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COGNITIVE CONSTRUCTS AND THE SENSEMAKING PROCESS

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Presentation Outline

1. INTRODUCTION
2. HOW COGNITIVE CONSTRUCTS EVOLVE FROM SENSEMAKING
3. REVIEW OF EXISING COGNITIVELY-ENABLED CONSTRUCTS
4. THE PAYE MODEL
5. SUMMARY & CONCLUSIONS

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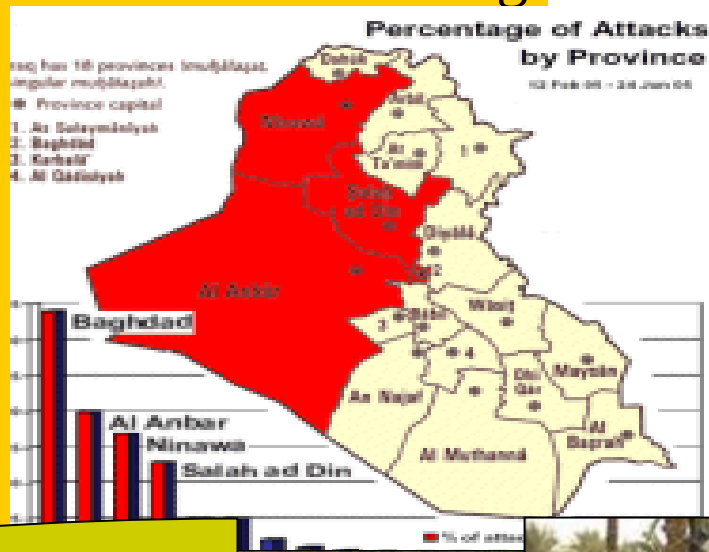
Why Sensemaking ? Situation Understanding

Iraqi Problems

- Insurgency
- Terrorism
- Civil Unrest
- Ethnic Rivalry
- Weapon of Mass Destruction
- Despotic Leadership



Solution Approach

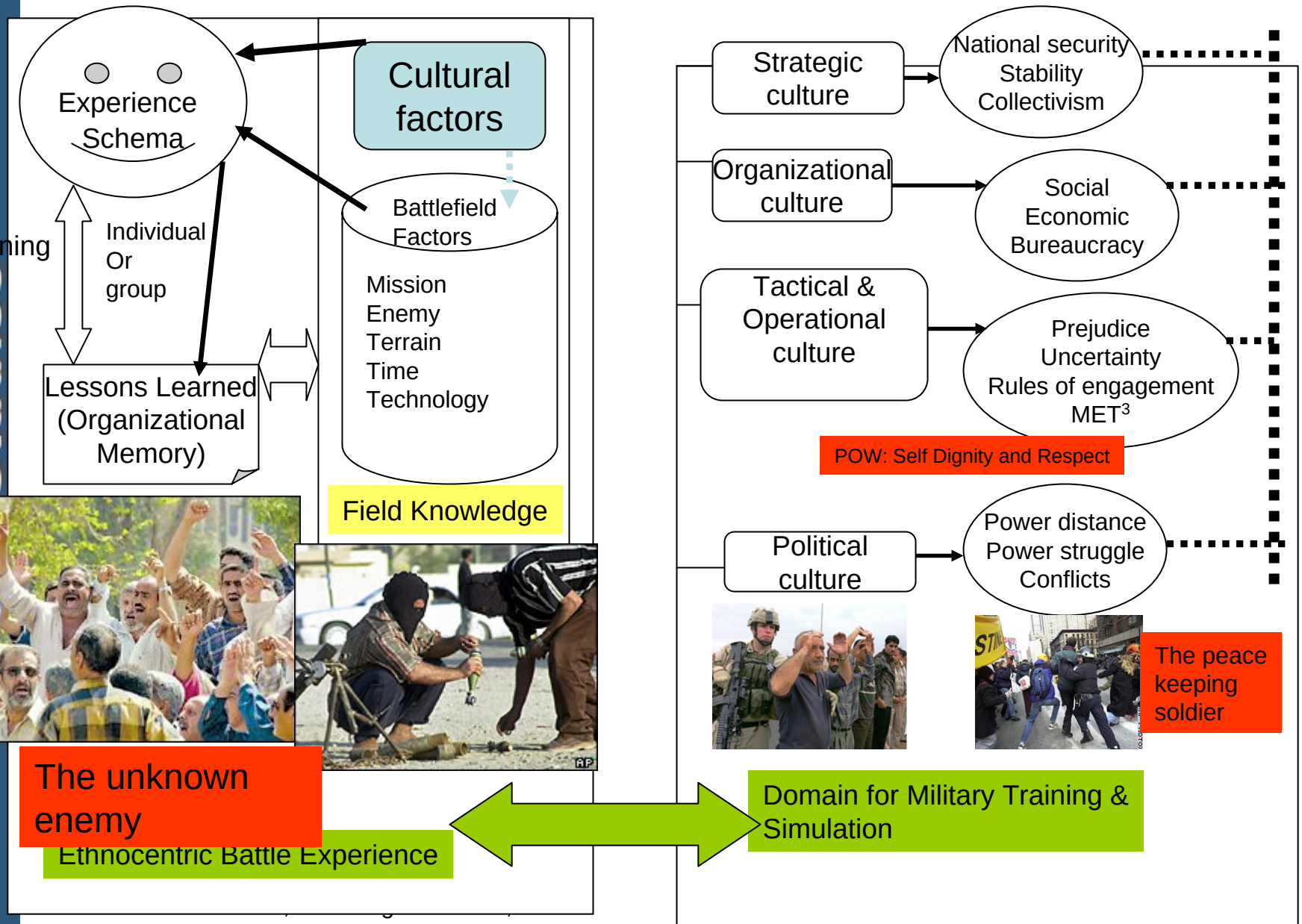
- Political
- Economic
- Military
- Social
- Information
- Infrastructure

Adversary Characteristics

Dynamic, Uncertain, Chaos, Complex, Novel, Ambiguous, Asymmetric

Enemy Or Friend?

Why Sensemaking ?
Dealing with Novel Situations



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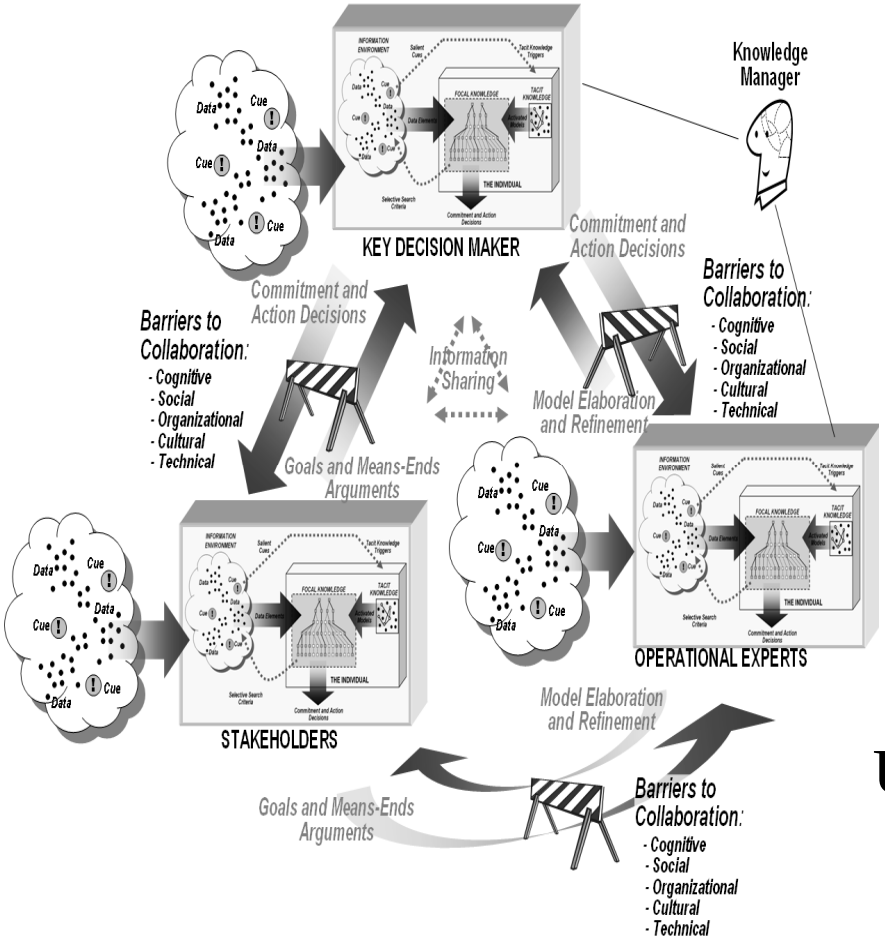
Why Sensemaking ? Information Equivocality—Multiple Meanings and Interpretations



Iraq

Cowardice

Peace Symbol

USA

We want peace

Why Sensemaking ?
Interpreting Commander's Intent

WHAT IS SENSEMAKING ?

Sensemaking: A process, design, or techniques of fusing information in context to derive understanding.

Making Sense: The art or science of making meaning
and/ or interpreting information in context for decision making.

Some Sensemaking Definitions

1. HOW MEANING IS CONSTRUCTED AT BOTH THE INDIVIDUAL & THE GROUP LEVELS – (Weick, 1995).

2. A SYSTEM OF ACTIONS, SYMBOLS AND PROCESSES THAT ENABLES AN ORGANIZATION TO TRANSFORM INFORMATION INTO VALUED KNOWLEDGE WHICH INTURN INCREASES ITS LONG-RUN ADAPTIVE CAPACITY – (Schandt, 1997; pp. 8)

Some Sensemaking Definitions

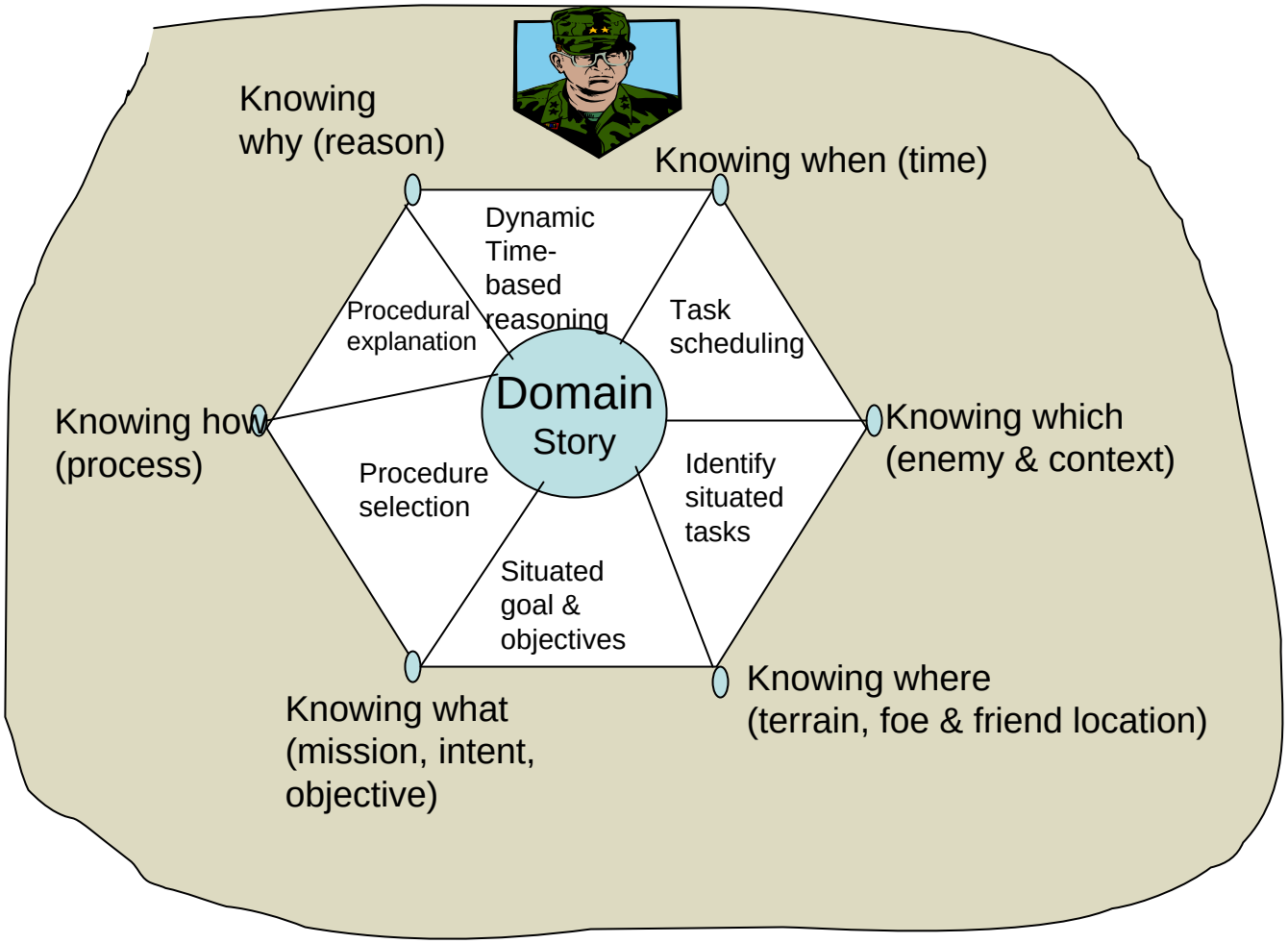
3. A THEORY AND A PROCESS OF HOW PEOPLE REDUCE UNCERTAINTY OR AMBIGUITY; SOCIALLY NEGOTIATE MEANING DURING DECISION MAKING ----(Weick, 1985)

4. ARTICULATING AND POSSIBLY CONTESTING THE MEANING AND SIGNIFICANCE OF AN ARTIFACT OR IDEA –(S.B. Shum & A. M. Selvin, In Distributive Collective Practices 2000: www.limsi.fr/WkG/PCD2000)

Some Sensemaking Definitions

5. COLLECTING “DOTS” and BRIDGING MEANING TO HUGE VOLUME OF DATA--- INQ-Tel (Arlington-based company).

6. DERIVING MEANING FROM FRAGMENTARY CUES–
(DARPA’S Information Awareness Project).



Our Sensemaking Inquiry System Research Architecture

How Cognitive Constructs Evolve: The Chronology Of Events, Time, Process, and Mental Maps

PAST

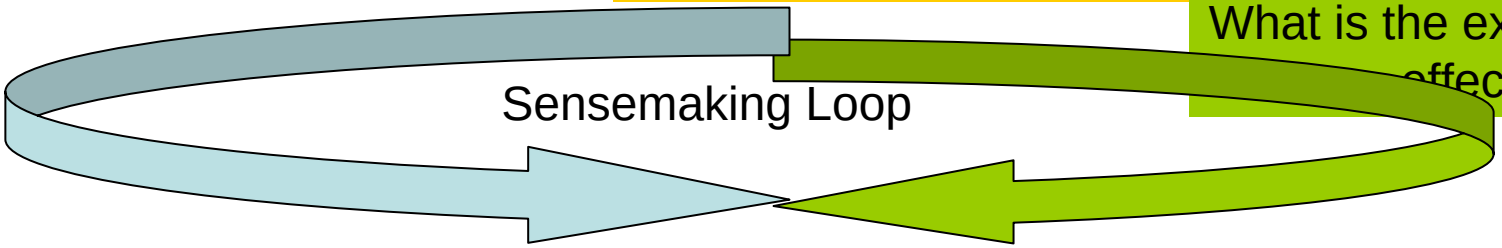
What happened?
When did it happen?
Where did it happen?
How did it happen?
What event, activity?
What and why the trigger?
What was the effect?
And so on

PRESENT

What is the current situation?
Who is involved?
What are the options?
How are things changing?
Why are things changing?
Where do the available information useful?
What is the effect?

FUTURE

What will happen next?
Where will it happen?
When should I act?
Why should I act?
What changes are expected?
What are the consequences?
What is the expected effect?



BLOOM'S COGNITIVE TAXONOMY / SCHEMA STRUCTURES

Bloom's Cognitive Schema (tasks)	Basic Skills / Human Performance	Intermediate Skills/ Human Performance	Expert Skills/ Human performance
Cognitive Readiness: **•Conceptual level** **•Knowledge of specifics** **•Knowledge of universal abstractions such as standards and terminology**	**General attention, memory, & central processing , fine motor control such as using computer mouse: speeds and errors**	**Conceptual reasoning, divided attention, auditory & visual processing: speeds, errors, etc.**	**Respond inhibitions , sustained attention, visuospatial classification and sequencing, visual tracking: errors, error rate, speed, etc.**

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	Basic Skills /	Intermediate Skills/	Expert Skills/
Bloom's Cognitive Schema (tasks)	Human Performance	Human Performance	Human performance
Comprehension of environment: **•Translation of command & control (C2) intent** **•Interpretation of C2 goals** **•Extrapolation of C2 goals during uncertainty and novel situations**	**Organizational level language learning, auditory and visual processing, working memory: speed, time, errors, etc.**	**Dual task paradigms, divided attention: error rate, number of errors, speed.**	**Advanced language for human-computer interface, use of special codes for security protection: number of violations, errors, error rate, etc.**

	Basic Skills /	Intermediate Skills/	Expert Skills/
Bloom's Cognitive Schema (tasks)	Human Performance	Human Performance	Human performance
Sensemaking of Battle Information: **•Discovering relationships between distributed C2 levels.** **•Recognizing enemy messages from friendly.** **•Emerging organizational principles into virtual C2**	**Similarity matching based on information features: errors, speed, accuracy, etc.**	**Pattern recognition based on information objects, maps, link analysis, and other forms of spatial representations: errors, speed, accuracy, duration, etc.**	**Random search and stochastic pattern matching based on evolving situations: speed, error rate, accuracy, synchronization of actions, etc.**

	Basic Skills /	Intermediate Skills/	Expert Skills/
Bloom's Cognitive Schema (tasks)	Human Performance	Human Performance	Human performance
Information Fusion (Synthesis): **•Production of a unique battle plan** **•Production of resilient communication across all spectrum of friendly network**	**Using information to develop deliberate plan structure, understanding basic battle process: errors, accuracy, etc.**	**Fusion of various information patterns, choice of automation aids to facilitate communicatio n modalities: degree of fit, errors, accuracy, speed, etc.**	**Coalition information fusion, non-deterministi c evolving plans based on novel incidents, ability to override automation aids: speed, response inhibition, working memory, etc.**

COGNITIVELY – ENABLED CONSTRUCTS

COGNITIVE MAPS

- Mental models of the relative locations and attributes of phenomena in spatial environments (Downs and Stea, 1973).
- Internal representation of experienced world, including cognitive tasks and use of information (Gibson, 2001).
- Anticipatory schema for search, sampling and interpretation of information based on experience (Neisser, 1967).
- Clusters of knowledge landmarks and routes that form minimaps (Sternberg, 1999).
- All elements of physical space with cognitive counterparts (Huff, 1992).
- A spatial mental model (Eden, 1988).

Gun fire reported

Just after Friday prayer at Najaf

Insurgents inside the Mosque

Insurgents at the roof top of the Mosque

Insurgents embedded in the crowd

Attention to draw Coalition forces

Coalition force engaged with insurgents

Most likely Based on history

Civilians are combatants

Deception, there is a plan to attack

An ongoing operation

Ignore

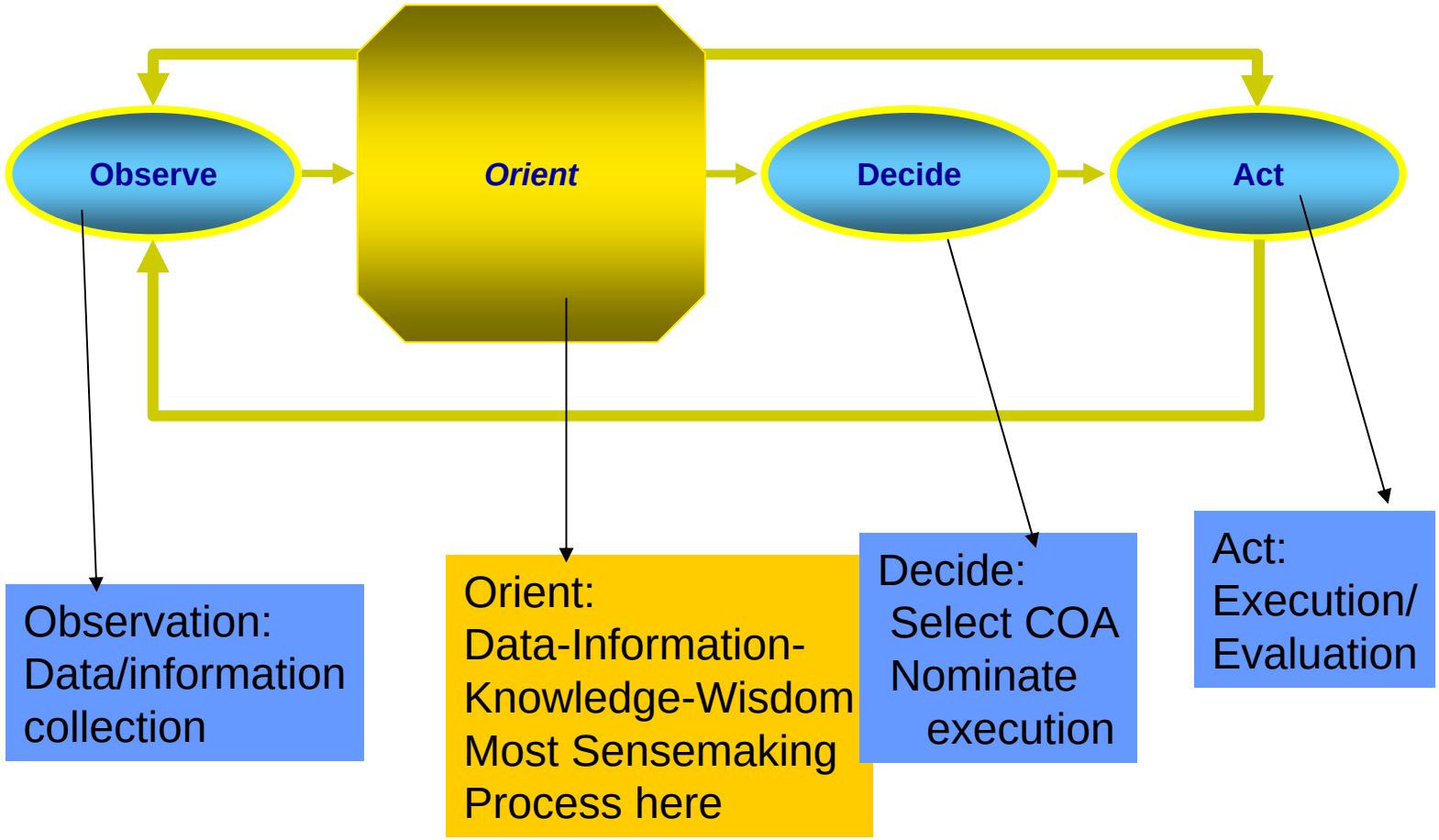
Respond

Ignore/ Talk to Emir

Ignore

Respond

OODA MODEL (BOYD, 1987)



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Dynamic Model of Situated Cognition (Shattuck/ Miller , 2004)

Sensemaking is viewed as a sequence of situated acts.

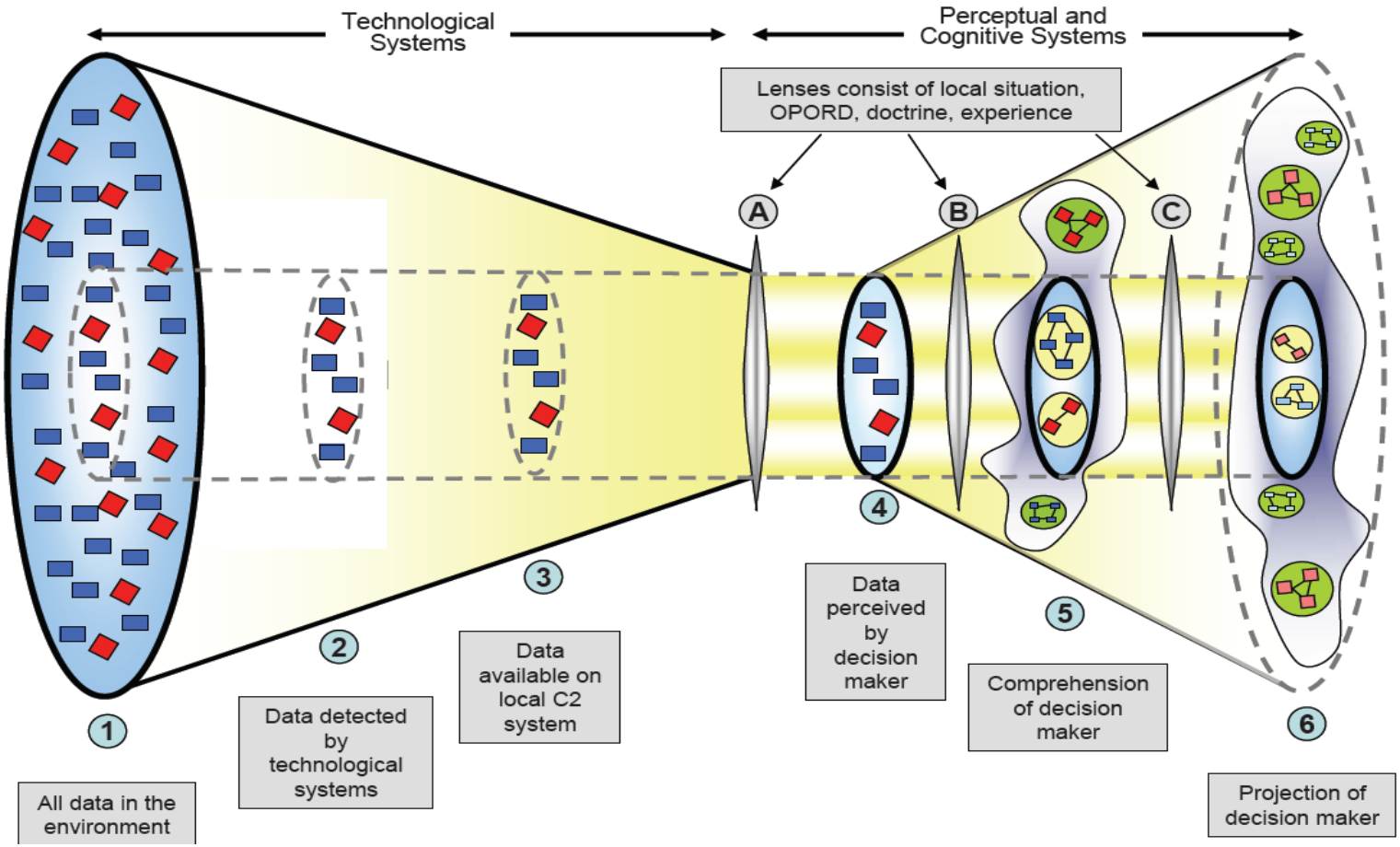
Situatedness: "Where you are, when you do, what you do matters" (Suchman , 1987; Clancey, 1997).

Situation chages-→ Require adaptive constructive memory (Dietrich & Markman, 2000).

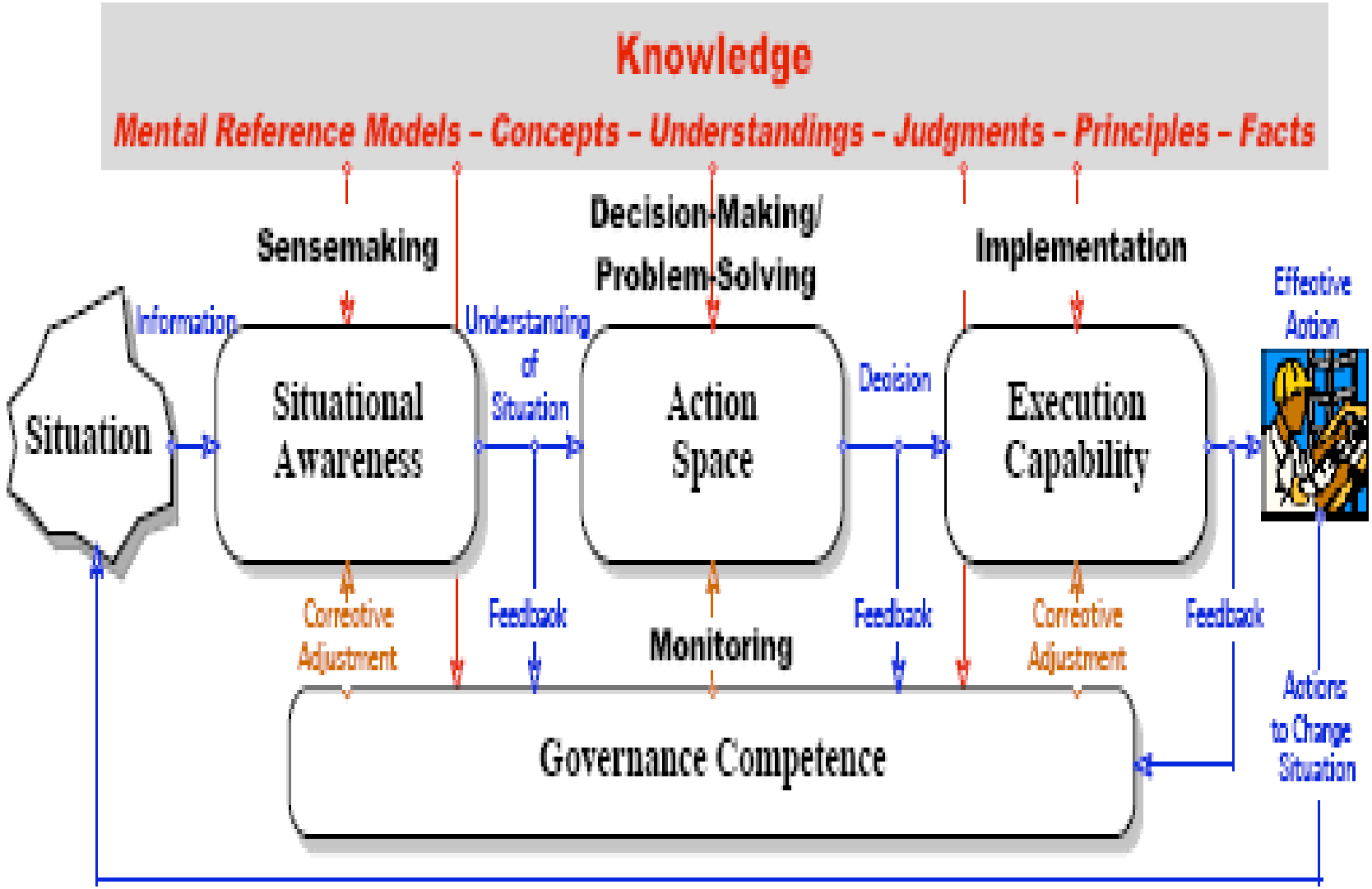
Dynamic Model of Situated Cognition (DMSC):

* Data flow (environment, sensors, etc)
* The human builds cognitive codes to cope with new
* Situation and context—co-exist and evolve

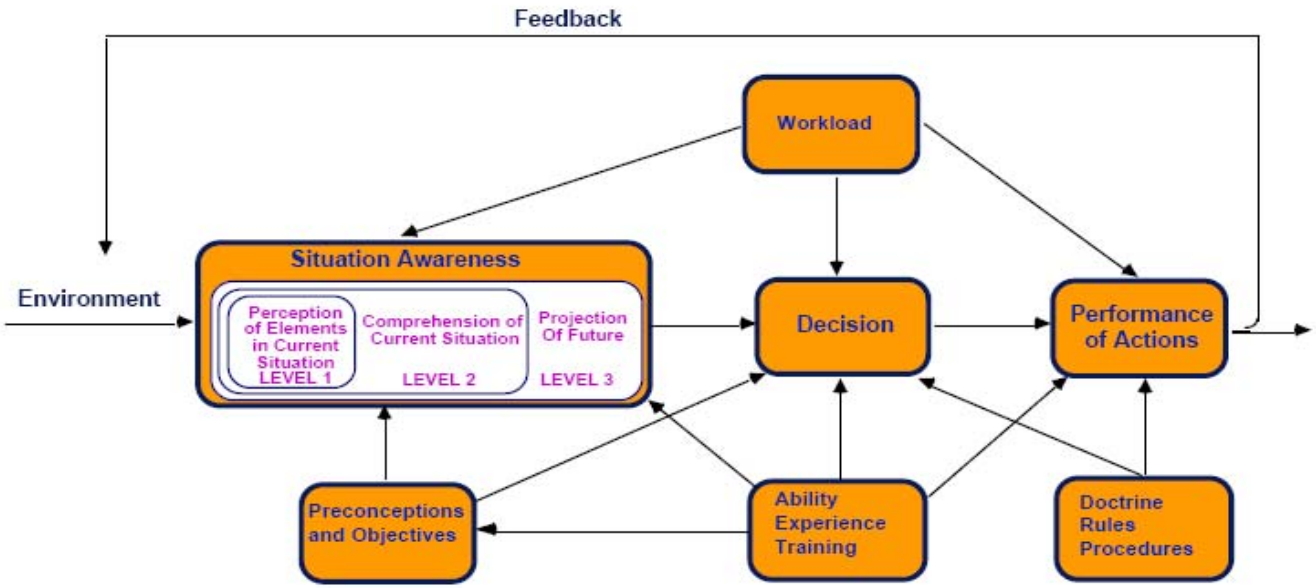
A Dynamic Model of Situated Cognition



Situation handling Model (Wiig, 2002)



Situation Awareness, Endsley, 1995)



Situation Awareness is the Perception of the Elements in the Environment within a Volume of Time and Space, the Comprehension of their Meaning, and the Projection of their Status in the Near Future. (Endsley, 1988)

SA technologies, Inc

Situation Awareness, Endsley, 1995)

Levels of SA	Knowledge Elements	Cognitive structures for information processing (Ntuen, 2004)
Level 1 SA	Perception of the status, attributes, and dynamics of the individual task-relevant elements in the environment	Perceptual-control or operational cognition—self-reverenced operation, corrective feedback is mediated by internal mechanisms responsible for perception.

Situation Awareness, Endsley, 1995)

Levels of SA	Knowledge Elements	Cognitive structures for information processing (Ntuen, 2004)
Level 2 SA	Holistic comprehension of the current situation, based on a synthesis and understanding of these elements in light of one's goals	Quasi-cognitive control of information transformation processes. Examples of military doctrines—a collection of behavioral and analytical rule-based models. Human sensemaking behavior vary in switching between modalities of mental models and information in context.

OODA MODEL (BOYD, 1987)

Levels of SA	Knowledge Elements	Cognitive structures for information processing (Ntuen, 2004)
Level 3 SA	Projection of the future actions in the environment, at least in the very near term	High-level cognitive control or meta-cognition. Knowledge-based projection of sensemaking activities into the future—"what if", "what next" situations. Time-invariant controlled by the human mind (Polyani, 1967)

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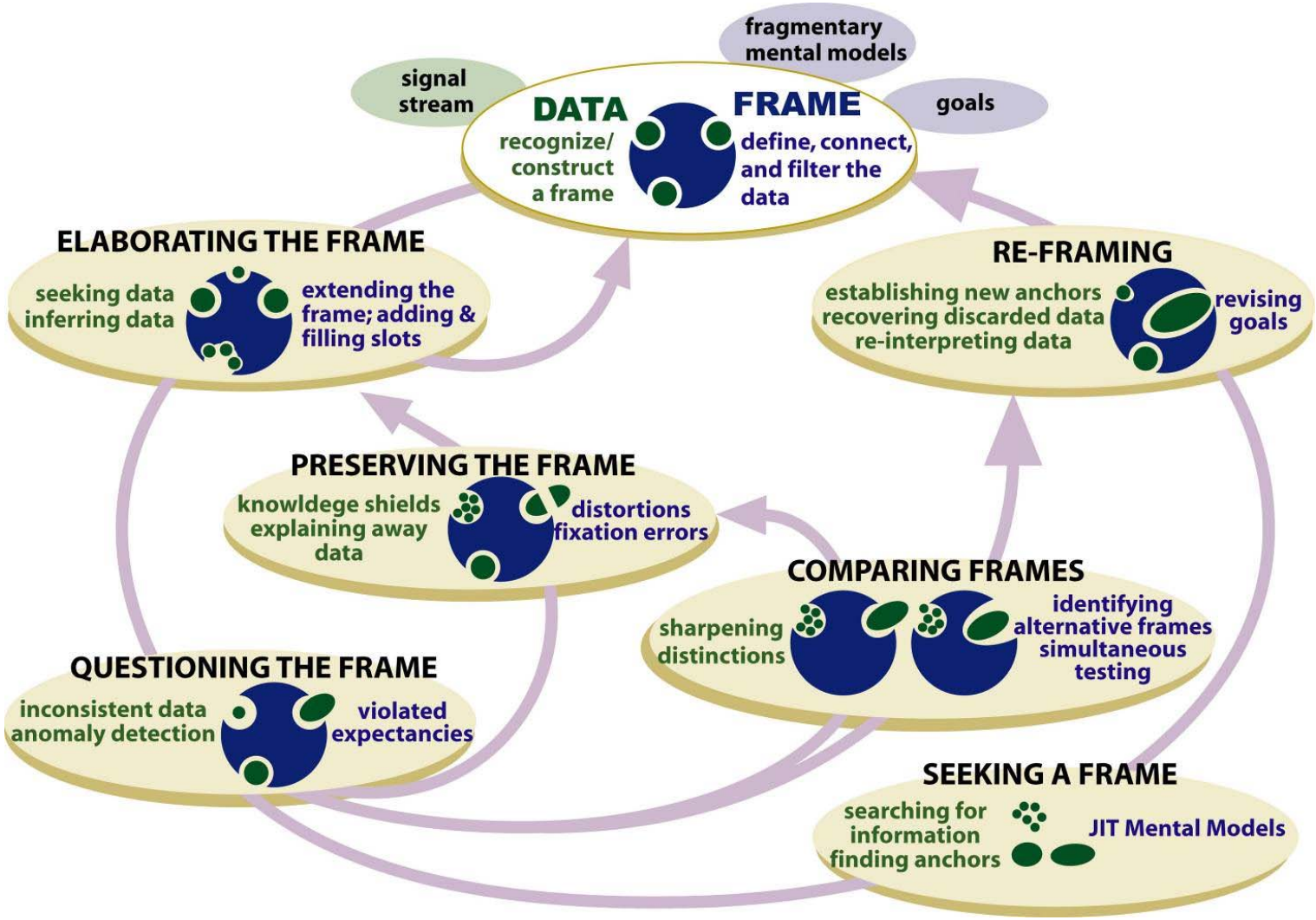
Data / Frame Model, Sieck, et al., 2004)



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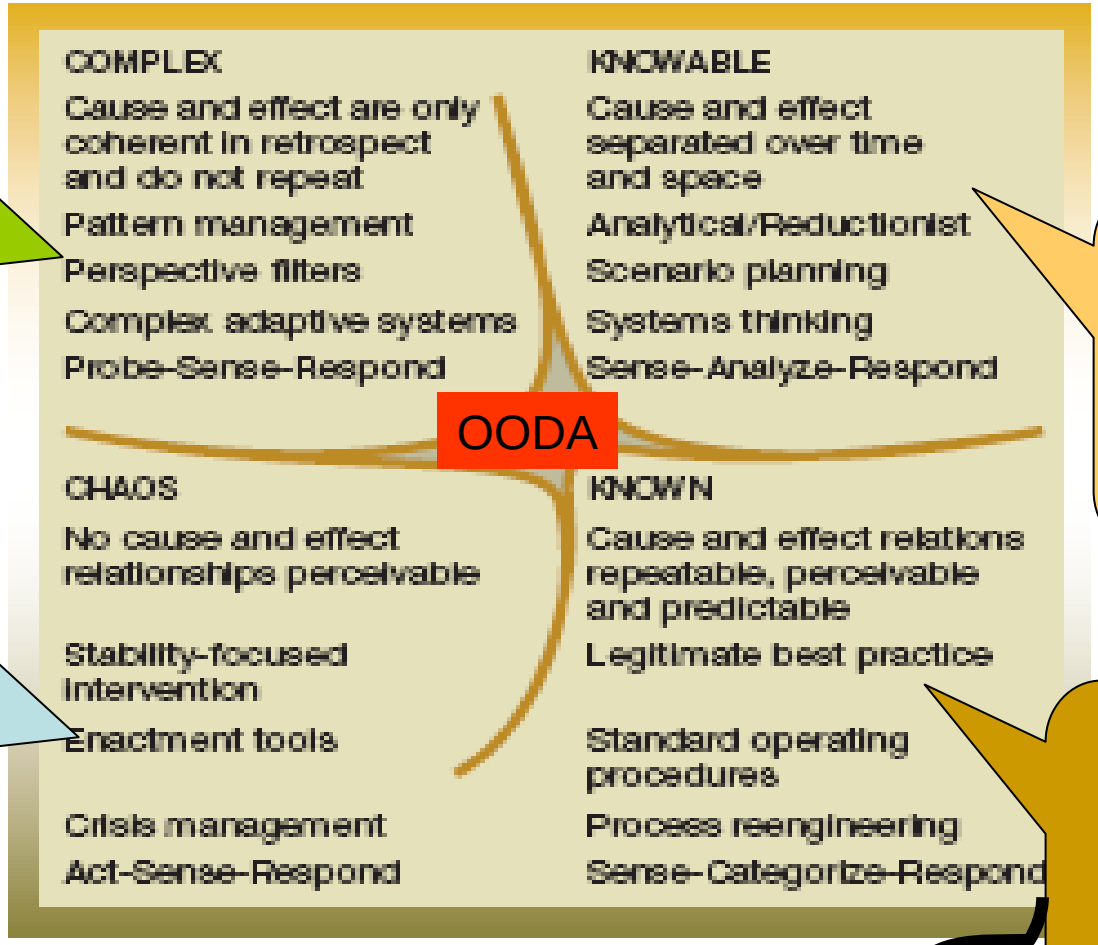
Quasi Analytical-Intuitive Cognition

Analytical/ Heuristic Cognition

Meta-cognition

Reflexive Cognition



The Cynefin Model (Kurt and Snowben, 2003)

Cultural Cognition Models)

Meaning in Iraq:
Peace for cowards

Peace Symbol

Meaning in USA:
We want peace, no war

A study of what people can say about what they know (Hutchins, 1996)
Interpretation of experience to guide action in a range of life domains (Schank & Abelson, 1977).

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THE PAYE MODEL

Rationales:

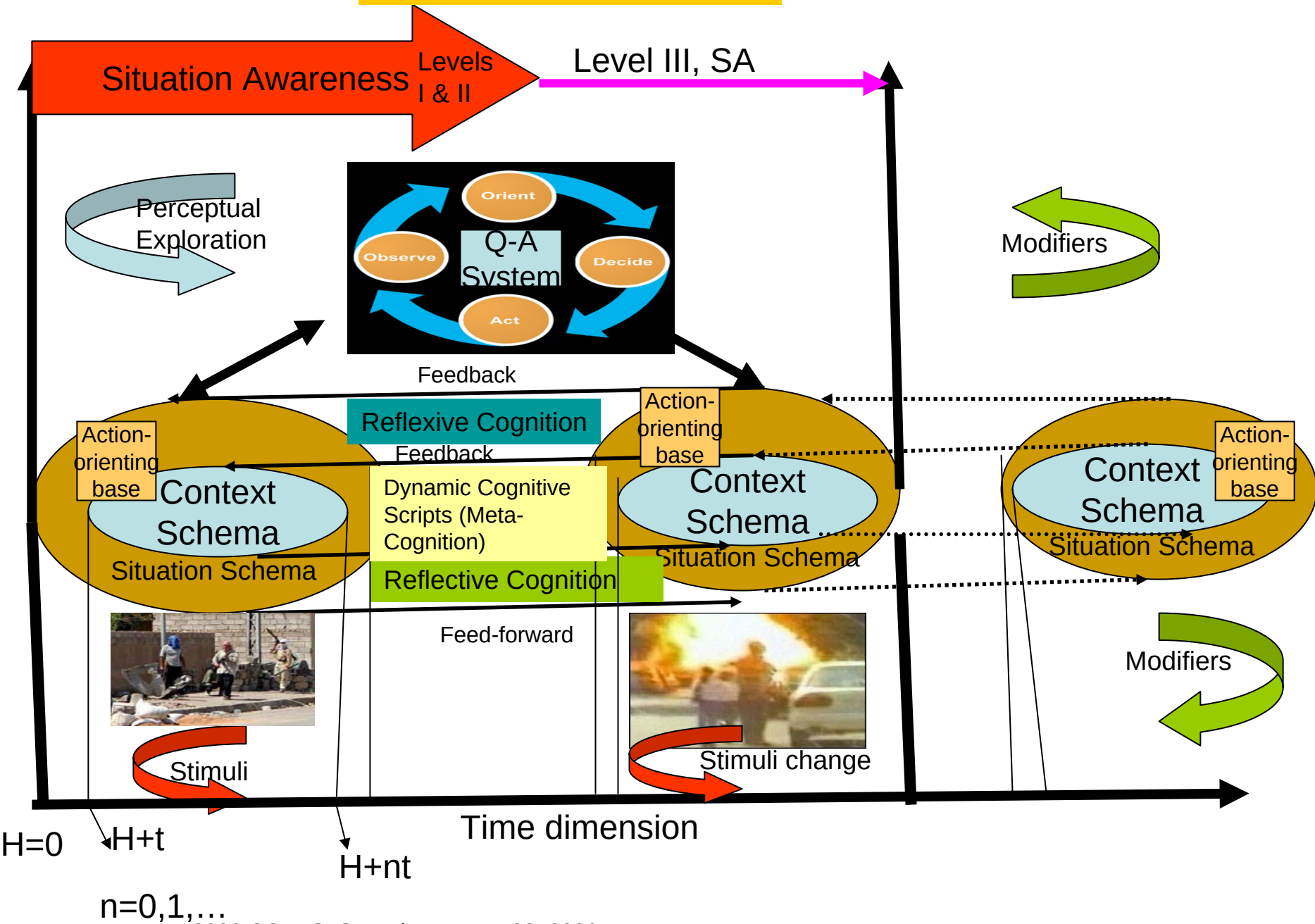
- Battlefield realities donot always match notional planning assumptions against the adversary.
- Modern warfare is populated with non-traditional adversaries.
- The enemy is unknown, almost all are embedded with the civilian population.
- Battlespace changes dynamically according to Cynefin model: →Known→ Knowable→ Complex→ Chaos→

Need:

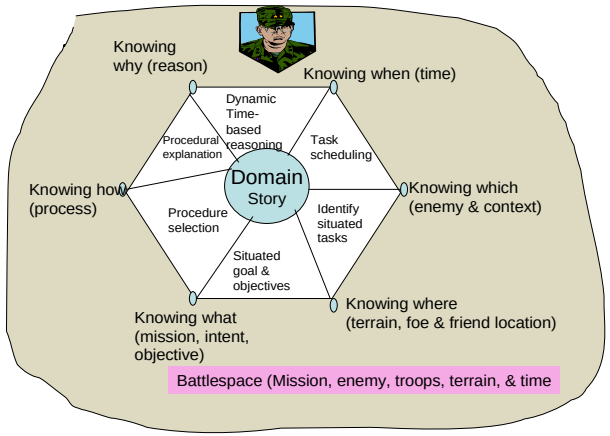
PLAN –AS-YOU-EXECUTE (PAYE) Strategy

- We know more than we can tell (Polanyi, 1967)

THE PAYE MODEL



THE PAYE MODEL



1. Question-Answeing (Q-A) Query System;

2. Reflexive Knowledge: Past knowledge Leading to a retrospective strategy– useful when results structure provides sufficient guidance or knowledge accessing means (Hoc, 1988; pp. 77)

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3 Reflective Knowledge: Conscious and thoughtful reaction to situations

It is a thoughtful activity—generating prospective plans

Allows for adaptation to new situations: our ability to learn new things, interact with new behaviors, etc.

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THE PAYE MODEL

4. Meta-Cognition: A compendium of dynamic cognitive scripts:

A generic footprint of events, activities, episodes, and histories of experiences

Supports cognitive dynamics—"many changes in an organism directly affecting that organism's cognitive processing or cognitive capacities (Dietrich & Markman, 2000; pp.7)

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4. Meta-Cognition:

Ecological niches	**Time scale (H+nt; n=0,1,2,….)**
Situation	→ Situation (change/ unchanged)
Situation	→ Context (center of gravity, focus of effort, etc.)
Context	→ Context (change / unchanged)
Context	→Situation (evolved to higher task dimensions, complexity, and chaos)

SUMMARY & CONCLUSIONS

- Sensemaking involves the use of human cognition
- Reviews many of the existing cognitive models/theories supporting the sensemaking process.
- The existing models offers context-specific advantages ; often lacks generality and difficult to apply when situation breakdowns or novel conditions arise.

SUMMARY & CONCLUSIONS

- The PAYE model is developed to reduce the existing problems:
- Provides real-time adaptation
- Recognizes evolving ecological niches
  - Evolving changes of contexts and situations, in time and space
- Supports sensemaking as a continuous cycle of interacting plans
- Open architecture:
  - Captures execution-monitoring in real-time.
  - Provides modules for sensemaking simulation codes.