



Supporting Threat Response Management in a Tactical Naval Environment

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Outline

- How do we design to support C2 work?
- Representational aiding
- Application: Threat Response Management on a HALIFAX Class frigate
- Method
- Rolling horizon planning framework
- Design seeds
- Conclusions

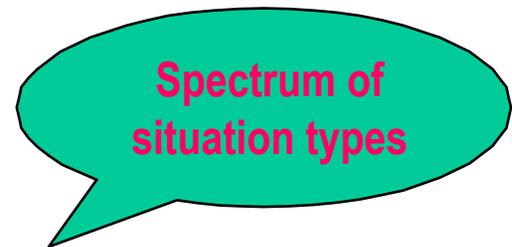


HALIFAX Class Frigate



How do we Design to Support C2 Work?

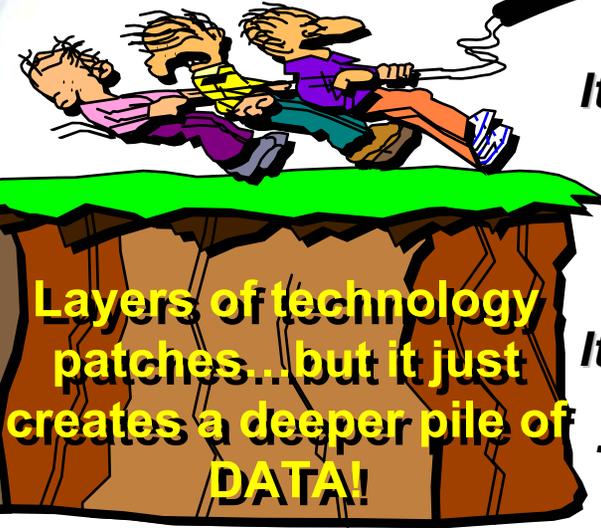
- Cognitive activity distributed across multiple, interacting actors
- Takes place in an **organizational context**, doctrine, SOPs
- Evolving **interconnected flow of activities**, varying phases and tempos
- Spectrum of situation types
- **New missions, new operational contexts** lead to evolving cognitive and collaborative demands and increasing complexities
- **Human expertise and capacity for adaptation vital for ensuring effective performance**
- **Few theoretical design frameworks exist**





A Cognitive Systems Engineering (CSE) Approach

Typical System Design



DATA SOURCES

It Requires...

... A new perspective

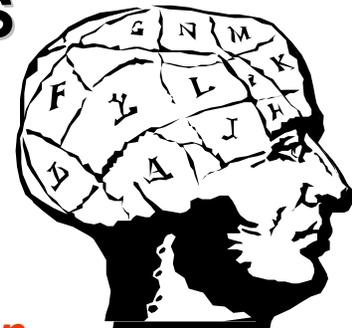
... A unique methodology

It Generates...

... A radically different solution!

... Designs to support **information extraction** INSTEAD OF **data availability**

INFORMATION NEEDS



CSE pulls from the work environment

“Information is a relation between data, the world the data refers to, and the operator’s expectations, intentions and interests” (Woods)



The CSE *Product*: What is a Representational Aid?

- Displays that allow operators to directly perceive the **information** they require
 - Gibson's work on direct perception
 - Zhang and Norman's work on problem solving

A speech bubble containing a 3x3 grid of numbers. Above the grid is the sequence '1,2,3,4,5,6,7,8,9' with a double horizontal line below it. The grid contains the following numbers:

2	9	4
7	5	3
6	1	8

Game of 15

- Make underlying work constraints and relationships visible via external representations
- Directly 'afford' information which would normally be hidden
- Replace mental manipulation with visual judgements
- Require less cognitive effort from the operator
- Provides external representations of the problem space that can be shared among a team of operators



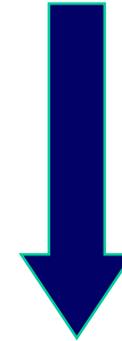
How are Representational Aids Different?

Complete automation

Computer produces solutions and selects between them

Automated aid

Computer produces solution(s) and operator accepts or selects between them



Representational aid

Computer processes data to make information “easy” for the operator to perceive

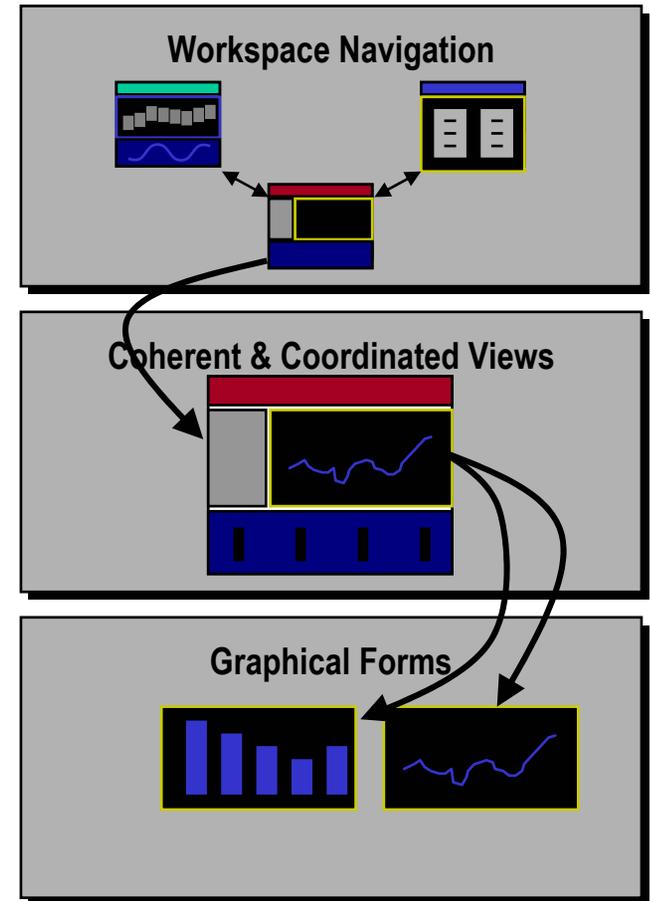
No support

Operator produces solutions from basic data

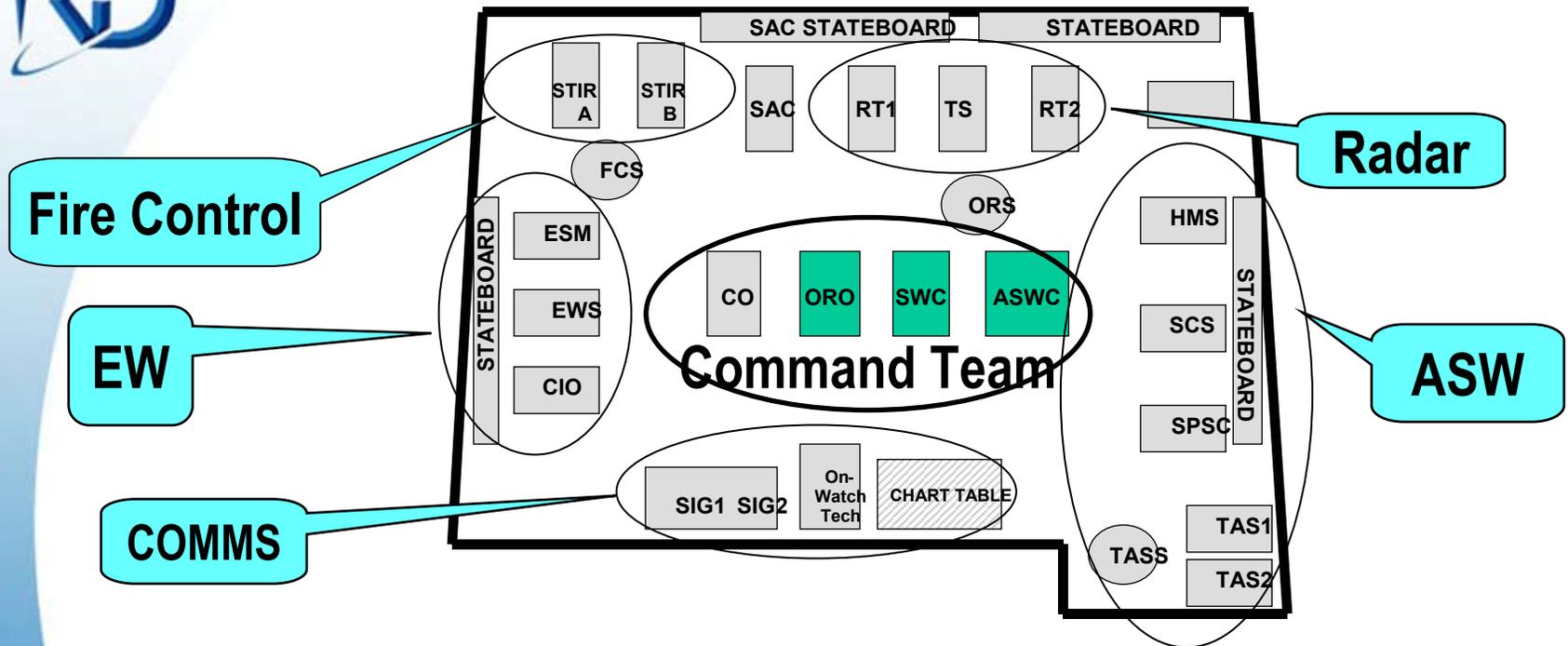
The CSE Process

- An opportunistic, dynamic evolution of multiple interacting activities to understand the cognitive and collaborative demands:
 - knowledge acquisition
 - work analysis
 - design concepts
 - implementation
 - evaluation and feedback
- Work analysis provides the domain understanding needed to **seed** design concepts
- Design seeds are **hypotheses** for support tools
- Multiple levels of analysis needed to fully develop effective design representations

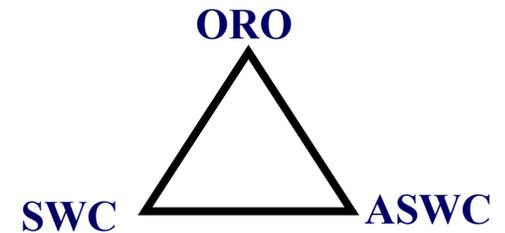
Designing work-centred information spaces



Threat Response Management



- Response Management: assess & prioritize threats; prepare & implement response plans; monitor plan implementation; assess action outcomes
- Ship's tactical coordinator is ORO – responsible for air, surface, subsurface areas
- ORO supported by 2 warfare directors
 - SWC: air & surface
 - ASWC: subsurface





Focus Area for Design: Plan Integration

- Doctrine in each warfare area tends to focus on rapid responses to individual threats
- Significant cognitive and collaborative demands on ORO to deal with dynamically changing interconnections within and across warfare areas: ORO, SWC, ASWC
- ORO must continually develop his own plan, at the same time as he assesses and integrates the plan recommendations of his directors
- ORO has a broader focus on the mission, warfare areas, and overall ship operations



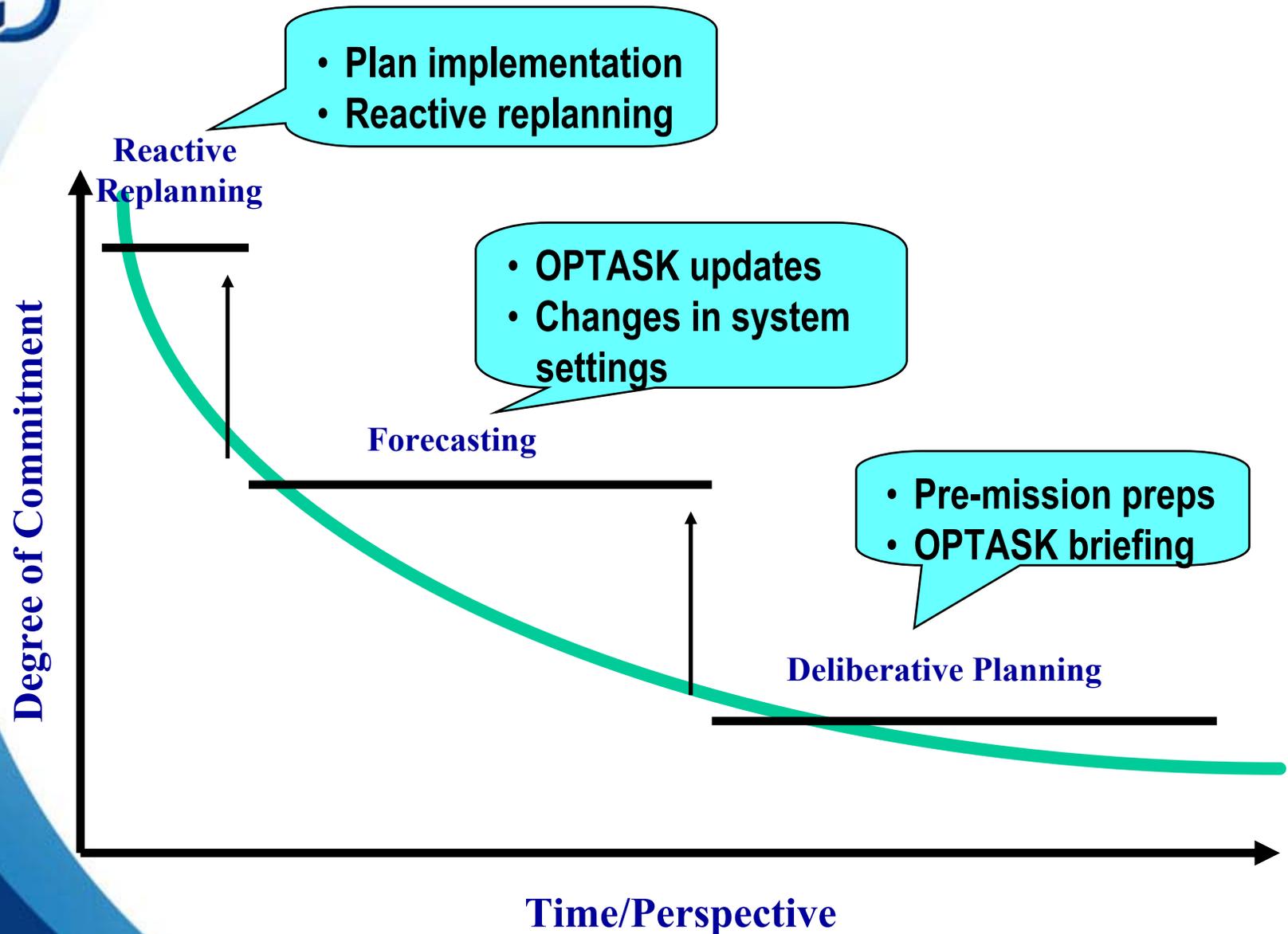


Method

- Identification of cognitively-based planning models (NDM literature)
- Knowledge acquisition (tactical doctrine, SMEs)
- Development of a littoral scenario involving multiple and concurrent air, surface and subsurface threats
- Identification of cognitive demands and decision reqmts in 6 areas:
 - Situation Awareness; Plan Generation; Plan Assessment & Validation; Plan Integration; Impact Assessment; Plan Monitoring
- Generation of design seeds (Representation Aids) to support ORO's plan integration
- Developed snapshots for a storyboard of the various seeds
- SME review



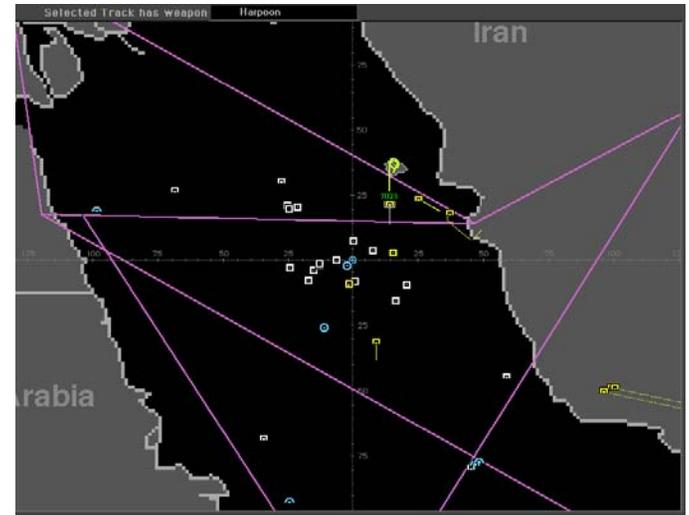
Rolling Horizon Planning Framework





Design Seed: Integrated Threat Picture

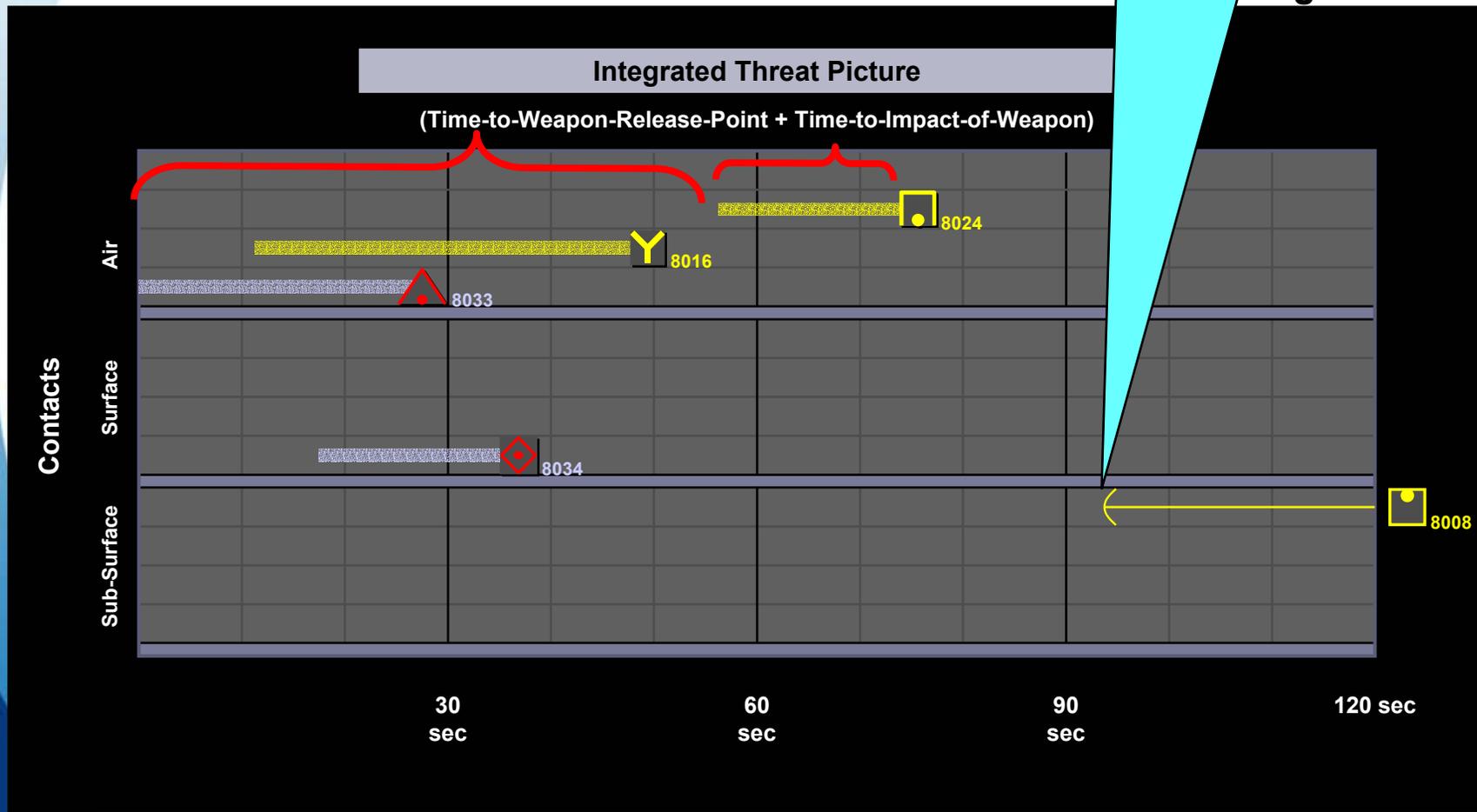
- Need a representation to integrate air, surface, and subsurface threats
 - Need to support both individual and integrated threat issues
- Standard tactical display is geo-spatial
- However, time is an increasingly important variable in the decision making
 - Time-to-decide
 - Attention sharing and focusing
 - * *What to deal with next?*
 - * *How to divide attention?*
 - Threat prioritization





Design Seed: Integrated Threat Picture (cont'd)

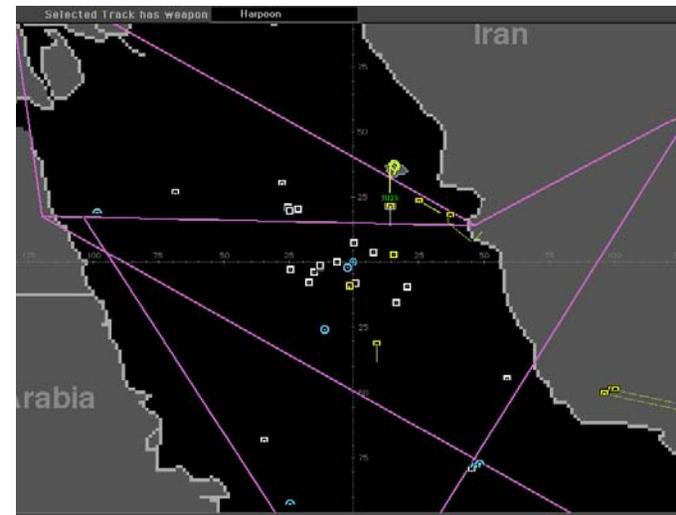
- Localization of sub wrt Furthest on Circle
- Time to target



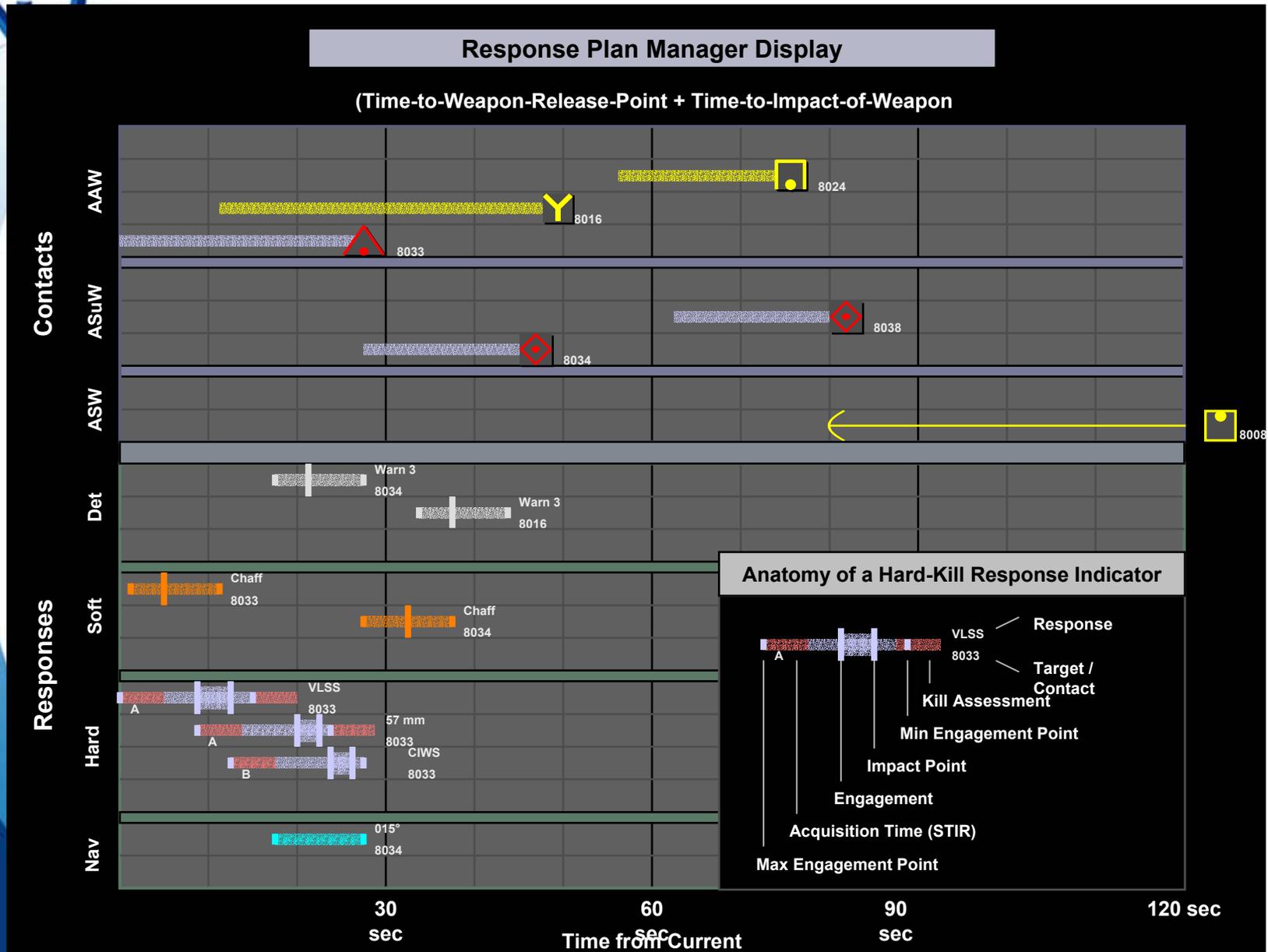


Design Seed: Response Plan Manager

- Geo-spatial tactical displays provide critical info for developing plans
 - Routing, disposition, mine-fields, air corridors, height/depth profiles
- However, time is not explicitly represented
 - Is some resource not only in the right place, but there at the right time?
 - Plans can be proposed with timelines that cannot be maintained
 - ORO needs to be able to visualize plans involving actions that have temporal extent
- Response plans need to be developed and tested in context of geo-spatial representations and integrated threat picture
- Representation should be consistent with Rolling Horizon Planning Framework and support interactions with directors concerning proposed partial plans or tentative plans



Design Seed: Response Plan Manager (cont'd)





Conclusions

- Three integrated design concepts generated to date
- Developed a tactical scenario and storyboard snapshots of the concepts and done a walkthrough with SMEs
 - Very favourable response from SMEs
 - However, concepts need fuller evaluation
- A work-centred CSE approach to design involves an initial (and ongoing) investment of resources to understand the work domain
 - However, “*Where you start often determines where you finish*”
 - Have to trade off the cost of a more directed search strategy against the risk of failure in the absence of domain understanding
- Future work needed to look at
 - Expanding problem space
 - Increase usefulness of design concepts
 - Instantiate and evaluate design concepts

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