11th ICCRTS
COALITION COMMAND AND CONTROL IN THE NETWORKED ERA
September 26-28, 2006

Coalition Interoperability: How Much Is Enough and How to Quantify It

Mr. George Galdorisi
Dr. Darren Sutton

"All the business of war, and indeed all the business of life, is to endeavour to find out what you don't know by what you do; that's what I call guessing what's on the other side of the hill."

The Duke of Wellington

Outline

- International Maritime Cooperation
- Importance of Coalition C4ISR interoperability
- Operational Challenges and need for solutions
- TTCP – one path to “building the networks”
- One model for international defense cooperation
- Implications for future coalition networks

International Maritime Cooperation: The 1,000-Ship Navy

"The power to create a voluntary network of maritime forces is within our grasp, We have the capability to seize on our inherent nature of cooperation at sea and, together, overcome transnational actors who threaten the very fabric of global safety and security ."

Admiral Michael Mullen
U.S. Navy Chief of Naval Operations
RUSI Future Maritime Warfare Conference
December 13, 2005

International Maritime Cooperation: The 1,000-Ship Navy

- A “1,000-Ship Navy” among peace-loving nations: Long a notion, today an aspiration, tomorrow a reality
- This 1,000-Ship Navy concept does not necessarily imply we’ll sail the same hulls or fly the same aircraft
- Navies have interoperated at sea for some time, but the degree of interoperability has been modest, at best
- The ability of coalition partners to work together effectively will depend on C4ISR compatibility

Importance of Coalition C4ISR Interoperability

"The most significant challenge in joint and coalition operations is the ability to communicate and exchange data. We shouldn't be fixing this on the fly when we are getting ready to cross the line of departure."

General Mike Hagee
Remarks at the 10th Annual
Expeditionary Warfare Conference
October 26, 2005

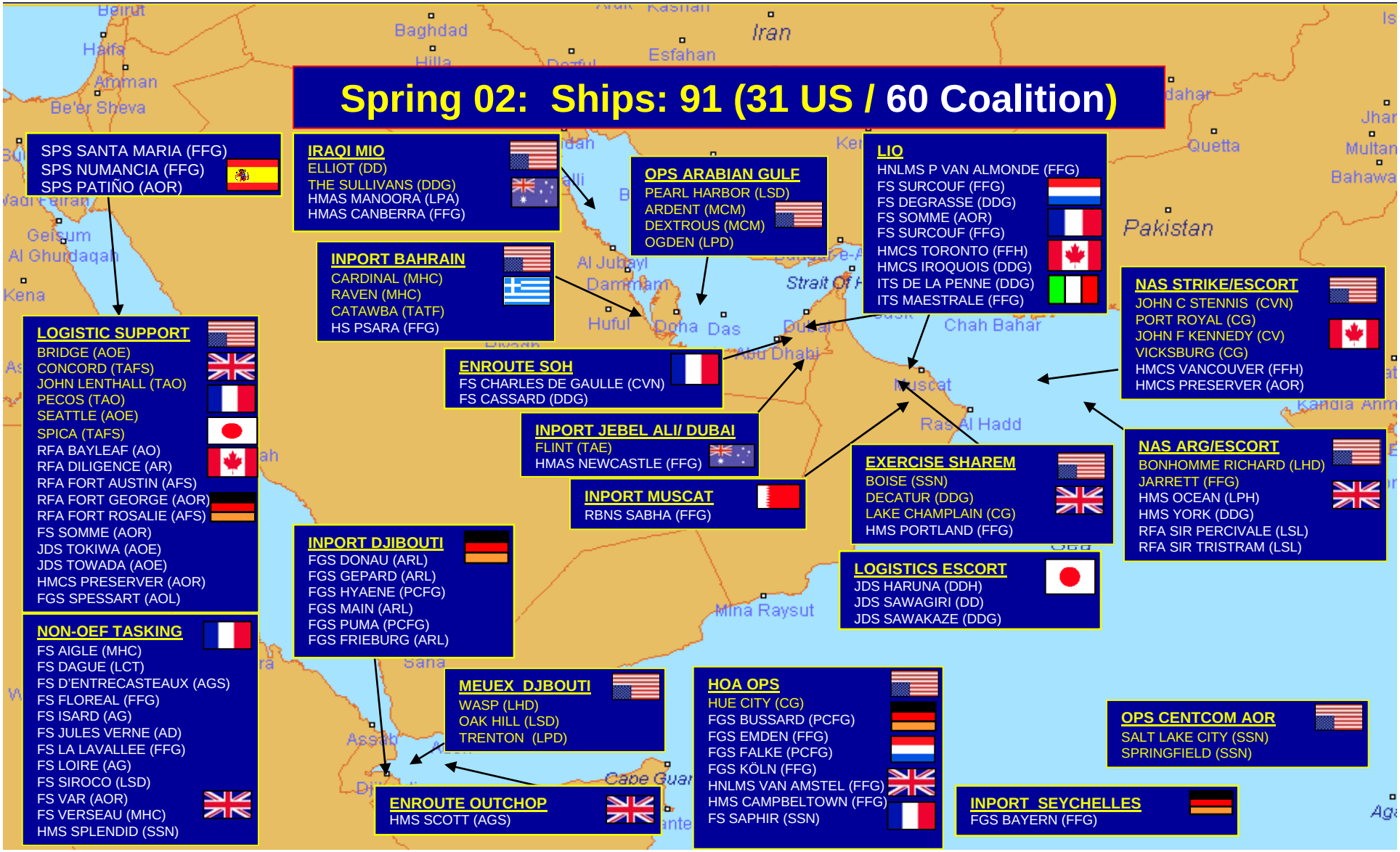
Importance of Coalition C4ISR Interoperability

- Coalition concerns – the price of admission
- U.S. realities – the price of omission
- Issue actively discussed at the working level
- Working its way to the leadership level
- Subject of U.S. Navy Deputy Chief of Naval Operations for Communications Networks "100-day memos"

"The significant involvement of coalition forces in Operation Enduring Freedom – including over 100 ships deployed in Central Asia for an extended period – has reemphasized the requirement for improved internet protocol data systems interoperability with allied and coalition forces."

Admiral Robert Natter
Commander, Fleet Forces Command
SSC Charleston *Combat Clips*
Summer 2002

The Importance of Connectivity



Operational Challenges and the Need for Solutions

"Is there a place for small navies in network-centric warfare? Will they be able to make any sort of contribution in multinational naval operations of the future? Or will they be relegated to the sidelines, undertaking the most menial of tasks, encouraged to stay out of the way– or stay at home?…The "need for speed" in network-centric operations places the whole notion of multinational operations at risk."

Professor Paul Mitchell
Director of Academics
Canadian Forces College
Naval War College Review – Spring 2003

Operational Challenges and the Need for Solutions

- Operational challenge of networking at sea
- Arguably, the most important networking arena
- “We’ve done it before” obscures the challenge
- If we do it well at sea…the rest follows…

The Technical Cooperation Program: One Path to “Building the Networks”

"…In coalition naval operations there are bound to be interoperability issues, especially with respect to command and control and communications."

Admiral Chris Barrie, AC RAN (Ret'd)
Former Chief Australian Defence Force
RAN Sea Power Conference
January 31, 2006

What Is The Technical Cooperation Program?

- Defense-wide organization with emphasis on S&T
- Stable vehicle for collaborative efforts between and among five allies
- Valuable worldwide network of scientists and engineers that delivers technical advice
- Facilitates interoperability downstream through S&T collaboration

TTCP Current Groups

- Aerospace Systems (AER)
- Command, Control, Communications, & Information Systems (C3I)
- Chemical, Biological, and Radiological Defense (CBD)
- Electronic Warfare Systems (EWS)
- Human Resources and Performance (HUM)
- Joint Systems and Analysis (JSA)
- Land Systems (LAN)
- **Maritime Systems (MAR)**
- Materials and Processes Technology (MAT)
- Sensors (SEN)
- Conventional Weapons Technology (WPN)

MAR Construct

- **Technical Panels:**
  - TP-1: C2 and Information Management
  - TP-9: Sonar Technology
  - TP-10: Maritime ISR & Air Systems
  - TP-13: Mine Warfare and HF Acoustics
- **Action Groups:**
  - AG-1: Net Centric Warfare Study*
  - AG-2: Novel Maritime Platform Systems
  - AG-3: Torpedo Defense
  - AG-4: Surface Ship Air Defence Systems
  - AG-5: Force Protection
  - AG-6: FORCEnet Implications for Coalitions*

One Model for International Defense Cooperation: MAR AG-1/AG-6

"…Our future success will be centered on international cooperation and better interoperability."

Vice Admiral Russ Shalders, AO, CSC
Royal Australian Navy Chief of Navy
RAN Sea Power Conference
January 31, 2006

One Model for International Defense Cooperation

- Maritime Action Groups
  - AG-1: “Maritime Network Centric Warfare”

  …morphed into…
  - AG-6: “FORCEnet Implications for Coalitions”

MAR Action Group 1: “Maritime Network Centric Warfare”

MAR Action Group 1: "Maritime Network Centric Warfare"

- Maritime Network Centric Warfare…open ended
- Focus on "bounding the problem"…good product
- Proof of concept through multilateral analysis
- Warfighting scenarios with traction for all
- Two Studies
  - Broad Issues: First Principles of NCW
  - Tactical Level Analysis: MIO/ASW/ASuW

AG-1 Membership

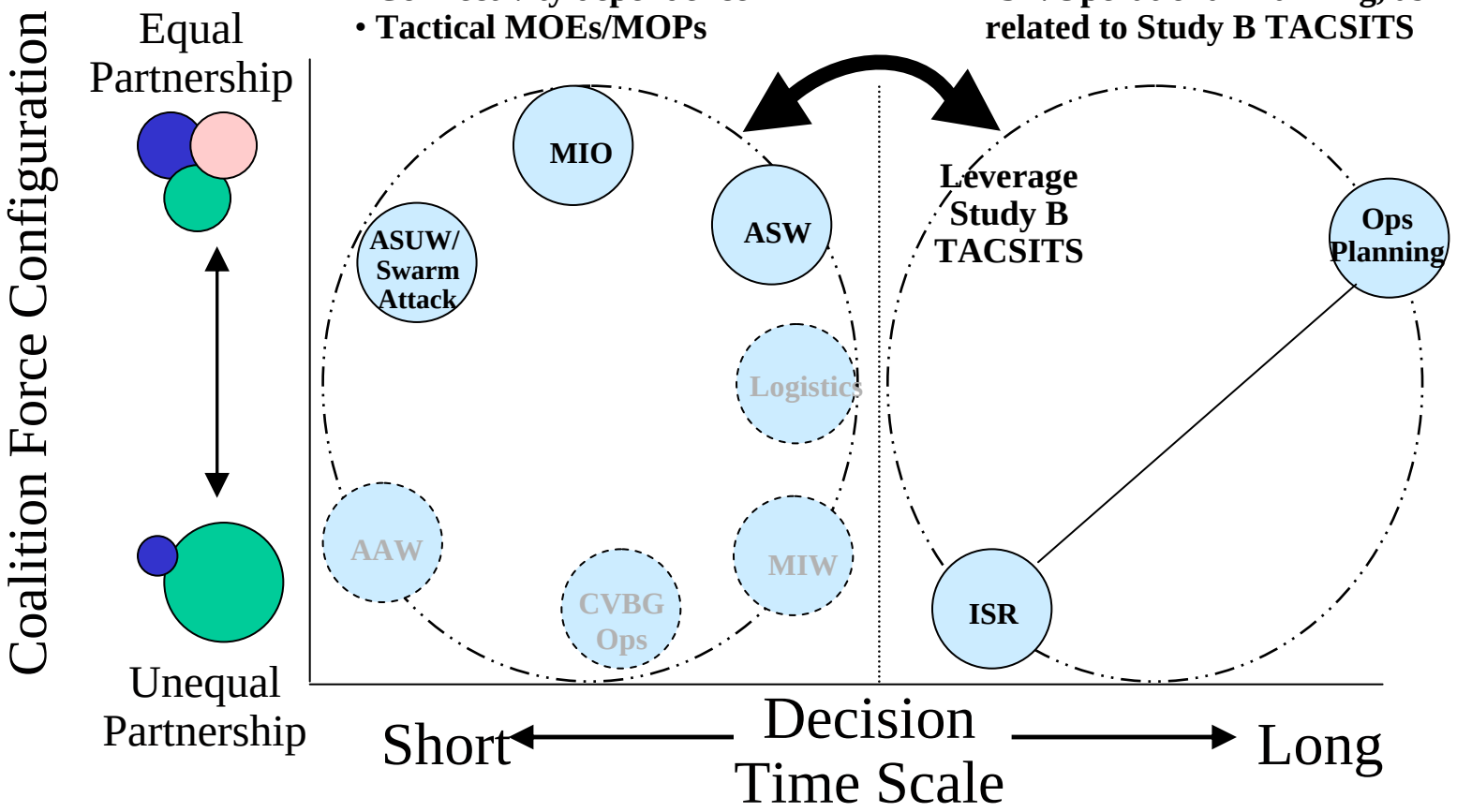
Australia	Canada	New Zealand	United Kingdom	United States
Dr. C. Davis (NL)	Mr. P. Sutherland (NL)	Dr. D. Galligan (NL)	Mr. A. Sutherland (NL)	Mr. J. Shannon (NL)
Ms. S. Andrijich (M)	Mr. R. Burton (M)	Mr. C. Phelps (M)	Mr. P. Marland (M)	Dr. R. Klingbeil (M)
Ms. M. Hue (M)	Mr. M. Hazen (M)		Mr. R. Lord (M)	Dr. S. Dickinson (M)
Dr. I. Grivell (M)	Mr. B. Richards (M)			Mr. G. Galdorisi (M)*
Dr. D. Sutton (M)				
Dr. M. Fewell (M)				

Notes: NL = National Leader
M = Member

Two Component Studies (Scales of Coalition Interoperability)

Study B (Tactical Level)
- **TACSIT-based analysis (relevant, littoral)**
- **Sense-Decide-Respond**
- **Connectivity dependence**
- **Tactical MOEs/MOPs**

Study A (Broad Issues)
- **First Principles in NCW**
- **Quantitative analysis of alternative networking options in ISR/Operational Planning, as related to Study B TACSITS**



MAR AG-1 Study B
Tactical Level Analysis

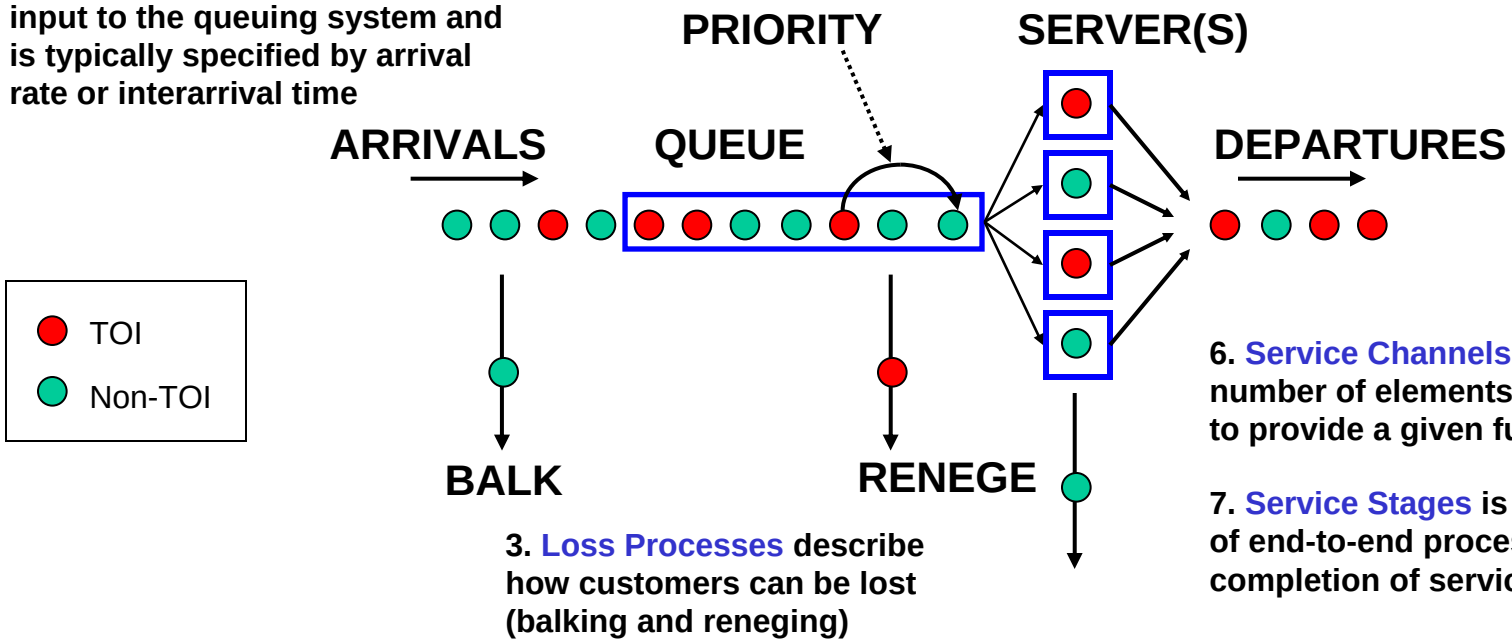
Study B: Sample Highlights Queuing System for MIO

4. Queue Discipline describes how a customer is selected for service once in queue (FIFO, priorities, etc.)

5. System Capacity is the maximum size of a queue; finite or infinite

2. Service Pattern is described by service rate or service time

1. Arrival Pattern describes the input to the queuing system and is typically specified by arrival rate or interarrival time



6. Service Channels are the number of elements available to provide a given function

7. Service Stages is the set of end-to-end processes for completion of service

3. Loss Processes describe how customers can be lost (balking and reneging)

KEY QUEUEING METRICS:
- **Probability of a customer acquiring service**
- **Waiting time in queue until service begins**
- **Loss rate due to either balking or reneging**

Queueing Theory interrelates key system characteristics and can be used to identify where investment should be made to improve performance and effectiveness

Study B: Sample Highlights
ASW TACSIT Analysis

Improving ASW Effectiveness – NCASW Concepts and Hypotheses

1 Shared Situational Awareness (SSA)

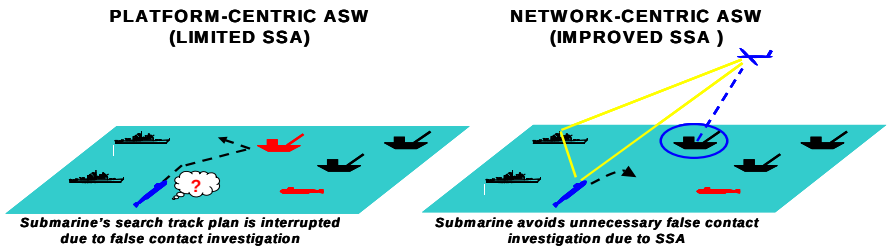
Network-enabled Shared Situational Awareness (SSA) can reduce false contact loading thereby increasing ASW effectiveness.

2 Collaborative Information Environment (CIE)

Sensor operators in a network-enabled collaborative environment can reach-back to ASW experts to improve target and non-target classification performance.

Queueing Theory can provide an intuitive mathematical and physical framework for the analysis any military system or operation that can be characterized as a "waiting line" or a "demand-for-service."

False Target Reduction Concept



- Congestion of sonar, high workload
- Time to investigate false contacts
- Reduction of effective search rate
- Missed detections of targets

- Information is essential
- System to remove specified sensor contacts
- Can possibly lower detection threshold
- Increased probability of target detection

- Use sensor correlation across all appropriate platforms in a task group to reduce the number of non-target contacts presented to sensor operators.
- Reduce non-object false contacts, such as reverberation spikes and wrecks, by using acoustic models, in situ data, and local data bases.

Metric for SSA Concept Analysis

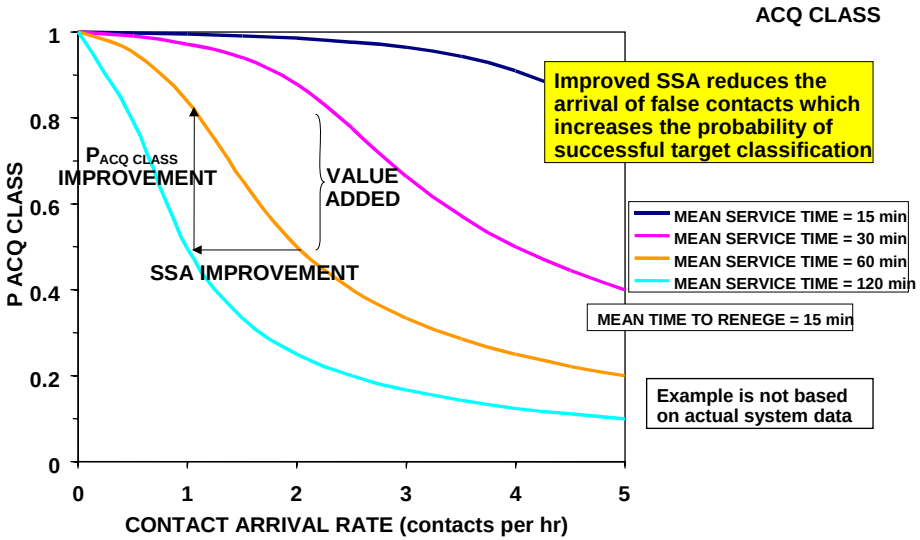
Reduce false contact loading on the ASW system by improving Shared Situational Awareness (SSA)

$P_{ASW} = P_{DET} * P_{CLASS} * P_{LOC} * P_{ATK}$

P_{CLASS}	$= P_{ACQ\ CLASS} * P(T\|t)$
$P_{ACQ\ CLASS}$	= probability that the target acquires classification service
$P(T\|t)$	= probability of recognizing the target contact as the actual target of interest (experimental data required)
T	= THREAT DECISION
t	= true target

There are queueing aspects (waiting line/demand for service) in each of the terms in P_{ASW}

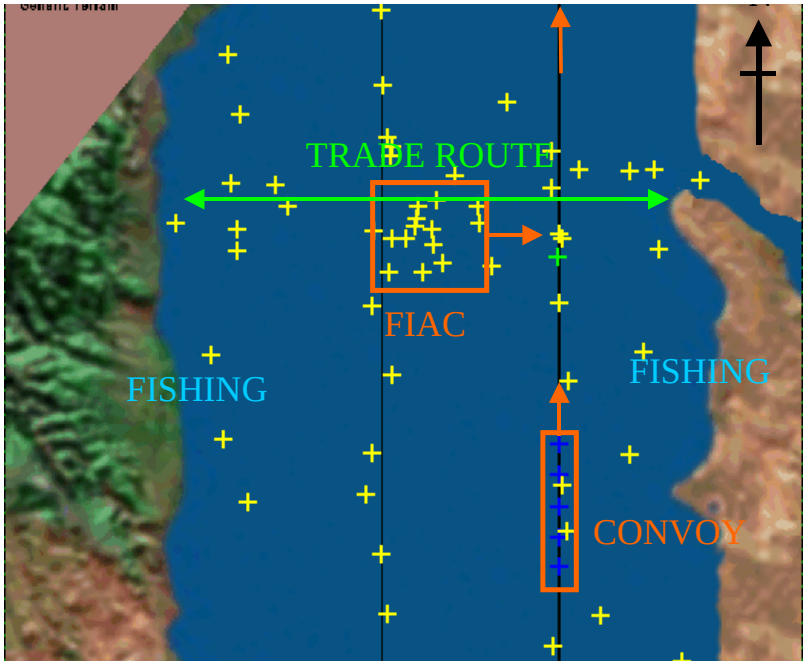
Effect Of Improved SSA and Service Time on P



Study B: Sample Highlights ASuW/Swarm TACSIT Analysis

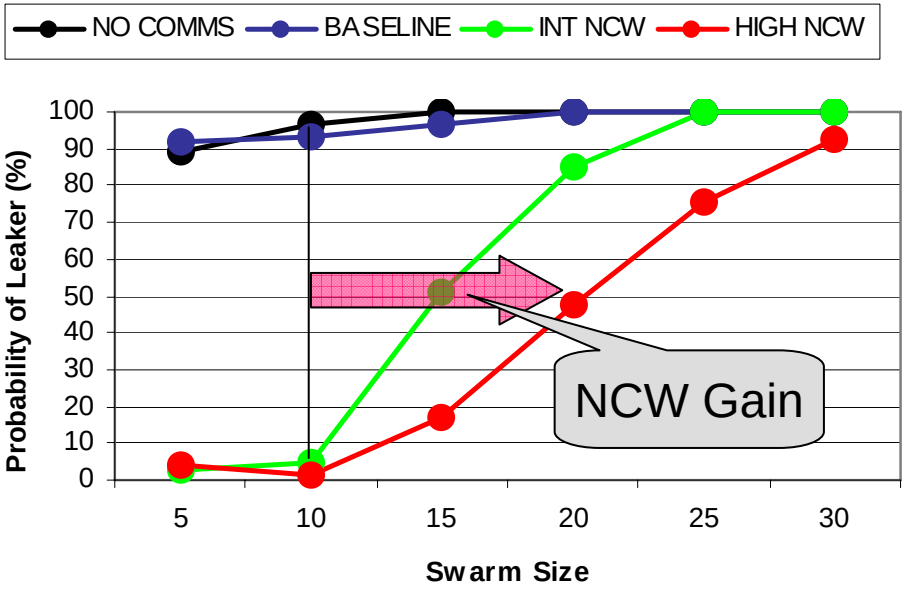
Tacsit: Blue force in restricted sea room is attacked by a swarm of FIAC. Network enabled Blue shared situational awareness and distributed targeting reduces the number of 'leakers.'

Metrics: Probability of one or more FIAC reaching firing position against HVU. Fractions of FIAC leaking, and of Blue escorts damaged. Collateral damage.



Study has used MANA agent based model to represent the Swarm's dynamic tactics, with four levels of Blue networking capability.

Sample Results: (30 knot FIAC)



- Intermediate and High levels of networking increase Force survivability versus Type 1 FIAC by factor of ≈9.
- Full results include dependencies on Red speed (leakers increase at 40 knots).

MAR Action Group 6
“FORCEnet Implications for Coalitions”

MAR Action Group 6:

"FORCEnet Implications for Coalitions"

- Group Composition
- Build on AG-1 Work
- Inform National Leadership
- Harmonize National Strategies

AG-6 Membership

Chairman

Mr. Don Endicott

Australia	Canada	New Zealand	United Kingdom	United States
Dr. A. Knight (NL)	Mr. R. Mitchell (NL)	Dr. D. Galligan (NL)*	Mr. A. Sutherland (NL) *	Mr. D. Endicott (NL)
Ms. R. Kuster (M)	Mr. M. Maxwell (M)	LCDR W. Andrew (M)	Mr. P. Marland (M) *	Mr. G. Galdorisi (M)*
Ms. A. Quill (M)	Dr. M. Lefrancois (M)		Mr. M. Lanchbury (M)	Mr. P. Shigley (M)
Mr. M. Coombs (M)				Ms. M. Gmitruk (M)
				Ms. K. Dufresne (M)
				Mr. D. Zatt (M)
				Dr. M. Green (M)
				Mr. T. McKearney (M)
				Ms. M. Schult (M)
				Dr. S. Gallup (M)
				Ms. M. Elliott (M)

Notes: NL = National Leader
M = Member
* = Former AG-1 member

MAR AG-6 Direction and TOR

- Leverage AG-1work as much as possible
- Build on AG-1 work but add:
  - More specificity regarding ops and force structure
  - More granularity to analysis and modeling
- Work within a realistic operational scenario that all member nations would participate in
- Produce a product that informs national leadership and acquisition officials

Premises

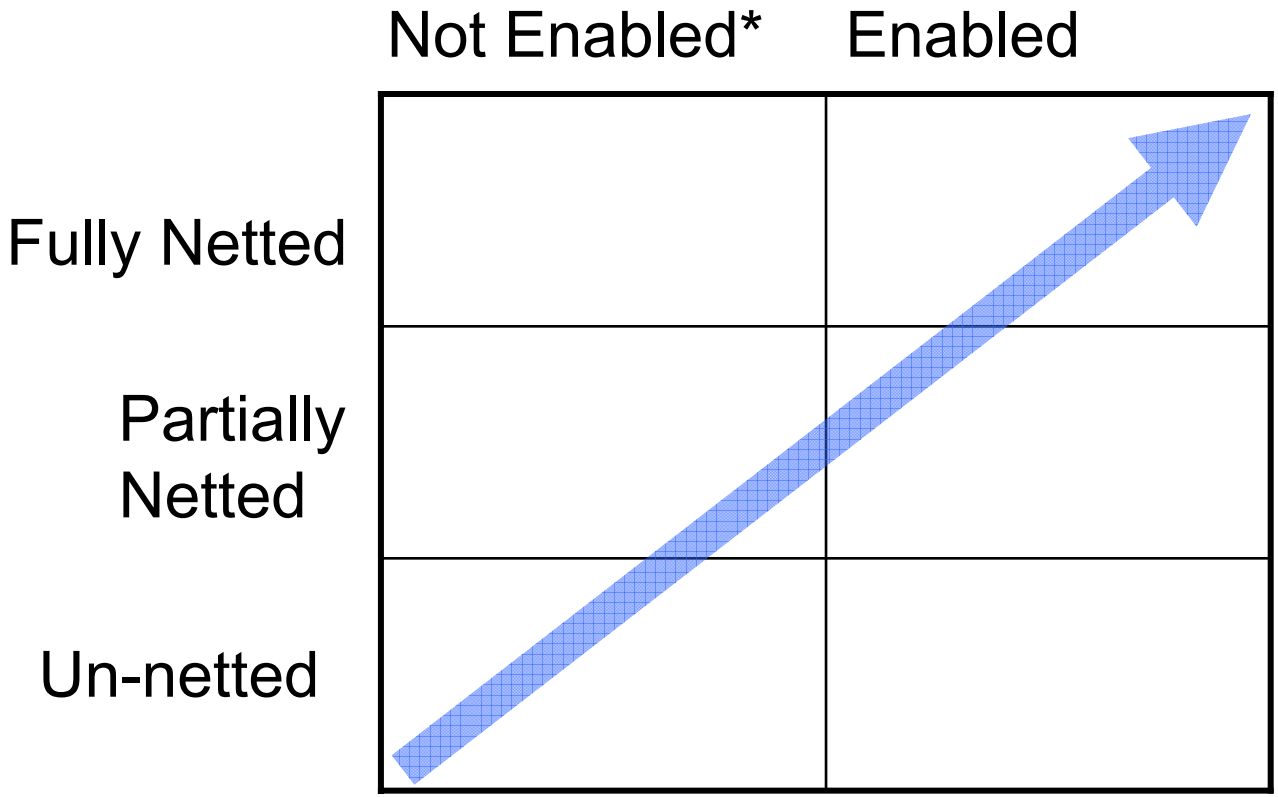
- FORCEnet will empower warfighters at all levels to execute more effective decision-making at an increased tempo, which will result in improved combat effectiveness and mission accomplishment.[1]
- The warfighting benefits of FORCEnet in a coalition context can be assessed through analysis and quantified to provide input to national balance of investment studies of the five member nations.[2]
- It is necessary that FORCEnet address current and near term information system requirements that support operations in the joint and coalition environments. **Coalition Communications was the clear number one priority** of all numbered fleet commanders and is a critical enabler in leveraging coalition partners in the GWOT.[3]

1. *FORCEnet: A Functional Concept for the 21st Century*
2. *MAR AG-6 Terms of Reference*
3. *FY 2006 Numbered Fleet Top Ten Information Technology Needs (CFFC consolidated message)*

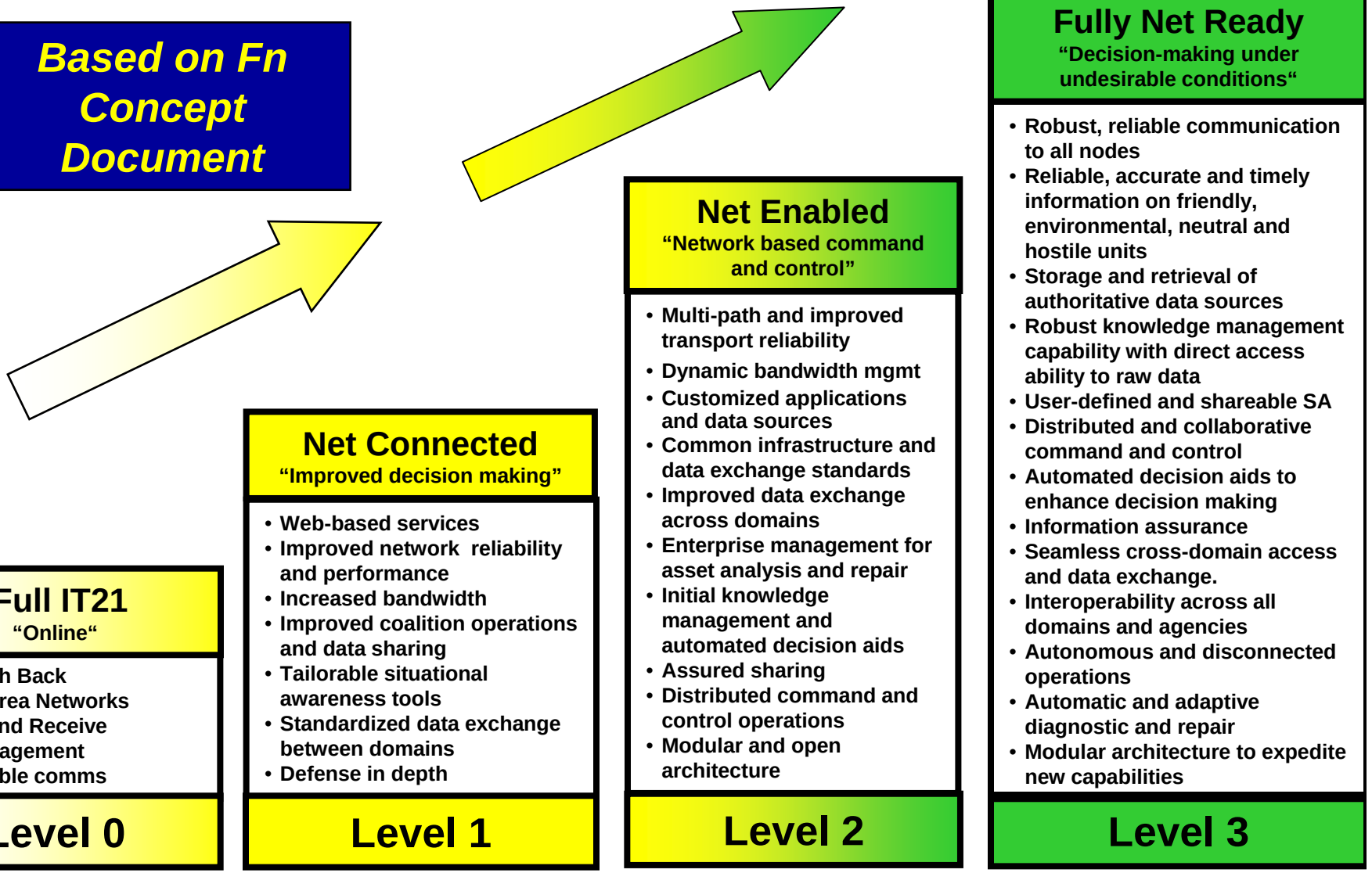
FORCEnet Implications for Coalitions Hypothesis

- Conducting modeling and simulation and detailed analysis to demonstrate the enhanced warfighting effectiveness of coalition partners (in this case – the AUSCANNZUKUS nations) netted in a FORCEnet environment can help inform national naval C4ISR acquisition programs.

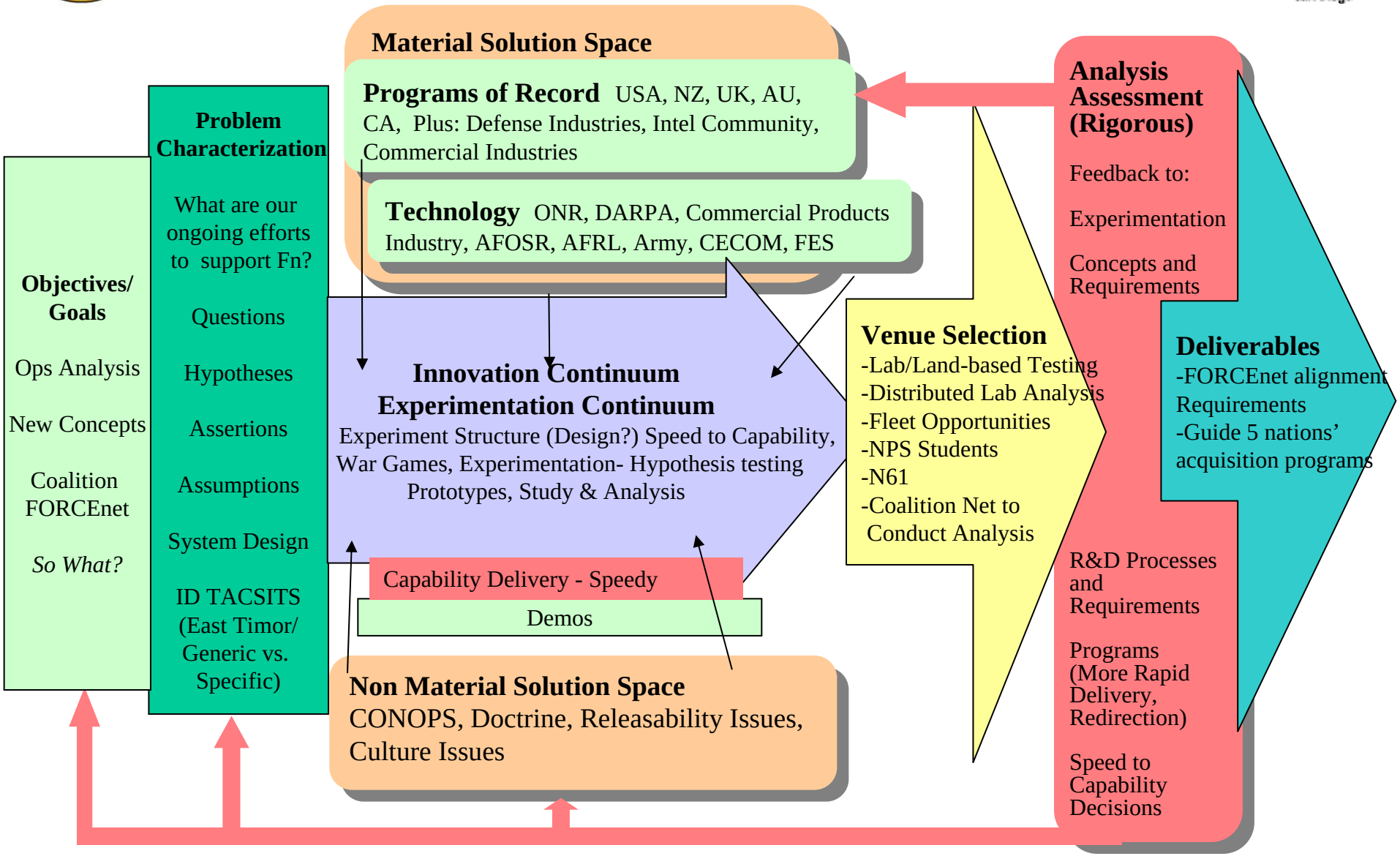
FORCEnet Implications for Coalitions Hypothesis



NCW Capability Stepping Stones
Levels of FORCEnet



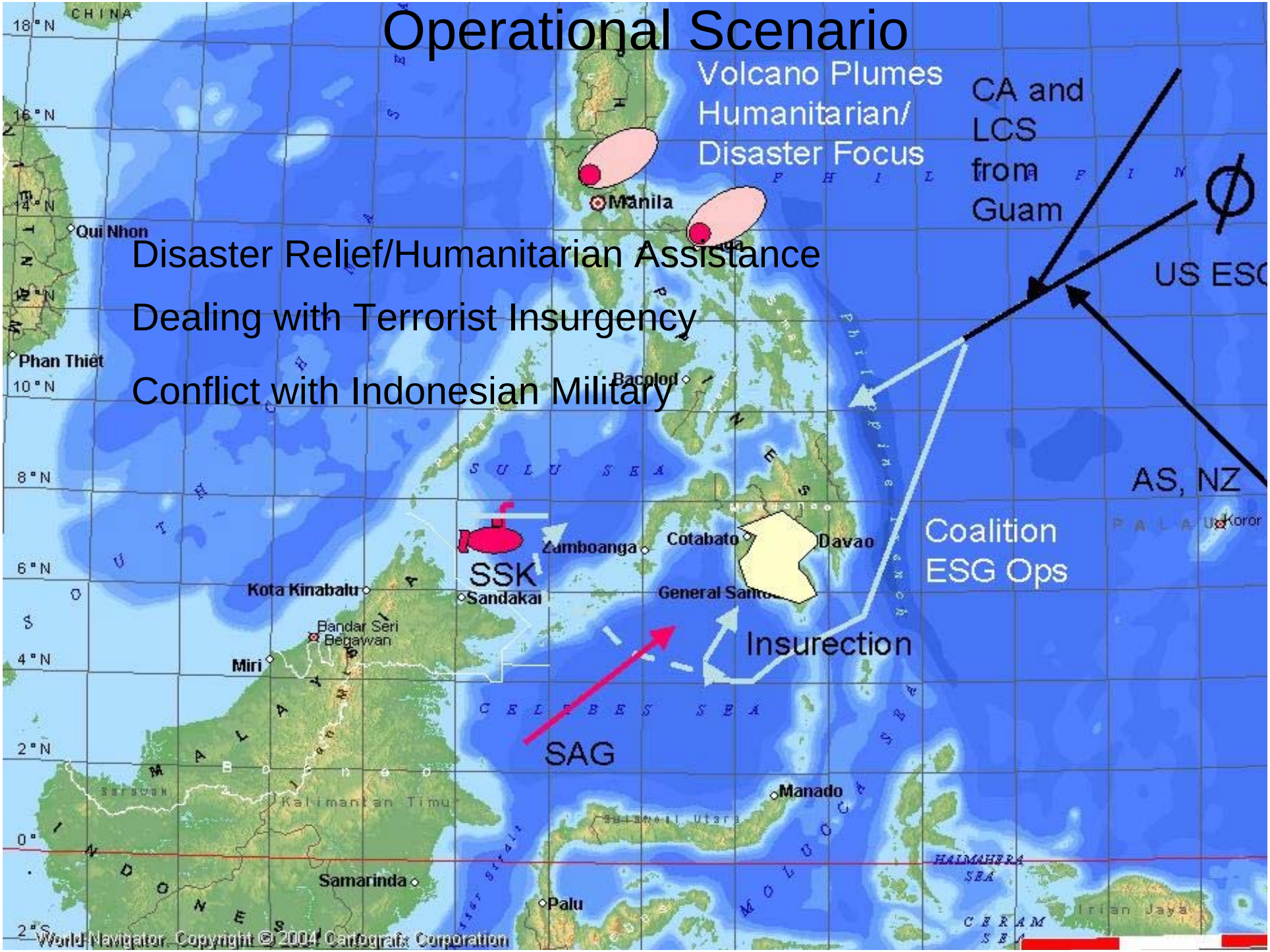
AG-6 Study Plan Process



Validation and Findings

- Vet results with other TTCP groups
- Conduct virtual battle experiments
- Conduct a robust war game
- Validate via Trident Warrior exercises

Operational Scenario

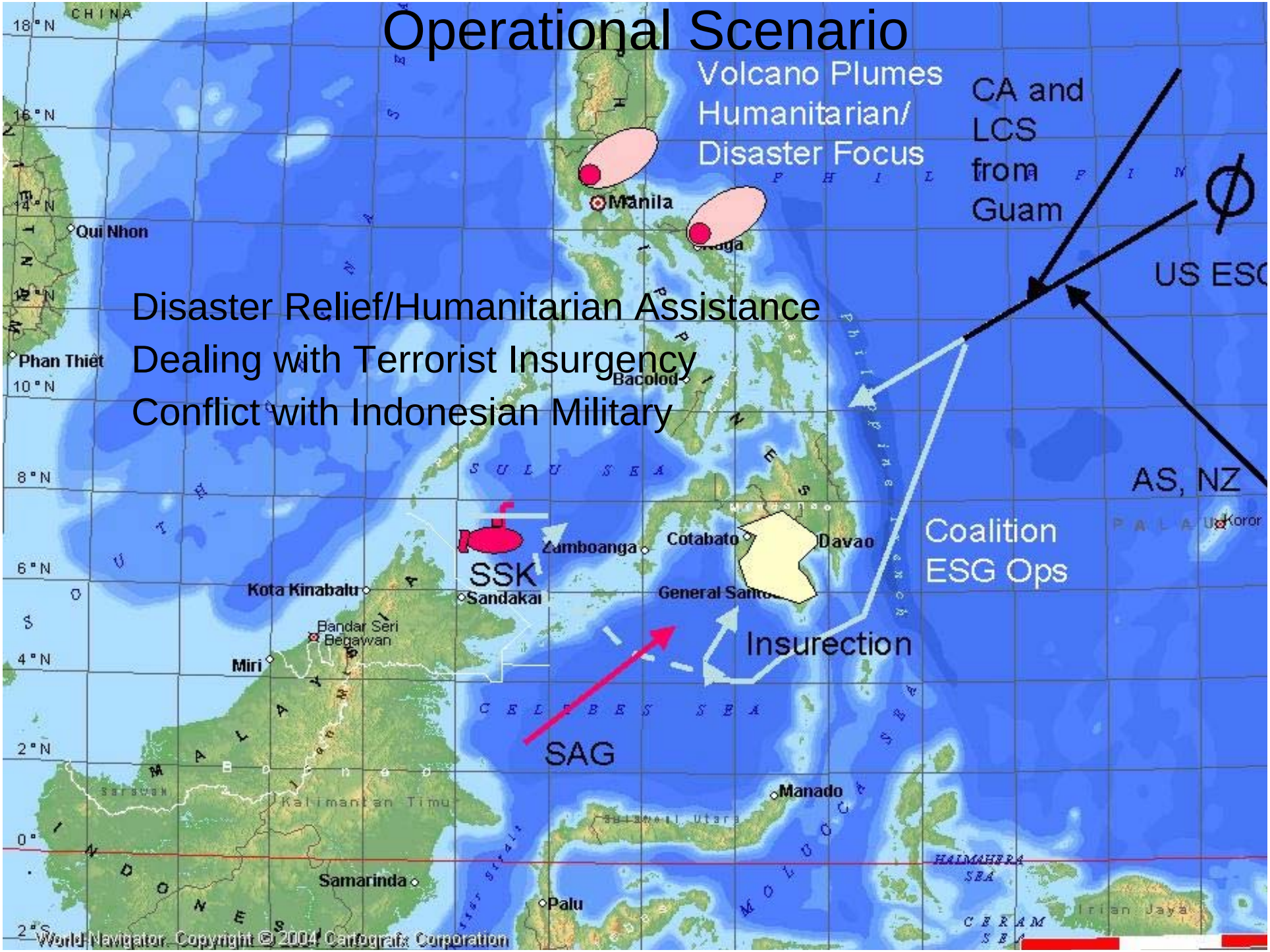


Disaster Relief/Humanitarian Assistance

Dealing with Terrorist Insurgency

Conflict with Indonesian Military

Operational Scenario



Notional Coalition Order of Battle

Australia	United Kingdom
•2 ANZAC Frigates •2 FFG •1 AWD	• 1 LPH/LPD • 2 LSD • 1 Replenishment Ship
Canada	**United States**
• 1 Destroyers • 2 Frigates • Replenishment Ship • Submarine	• 3 Amphibious Assault Ships • 1 Cruiser • 2 Destroyers • 3 Littoral Combat Ships • 1 Attack Submarine
New Zealand	
• 2 ANZAC Frigates • 1 Replenishment Ship • 1 Multi-role Vessel	

AG-6 Measures of Effectiveness

High Level MoE:	Contributing Elements and Notes:
MoE1 Time to Capability	Number of MEU major Amphib units delivered time to achieve Gives credit for safe delivery ashore, and factors in transit speed, i.e. Fn will reduce timeline, by incorporating planning and rehearsal into transit
MoE2 Economy of Effort	Cost, for fuel and munitions used in Campaign
MoE3 Risk	Minimise blue attrition - sum total of unit losses for all eight slices (assemble, Littoral transit, ASW, ASuW, AAW/ASMD, Offload, NFS and MIO)
MoE4 Campaign Success	Probability of success for each warfighting slice (Littoral transit, ASW, ASuW, AAW/ASMD, NFS) multiplied by Time to Capability (MoE1) minus MoP for MIO phase Safe delivery of Campaign effectors (landing force ashore), minus red's ability to interfere with/ degrade our operations by reinforcing insurgents

The Technical Cooperation Program

SUBCOMMITTEE ON NON-ATOMIC MILITARY RESEARCH AND DEVELOPMENT

TTCP TECHNICAL REPORT

FORCENET IMPLICATIONS FOR COALITIONS

OCTOBER 2007

TR-MAR-XX-2007

Implications for Future Coalition Networks

"Ensuring the security of the Maritime Domain must be a global effort in which U.S. Government efforts are developed and furthered with the support of other governments."

NSPD-41/HSPD-13
December 21, 2004

Implications for Future Coalition Networks

- Back to the beginning:
  - The price of admission
  - The cost of omission
- Designing FORCEnet the right way
- One model for this design
- “Composeable FORCEnet”

What Is FORCEnet?

Network Centric Warfare Is the Theory

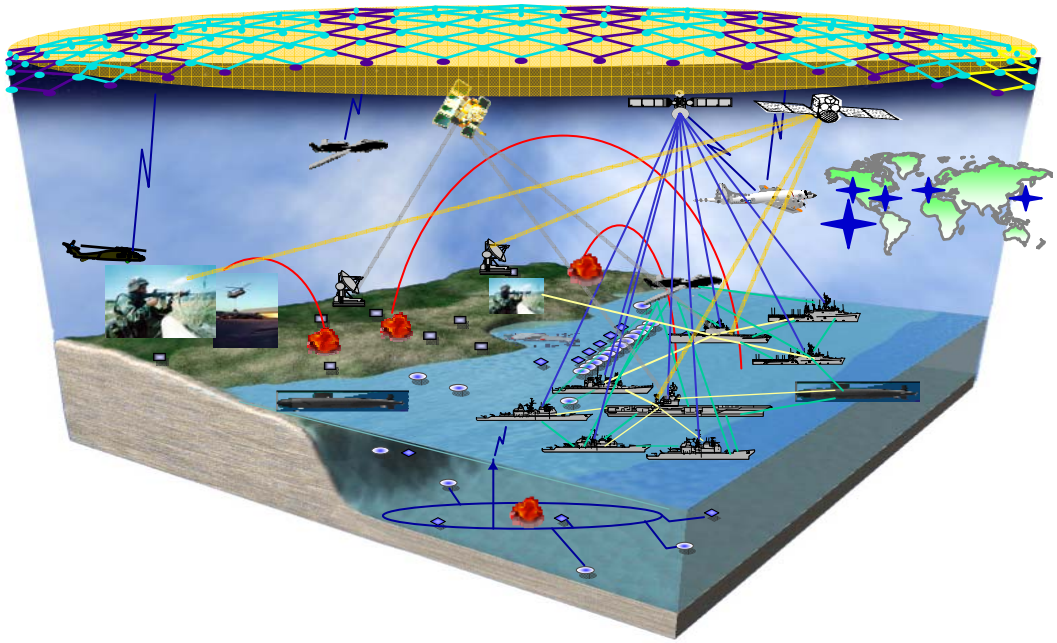
Net-centric Operations Is the Concept

FORCEnet Is the Process of Making the Theory and Concept a Reality

"FORCEnet Is defined as the operational construct and architectural framework for naval warfare in the Information Age, integrating warriors, sensors, command and control, platforms and weapons In a networked, distributed combat force."

FORCEnet: A Functional Concept for the 21st Century

February 2005 (CNO and CMC)

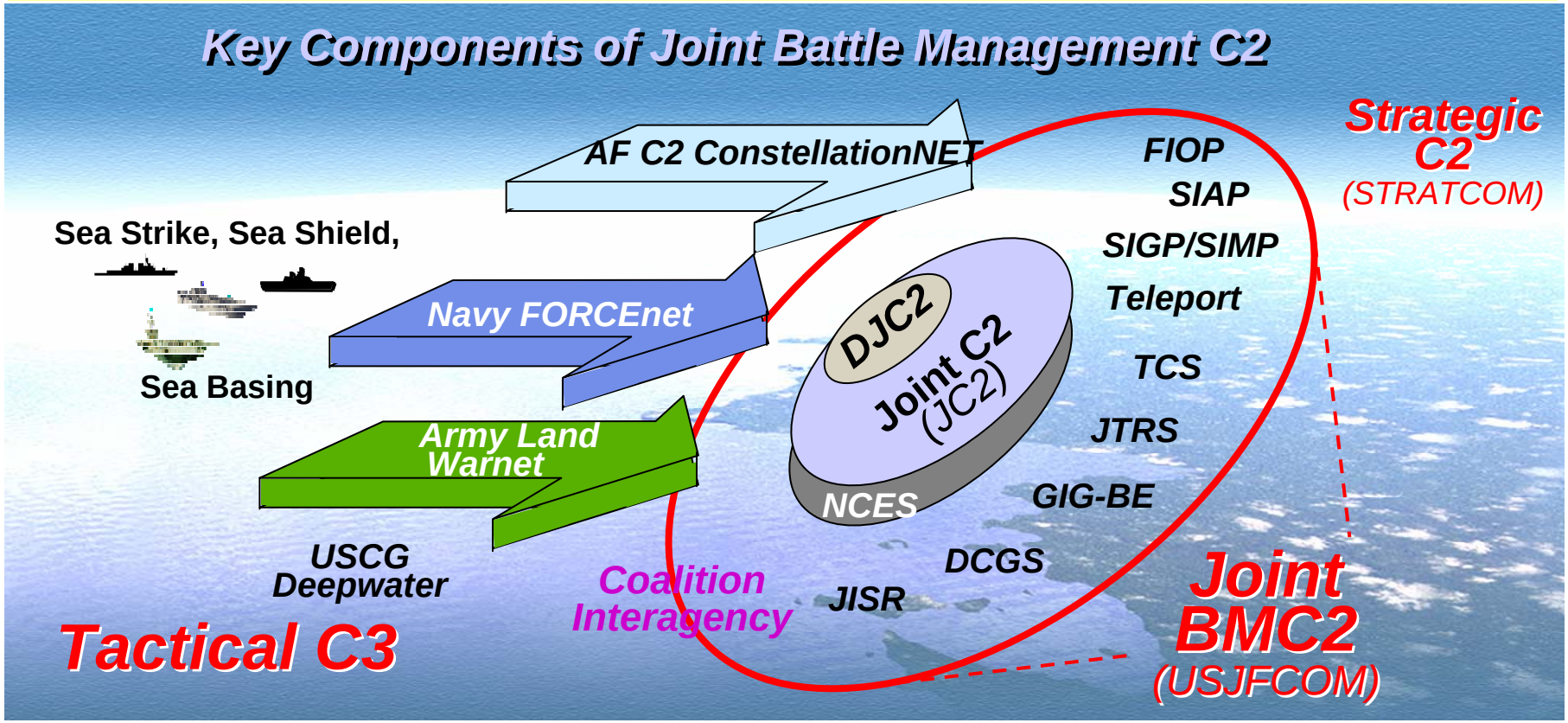


FORCEnet is Not

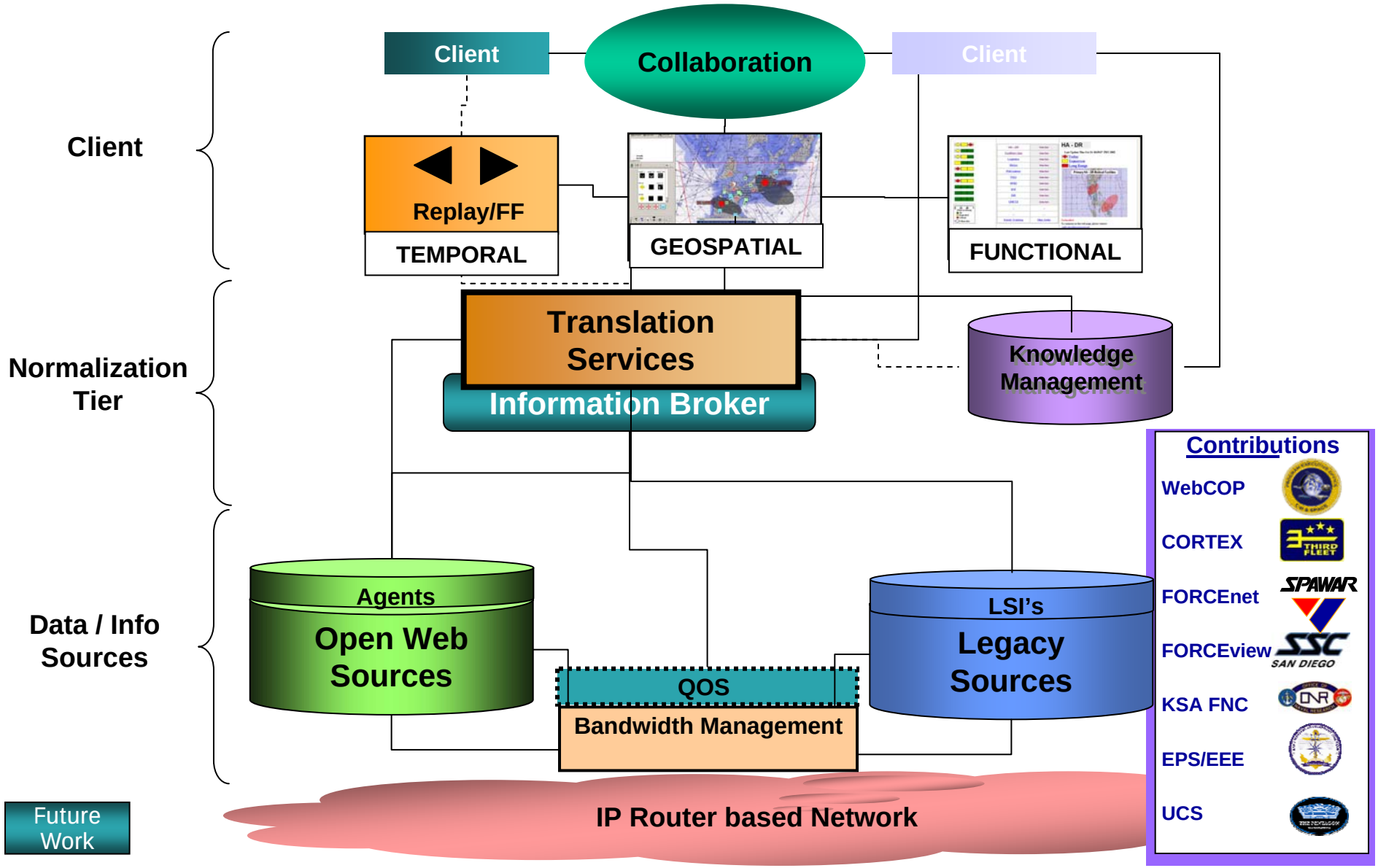
- **A Program of Record**
- **A Redundant Effort**
- **A Box or System**
- **Just a Network**

FORCEnet: Naval Component of Global Information Grid (GIG)

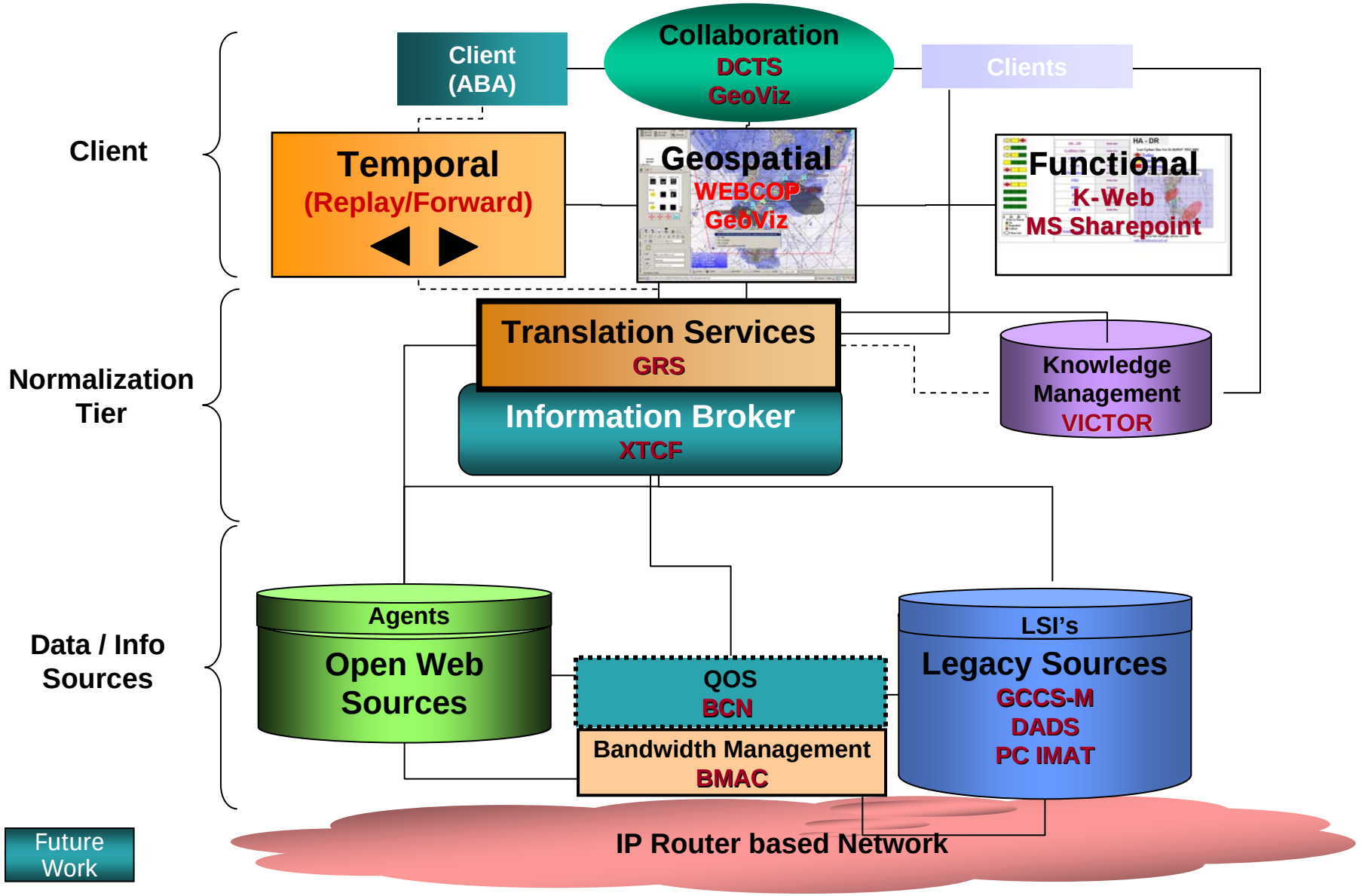
FORCEnet Is an Inherently Joint/Coalition Concept, Both Relying on and Providing Essential Capabilities to the Joint/Coalition Community and Other Services and Agencies



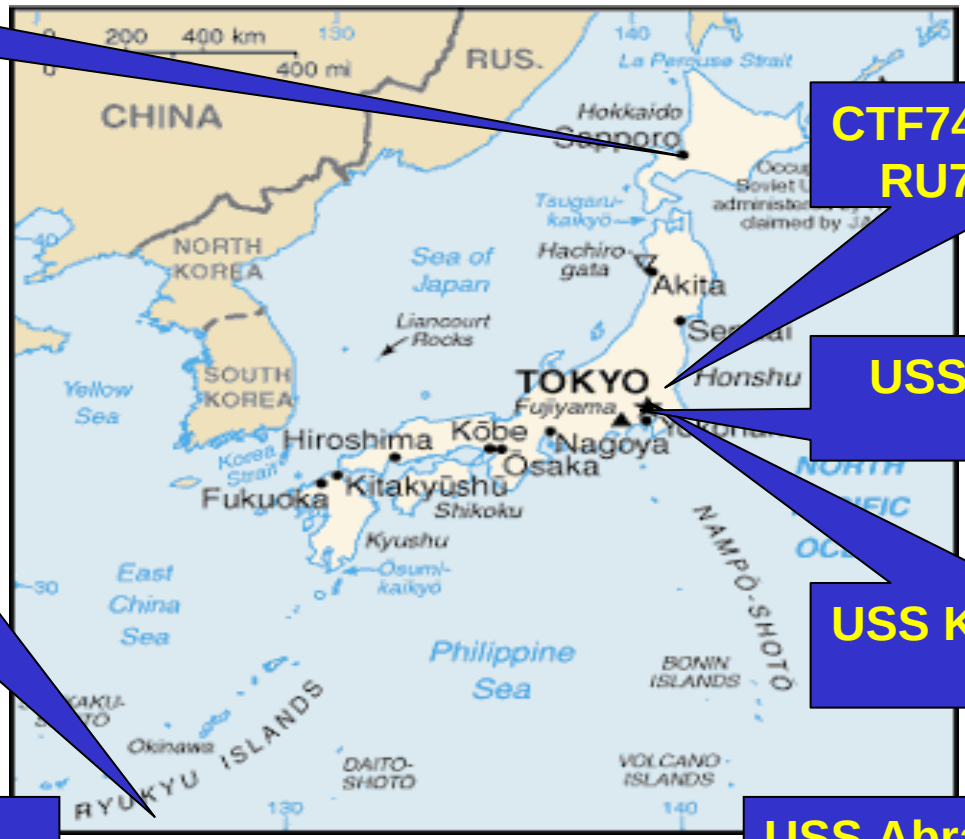
Composeable FORCEnet
A Coalition-Capable Approach



Composeable FORCEnet
A Coalition Capable Approach



Where Composeable FORCEnet is Currently Deployed



CTF72 (Misawa)

CTF74/COMSUBG RU7 (Yokosuka)

USS Blue Ridge

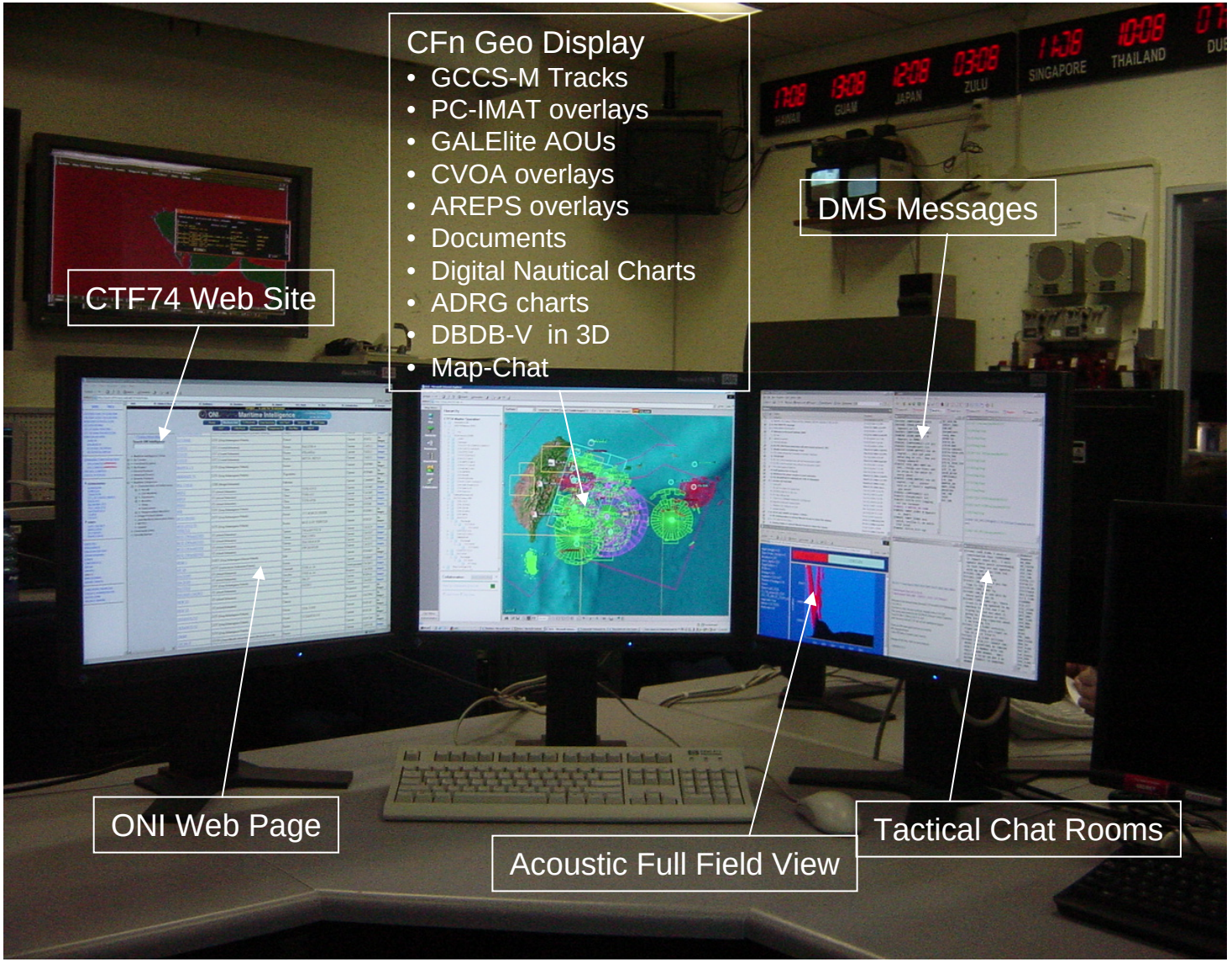
CTG72.2 (Kadena)

USS Kitty Hawk

USS Ronald Reagan

USS Abraham Lincoln

TASW CFn BWC Display at CTF 74



CFn Web based C2 provides improved understanding

Summary

- The importance of coalition operations is growing, and coalition operations now represent the norm for any significant operation.
- One of the most important pillars of coalition interoperability – and arguably the most critical one – is C4ISR.
- The technical details of enabling coalition partners to achieve C4ISR interoperability are not trivial and must be worked by all.
- TTCP offers an extant vehicle to continue to analyze the value-added of enhanced coalition C4ISR interoperability.
- The TTCP MAR AG-1 and AG-6 groups have done – and continue to do – significant work to examine the effectiveness of coalition interoperability.
- Composeable FORCEnet offers one methodology to ensure FORCEnet is coalition capable and provides seamless interoperability at sea.

"Why do we need a global network to provide maritime security? The short answer is the maritime domain is vital to most nations' economic prosperity and no nation can provide the requisite level of security by itself. It must be a shared endeavor among most of the world's nations if it is to be effective and efficient."

Admiral Michael Mullen
U.S. Navy Chief of Naval Operations
RUSI Future Maritime Warfare Conference
December 13, 2005

AG-6 Members


THE TECHNICAL COOPERATION PROGRAM
TTCP


SPAWAR
Systems Center
San Diego

Backups

Vetting With Other TTCP Groups

- Aerospace Systems (AER)
- Command, Control, Communications, & Information Systems (C3I)
- Chemical, Biological, and Radiological Defense (CBD)
- Electronic Warfare Systems (EWS)
- Human Resources and Performance (HUM)
- Joint Systems and Analysis (JSA)
- Land Systems (LAN)
- Maritime Systems (MAR)
- Materials and Processes Technology (MAT)
- Sensors (SEN)
- Conventional Weapons Technology (WPN)

Vetting With Other TTCP Groups

- Acting Chair and National Leaders identified a number of Technical Panels (TPs) and Action Groups (AGs) as candidates for collaborative work
- Actions assigned to make contact with each of these groups to determine mutual interests
- Two likely candidates for mutual integration and potential collaboration:
  - HUM TP-9 (Human Systems Integration – Maritime)
  - MAR TP-1 (Maritime C2 Information)

Virtual Battle Experiments

- Provide an opportunity verify or validate aspects of FORCEnet modeling
- Conducted in a “controlled environment” with advanced modeling and simulation
- MAR TP-1 identified as one potential collaborator for a virtual battle experiment

War Game

- Ongoing dialogue with Naval War College War Gaming Department for war game
- Will definitize cost/benefit tradeoffs within next several months
- War game would take modeling results to the next level

Trident Warrior

- Opportunity exists for future Trident Warrior games to adopt MAR AG-6 Philippine Comfort Scenario, vignettes and measures in order to validate various elements of AG-6 modeling
- MAR AG-6 modeling results could be shaped to provide baseline data for Trident Warrior efforts, ensuring that the experimentation is based on good analysis and modeling.

SPAWAR
Systems Center
San Diego

Capstone Report

- Abstract
- TOC
- Executive Summary **(Goal is unlimited distribution)**
- Chapter 1: Introduction
- Chapter 2: FORCEnet for the Coalition Context
- Chapter 3: Study Approach
- Chapter 4: Summary of Vignette Results
- Chapter 5: Experimental Validation
- Chapter 6: Aggregation
- Chapter 7: Capability Issues and Opportunities
- Chapter 9: Summary of Findings/Recommendations
- Chapter 10: References

Capstone Report

- Annex A: TTCP AG-1 Executive Summary
- Annex B: TTCP AG-6 Terms of Reference
- Annex C: MAR Guidance to AG-6
- Annex D: Networking Coalition Interoperability
- Annex E: Coalition FORCEnet Study
- Annex F: NPS Report 1
- Annex G: NPS Report 2
- Annex H: NPS Report 3
- Annex I: NPS Report 4
- Annex J: AG-6 US Proposed Study Plan
- Annex K: Challenges
- Bibliography

"Network-centric warfare broadly describes the combination of emerging tactics, techniques, and procedures that a fully or even partly networked force can employ to create a decisive warfighting advantage."

Network-Centric Warfare
Office of Force Transformation
December 2003

"…A fleet of ships fully netted and connected not only to each other, but integrated with the joint force as well as DEA or the FBI, or the customs and border control agencies of any number of other nations…Just imagine the power that would reside in that kind of fleet, imagine the depth and breadth of skills it would bring to the table."

Admiral Michael Mullen
Chief of Naval Operations
Remarks at the U.S. Naval War College
August 31, 2005

"The essence of the 1000-ship navy is how do we marry with our coalition partners on the global commons."

Admiral Michael Mullen
Remarks at the 10th Annual
Expeditionary Warfare Conference
October 26, 2005

TTCP Background

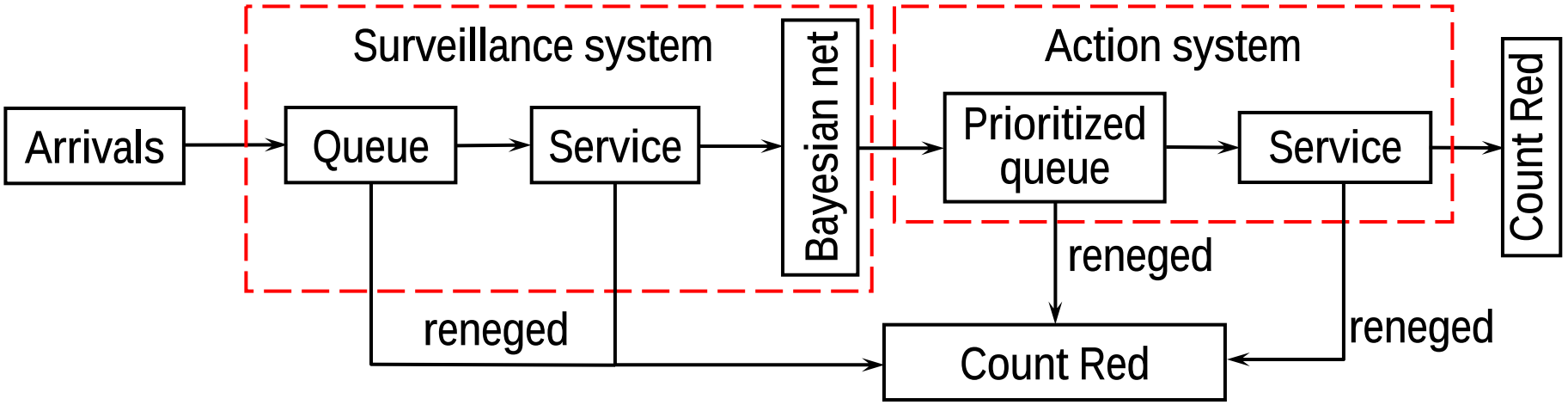
- In October 1957 the President of the United States and the Prime Minister of Great Britain made a Declaration of Common Purpose to combine resources and share tasks
- Canada joined to form the Tripartite Technical Cooperation Program (TTCP)
- Australia joined in 1965, name was changed to The Technical Cooperation Program
- New Zealand joined in 1969

TTCP Current Groups

- Aerospace Systems (AER)
- Command, Control, Communications, & Information Systems (C3I)
- Chemical, Biological, and Radiological Defense (CBD)
- Electronic Warfare Systems (EWS)
- Human Resources and Performance (HUM)
- Joint Systems and Analysis (JSA)
- Land Systems (LAN)
- Maritime Systems (MAR)
- Materials and Processes Technology (MAT)
- Sensors (SEN)
- Conventional Weapons Technology (WPN)

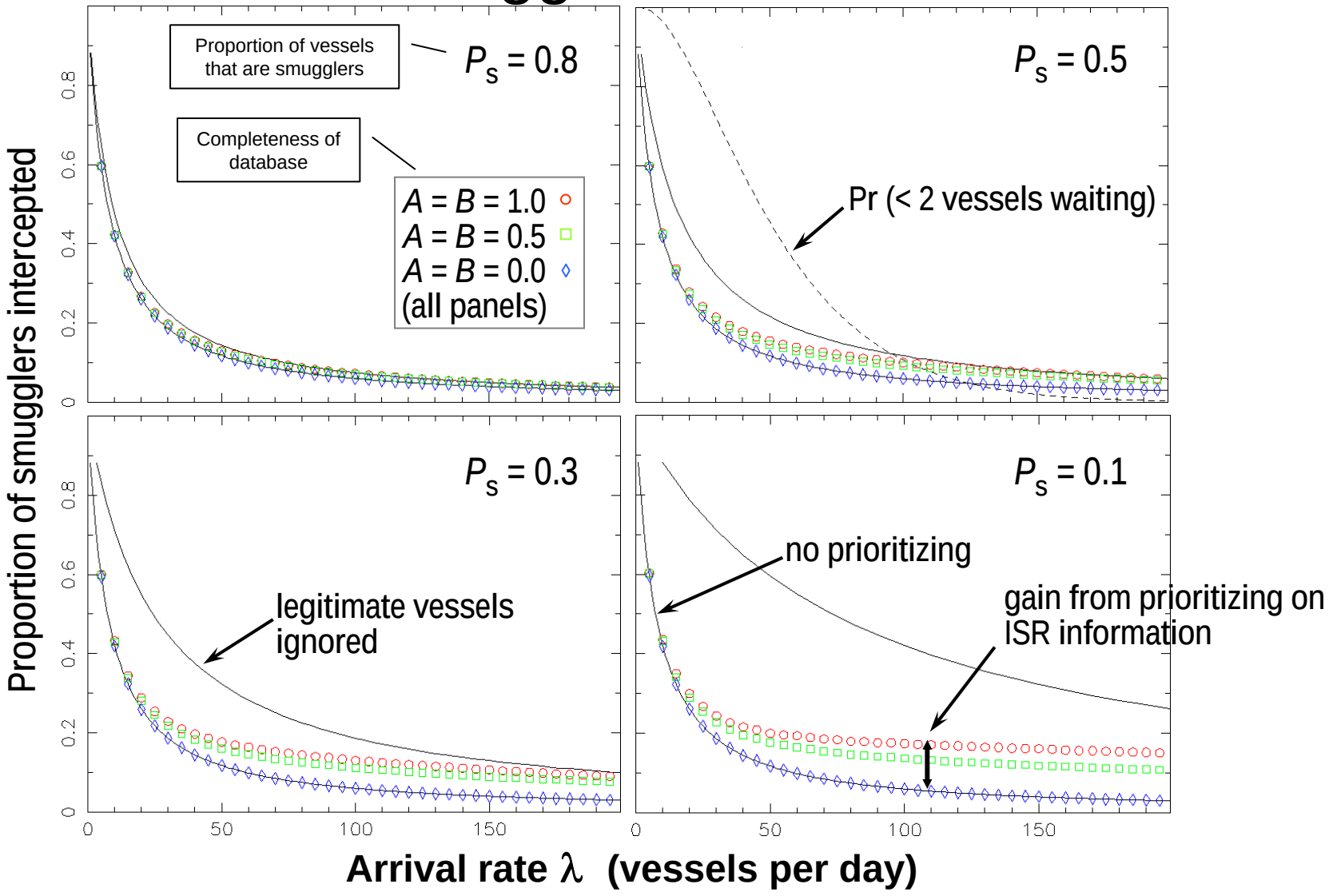
MAR AG-1 Study A
Broad NCW Issues

Study A: Sample Highlights (End-to-End Modeling Approach)



- The Bayesian net requires redesign for each scenario — i.e. must decide how to determine 'priority.'
- The structure of the queues may also require adaptation.

Sample Results: Impact of ISR Combined with Database of Smuggler Vessels



"I am convinced that freedom depends upon our navies remaining highly capable, resolute, and together."

Admiral Michael Mullen
U.S. Navy Chief of Naval Operations
RUSI Future Maritime Warfare Conference
December 13, 2005