

A Hybrid Approach to Cognitive Engineering: Supporting Development of Revolutionary Warfighter-Centered Command and Control Systems

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Continuum of Change

Minor Change

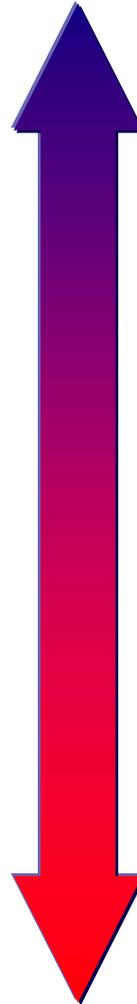
C2 structure left intact
C2 systems slightly altered
New user front-end

Evolutionary Change

C2 structure left intact
C2 systems redesigned
New user front-end
Changes to back-end

Revolutionary Change

C2 structure redesigned
C2 systems redesigned
New user front-end
New back-end
New work structure



Minor Change

Many cognitive
systems engineering
methods available

Evolutionary Change

Some cognitive
systems engineering
methods available

Revolutionary Change

Very few cognitive
systems engineering
methods available



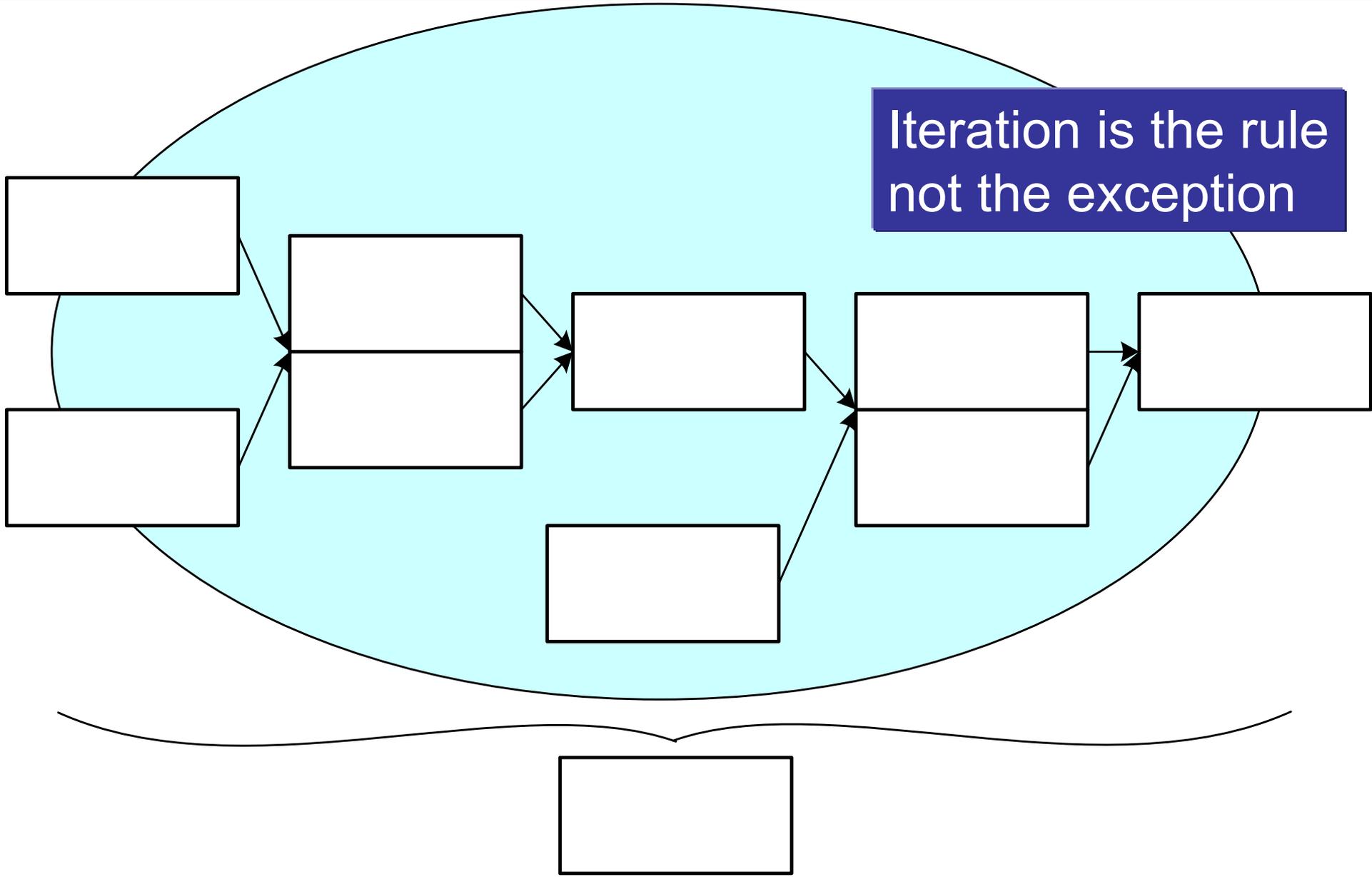
Effects-based Decision Analysis Methodology (EDAM)

- Designed for revolutionary change
- Based on cognitive engineering methodologies
 - Scenario Based Design
 - Cognitive Work Analysis
 - Situation Awareness Analysis
 - Cognitive Task Analysis
 - Team Cognitive Task Analysis
 - Use Cases
 - Storyboarding

Multiple methods to meet complete system design

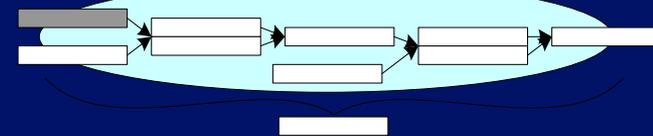


Effects-based Decision Analysis Methodology (EDAM)

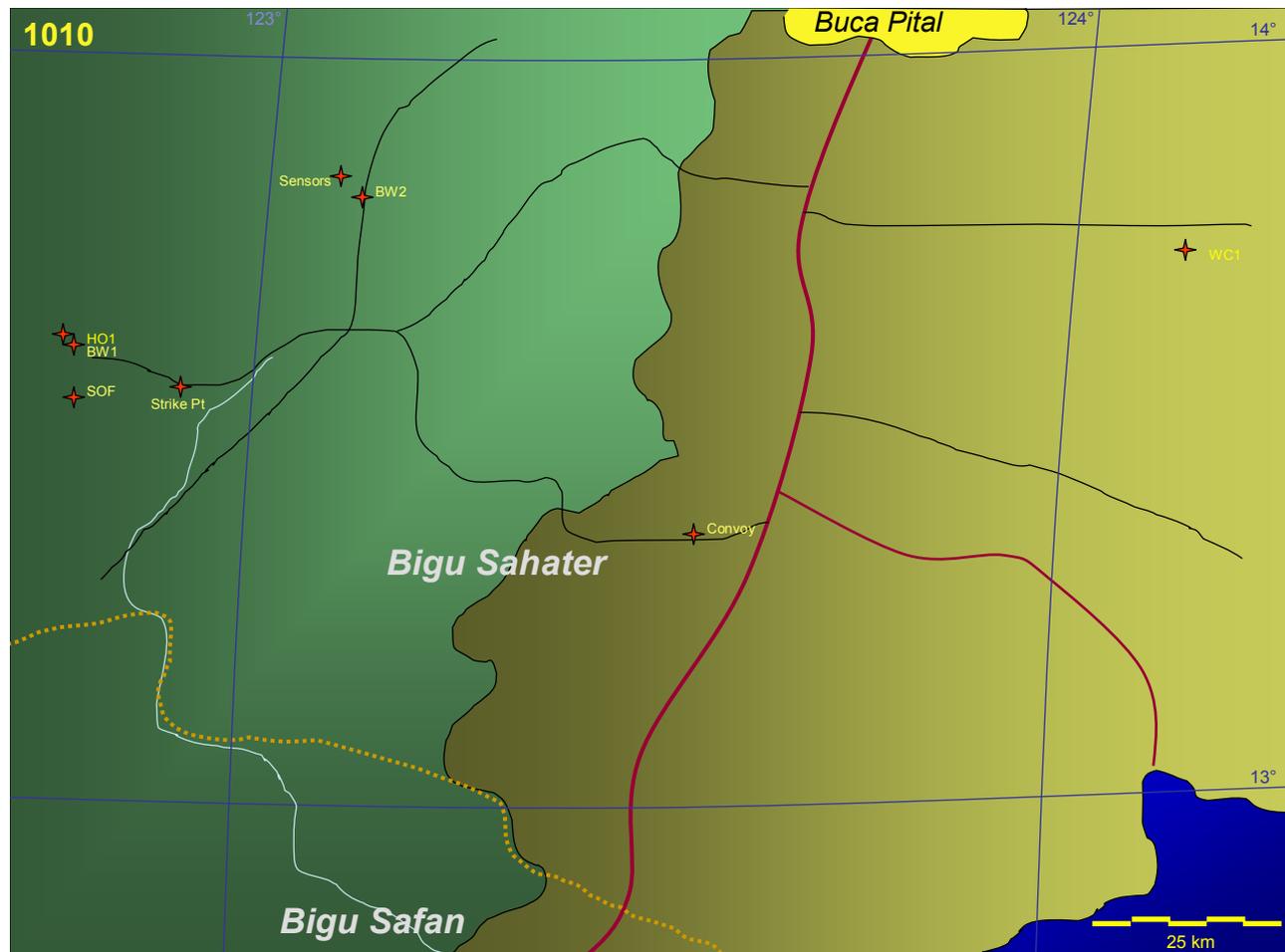




Scenario Design

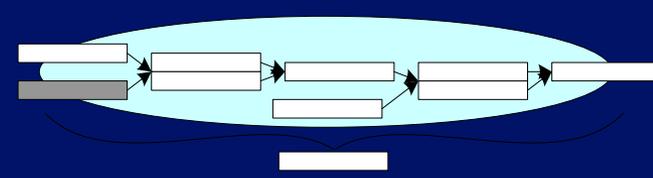


- Provide context
- Textual and/or graphical
- Used for structure throughout EDAM from knowledge elicitation through human performance evaluations





Work Domain Analysis

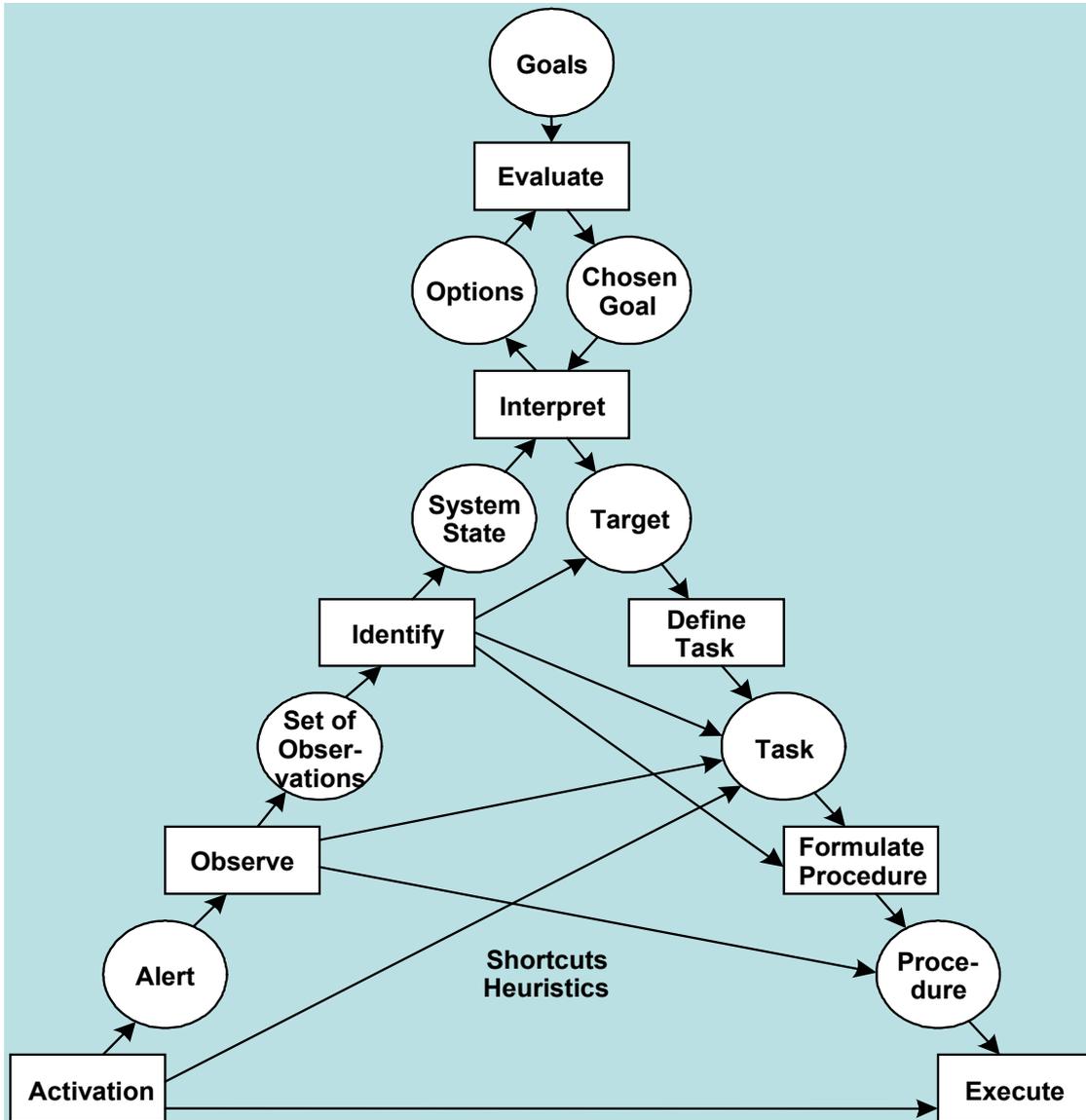
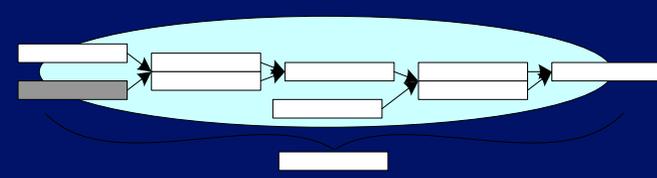


- Defines a work domain's goals and constraints
- Often portrayed by a combined abstraction hierarchy and system decomposition
- Updated and refined throughout EDAM to reflect current design and ensure that design concepts meet the high-level goals

	Whole System	Subsystem A	Subsystem B
Functional Purpose/Goal			
Abstract Function			
Generalized Function			
Physical Function			
Physical Form			



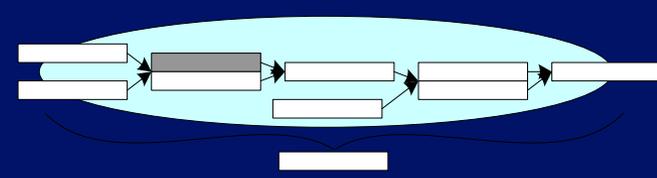
Control Task Analysis



- Describes means of controlling or interacting with work domain
- Independent of agent (human or machine)
- Can be used to aid in the completion of a function/task allocation matrix



Decision Knowledge Elicitation



Goals

What are your specific goals at this time?
How do you prioritize these goals? Are there conflicts?
How does the outcome of a particular goal influence the success of your prioritization/reprioritization of the other goals?

Decisions

In this event in the scenario, what are the key decisions you are making?

Information Requirements

In this situation, how would you go about making the required decisions, what would cue you?
What information would you seek?
Can you get this information? Is it currently available?
Who would interact with you?
What ambiguities would you try to resolve?

Errors

What type of errors are likely at this point? In this decision?
What makes this difficult?

Situation Awareness – ability to respond

How do you maintain SA, what are you looking for, where does it come from?

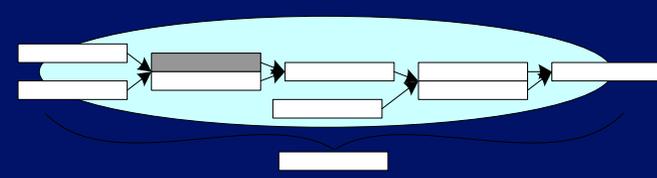
Response

What is the effect of the decision? To whom are you providing information and action cues?
Who needs to know your decisions, information generated?

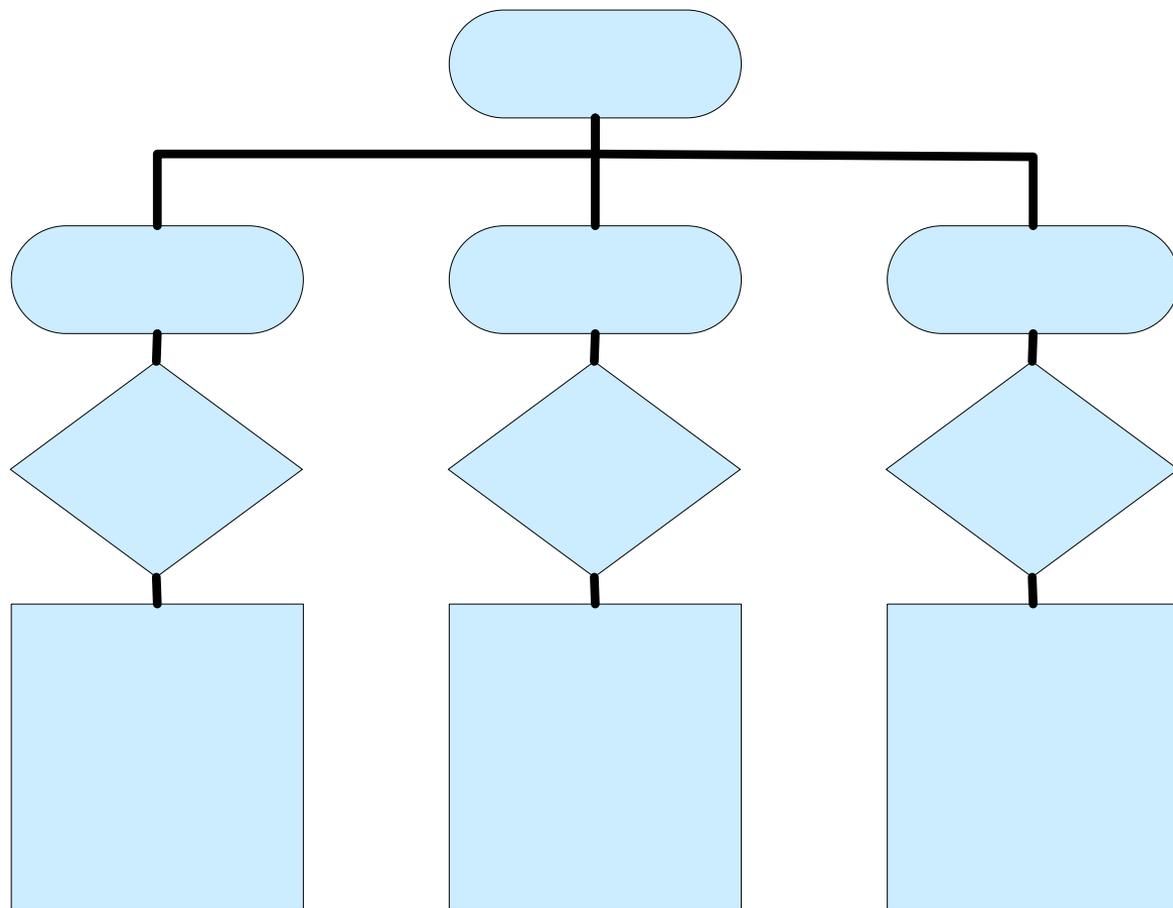
- Structured by scenarios
- Focused on goals and decisions as opposed to current methods or systems
- Interviews with Subject Matter Experts, in groups and individually



Decision Knowledge Elicitation



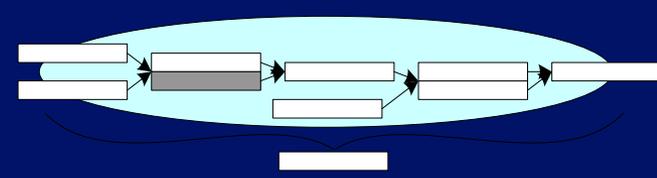
- Goal Directed Task Analysis
- Decomposes to increasing levels of detail



Derives requirements for decision support system design

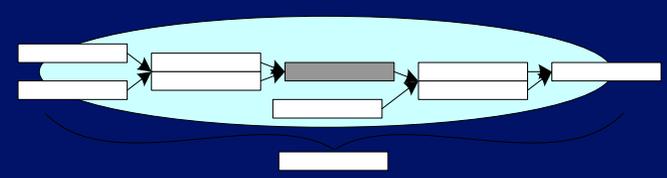


Work Environment Knowledge Elicitation



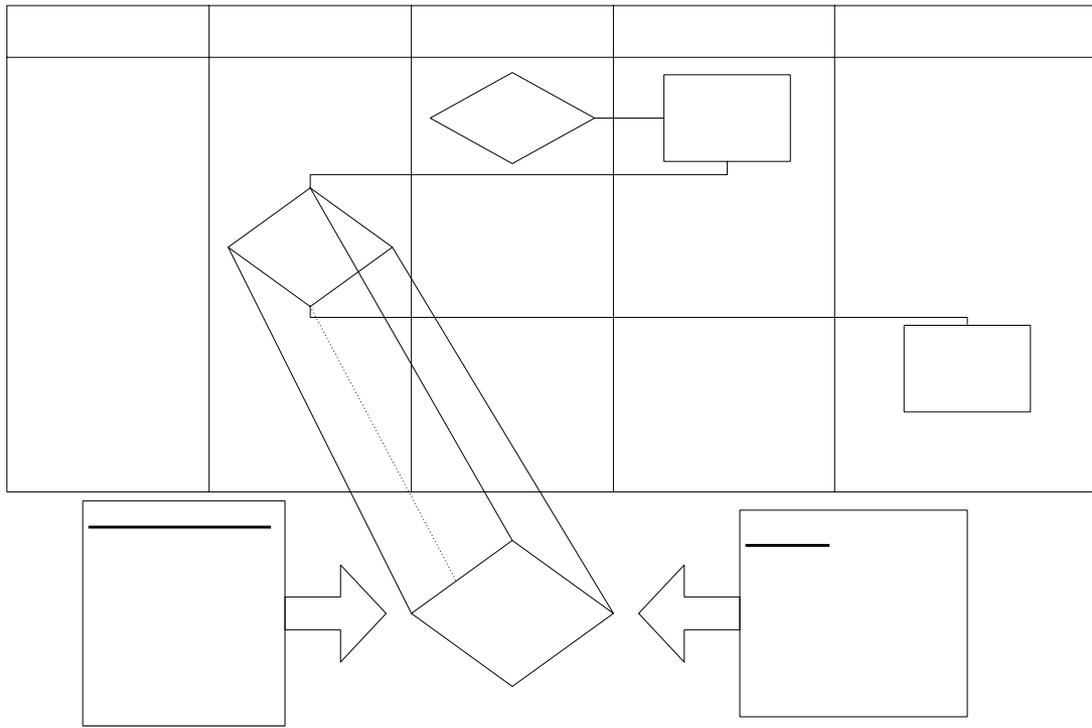
- Field observations and ethnographic studies of C2 operations, exercises, and/or training
- Focus on work in context – environment, layout of physical space, equipment, formal and informal social organization, communication
- Possible steps to follow for timeliness:
 - Review doctrine prior to exercise or observation
 - Observe work in actual work environment
 - Conduct post-observation interviews with observed subjects

Derives requirements for complete system design



Knowledge Organization and Representation

Activity Diagram



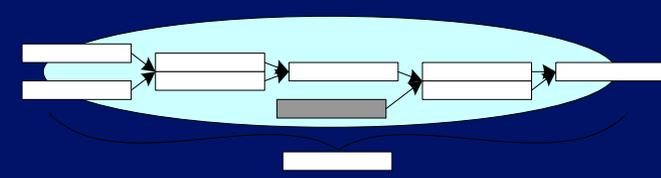
	Function 1	Function 2	Function 3
Human 1	X		X	
Human 2		X		
Agent 1			X	X
Agent 2			X	
.....				

Function Allocation Matrix

Abstracts knowledge gained in field observations



Technology Trade-Off Study

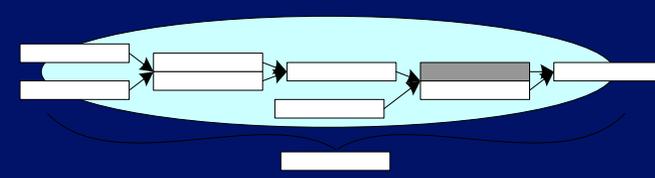


- Led by software/hardware development team
 - Consider future and near-future technologies
- Input from EDAM team
 - human roles
 - human factors
 - usability
 - supportability

Selecting the optimal technology (cost/performance trade) to support decision making



Decision Support Systems Design Concept

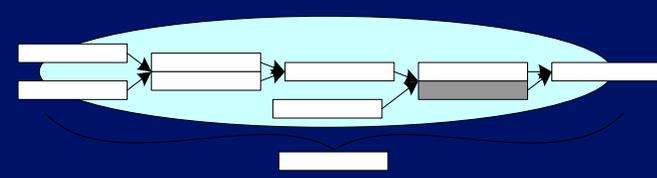


- Use Cases in UML
 - Operational aspects of the design
 - what the system does
 - how the human interacts with the system
- Storyboards and Paper Prototypes
 - Graphical User Interface concepts
 - information architecture
 - interactions
 - navigation
 - graphics

Easing the transition to software developers



System Design Concept

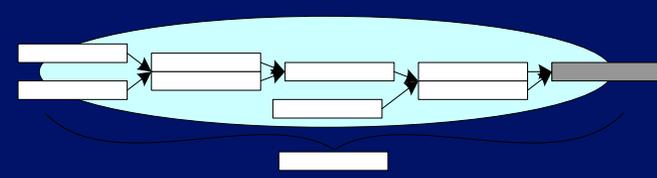


- Concurrent with decision support system design
- Complete system design
 - physical work environment
 - organizational structure
 - policies and procedures
 - software/hardware
- Supported by workload modeling and simulation

Supports all aspects of decision making



Prototype

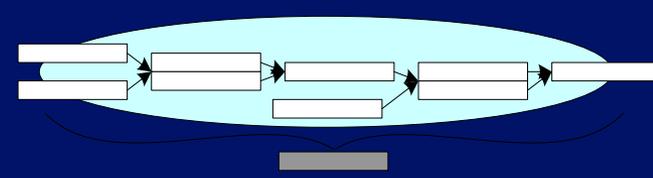


- Levels of prototyping
 - Storyboards and requirements animation (EDAM team)
 - Rapid, incremental, and evolutionary (S/HD team)
- Uses
 - Translate requirements from EDAM to SD team
 - Human performance assessments
 - cognitive walkthroughs
 - usability testing

Enables iterative evaluate/testing of system design



Human Performance Assessment



- Performed frequently throughout EDAM
 - Identify early as part of requirements analysis, validate metrics using prototypes and modeling & simulation
 - sparse scenarios to detailed paper prototypes to software development prototypes
- Metrics developed as appropriate to the system
 - successful and timely completion of tasks
 - time spent on errors, number of errors
 - number of actions used to complete task
 - number of regressive behaviors
 - subjective user evaluations

Provides technical performance measures for the human element of the system



Conclusion

Minor Change

*C2 Structure intact and Systems Altered
New user front-end
Many Cognitive Engineering Methods*

**Evolutionary
Change**

*C2 Structure intact and Systems Redesigned
New user front-end
Changes to back-end
Some Cognitive Engineering Methods*

**Revolutionary
Change**

*C2 Structure and System Redesigned
New user front-end
New back-end
New work structure
Very few Cognitive Engineering Methods*



EDAM address the human element in C2 design
and fills the gap in revolutionary change



QUESTIONS?



Decision Knowledge Elicitation

Probe	Things to consider asking if SME is having hard time identify decisions/information requirements
Goals	
what were your specific goals at the time?	does this scenario fit a standard or typical scenario?
How did you prioritize these goals? Are there conflicts?	
how does the outcome of a particular goal influence the success of or your prioritization/re-prioritization of other goals?	
decisions	
in this event in the scenario what are the key decisions you are making?	did this scenario remind you of any previous case or experience?
	what decisions <i>would</i> you actually make?
	what would cause you to make a decision at the time it was made
	what decisions would be considered but deferred/why?
	would any decisions be made in collaboration with other staff?
	would any decisions made require review and approval
information requirements	
in this situation how would you go about making the required decision, what would cue you,	how do you communicate with external teams (i.e. SOF), particularly in Event 3?
what information would you seek,	how do you combine information to aid in decision making?
can you get this information? Is it available?	
who would you interact with,	
what ambiguities would you try to resolve?	
errors	
what type of errors are likely at this point? In this decision?	
what makes this difficult?	
situation awareness - ability to respond	
how do you maintain SA, what are you looking for, where does it come from	who are you talking to, what displays/systems do you use?
response	
what the effect of the decision, who are your providing information, what are the action cues to respond	
who needs to know your decisions, information generated	