus
- Program examines critical S&T needs of
 - Automatic association and merger of information for unified presentation
 - Automated recognition and cueing for significant patterns of information, computer-aided reasoning for task-oriented information dissemination
 - Timely, accurate information and sensor fusion from heterogeneous sources
 - Supporting technologies to provide information assurance.
- Specific goals
 - Automated image understanding
 - Automated integration of disparate sources of information
 - Level 2 / Level 3 Information Fusion
 - Information Integrity

Capabilities Based Planning Approach

A top-down, competitive process that weighs options vs. resource constraints across a spectrum of challenges

- Link DoD decision-making to the Defense Strategy
 - Apportion risk across external challenges – traditional, irregular, catastrophic, and disruptive
 - At the level of portfolios and current/future concepts
- Inform risk tradespace – identify joint capability gaps, redundancies, and opportunities
- Facilitate the development of affordable capability portfolios that:
 - Hedge against uncertainty
 - Increase costs to adversaries while suppressing our costs
- Establish a common language that links COCOM capability requirements to Service force development and provider efforts, and integrates the five fundamental Departmental business processes (*Policy Formulation, Planning, Requirements, Resourcing, Acquisition*)

Why we created Joint Capability Areas...

An SPG-directed study as a part of Operational Availability (OA) – 05

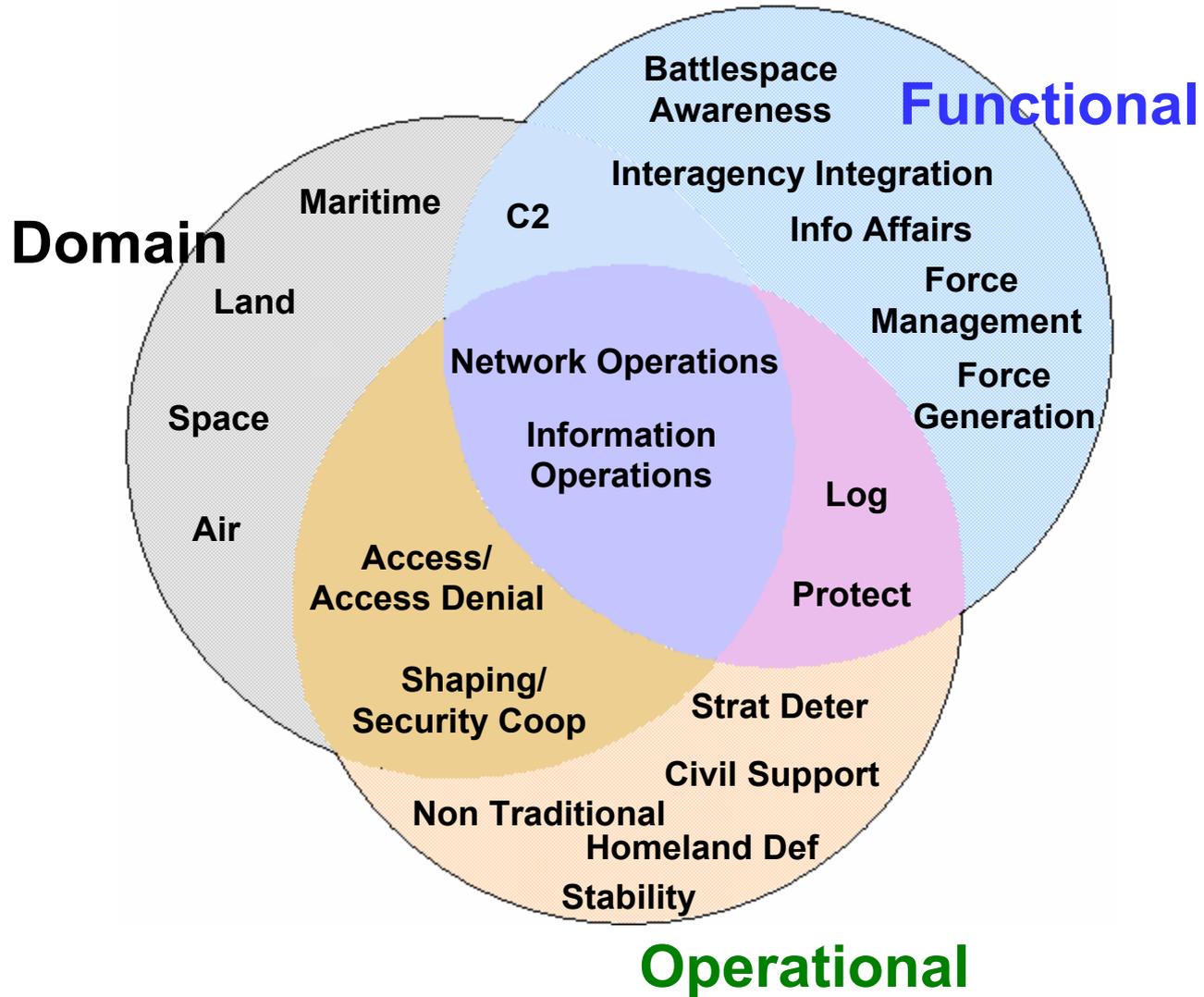
- Provide a common framework to:
 - define joint capability needs
 - allow Services to map their capabilities into something
- Identify “peer-level” capability categories to:
 - facilitate organizational binning
 - tee-up decision space for cross-Service trades
 - support strategy/senior leader guidance articulation
 - permit gap analysis and evaluation on capability contributions to various capability categories
 - Develop a compatible planning and programming framework
- Foster a “capabilities culture” in support of CBP ³²

Tier 1 Joint Capability Areas

As of 15 Dec 04

- **Battlespace Awareness**
- **Command and Control**
- **Network Operations**
- **Interagency Integration**
- **Information Affairs**
- **Information Operations**
- **Protection**
- **Logistics**
- **Force Generation**
- **Force Management**
- **Homeland Defense**
- **Strategic Deterrence**
- **Shaping & Security Cooperation**
- **Stability Operations**
- **Civil Support**
- **Non-Traditional Operations**
- **Access & Access Denial Operations**
- **Land Control Operations**
- **Maritime/Littoral Control Operations**
- **Air Control Operations**
- **Space Control Operations**

JCA Mapped across Ops/Domain/Functional Views



JWSTP Example

Capability	Related Limitations	Related Technology	Related DTOs
Establish Appropriate Organizational Relationships	Ability to set up and change formal organizational and command relationships in accordance with mission and task needs Need flexible organizational constructs Need flexible authority relationships	Decision aids Visualization technology	HS.42, 47
Collaborate	Doctrinal, cultural, and organizational limits to full collaboration Lack of trust in collaborative decisionmaking processes Coalition interoperability Geographic limitations to collaboration	Collaboration support tools Effective user-centric displays Geographical information systems Automated embedding of geospatial data Multilingual translation technology	JF.04, 06; JA.25; JC.54; BE.11; HS.41, 47, 50, 57, 58, 63

Draft C2 JIC

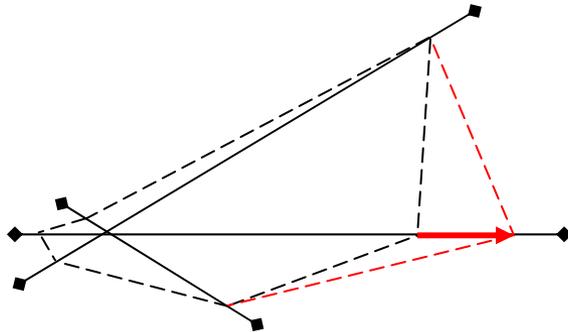
Capability	Operational Task	Attributes	Standard (2010)
<p>5. Plan Collaboratively Future planning must be conducted with the collective knowledge of the decisions and plans of others. An effects-based approach that directly ties offensive actions to campaign objectives must guide plan development. Planners must be able to focus on exploiting critical adversary vulnerabilities and also must consider friendly critical capabilities and potential collateral damage. Parallel, distributed, collaborative planning capabilities and improved assessment tools are needed compress process timelines. The ability to assess the suitability of a plan and to rehearse prior to execution is also needed.</p>	<p>5.1 <u>Form collaborative planning teams across components, missions, functions, and geographies, and with mission partners</u> Develop, coordinate and build effective collaborative teams for specific missions and tasks. Use existing, historical and available staff collaboration structures and processes to develop tailored structures and processes.</p>	<p>Cohesion Interoperability Understanding</p>	<p>Cohesion -- XX% of group or team rewards match or meet unit and individual mission goals</p> <p>Interoperability--Users can access and use resources across all partners XX% of the time.</p> <p>Understanding— XX% of personnel receive necessary guidance and act in accordance with that guidance XX% of the time.</p>

C2 Capabilities		Fn6	Fn7	Fn8	Fn15	Fn1	Fn4	Fn5	Fn9	Fn10	Fn11	Fn12	Fn13	Fn14	Fn2	Fn3
		Provide Situation Info	Provide Collab Environ	Automate Low C2, Decision Aids	Provide Quick/Good Decisions Capability	Coms All Nodes	Store/Retrieve Info	Process Info, Access	Provide IA	Multi-Level Security	C2 Systems Interoperability	Autonomous Nodes	Network Management	New Capabilities Incorporation	Provide Blue Info	Provide Red Info
Basic C2 Capabilities																
The ability to monitor and collect data	N															
The ability to develop situational understanding																
The ability to develop courses of action and select one																
The ability to develop a plan																
The ability to execute the plan including providing direction and leadership to subordinates																
The ability to monitor the execution of the plan and adapt as necessary																
The ability to execute the basic C2 process																
Collaborative C2 Capabilities		Fn6	Fn7	Fn8	Fn15	Fn1	Fn4	Fn5	Fn9	Fn10	Fn11	Fn12	Fn13	Fn14	Fn2	Fn3
The ability to network																
The ability to share information	C															
The ability to interact	C															
The ability to develop shared awareness	C															
The ability to develop shared understanding	C															
The ability to decide in a collaborative environment	C															
The ability to synchronize	C															
The ability to execute the collaborative C2 process	C															

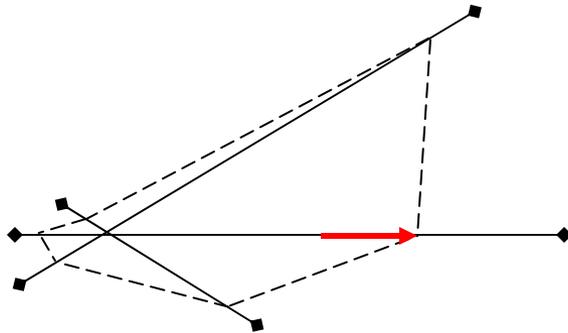
Net Centric Knowledge Area Capabilities		Fn6	Fn7	Fn8	Fn15	Fn1	Fn4	Fn5	Fn9	Fn10	Fn11	Fn12	Fn13	Fn14	Fn2	Fn3
		Provide Situation Info	Provide Collab Environ	Automate Low C2, Decision Aids	Provide Quick/Good Decisions Capability	Coms All Nodes	Store/Retrieve Info	Process Information	Provide IA	Multi-Level Security	C2 Systems Interoperability	Autonomous Nodes	Network Management	New Capabilities Incorporation	Provide Blue Info	Provide Red Info
Ability to establish appropriate organizational relationships	C															
Ability to collaborate.	C															
Ability to synchronize actions.	C															
Ability to share situational awareness	C															
Ability to share situational understanding	C															
Ability to conduct collaborative decisionmaking/planning	C															
Ability to achieve constructive interdependence	C															
Net Centric Technical Capabilities		Fn6	Fn7	Fn8	Fn15	Fn1	Fn4	Fn5	Fn9	Fn10	Fn11	Fn12	Fn13	Fn14	Fn2	Fn3
Ability to create/produce information.	I															
Ability to store, share, and exchange information and data.	I															
Ability to establish an information environment.	I															
Ability to process data and information	I															
Ability to employ geo-spatial information	I															
Ability to employ information.	I															
Ability to find and consume information	I															
Ability to provide user access	I															
Ability to access information	I															
Ability to validate/assure.	I															
Ability to install/deploy	D															
Ability to operate/maneuver	D															
Ability to maintain/survive.	D															
Ability to provide network services.	N															

Battlespace Awareness Operational Capabilities		Fn6	Fn7	Fn8	Fn15	Fn1	Fn4	Fn5	Fn9	Fn10	Fn11	Fn12	Fn13	Fn14	Fn2	Fn3
		COP / UDOP	Provide Collab Environ	Automate Low C2, Decision Aids	Provide Quick/Good Decisions Capability	Coms All Nodes	Store/Retrieve Info	Process Information	Provide IA	Multi-Level Security	C2 Systems Interoperability	Autonomous Nodes	Network Management	New Capabilities Incorporation	Provide Blue Info	Provide Red Info
Command and Control of BA Assets	C															
Execute Collection																
Exploitation and Analysis																
Model, Simulate and Forecast																
Manage Knowledge	I															
Battlespace Awareness Enabling Capabilities		Fn6	Fn7	Fn8	Fn15	Fn1	Fn4	Fn5	Fn9	Fn10	Fn11	Fn12	Fn13	Fn14	Fn2	Fn3
Integrate BA Network	N															
Rapidly Infuse Technology																
Recruit, Retain, and Train World-Class BA Personnel																

Capability Gaps



Progress
New systems
Demo “leave-behinds”
DOT_LPF innovations



Effort
New programs
Experimentation
S&T investment

Accomplishments

- Demonstrated value of analytical framework:
 - Connects FORCEnet capabilities and NCW Framework
 - Capabilities under revision
 - Quantitative measures partially successful and improvements proposed
- Improved representation of C4ISR in campaign analysis
- Increased analytical support for PR-05, POM-06, PR-07 submissions
- Provided additional products: S&T Roadmap, M&S Plan, IT/IM Capital Planning Metrics, Compliance Checklist, Experimentation CD&E Plan