Linking Cognitive Data to Design In Navy Command and Control

Annual INCOSE International Symposium
Denver, 22 June 2011

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Linking Data to Design in Navy C2

- Quick Overview of Project
- Explanation of Cognitive Systems Engineering
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- Explanation of Cognitive Systems Engineering
-

Project Overview

We used Cognitive Systems Engineering methods to collect data, and transformed the data into Requirements, Display Designs, and a Guidebook

Data Hub GUIDANCE - this file contains the following:
1) Cognitive Demands Table; 2) Findings unique to the Riverines for this category ; 3) Notebook space for recording record insights, questions about the table/findings, additional issues, etc. Please feel free to add to it, please note your name and the date with any content you add; 4) Interview excerpts—from our most recent data pull (July 2010) these are segments of MESF interview data that provide illustration of the particular cognitive demand category

CGD TABLE A: Understanding the Operational Picture
This individual-level activity involves **building and maintaining an understanding of the operational situation,** including **status and capability of assets; potential threats; and schedules and movement of other craft.** .....it is a sensemaking activity that involves tracking, filtering, and integrating information from multiple sources, and constantly updating one's understanding.

A-1 Cognitive Demands Inventory

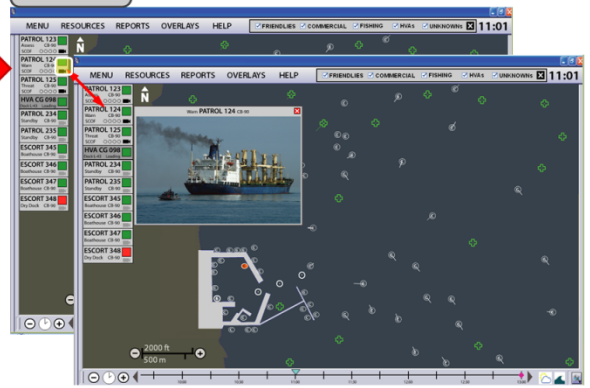
Need to be able to *Understand operational picture* in order to... (from MOC perspective)	If can't do this then... (costs)	Things that get in the way... (glitches/challenges)	Requirements - in order to do this they need...
➢ Provide info relay between the JOC and the water ➢ Understand implications of information they're receiving ➢ Accurately interpret what the PL reports about the status of boats, ➢ Know what action to take to ensure mission continues ➢ Provide 'oversight' – grasp implications of specific events for the overall mission picture ➢ Step in and drive the situation if/when the PL actions are inconsistent with	➢ Watch officer cannot make timely, effective, appropriate decisions, ➢ WO cannot provide guidance/direction to the PLs re accomplishing the mission. ➢ Watch officer will not know implications of patrol craft status for security plan and ongoing mission ➢ WO are "behind the curve" --Response time is shorter; lose ability to anticipate or react ➢ JOC Watch officer not able to provide CO/XO with	➢ Unreliable radio comms ➢ No sensors ➢ Delayed/distorted information from boats ➢ Vessels not submitting their movements ➢ Delayed (or lack of) communication from host nation Port Authority about schedule and vessels coming in/out of port ➢ Difficulty finding the person who has the info you need	➢ Need reliable radio comms for info-sharing and updating ➢ Need accurate, timely info from other links in the C2 chain ➢ Need information that is real-time (not time-delayed), or capability that allows operators to check recency of info update ➢ Need integration of both perspectives – boat/water perspective and bigger picture (MOC) ➢ Need understanding of capabilities and status of all patrol craft, with respect to current environmental conditions (e.g., sea state). ➢ Need to know what the available human resources are: who has what information and how they can be reached ➢ Need ability to distinguish contacts on radar (many returns are ambiguous) ➢ CO (Sq WO) needs to know what his patrol boats

Key:
R = Riverine
M = MESF
WW=Wall Walk
A-O correspond to data tables derived from interviews [located at https://sharepoint.ara.com].
Asmd = assumed as required for a given component command, based on understanding of operational context

Information Requirements	Unique	Shared	Common	Source
1. Access to an operational picture that integrates information from both MOC and boats and provides each C2 node with an understanding of the operational picture that others in the C2 chain see simultaneously. (Referred to as "Operational Picture in requirements below)	M			A, B, E, G, H, O
2. Provide TOC (Squadron and Det) with access to an operational picture display *console* that co-locates multiple information sources, systems, and displays (currently systems are scattered around ops center, and information must be integrated in WO's head)	R			A, I
3. Access to an operational picture that specifically shows **capabilities and status of own patrol boats**		•		
• Patrol boat number shown		•		WW, Asmd Riv
• Which patrol boats are out and which ones are "benched."	M			WW
• Which patrol boats are engaged in HVA escort	M			WW

Camera Icon in Stacks allows MOC/JOC to "see what boat sees"

Requirements Mapping



Req 1. System shall provide access to an operational picture that integrates information from both MOC and boats, permits 'seeing what others see'

Why Cognitive Systems Engineering?

Three driving factors (Hollnagel & Woods, 2005):

- Growing complexity of socio-technical systems
- Problems and failures created by clumsy use of emerging technologies
- Limitations of linear models and the information processing paradigm

Navy Systems Development accounts for human performance through Behavioral Task Analysis methods; these do not address the support for cognitive work needed in high hazard operations

What is Cognitive Systems Engineering?

requirements of users

requirements of users

- ..such as decision making, sensemaking, team collaboration, etc.

- Several methodologies for accomplishing CSE:
  - Cognitive Task Analysis
  - Cognitive Work Analysis
  - Situation Awareness Oriented Design
  - Work Centered Design

Situation Awareness Oriented Design

Systems Engineering in the Systems Engineering Design Process. *Systems Engineering*,

5

Naval Expeditionary Combat Command (NECC) Missions

- Waterborne and ashore anti-terrorism (think USS Cole)
- Force protection
- Theater security cooperation and engagement
- Humanitarian assistance/disaster relief contingencies
- Waterborne and ashore anti-terrorism (think USS Cole)
- Force protection
- Theater security cooperation and engagement

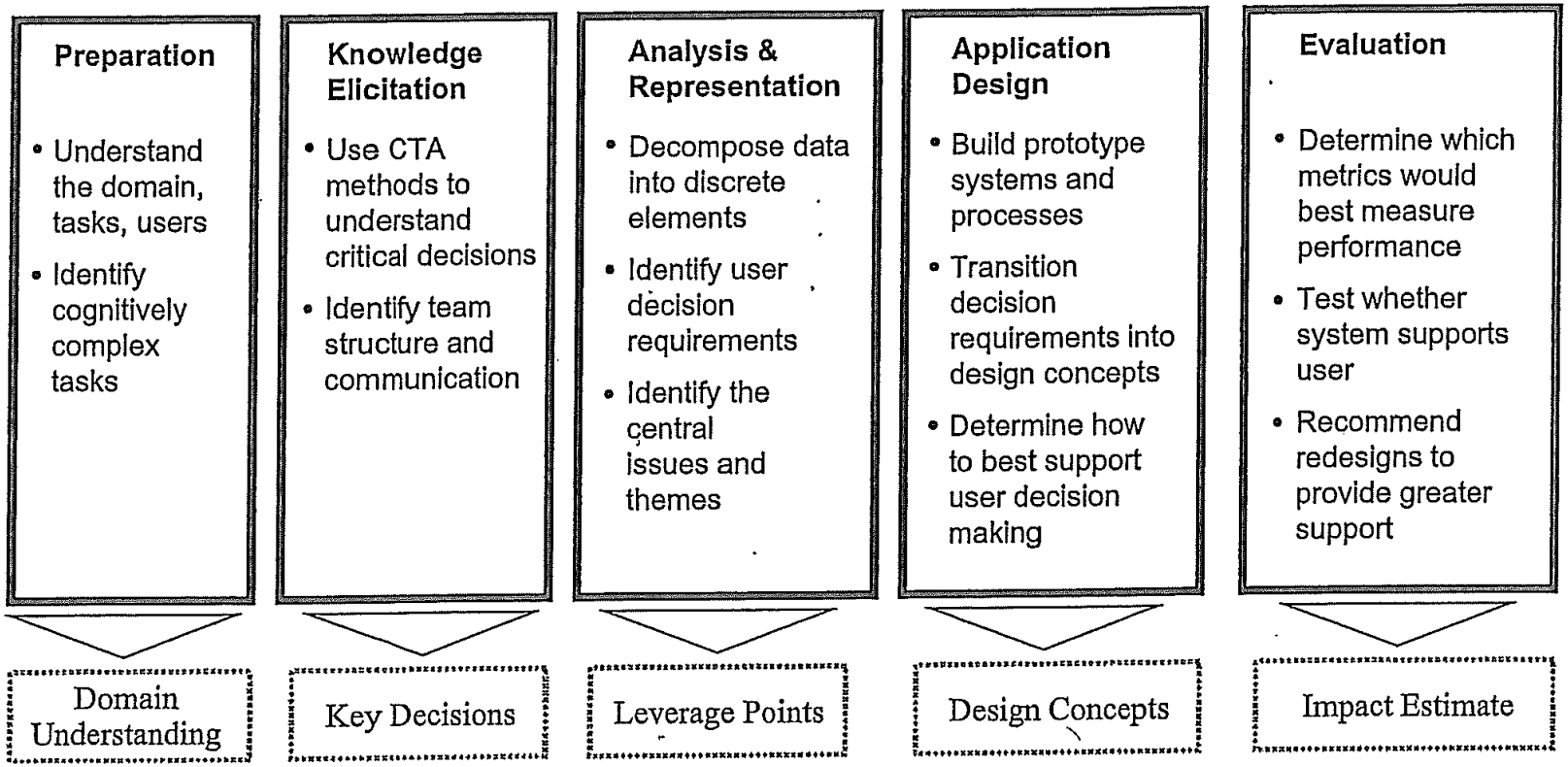
NECC Sub-Commands

- Maritime Expeditionary Security Force
  -
- Maritime Expeditionary Security Force
-
  - Harbor protection of High Value Assets
  - Inland waterway security, force projection
- Riverine Force
- Construction Battalions
-
- Mobile Diving and Salvage
- Construction Battalions
- Combat Camera

Ash Shuaybah Port, Kuwait

ARA

What We Did for NECC: Cognitive Task Analysis



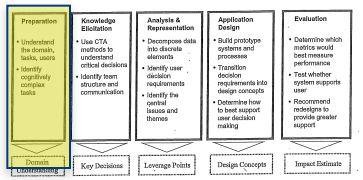
Documenting the 'How To'

While doing the project, we:

- Reflected on 'Reasonable Scientific Criteria' for cognitive task analysis
- Researched what others had published
- Documented criteria and how to do this work in Guidebook

  For Incorporating Human-Centered Design in Category IV & below Military Acquisition Programs

Step 1: Preparation & Framing



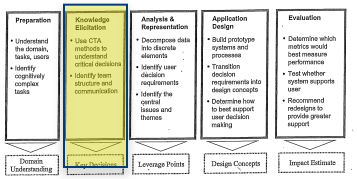
GOALS – Preparation & Framing Component:

- **Understand the work domain**
- **Identify where to focus resources—what are the high payoff items?**
- **Select CTA methods**
- **Identify preferred participants/ informants**

Reasonable Scientific Criteria

Define, document, & understand:

1. The Issue and problem
2. Our systematic learning about the domain
3. Rationale for selection of the method, settings, and project participants



Step 2: Knowledge Elicitation

GOALS – Knowledge Elicitation Component:

- **Identify & document the key decisions, cognitively complex tasks, and aspects of cognitive performance that matter most**
- **Describe the work context (notes, photos, sketches, other artifacts)**
- **Identify and document the work setting and organizational influences on performance**

Reasonable Scientific Criteria

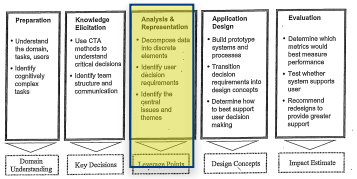
1. Use multiple methods
2. Use interview/observation guides
3. Purposeful sampling
4. Experienced collectors
5. Protocol for documenting data
6. Disciplined flexibility: allow for exploration, discovery
7. Rigor that supports consistency, comparability

What we did: NECC Data Collected

- Interviewed 38 NECC personnel, post-deployment
- 24 MESF (Harbor Protection), 14 Riverine
- 14 in Iraq, 16 in Kuwait, 7 in UAE
- Roles:
  - 9 MESF Watch Officers
  - 7 Boat Patrol Leaders
  - 8 Riverine Boat crewmembers
  - 3 Communications experts
  - 3 Command & Control operators
  - Several combinations of the above

Rank/Rate	SME Code	Role(s) category	Where deployed
IT2	MESF 14, TW4	GDFS Op	KUW
LT	MESF 15, TW5	Ops Center WO	UAE
IT1 (PO)	MESF 16, TW6	EST	KUW
LTJG	MESF 18	Boat--HVA rider, SSO	UAE
LT	MESF1	JOC WO	KUW
IT1	MESF10	MOC Watch Sup	KUW
ETC	MESF11	MAST Sup/MOC WO	KUW
OS3	MESF12, TW2	GDFS Op	KUW
PO	MESF13, TW3	GDFS Op	KUW
ITC	MESF17, TW7	MOC WO	KUW
LT	MESF19	MAST OIC	Haiti
OS3	MESF2	MOC Watch Sup	KUW
LCDR	MESF20	TOC WO	UAE
BM1 (E7), LPO	MESF21	PL	UAE
LCDR	MESF22	Msn Cdr, SSO	UAE
OSC (E7)	MESF23	TOC WO	UAE
MA2 (E5)	MESF24	PL	UAE
OSC Masterchief	MESF3	MOC WO	KUW
OSC	MESF4	JOC WO	KUW
all	MESF5	PL	KUW
ITC	MESF6	MAST Sup	KUW
LT	MESF7	MOC WO	KUW
LTJG	MESF8	MOC WO	KUW
BMC	MESF9	PL	KUW
LT	RIV1, TW1	PL	Iraq
[?]	RIV10	PL and TOC BWC	Iraq
LCDR	RIV11	Sq TOC/Ops Officer	Iraq
ENC	RIV12	Boat--JTAC, Msn Cdr	Iraq
ET1	RIV13	Det Comms, Boat Comms	Iraq
CPO E7	RIV14	Boat Capt, Det TOC WO	Iraq
IT2	RIV2	Comms	Iraq
IT2	RIV3	Comms	Iraq
EN1	RIV4	PL	Iraq
IT1 (E6)	RIV5	Boat-Comms	Iraq
LPO	RIV6	Boat-Comms	Iraq
LT	RIV7	Det TOC WO (OIC)	Iraq
LPO	RIV8	Boat, Det TOC, Sq TOC Intel	Iraq
CPO	RIV9	Boat-Intel Analyst	Iraq

Step 3: Analysis & Representation



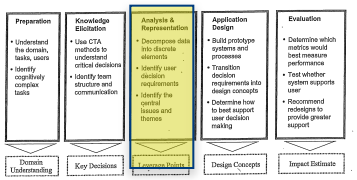
GOALS – Analysis & Representation Component:

- **Identify cognitive work requirements and challenges with greatest operational impact**
- **Create representations that communicate key findings**

Reasonable Scientific Criteria

1. Systematic, documented analysis process
2. Audit trail to connect data elements to findings and design
3. Use of multiple analysis processes and multiple passes through the data
4. Experienced analysts
5. Thoughtful, goal-driven selection of qualitative vs quantitative analysis methods
6. Validity checks on the credibility, consistency, comprehensiveness, and centrality of findings

What We Did: Analysis Approach



Systematically review interview notes and operational incidents/examples

Identify:

- Mission requirements
- Cognitive demands
- Barriers/gaps to effective C2, and operational impact
- Information needs

Develop requirements to support cognitive demands and overcome gaps/barriers:

- Information *
- Technology/Architecture
- Training
- Organizational/Operational

Analysis: From Data to Data Hub

1. Initial sweep through data

LTJG XXXXXX, Patrol Leader and SSWO
MSRONX
5/6/10
Lead: Anna
Second: Cindy

Background:

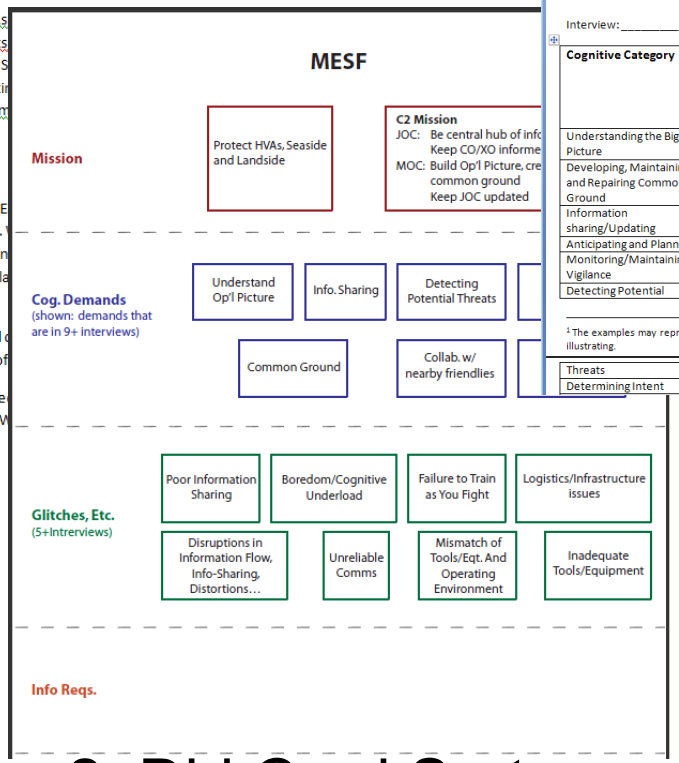
1st NECC experience, Sept 2008. As
underneath that are two boat dets
officer (SSWO) qualified also. The S
putting boats on water, coordinati
those boats. Less administrative, m
on last deployment.

Deployments:

1 full one in Kuwait. Also on Foal E
active duty MSRON to participate.
Also, I was in charge of planning an
counterpart, we were in Rhode Isla
June 12 09 til Jan 24th 2010.

I'm always an AOIC. For SSWO I'd
a different viewpoint, get a view of

I have an interesting SSWO perspe
sides of the puzzle, most other SSW



2. Did Card Sort: created categories

3. Checklist sweep back through data

each category across the full data set; pull illustrative examples

We'll use a separate template for each interview.

Interview:_____

Cognitive Category	Check box if category is present in interview (and note page #s)	Illustrative Examples (not meant to be comprehensive)[1]	notes/issues/questions
Understanding the Big Picture			
Developing, Maintaining, and Repairing Common Ground			
Information sharing/Updating			
Anticipating and Planning			
Monitoring/Maintaining Vigilance			
Detecting Potential Threats			
Determining Intent			

[1] The examples may represent illustrating.

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A-1 Cognitive Demands Inventory

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4. Data Hub Representation

Analysis Product: Data Hub

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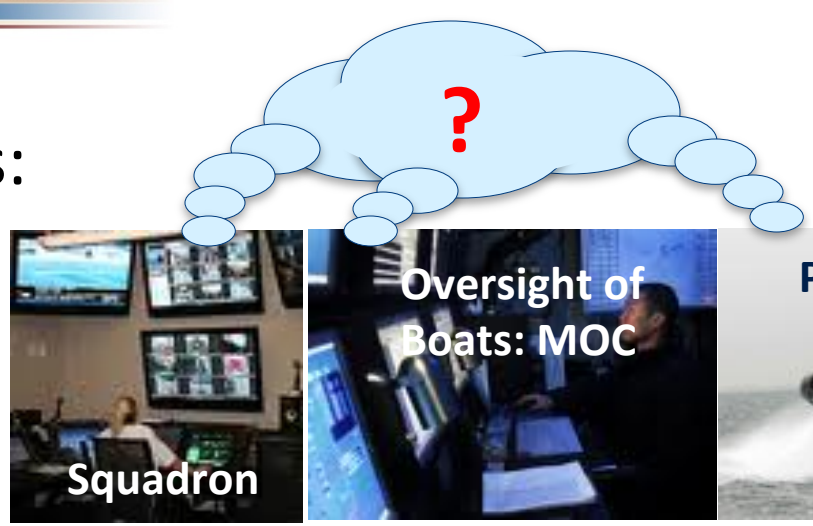
3 Cognitive Challenges:



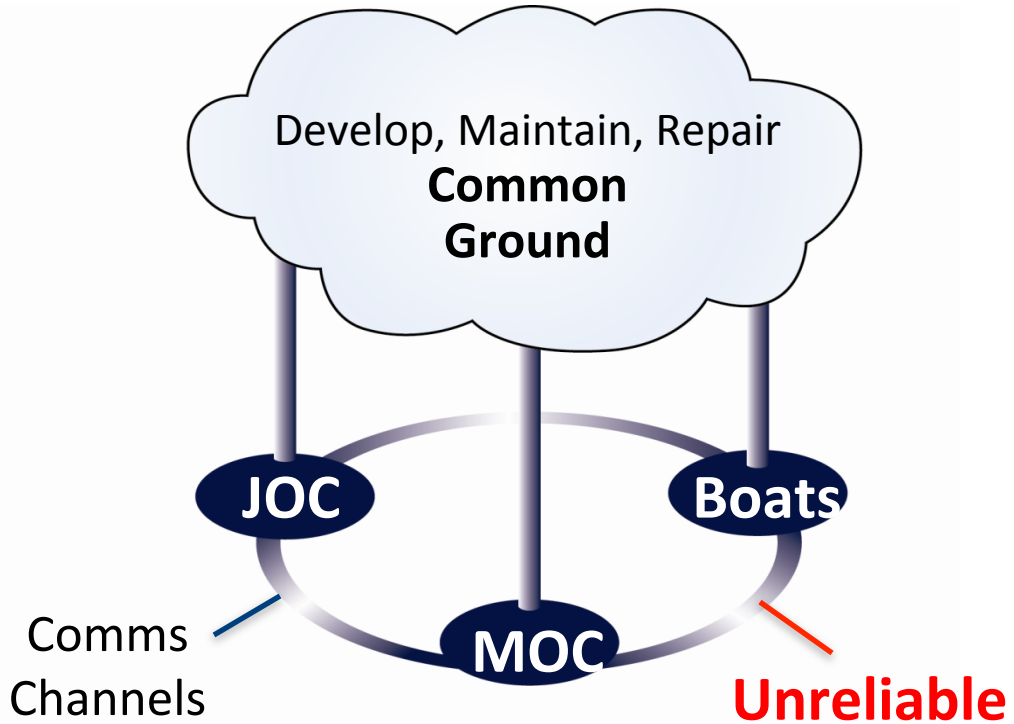
A. Understand the Operational Picture

How?

B. Common Grounding

How?

C. Information Sharing



Requirements

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• Patrol boat number shown		•		WW, Asmd Riv
• Which patrol boats are out and which ones are "benched."	M			WW
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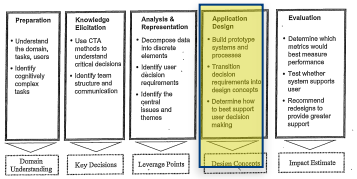
Right column shows which data hub table the requirement can be traced to.

Step 4: Design

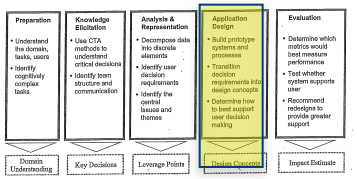


GOALS –Design:

- **Identify design elements that support users' cognitive work**
- **Develop elements into design concepts and features**
- **Determine the set of design features likely to have greatest impact, benefit**

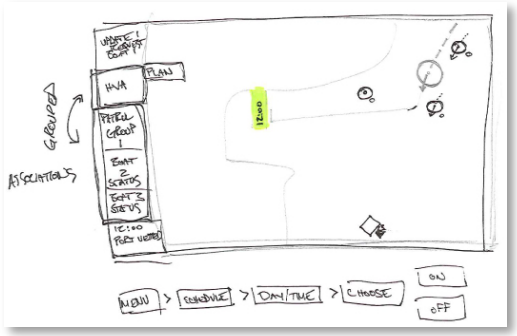
Reasonable Scientific Criteria

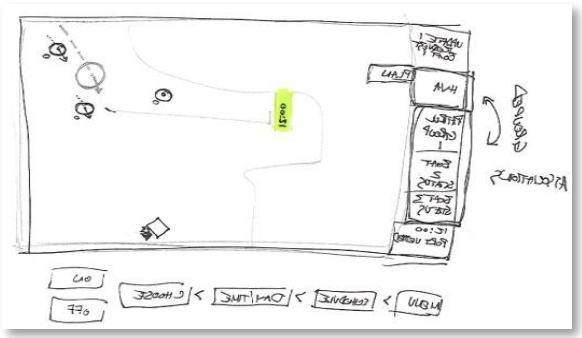
1. Systematic, purposeful use of an iterative design→build→evaluate process
2. Use of SMEs to provide reality checks on value of design ideas
3. Audit trail to connect data elements to findings and to design results



What we did: Design

- 3-day Design Workshop with 3 analysts, designer
- Began after immersion in data: all totally familiar
- Solicitation and generation of multiple sketches per requirement
- Final review and prioritization of sketched ideas
- Designer developed in flash, did multiple reviews with analysts

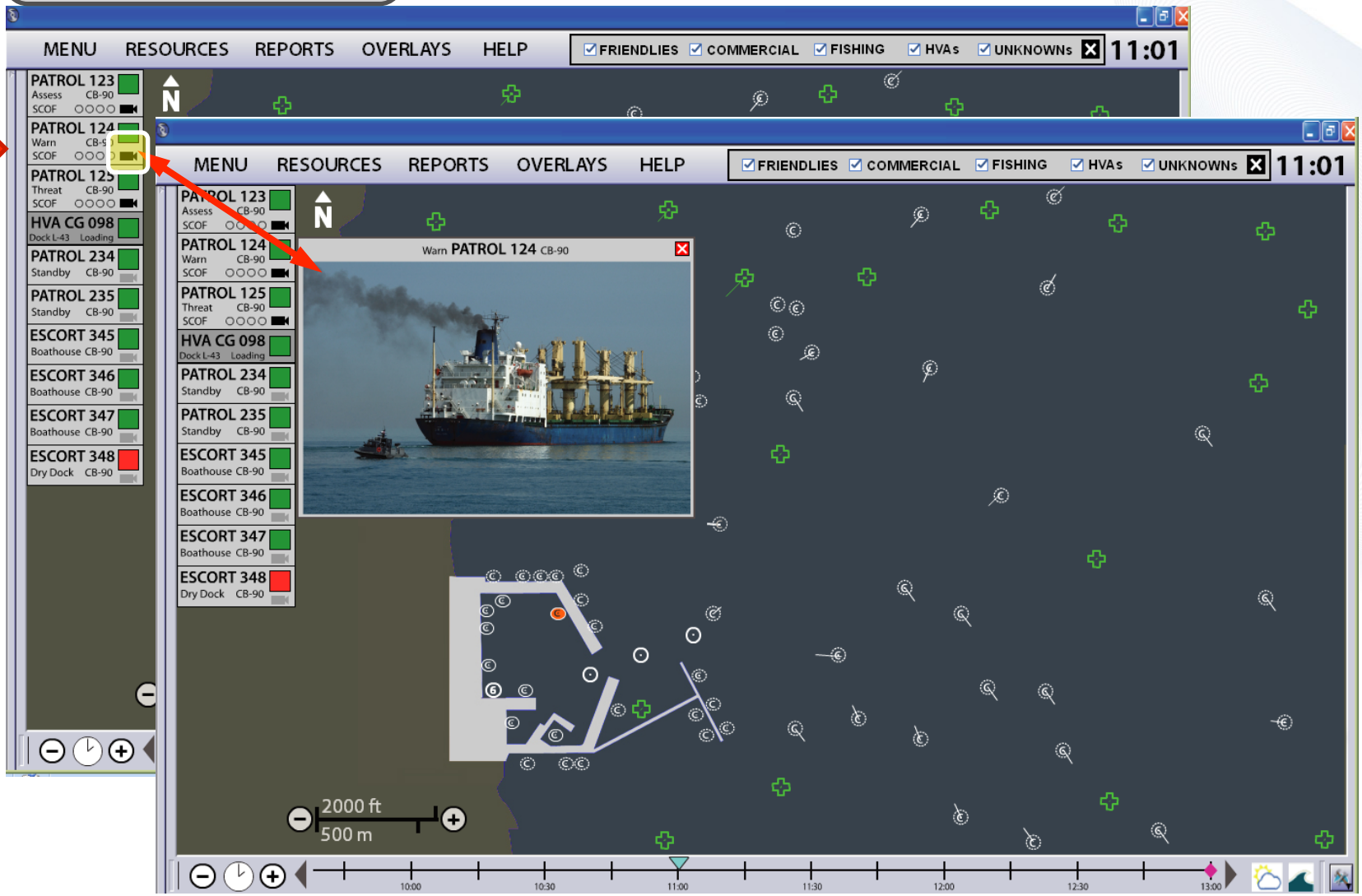




Requirements Mapping

Camera Icon in Stacks allows Watch Officers to "see what boat sees"

1



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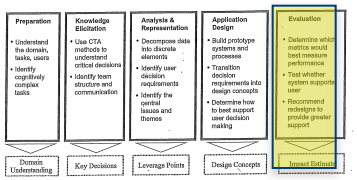


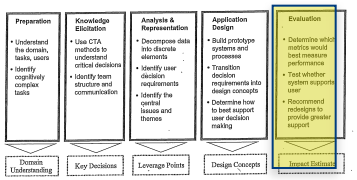
Evaluation

GOALS – Evaluation:

- Assess the impact of the new system or tool
- Identify revisions in design requirements and improvements for design
- Refine/augment understanding of the cognitive work challenges and work context

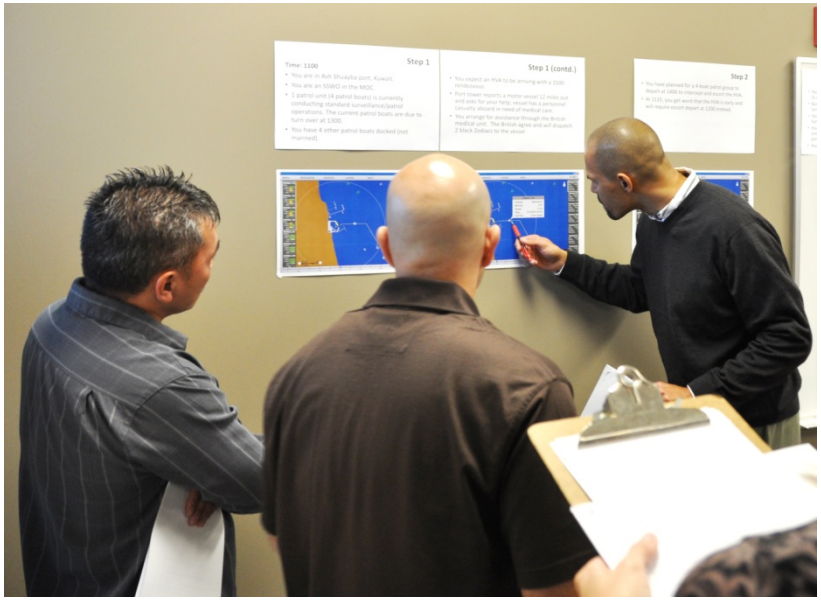
Reasonable Scientific Criteria

- Specification of intended and desired outcomes
- Systematic, purposeful evaluation
- Evaluation methods that reflect key cognitive components
- Thoughtful, goal-driven selection of evaluation methods
- Centrality: do evaluation outcomes reflect critical cognitive and behavioral issues?



What We Did: Cognitive Wall Walks

- Brought Riverine and MESF users to 2-day workshop
- Printed design concepts, developed scenarios from data
- Walked SMEs around room, eliciting feedback stepping through scenario while ‘using’ new displays
- Incorporated changes and conducted 2 WebEx sessions to further review and refine displays



Results

- 60-page Guidebook to account for human-centered design process in DoD context
- Prototype demonstrating new C2 Display structure, functions
  - Flash prototype for showing concept designs, functionality
  - Displays coded in Raytheon Solipsys' JEC3
- Requirements: KPP, KSAs

C2 System for NECC

- User Operational Evaluation System (UOES) command and control (C2) system for all commands within the Naval Expeditionary Combat Command (NECC).
- First human-centered acquisition strategy for smaller scale (ACAT IV and below) system development projects.
- Results expected to increase expeditionary force resilience by improving NECC's ability to adapt to widely varying missions and force configurations.

Why do this?

- Buys the system developer validation—happy user quotes:
  - "This system will have everything I need, all in one place"
- Supports human thinking as critical part of system success
- Leverages human capabilities, supports judgment by providing decision support
- Contributes to resilience—system's adaptive capacity
- Makes product launch efficient—gets it right sooner

Takeaways

- CSE adds value when dealing with combinations of complex tasks, human(s), and technology or systems under *time pressure, high stakes, uncertainty,* or *rapid change*.
- Offered some guidance on process and criteria for success in applying CSE to develop requirements, display designs

Linking Cognitive Data to Design In Navy Command and Control

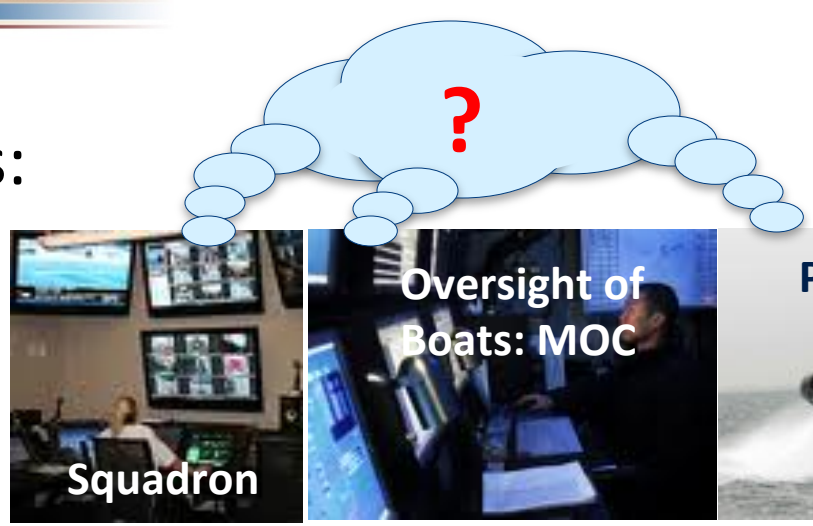
Annual INCOSE International Symposium
Denver, 22 June 2011

Presented by:
Cynthia Dominguez
Principle Scientist
Cognitive Systems Engineering

cdominguez@ara.com

BACKUPS

3 Cognitive Challenges:



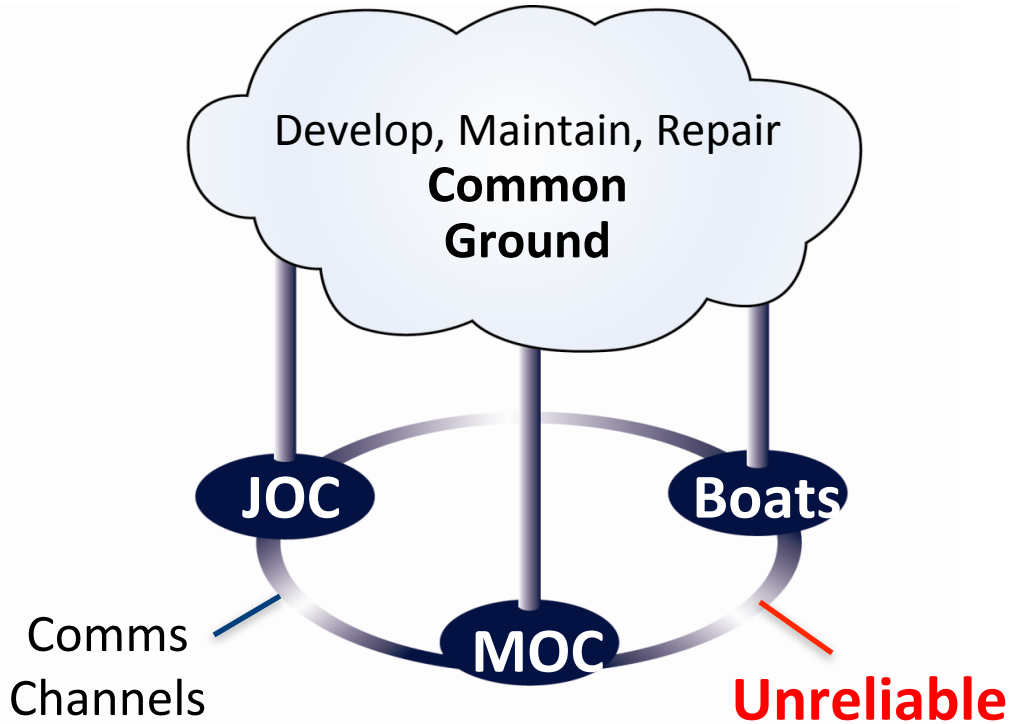
A. Understand the Operational Picture

How?

B. Common Grounding

How?

C. Information Sharing



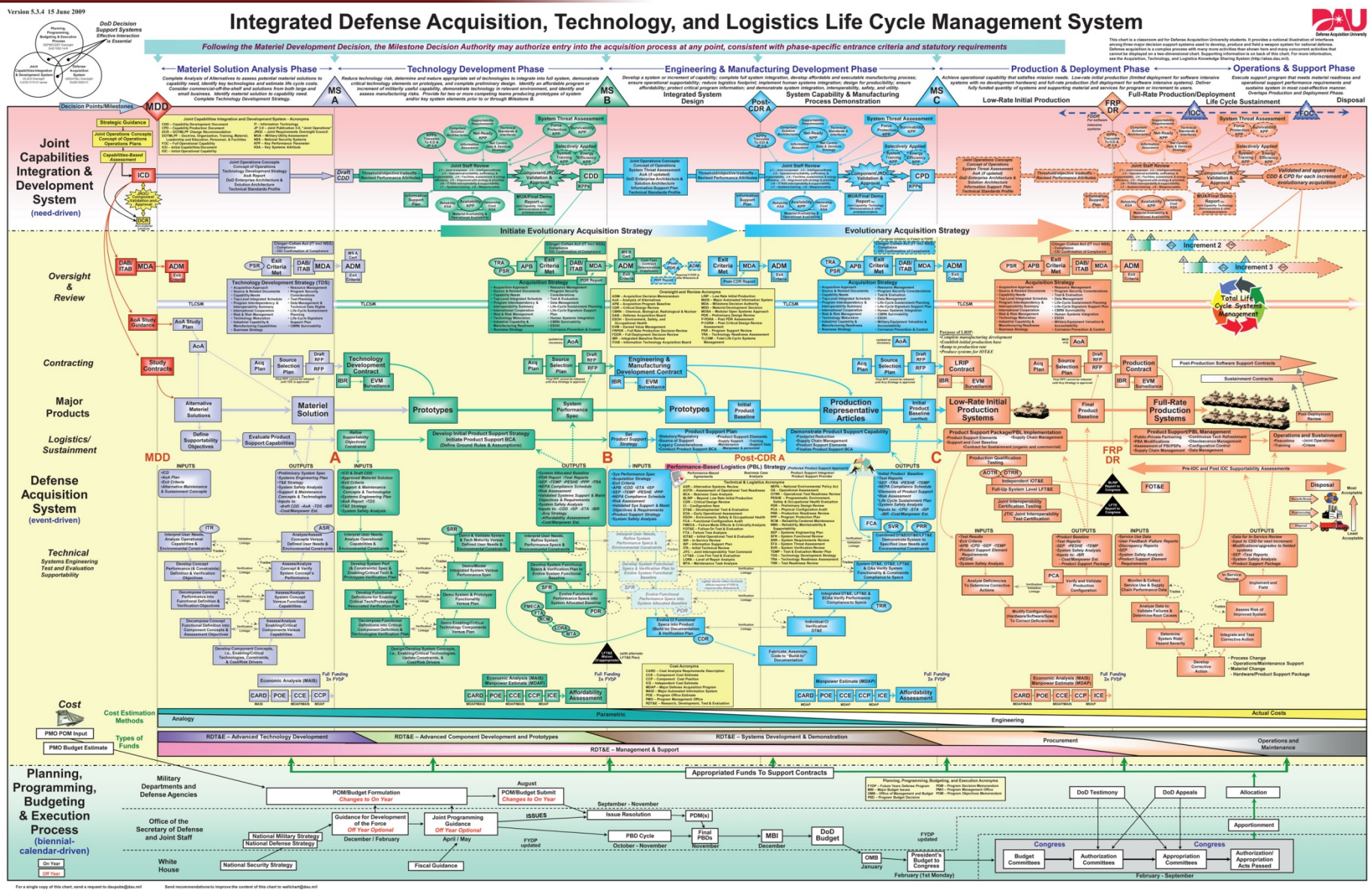
Command and Control

"[t]he exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission.

Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

Also called C2."

DoD Dictionary of Military and Associated Terms


Version 5.3.4 15 June 2009
Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System
Following the Materiel Development Decision, the Milestone Decision Authority may authorize entry into the acquisition process at any point, consistent with phase-specific entrance criteria and statutory requirements
Materiel Solution Analysis Phase
Technology Development Phase
Engineering & Manufacturing Development Phase
Production & Deployment Phase
Operations & Support Phase
MS A
MS B
MS C
MDD
FRP DR
IOC
FOC
Joint Capabilities Integration & Development System (need-driven)
Oversight & Review
Contracting
Major Products
Logistics/ Sustainment
Defense Acquisition System (event-driven)
Technical
Cost
Planning, Programming, Budgeting & Execution Process (biennial-calendar-driven)
Initiate Evolutionary Acquisition Strategy
Evolutionary Acquisition Strategy
Post-CDR A
Increment 2
Increment 3
Total Life Cycle Systems Management
Appropriated Funds To Support Contracts
Congress
Budget Committees
Authorization Committees
Appropriation Committees
Authorization/ Appropriation Acts Passed
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Why Does the Navy Care about CSE?

Altitude Trends and Airline Schedules

Threats

IFF info;
Track number;
Warning response

Time Pressure,
High Risk, Uncertainty

What information is needed to decide?

USS Vincennes

Cognitive Demand

Understand the Operational Picture

Barriers/Gaps that impede Cognitive work

Unreliable Comms Equipment:

Operational Impact of Barrier/gap

- Security boat patrols distracted from tactical situation
- Information is dropped, distorted over multiple relays
- Threats may go undetected, or detected too late,
- Reaction time limited, hampering ability to manage threat

Information required to meet cognitive requirement and perform mission

Operators at each C2 node need an accurate, real-time operational picture that integrates information from both patrol boat and MOC perspectives.

Specific info needed for that accurate, integrated, real-time contact picture include:

a) **capabilities and status** of own patrol boats: fuel level, engine status, comms status, SCOF levels and contact response to SCOF

b) potential **threats**

c) **port schedule information** for ships coming in and out of port, including HVA schedules, Ship name, Cargo type, Flag, Last port of call, Next port of call, Movement updates, Whether ship is approved to enter port, Whether HVA pier has been vetted