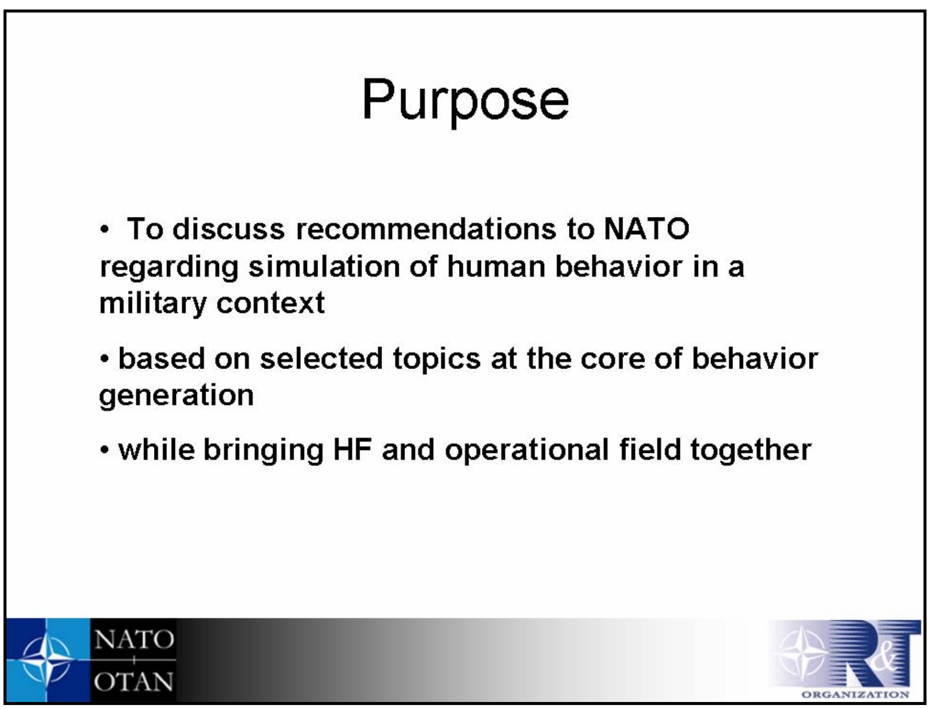
Appendix 3 – PRESENTATION SLIDES

A3.1 HFM-128 CHAIRMAN'S MESSAGE



HFM 128 – HFM 143

- HFM 128 on HBR in constructive modeling to report in concept this summer
- Concept report is input to HFM 143. A separate report will be produced on the Specialist Meeting

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Still a problem ....

- Balanced HF input to operational studies
- Generation of likely behaviors and selection of behavior
- Models fit for purpose
- Performance metrics
- Reduction of complexity, reduction of effort, reuse of developments

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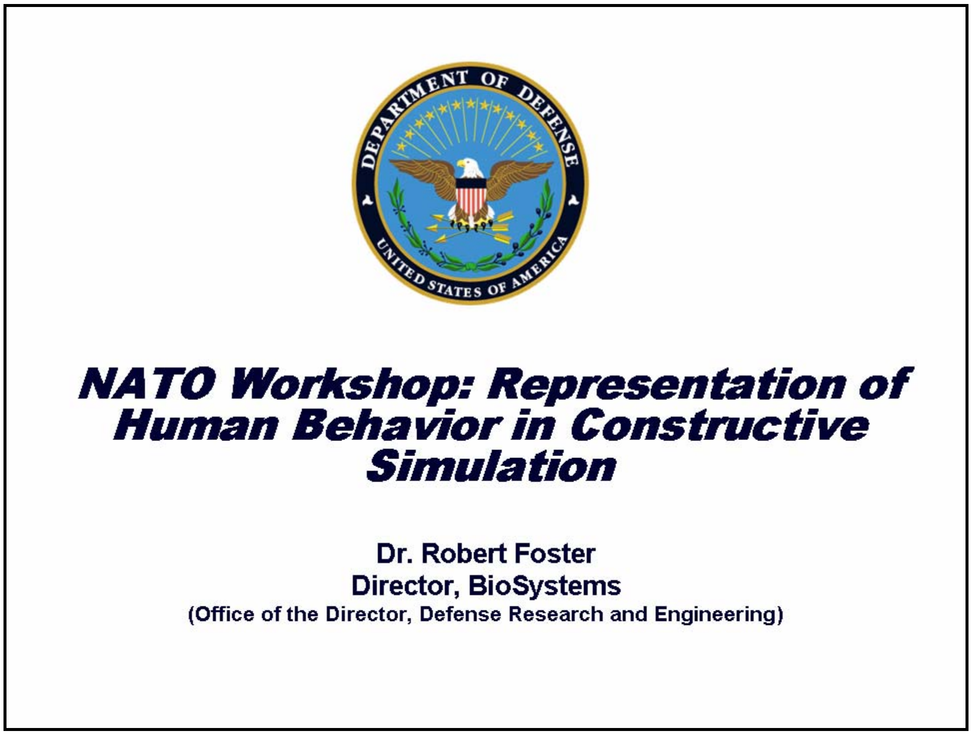
HFM 128 vision

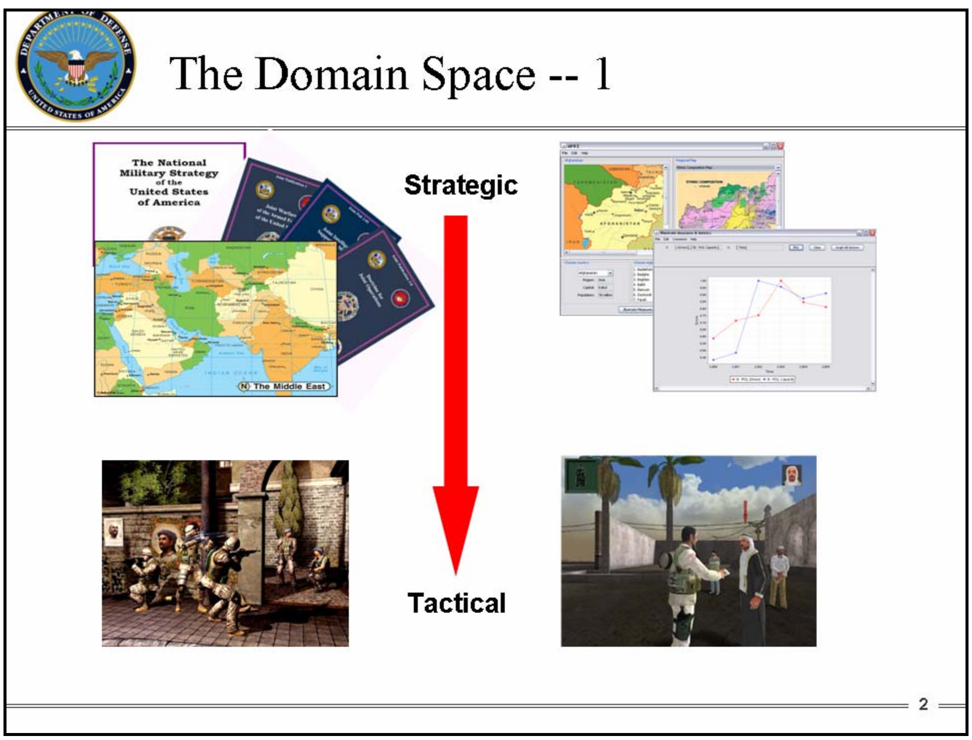
- Careful framing of a study
- Science based parameter choices
- Moderator concept to reduce complexity of HF
- Behavioral choices to generate course of action
- Performance in military perspective

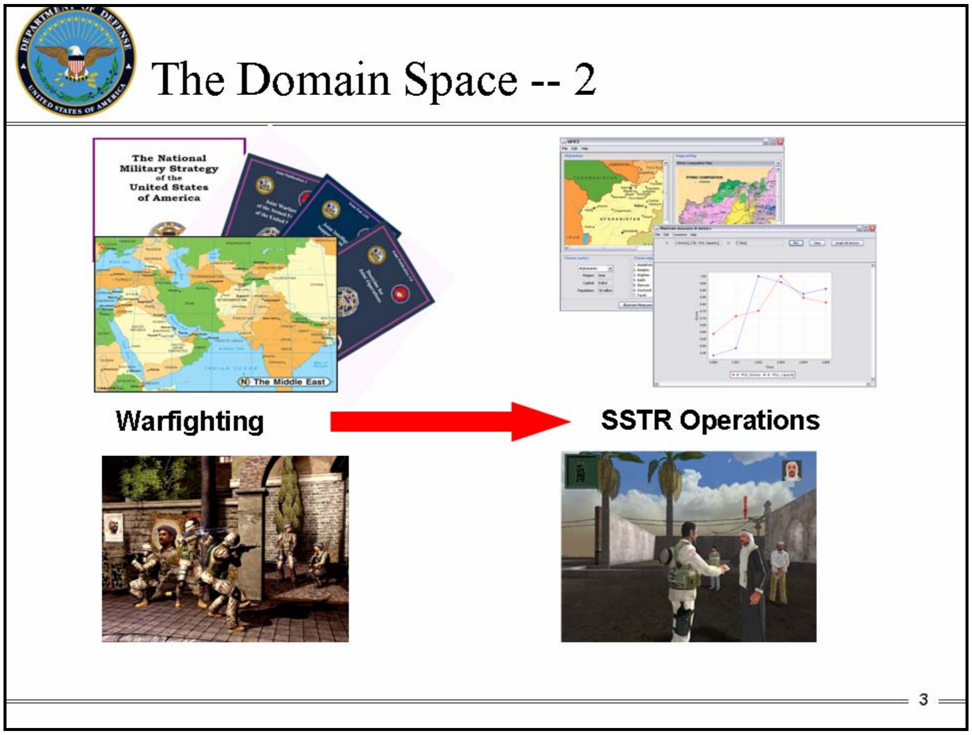
This meeting

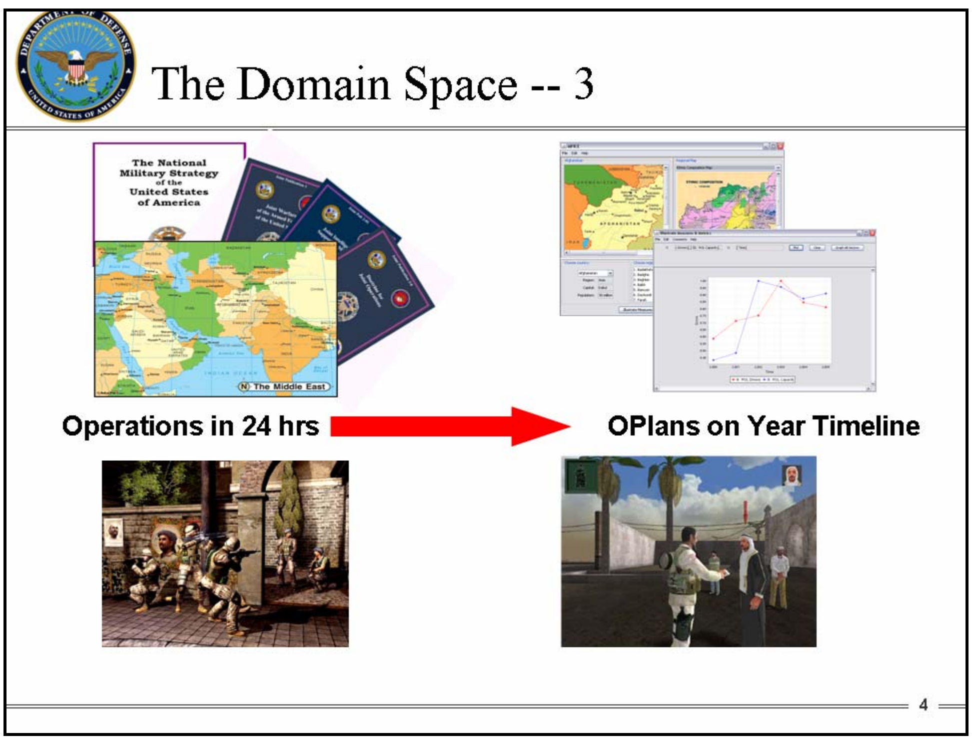
- Selected topics
- Discussions introduced and steered by HFM 128 reps
- Notes and reporting.
- Your involvement is key

A3.2 KEYNOTE ADDRESS – DAY 1

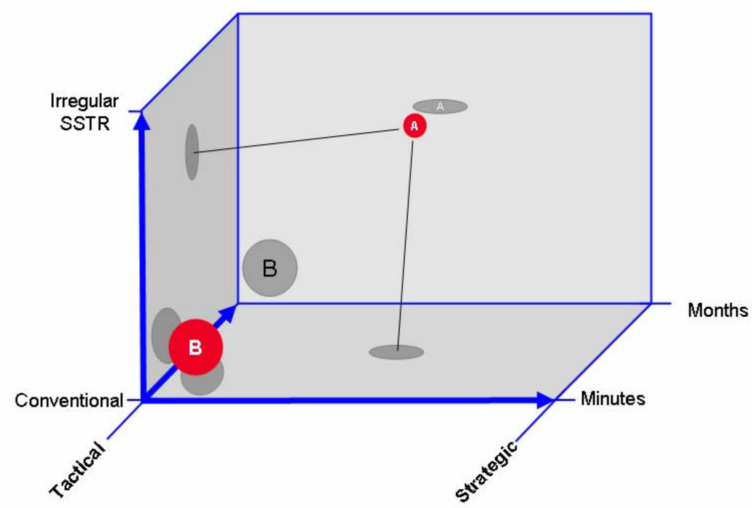





The Domain Space -- 2
The National Military Strategy of the United States of America
The Middle East
Warfighting
SSTR Operations
3


The Domain Space -- 3
The National Military Strategy of the United States of America
The Middle East
Operations in 24 hrs
OPlans on Year Timeline
4

Domain Space and M&S Applications



5

Modeling Human Behavior

- Where is the current State of the Art?
  - Underlying science and theory
    - **Cognitive Theories/Modeling**
    - Human Performance Modeling
    - Physiological Systems
    - Emotional, Social and Cultural Theories/Models.
  - Supporting Technologies
    - High Performance Computing
    - Commercial Technologies
  - Challenges
    - Affordability
    - Flexibility
    - **Ease of Authoring**
    - **Flexibility**
    - **Verification**
    - **Validation**

6

Cognitive Theories/Modeling

- Cognitive Science and Theories:
  - The 'Decade of the Mind'
    - DoD cognitive science investments are 'stable' in
      - Human-Computer Interface (Future Combat Systems, Helmet Mounted Display Technologies within Joint Strike Fighter, Navy DDG-1000)
      - Training and Simulation (Leadership, Socio-cultural awareness, etc.)
    - DoD investment in socio-cultural understanding and modeling is increasing
      - Recognition of need for broader understanding of socio-cultural factors from Phase 0 to Phase 4 of military operations
      - Security, Stability, Transition and Reconstruction (SSTR) operations
      - New Start program in Human, Social, Culture and Behavior Modeling

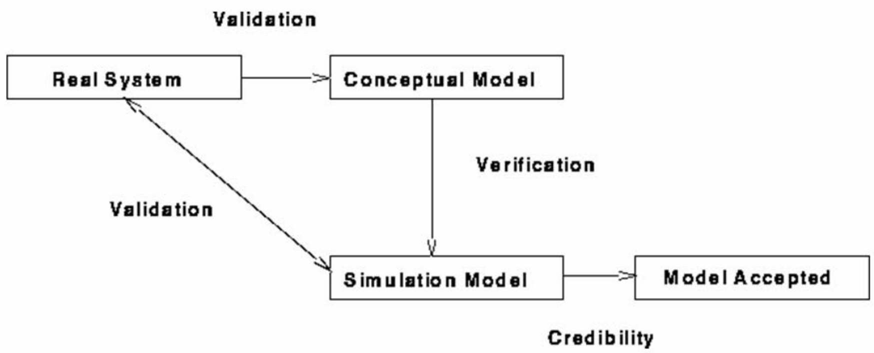
7

Ease of Authoring & Flexibility

- Focus is on transition of cognitive & behavioral models into systems/programs of record.
  - Need to be extensible beyond 'Experimentation'
  - Training Systems, Mission Rehearsal, Planning, Forecasting
- We can't have the modelers doing the 'modeling'
  - To be successful, end user authoring tools must be developed
  - Must allow users to create entity behaviors, not just scenarios
  - Need to be able to understand, model and code general principles of behavior
  - Must decrease the manhours and cost to create simulations

8

Verification, Validation and Credibility



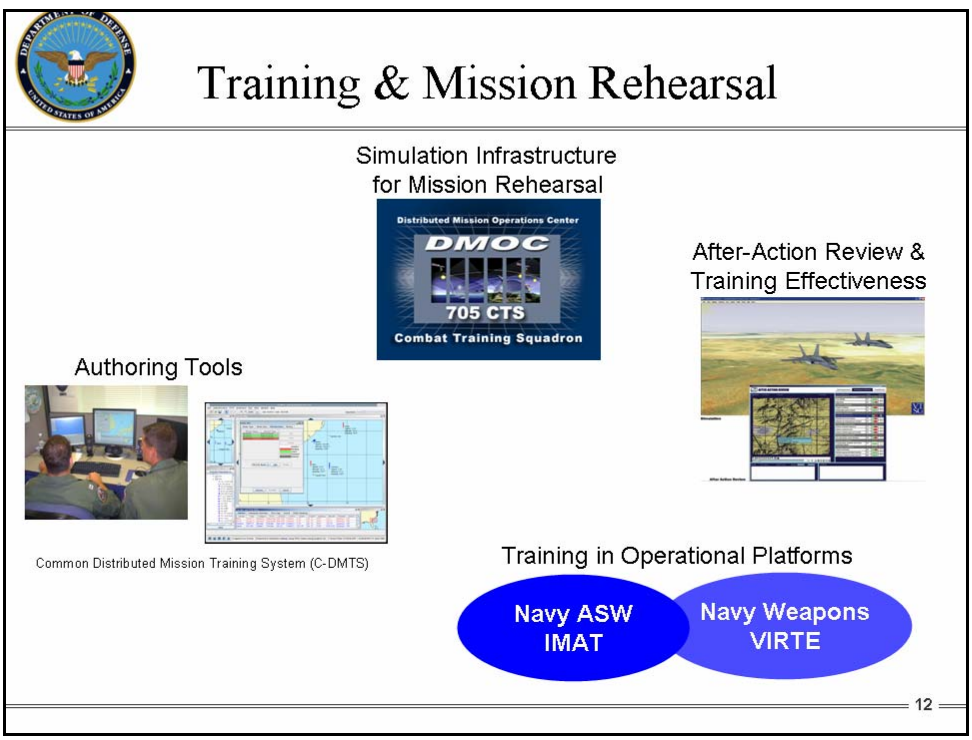
9

Verification & Validation

- Verification
  - There is a proliferation of models and simulations that go straight to use without V V & A
  - Lack of proper documentation
  - Lack of empirical analysis
- Validation
  - Face validity vs. Structural/Predictive validity
    - Going beyond SME-based assessments
    - Going beyond the existing range of parameters
    - Many models are not empirically testable
  - Structure vs. Content
    - Frameworks and architectures often come first
    - Some frameworks can be used as testbeds for demonstration and validation
- Credibility
  - When the real world is poorly understood…then the conceptual model is poor and it may be verified, not valid AND not credible
  - Need for effectiveness measures

10

There Are Some Successes, I Think



Are There Testing Environments ?

Traditional M&S

- SEAS
- ??

Games

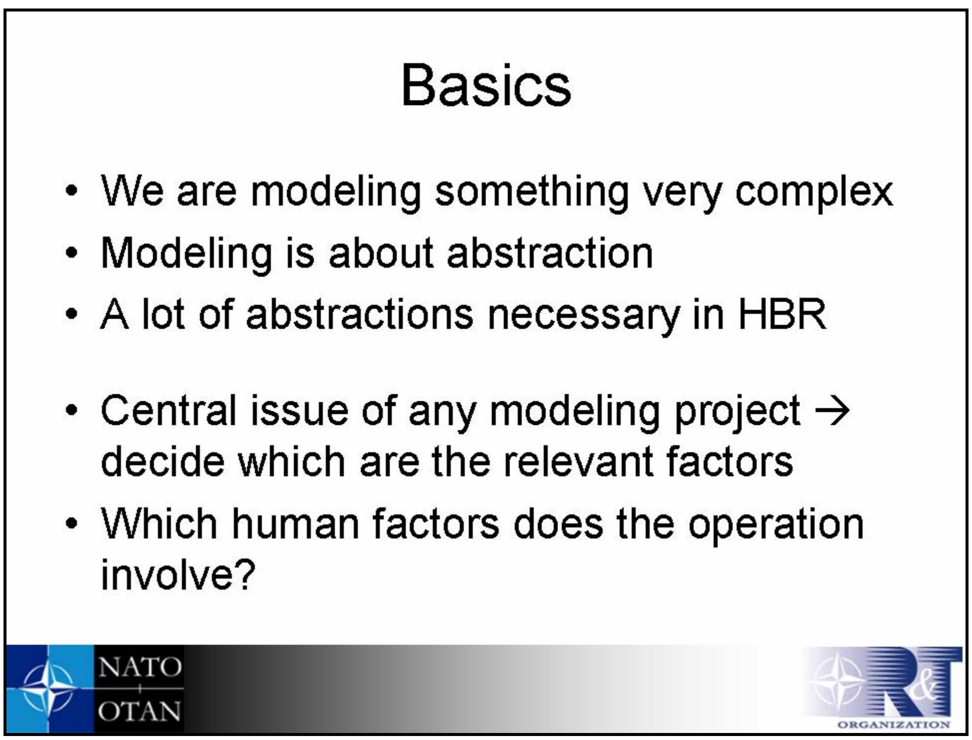
- RealWorld
- "A Force More Powerful" (BreakAway Ltd)
- ??

13

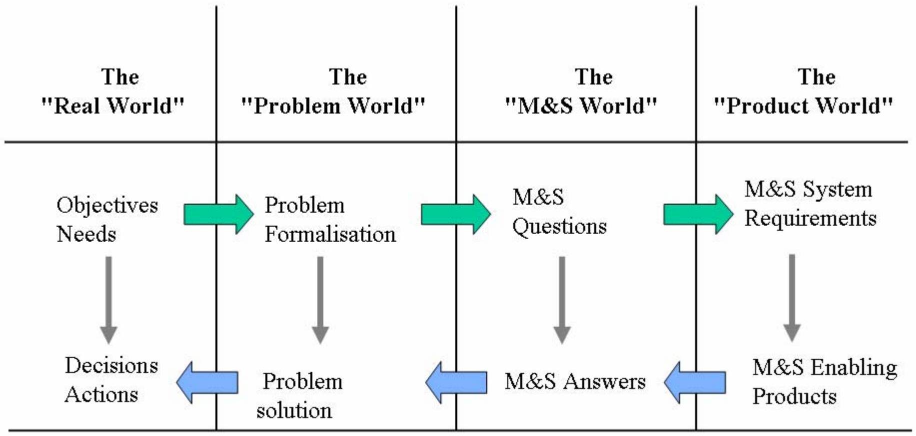
In Summary There Are Challenges

- Authoring
  - ❑ From real experiences
  - ❑ Application Users (not experts/"pucksters")
- Behaviors
  - ❑ Include actual physiology (not just "moderators)
  - ❑ Include human social & culture dynamics
- Validation
  - ❑ Data
  - ❑ Datasets for research and developers

A3.3 WHAT HUMAN FACTORS DOES THE OPERATION INVOLVE?



"REVVA Worlds"



Picture from REVVA 2 project .To appear on SISO General Methodology VVA this summer

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Discussion

- It depends!
- We can model "everything" but conceptual model and empirical data often a problem
- Can formal approaches to selection of relevant human factors and scenarios exist?
- Advice to NATO

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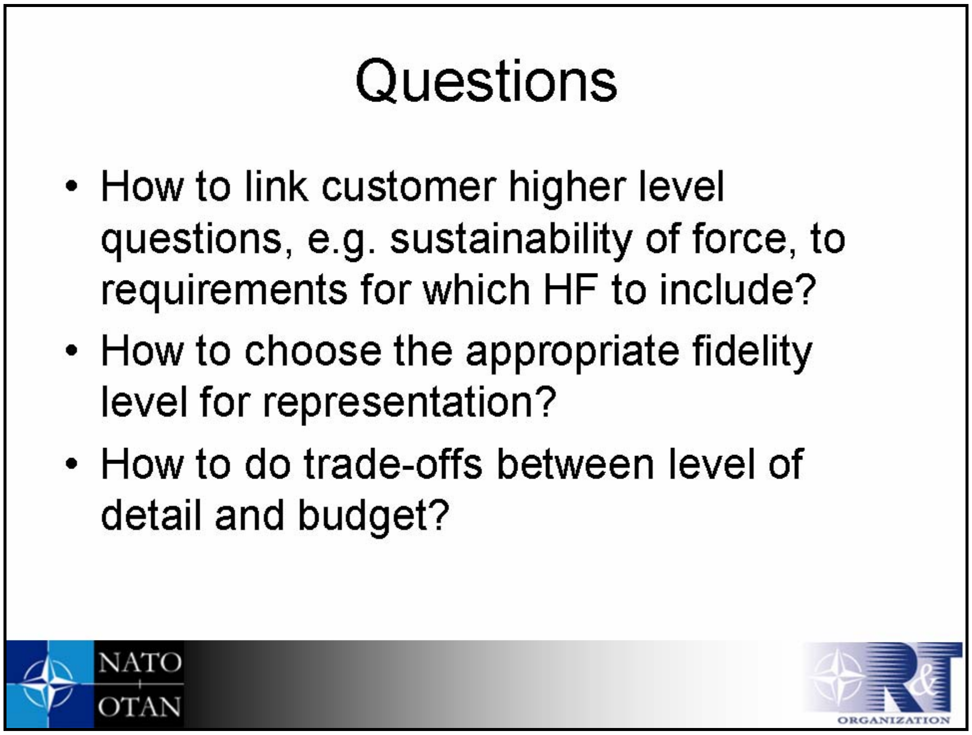
Questions
• How to link customer higher level questions, e.g. sustainability of force, to requirements for which HF to include?
• How to choose the appropriate fidelity level for representation?
• How to do trade-offs between level of detail and budget?
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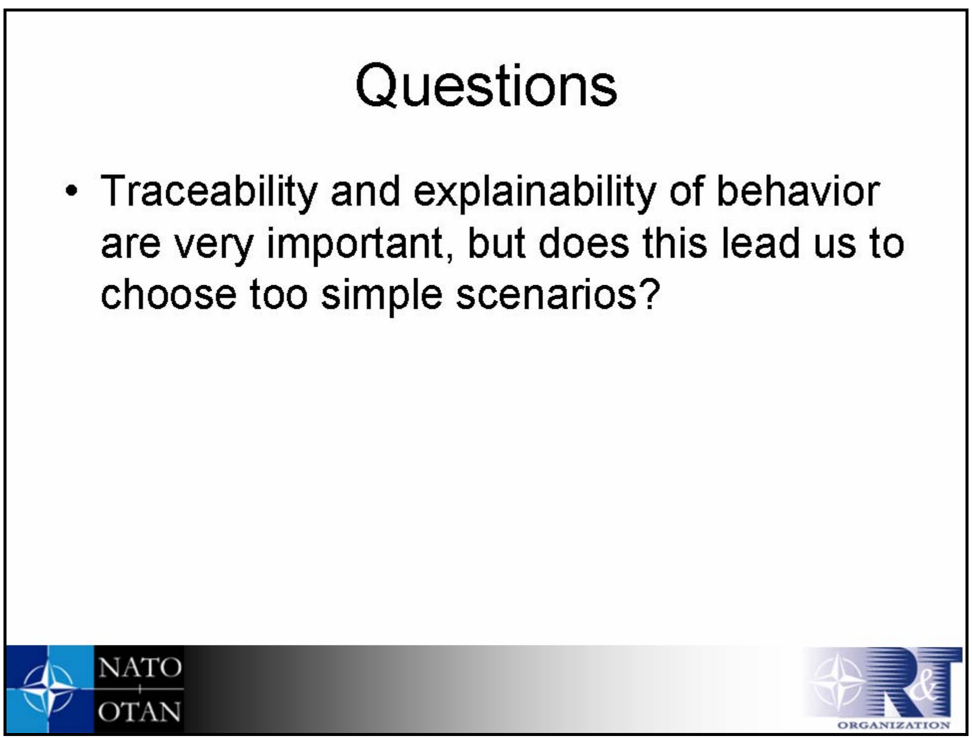
Questions
• Traceability and explainability of behavior are very important, but does this lead us to choose too simple scenarios?
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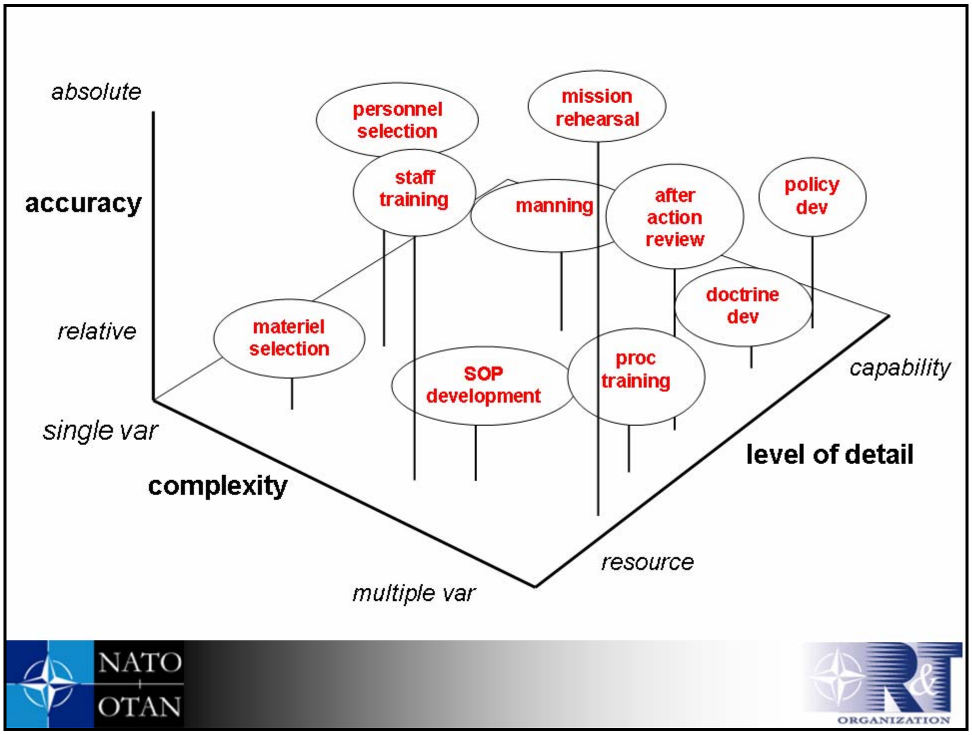
absolute
accuracy
relative
single var
complexity
multiple var
resource
level of detail
capability
personnel selection
mission rehearsal
staff training
manning
after action review
policy dev
doctrine dev
materiel selection
SOP development
proc training
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Modelling Low Flying Activity
NATO Specialist Meeting
Toronto May 30 2007
Andy Belyavin, QinetiQ
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Representing human factors

- Choice of what human factors need to be represented is an important decision in any study
- By way of illustration I will describe a study involving a complex two part model
- An early decision was made to limit the human factors detail
- Was it right?

Study Objectives

- Basic principle operated in the UK low flying system (LFA) is “See and Avoid”
- Responsibility lies with aircraft flying in the system to detect potential conflicts visually and take appropriate action
- Primary aim of the study was to identify the effect of measures that could reduce random collision rate

Approach adopted

- Clearly human factors in collision avoidance
  - Visual detection
  - Avoidance action
- Possible human factors in flight tracks….
- Since intersections between tracks are random decided that no need to describe HF in flight pattern
- Could split the model into two parts:
  - Track & intersection generation
  - Given track geometry can the potential decision be detected?

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Track generation

- Track generation is not simply set of tracks in arbitrary directions
- Intersections are a “squared” problem (n*n)
- Low flying area has some flow control influencing local density
- Traffic (Military & Civilian) has different altitude patterns

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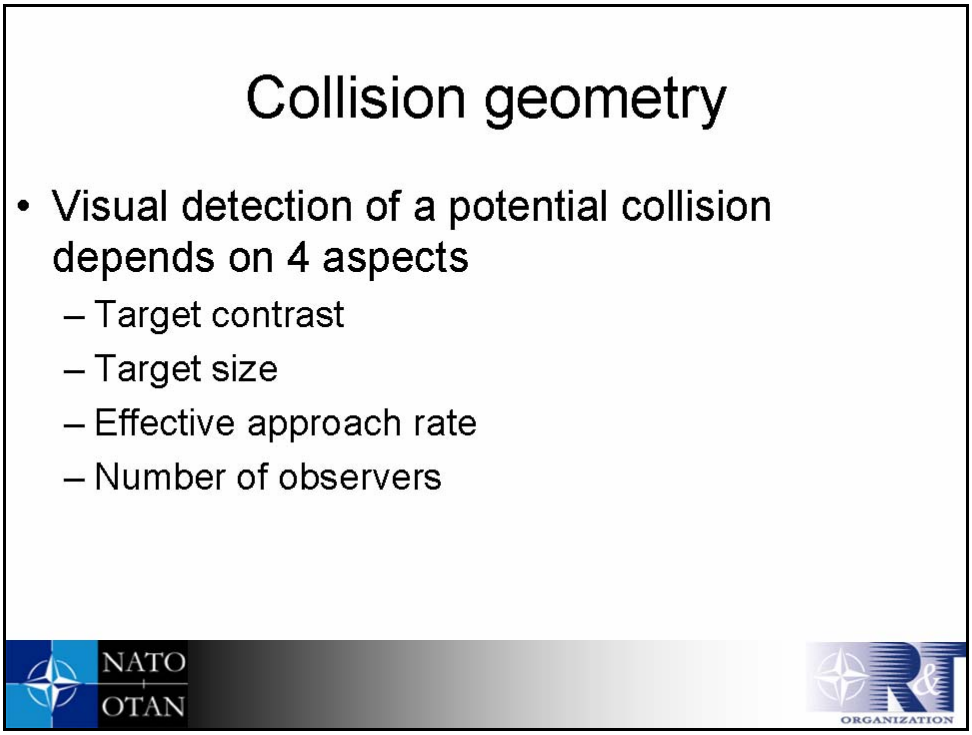
Generation Model

- Model constructed of traffic in LFA according to observed data on patterns
- Careful construction so that traffic density would conform to observations
- Generate a series of potential conflicts
- Define the geometry of the conflict in terms of directions/angles/aircraft types
- Validate conflict rate against observations

Validation basic model

- For Military/Military and Civil/Civil conflict rate validated satisfactorily against reported air prox. Reports
- Military/Civilian was not consistent with observations or with the other categories
- Indications of over-reporting


Collision geometry
• Visual detection of a potential collision depends on 4 aspects
– Target contrast
– Target size
– Effective approach rate
– Number of observers
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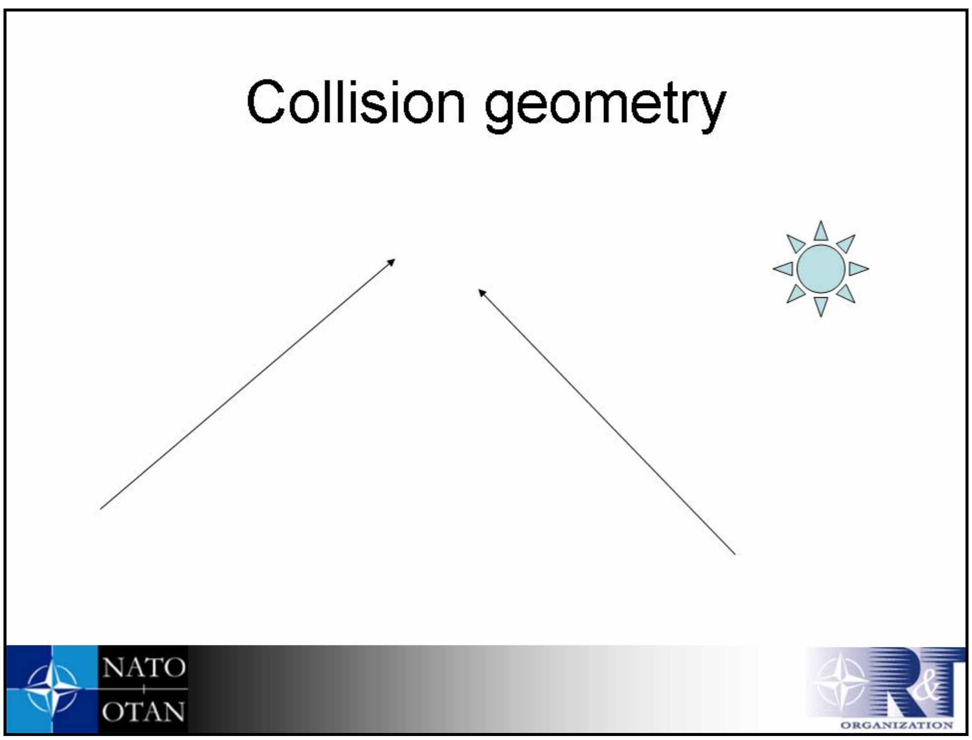
Collision geometry
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Visual detection

- Visual detection further depends on
  - Time of day
  - Day of year
  - Geometry relative to solar position

Full model

- Generate conflicts using first model run for 100 years
- Use HF visual detection model to assess probability of detection a prescribed number of seconds from impact
- Can vary assumptions about detection aids and compare
- Use baseline to validate model

Summary

- Full model validated at collision and conflict level
- Composed of a non-HF piece and a critical HF piece
- Overall model appeared satisfactory
- Two components distinct

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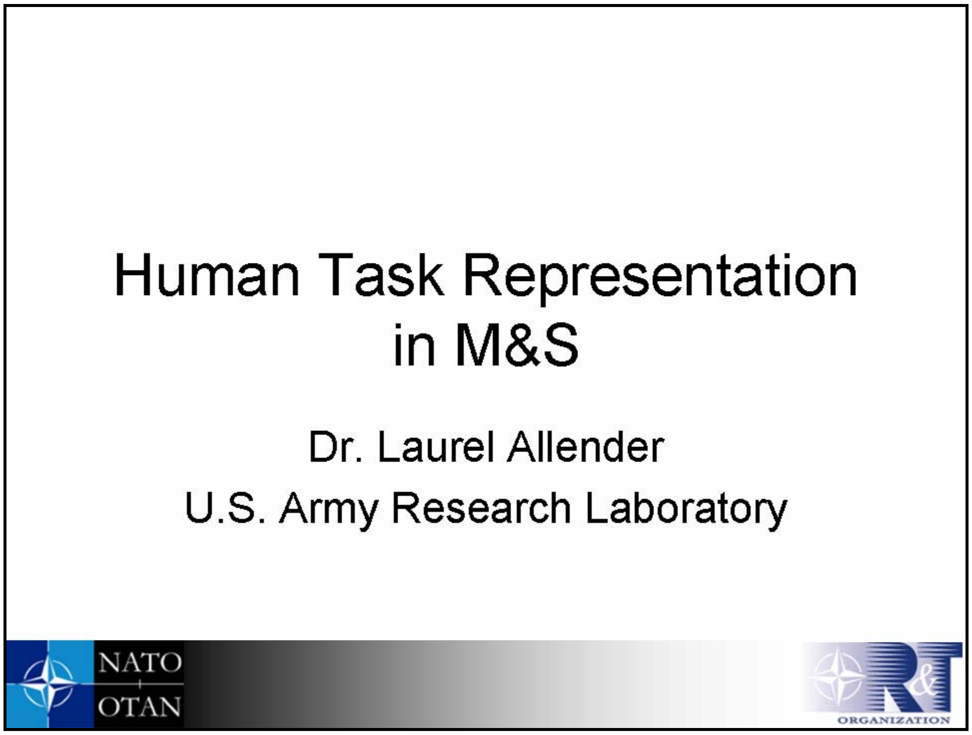
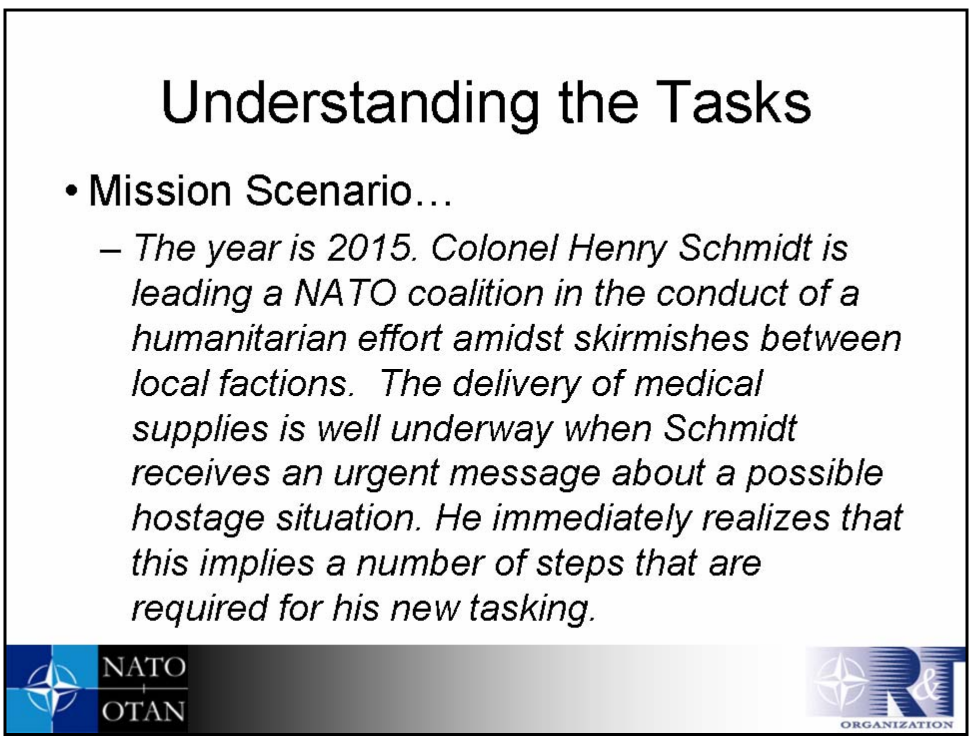
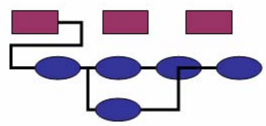
A3.4 HUMAN TASK REPRESENTATION IN M&S





Understanding the Tasks for M&S

- Task Analysis
  - – Starting point for human factors efforts
  - – Military regulations describe/perscribe task analysis
  - – Types of task analyses
    - Cognitive
    - Goal directed
    - Hierarchical
    - Work-centered…



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Understanding the Task: ”Secure the Building”

- The Army surrounds the building with defensive fortifications, tanks, and concertina wire.
- The Marine Corps assaults the building using overlapping fields of fire from all appropriate points on the perimeter.
- The Navy turns out the lights and locks the doors.
- And the Air Force takes out a three-year lease on the building with an option to buy.

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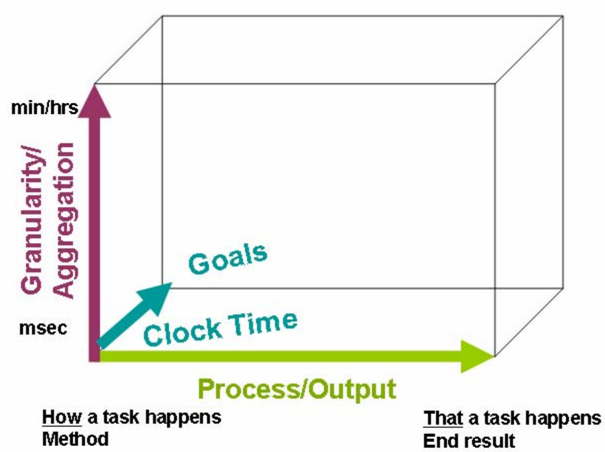
So, What Must Be Considered to Represent Human Tasks in M&S?

- What level of task granularity or aggregation is appropriate?
- At what level or under what circumstances is it sufficient to represent the end state of task performance? Should the underlying process that generated the performance be represented?
- How much context must be specified?
- Can we create an engine that allows us to give high-level commands to the model?
- Is natural language understanding a desired or necessary capability for human behavior representations?

Task Representation Considerations



- Where does context specification fit?
- Learning?
- Natural lanuage commands?

- How does this vary for concept exploration, design, training, or mission rehearsal?

DEFENCE R&D DÉFENSE

Role of Conscious Deliberation in Simple vs. Complex Tasks

Oshin Vartanian

Defence Research and Development Canada

Defence Research and Development Canada Recherche et développement pour la défense Canada

Canada

Problem

- How is a task (e.g., a command) represented?
  - e.g., "Secure the building!"
  - Explicitly vs. implicitly?
- How does conscious deliberation affect representation?
  - Conscious deliberation = attention
- Key Question: Is conscious deliberation always advantageous?

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Problem (cont.)

- Classical wisdom:
  - Conscious deliberation$\uparrow \Rightarrow$ quality of choice $\uparrow$
  - Time pressure/anxiety $\Rightarrow$ quality of choice$\downarrow$
- Is this true for tasks of varying complexity?
  - Complexity = Number of attributes

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Problem (cont.)

- Complex tasks have many attributes
  - e.g., "Secure the building!"
    - Time
    - Space
    - Sequencing of actions
    - Cost and benefit of engagement
    - etc.

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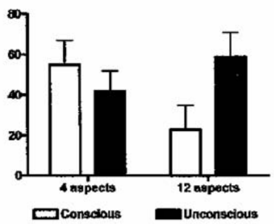
Problem (cont.)

- Key insight: Value of conscious deliberation is a function of complexity:
  - Simple tasks (e.g., buying shoes) ⇒ value↑
  - Complex tasks (e.g., choosing a car) ⇒ value↑

Quality



Dijksterhuis et al. (2006)

Fig. 1. Percentage of participants who chose the most desirable car as a function of complexity of decision and of mode of thought (n = 18 to 22 in each condition). Error bars represent the standard error.

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Problem (cont.)

- Conscious deliberation:
  - Limited capacity
    - Attention can be directed at few attributes
  - Rule-based (e.g., don't exceed a certain price)
- Unconscious (implicit) deliberation:
  - Geared toward pattern recognition
  - Not limited by capacity

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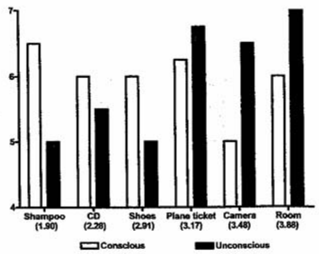
Problem (cont.)

- Upshot? Deliberation will not help if task is complex
- This is true in terms of:
  - Objective quality of choice
  - Post-choice satisfaction

Satisfaction



Dijksterhuis et al. (2006)

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Implications: Operations

- Training is key!
  - Must facilitate pattern recognition.
  - Command carried out without deliberation.

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Implications: M&S

- Emotion?
  - Negative emotion (anxiety) ⇒ ↓cognitive capacity
  - ↓cognitive capacity ⇒ ↓conscious deliberation
- Study how emotion affects (cognitive) task representation
  - Implicit vs. explicit

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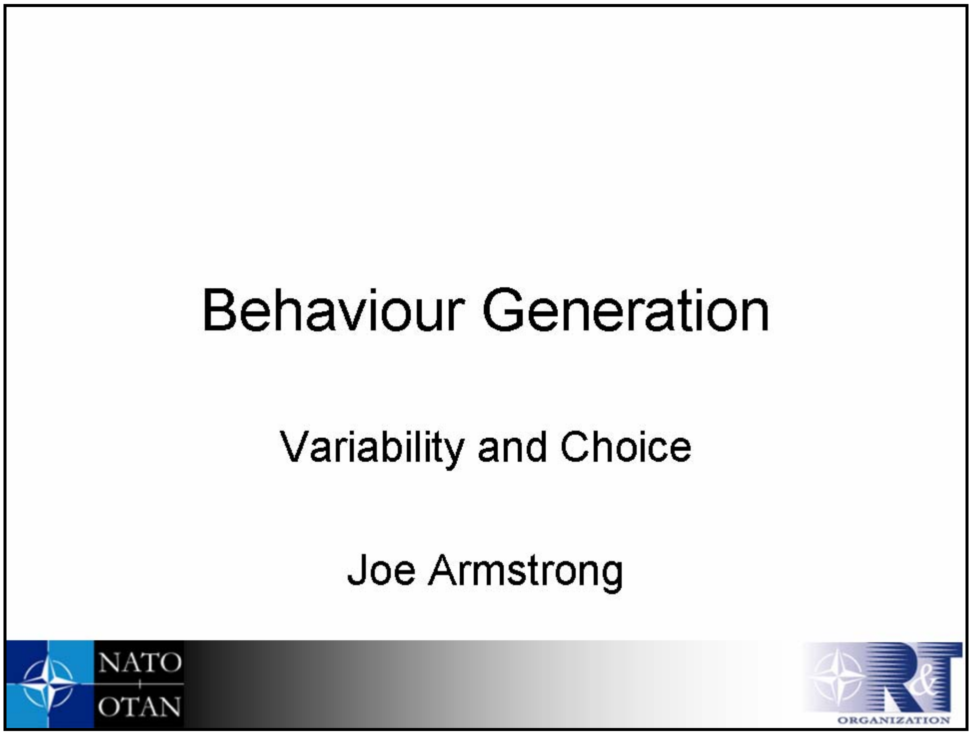
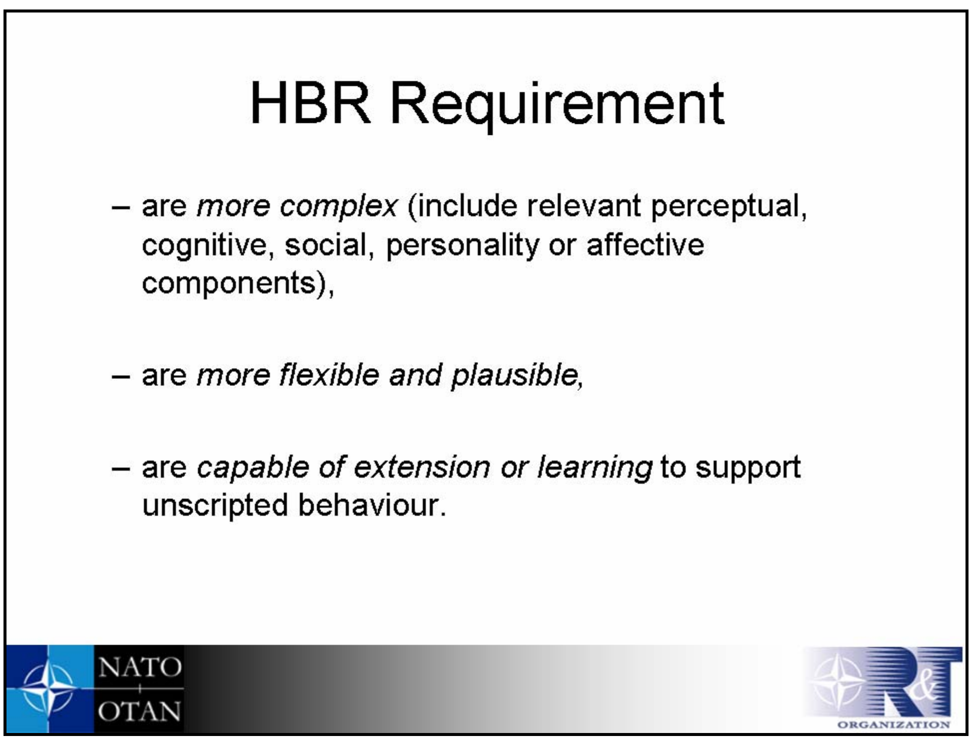
A3.5 BEHAVIOUR GENERATION: VARIABILITY AND CHOICE





Variability

- Sources of Variability
  - Trait Characteristics
    - Physiology
    - Anthropometry
    - Personality
    - Socio-Cultural Factors
  - Environmental Factors
    - Time of day
    - Temperature
    - Vibration
  - Behavioural Characteristics
    - Task Selection
    - Task Alternatives

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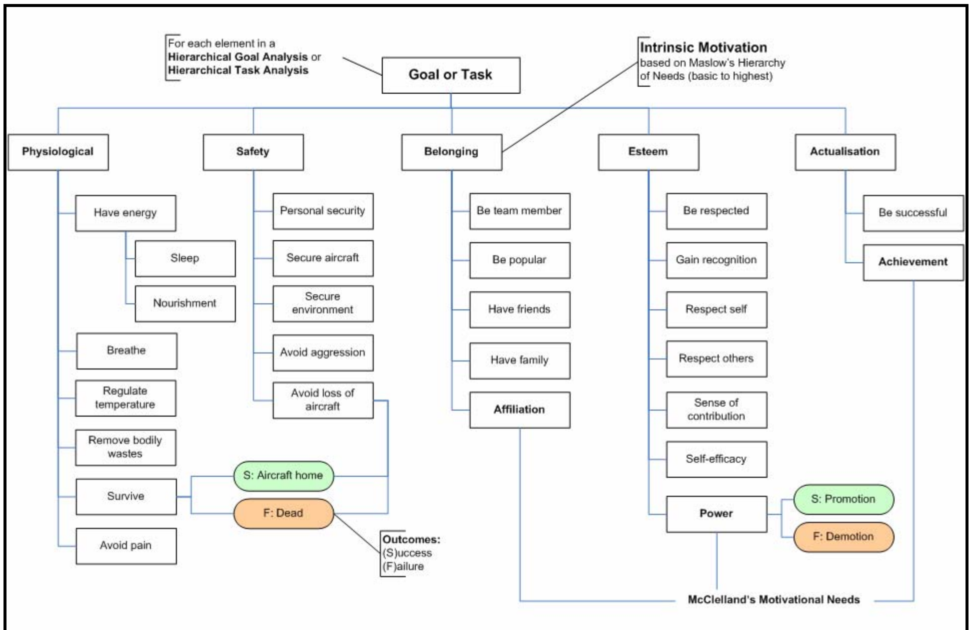

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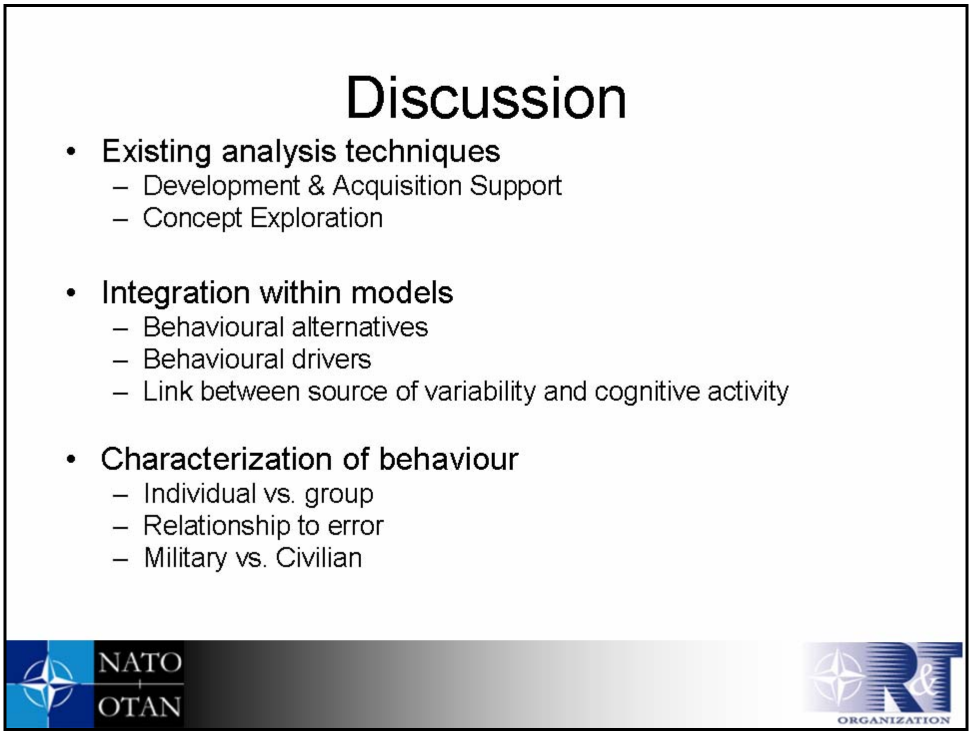
Discussion
• Existing analysis techniques
– Development & Acquisition Support
– Concept Exploration
• Integration within models
– Behavioural alternatives
– Behavioural drivers
– Link between source of variability and cognitive activity
• Characterization of behaviour
– Individual vs. group
– Relationship to error
– Military vs. Civilian
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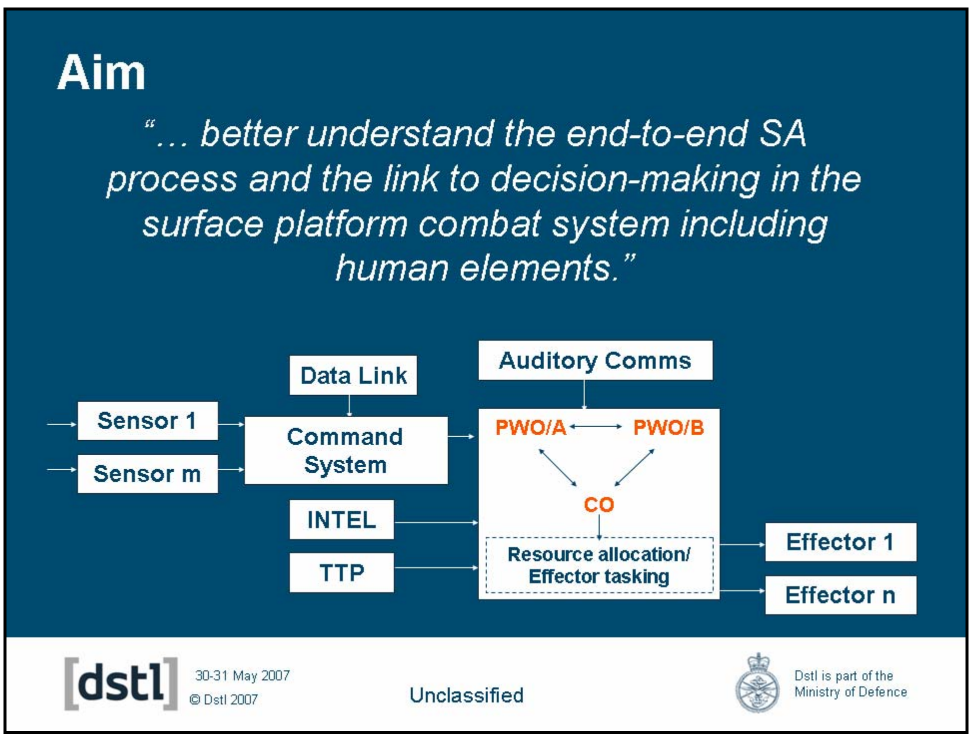
[dstl]
CSEM
Combat System Engineering Model
HFM-143: 30-31 May 2007
Carol Cooper Chapman


Aim
"… better understand the end-to-end SA process and the link to decision-making in the surface platform combat system including human elements."
Data Link
Auditory Comms
Sensor 1
Sensor m
Command System
PWO/A
PWO/B
CO
INTEL
TTP
Resource allocation/ Effector tasking
Effector 1
Effector n
[dstl]
30-31 May 2007
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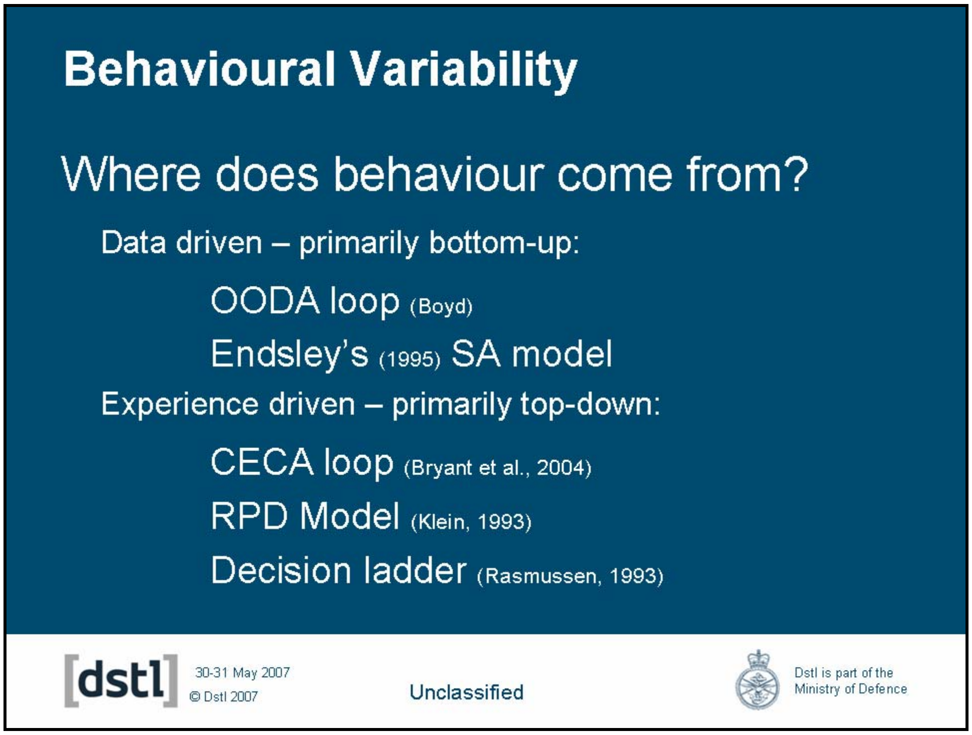
Behavioural Variability
Where does behaviour come from?
Data driven – primarily bottom-up:
OODA loop (Boyd)
Endsley's (1995) SA model
Experience driven – primarily top-down:
CECA loop (Bryant et al., 2004)
RPD Model (Klein, 1993)
Decision ladder (Rasmussen, 1993)
[dstl]
30-31 May 2007
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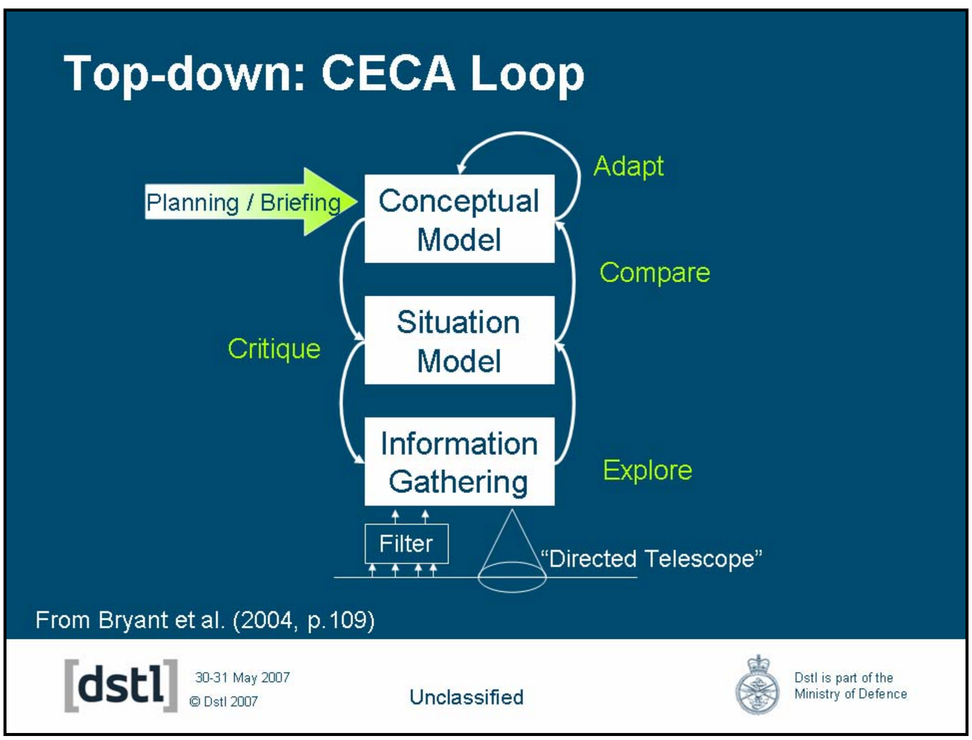
Top-down: CECA Loop
Planning / Briefing
Conceptual Model
Situation Model
Information Gathering
Adapt
Compare
Critique
Explore
Filter
"Directed Telescope"
From Bryant et al. (2004, p.109)
[dstl]
30-31 May 2007
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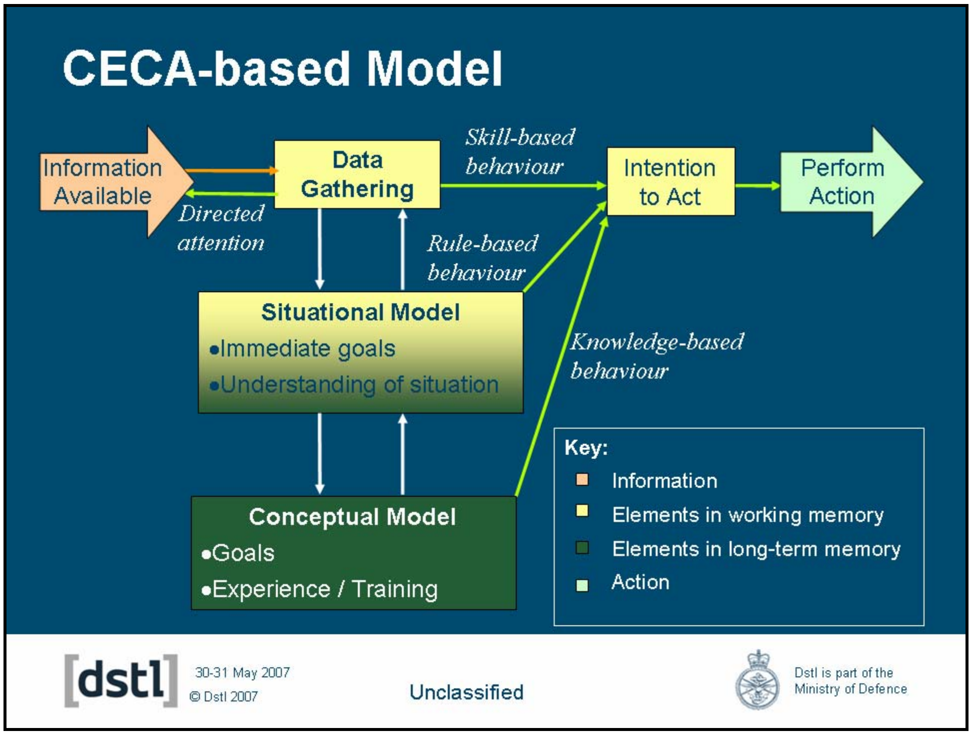
CECA-based Model
Information Available
Data Gathering
Skill-based behaviour
Intention to Act
Perform Action
Directed attention
Rule-based behaviour
Situational Model
•Immediate goals
•Understanding of situation
Knowledge-based behaviour
Key:
Information
Elements in working memory
Elements in long-term memory
Action
Conceptual Model
•Goals
•Experience / Training
[dstl]
30-31 May 2007
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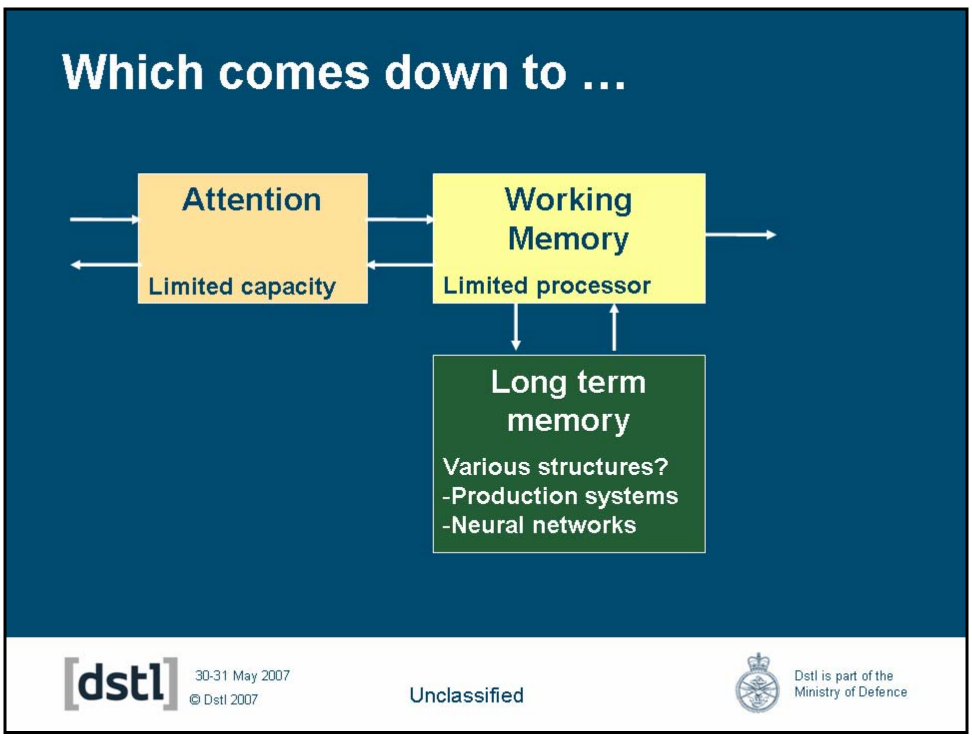
Which comes down to …
Attention
Limited capacity
Working Memory
Limited processor
Long term memory
Various structures?
-Production systems
-Neural networks
[dstl]
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- Endsley, M.R. (1995) 'Toward a Theory of Situation Awareness in Dynamic Systems', *Human Factors*, vol. 37(1), pp.32-64.
- Klein, G.A. (1993) 'A Recognition-Primed (RPD) Model of Rapid Decision Making', in Klein, G.A., Orasanu, J., Calderwood, R. and Zsambok, C.E. (eds) *Decision Making in Action: Models and Methods*, Ablex: Norwood, NJ.
- Rasmussen, J. (1993) 'Deciding and Doing: Decision Making in Natural Contexts, in Klein et al. (eds), op cit.

[dstl] 30-31 May 2007

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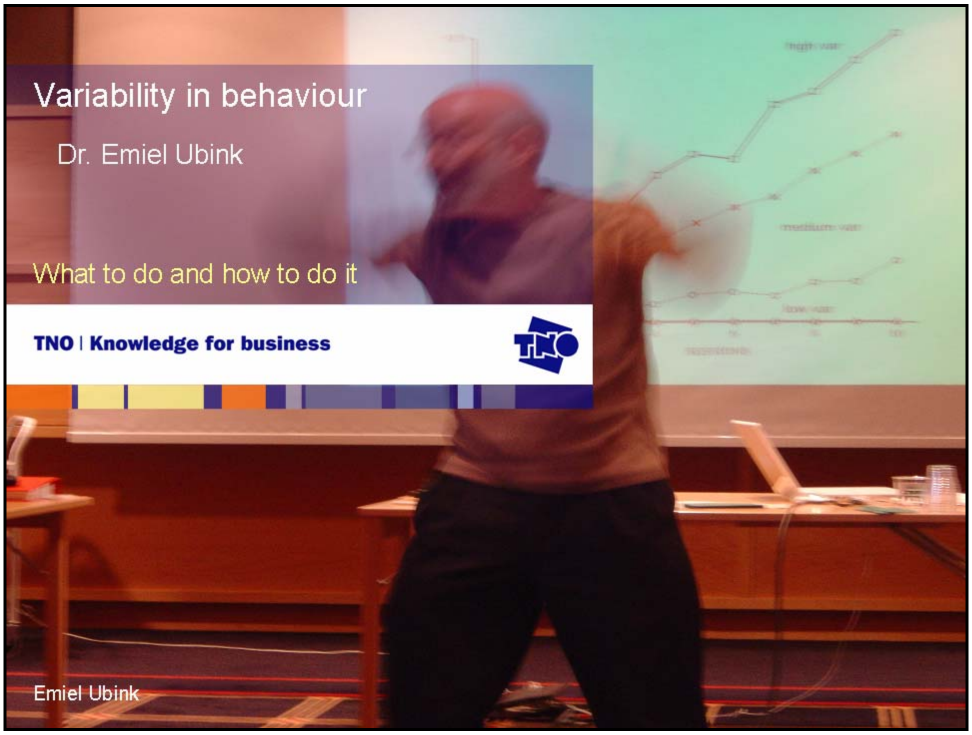


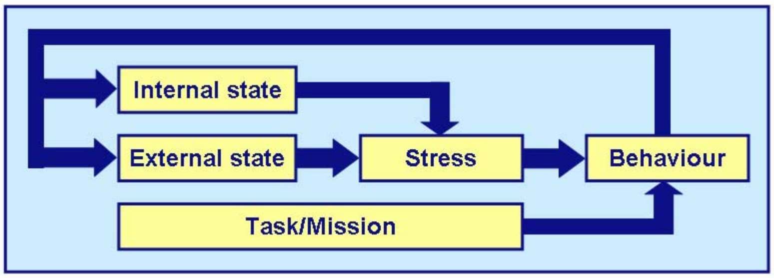
Variability: AI, HF & HBR

- AI: **what** to do (action selection)
- HF: **how** to do it (performance, intensity, ..)
- HBR: 'what' & 'how' are both important and often not separable

2 30 May 2007 TNO

Tasks & Stress

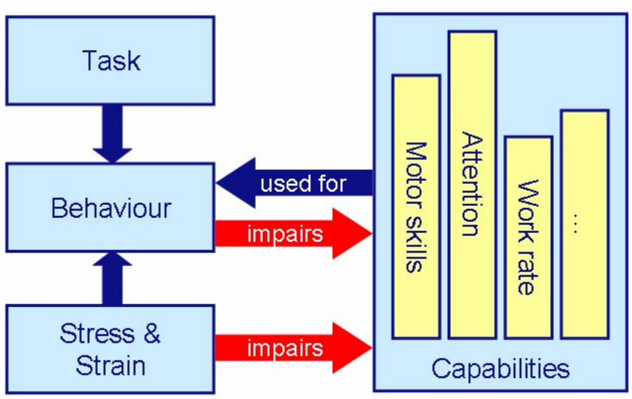
- What & How both depend on relative importance of "stimuli"
  - Tasks → proactive behaviour
  - "Stress" → reactive behaviour



3 30 May 2007

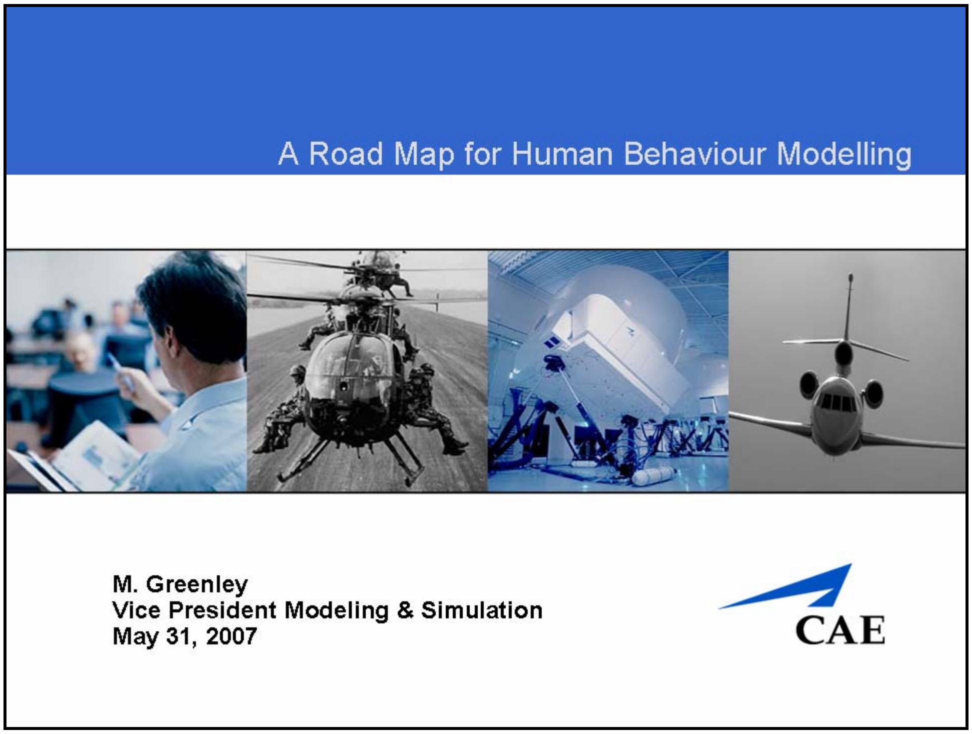
Capabilities

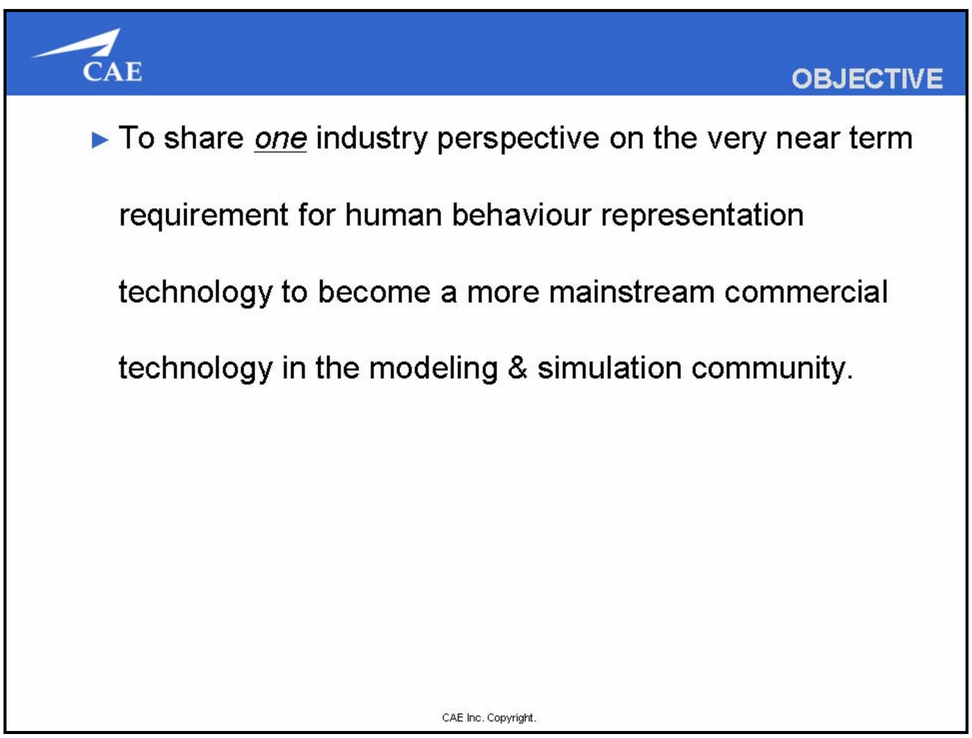
- What & How also depend on availability of resources/capabilities

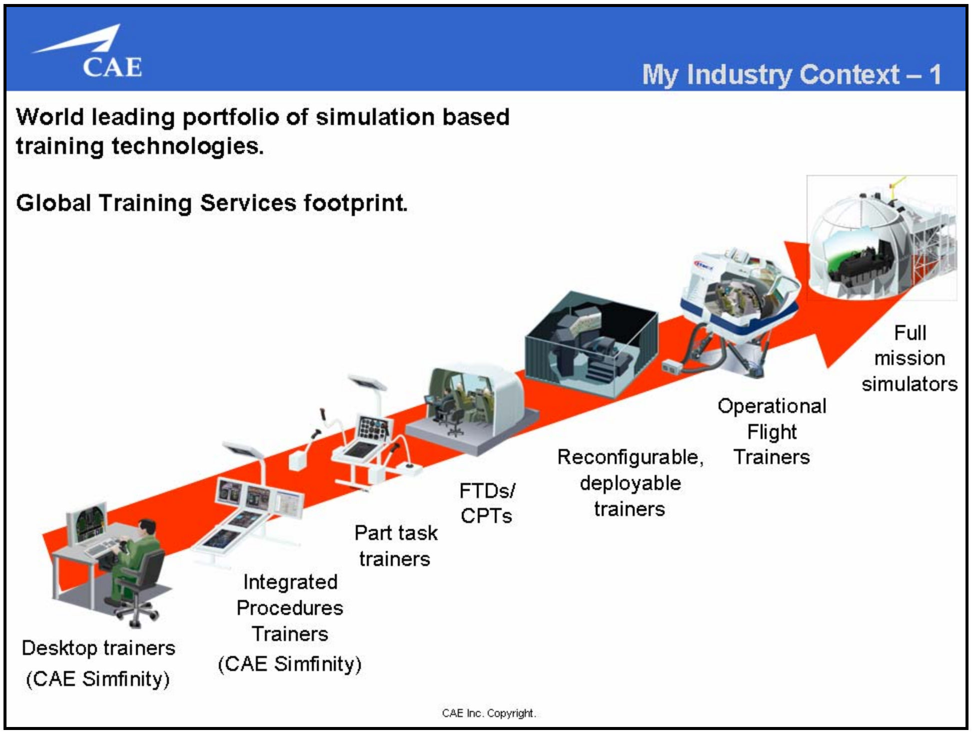


4 30 May 2007

A3.6 KEYNOTE SPEECH – DAY 2






CAE
My Industry Context – 1
World leading portfolio of simulation based training technologies.
Global Training Services footprint.
Desktop trainers (CAE Simfinity)
Integrated Procedures Trainers (CAE Simfinity)
Part task trainers
FTDs/ CPTs
Reconfigurable, deployable trainers
Operational Flight Trainers
Full mission simulators
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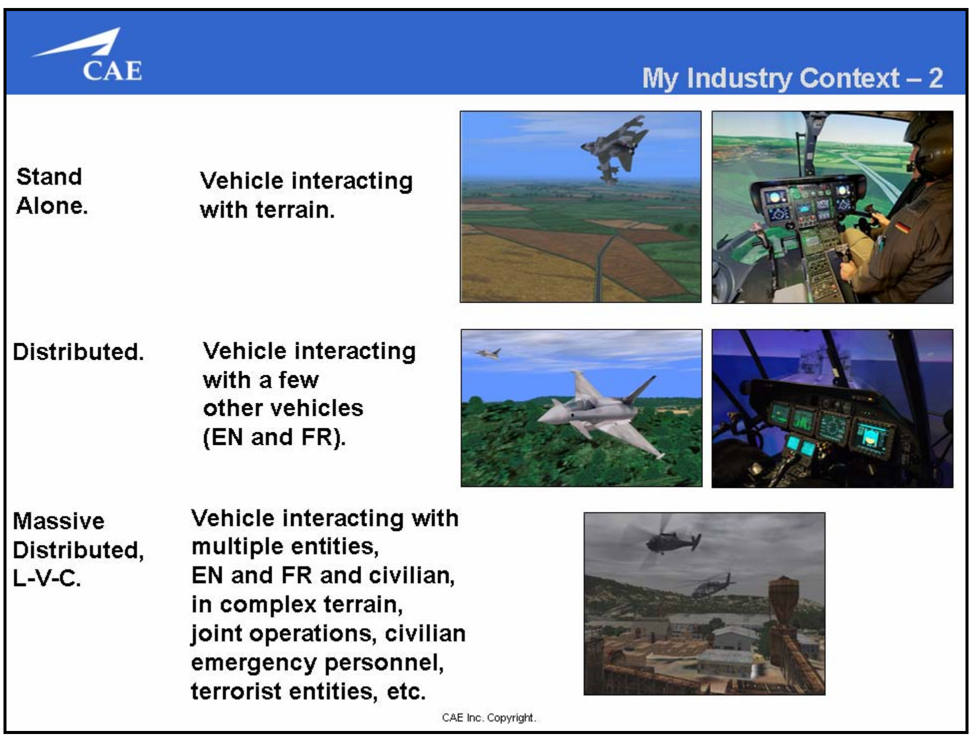
CAE
My Industry Context – 2
Stand Alone.
Vehicle interacting with terrain.
Distributed.
Vehicle interacting with a few other vehicles (EN and FR).
Massive Distributed, L-V-C.
Vehicle interacting with multiple entities, EN and FR and civilian, in complex terrain, joint operations, civilian emergency personnel, terrorist entities, etc.
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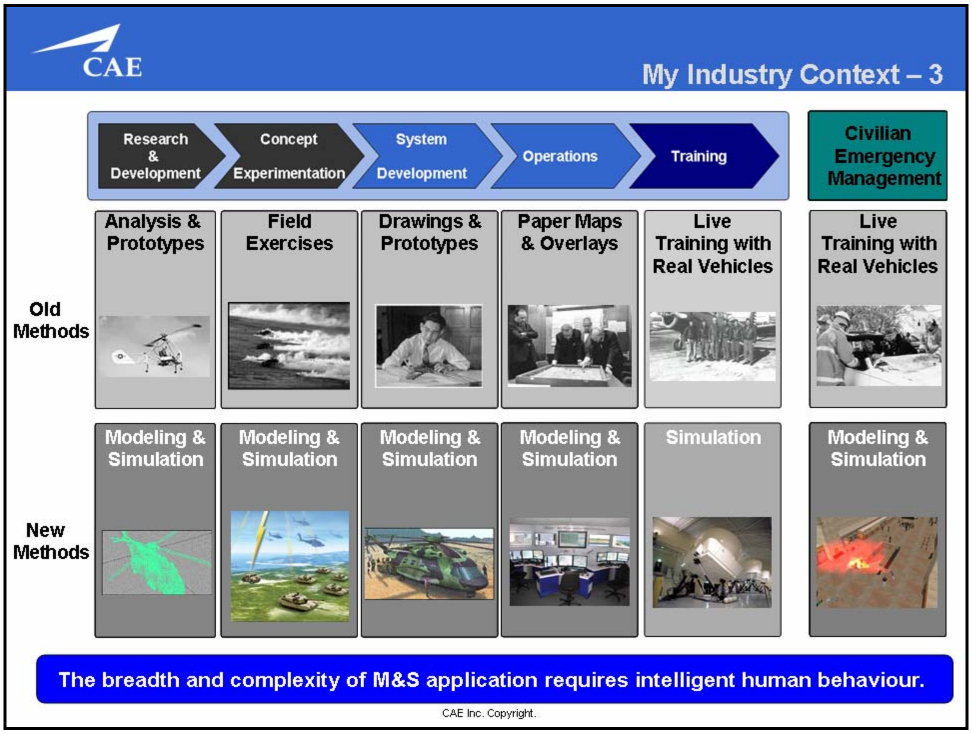
CAE
My Industry Context – 3
Research & Development
Concept Experimentation
System Development
Operations
Training
Civilian Emergency Management
Old Methods
Analysis & Prototypes
Field Exercises
Drawings & Prototypes
Paper Maps & Overlays
Live Training with Real Vehicles
Live Training with Real Vehicles
New Methods
Modeling & Simulation
Modeling & Simulation
Modeling & Simulation
Modeling & Simulation
Simulation
Modeling & Simulation
The breadth and complexity of M&S application requires intelligent human behaviour.
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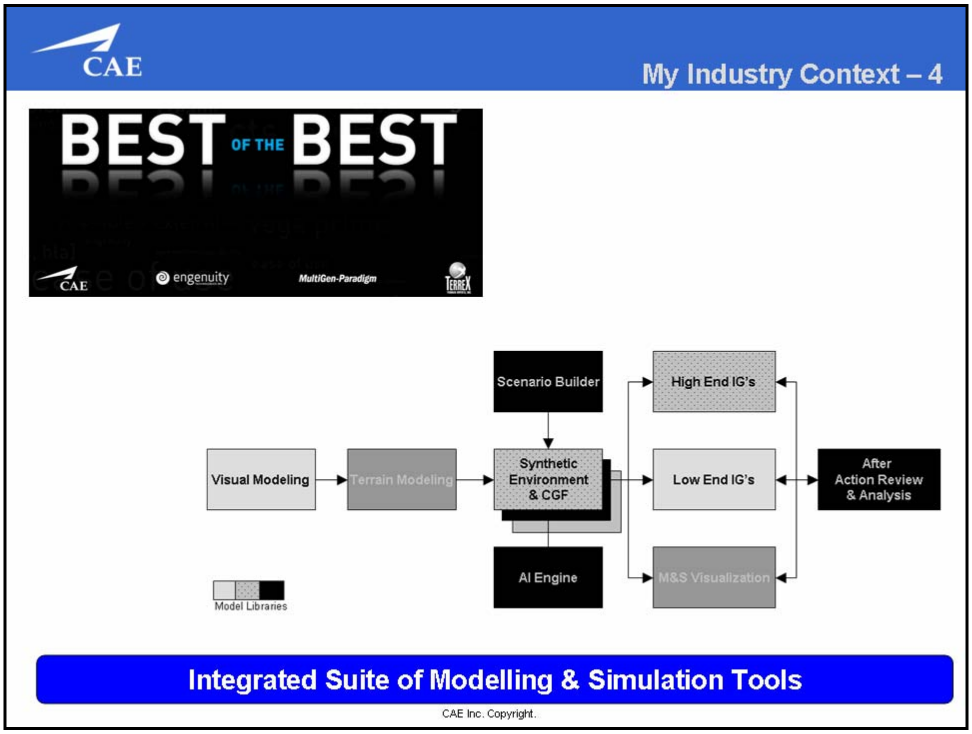
CAE
My Industry Context – 4
BEST OF THE BEST
engenuity
MultiGen-Paradigm
Scenario Builder
High End IG's
Visual Modeling
Terrain Modeling
Synthetic Environment & CGF
Low End IG's
After Action Review & Analysis
AI Engine
M&S Visualization
Model Libraries
Integrated Suite of Modelling & Simulation Tools
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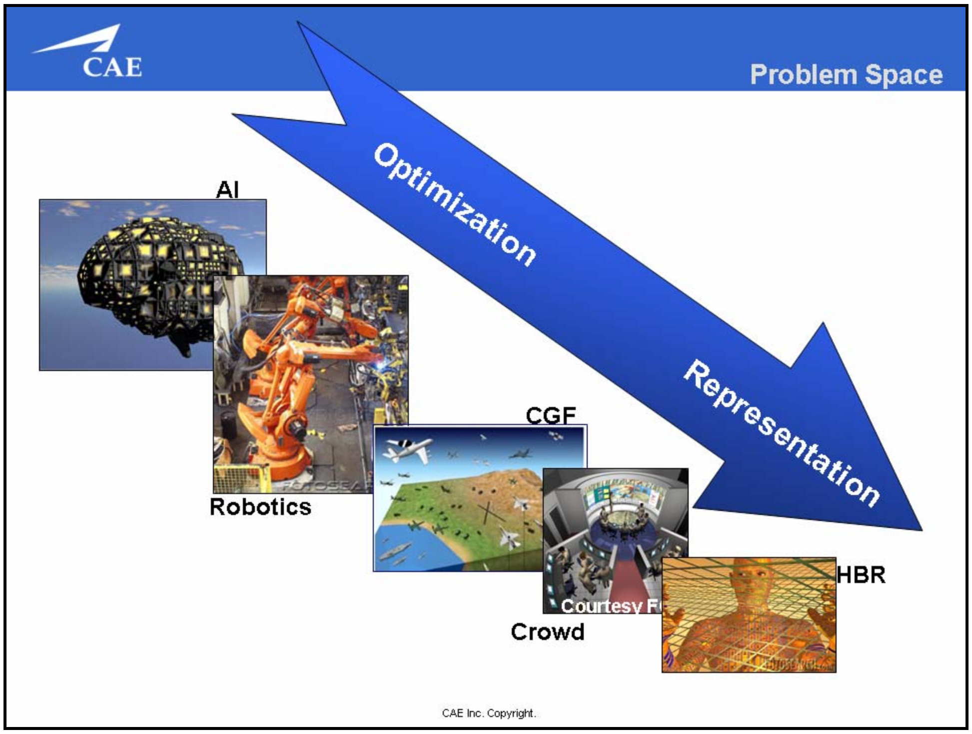
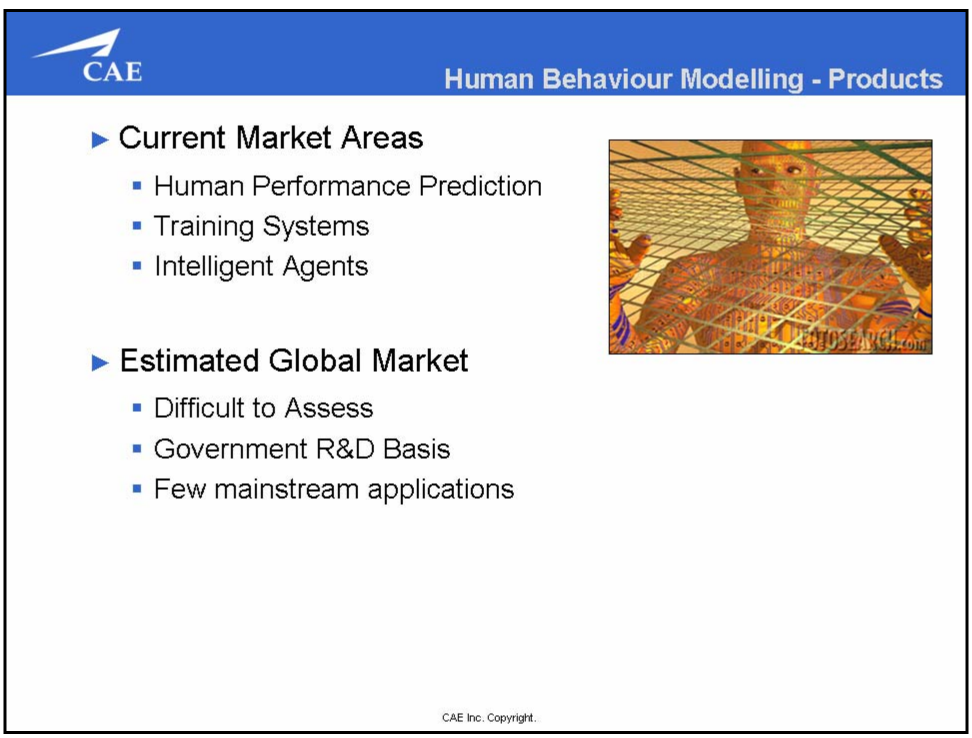

CAE
Problem Space
Optimization
Representation
AI
Robotics
CGF
Crowd
HBR
CAE Inc. Copyright.


CAE
Human Behaviour Modelling - Products
► Current Market Areas
▪ Human Performance Prediction
▪ Training Systems
▪ Intelligent Agents
► Estimated Global Market
▪ Difficult to Assess
▪ Government R&D Basis
▪ Few mainstream applications
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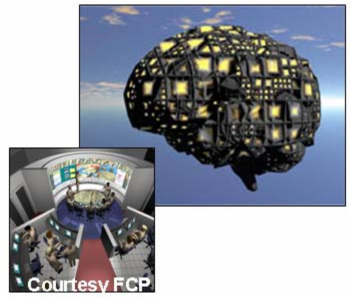
Artificial Intelligence

Current Market Areas
- Dynamic/Intelligent Systems
- Knowledge Management/Decision Aids
- Data Mining
- Interactive Media
- Economic Forecasting
- Environmental Prediction & Analysis
- Expert Systems
- Automated/Autonomous Systems


Courtesy FCP

- Estimated Global Market
  - ~900$ Million USD (US Department of Commerce, 1993)
  - ~11.9$ Billion USD (BCC, 2002)
  - +21$ Billion USD (BCC, 2007)

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Robotics

- Current Market Areas
  - Industrial Manufacturing (Automotive, Aerospace, Marine)
  - Autonomous Systems
    - Aerospace and Ground Vehicles
  - Medical Systems
  - Nanotechnology

- Estimated Global Market
  - +16$ Billion USD (BCC, 2007)
  - +24.3$ Billion USD by 2007

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CGFs

- Current Market Areas
  - Military Simulation
  - Emergency Response
  - Civilian Response
  - Infrastructure Analysis (BP)

- Estimated Global Market
  - Up to $1B of global activity mixed between a large services market around the application of Government Off the Shelf (GOTS) technologies and a smaller COTS technology demand.

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Crowd Modelling

- Current Market
  - Simulation & Training
  - Games & Entertainment
  - Autonomous System Control
    - UAVs/UGVs
    - Nanotechonology
  - Command & Control

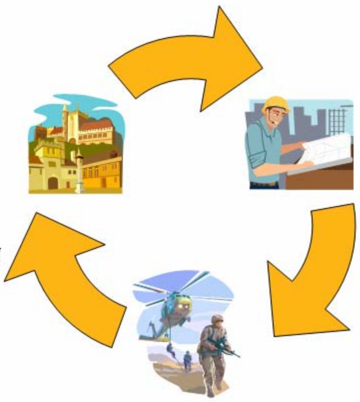
- Estimated Global Market
  - ~3.5$ Million USD in G&E
  - Growing new markets in defense, homeland defense, urban planning, architecture, among others.

CAE

Problem Space

History of Development

- Requirements evolved from military simulations
  - CGFs
  - Performance Prediction
  - Acquisition Support
  - Training Applications
- Theory evolved from academia
  - Cognitive Science/Psychology
  - Computer Science
- Implementation dependant on Industry
  - Product Development
  - Software Integration

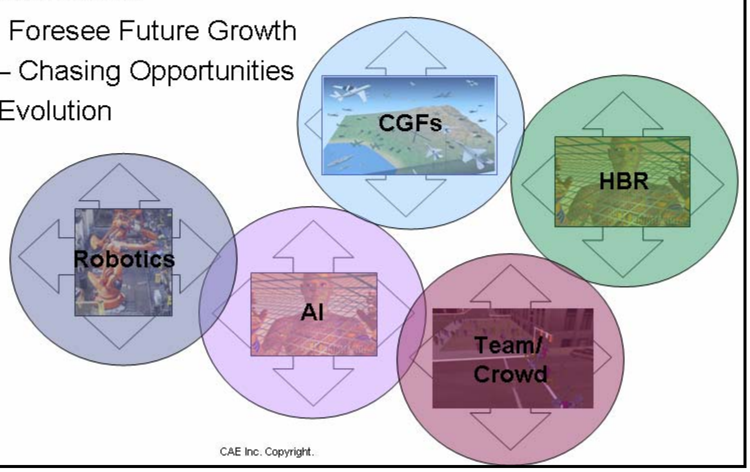


CAE

Problem Space

Current Approach

- Fragmented
- Minimal Cohesion
- Minimal Coordination
- Difficult to Foresee Future Growth
- Reactive – Chasing Opportunities
- Requires Evolution



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Problem Space

- **Fragmented Industry**
  - Low barriers to entry
    - Many specialized firms
    - Similar to fledgling AI industry in 1980s
  - Highly Specialized Market
    - Niche oriented
    - Independent evolution of technology
    - Multiple toolsets for similar requirements
    - *Dependent on Services for implementation*
  - Lack of Standardization
    - Awareness of requirement
    - Problems for integration

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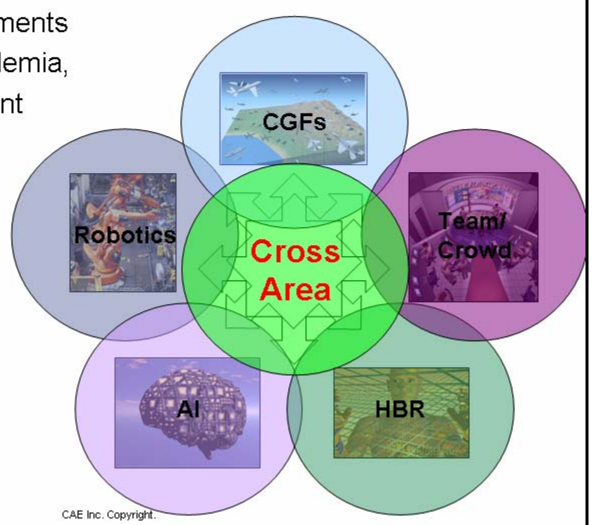
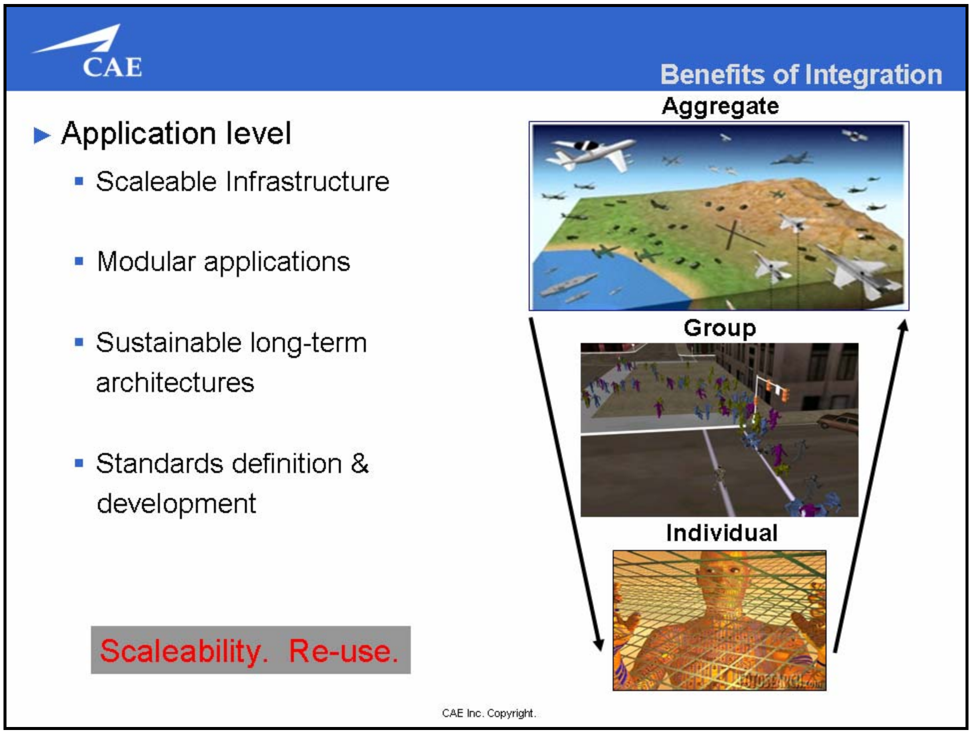
Future Requirements

- **Domain Evolution**
  - Interaction across areas
  - Define global requirements
  - Defined roles of Academia, Industry & Government




CAE
Benefits of Integration
Application level
Scaleable Infrastructure
Modular applications
Sustainable long-term architectures
Standards definition & development
Scaleability. Re-use.
Aggregate
Group
Individual
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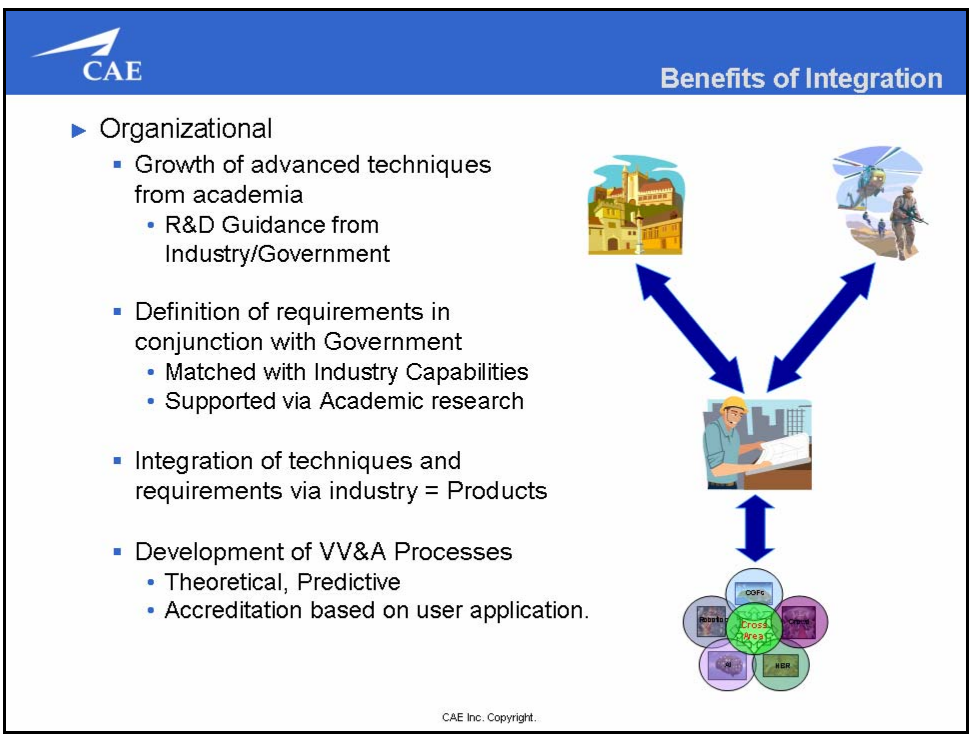
CAE
Benefits of Integration
Organizational
Growth of advanced techniques from academia
R&D Guidance from Industry/Government
Definition of requirements in conjunction with Government
Matched with Industry Capabilities
Supported via Academic research
Integration of techniques and requirements via industry = Products
Development of VV&A Processes
Theoretical, Predictive
Accreditation based on user application.
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Thank You
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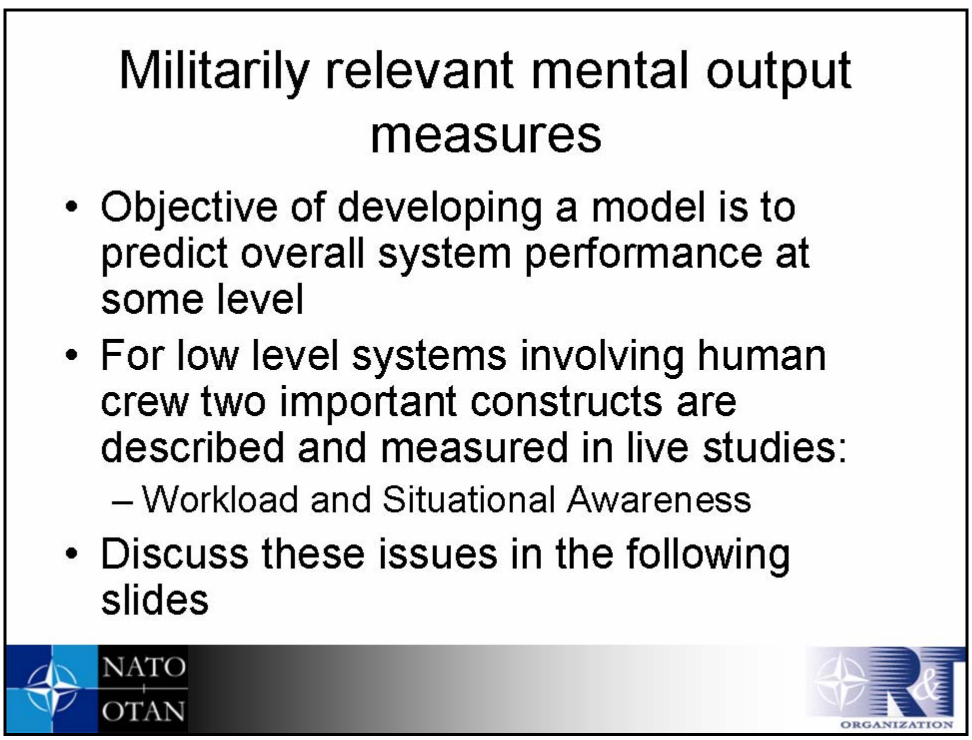
A3.7 MILITARILY RELEVANT MENTAL OUTPUT MEASURES



Workload

- A measure of resource demand on the members of the crew
- Important element is time
- Definition of workload involves the idea of rate of resource consumption per unit time
- Less than 100% - fine > 100% problems

Modelling workload

- Many models of workload have been developed
- POP, IP/PCT, POPIP, W/Index, VACP
- POP predicts changes in performance does not address scheduling
- POPIP, IP/PCT models scheduling
- Is a model of workload useful if it does not predict performance/behaviour effects?
- If we can predict performance do we need to predict a measure of workload?

Situational Awareness

- Best definitions of SA articulate the basic idea that people need understanding to make good decisions
- Understanding can be defined as having a mental model of how the "world" will evolve that is consistent with reality
- Access to and acquisition of relevant information is part of the problem but is not sufficient

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Metrics?

- We can model the possession of a good mental model
- In principle could define metrics for a model that we cannot define for live experimental subjects
- Is that useful?
- If behaviour is good and performance is good do we need to define the abstraction comprising SA?

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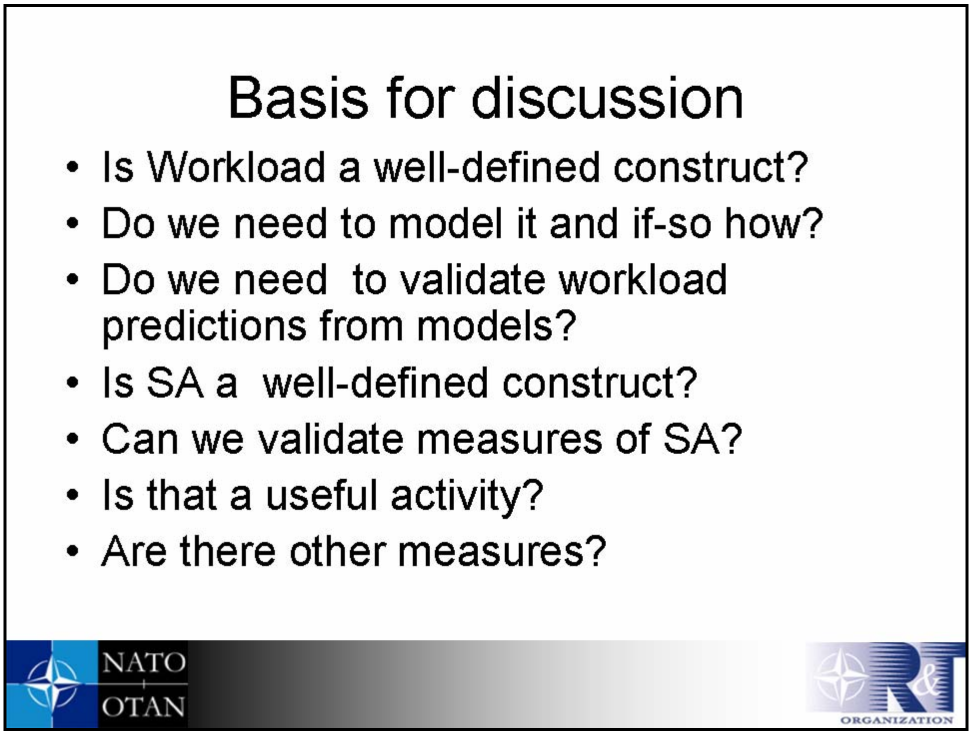
Basis for discussion
• Is Workload a well-defined construct?
• Do we need to model it and if-so how?
• Do we need to validate workload predictions from models?
• Is SA a well-defined construct?
• Can we validate measures of SA?
• Is that a useful activity?
• Are there other measures?
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OTAN
ORGANIZATION

Workload Constructs and Models

Joe Armstrong

CAE

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Workload Concepts

- Operator Workload
  - Non-uniform concept (Hart & Staveland, 1988; Xie & Salvendy, 2000)
  - Hypothetical Construct vs Intervening Variable (Gopher & Donchin, 1986)
  - Meta-cognitive
- Multi-Dimensional
  - Task demands vs resources (Wickens, 2002; Young & Stanton, 2002)
  - Dynamic & Static Attributes (North & Riley, 1989; Hendy & Farrell, 1997)
  - Non-attentional parameters (Kahneman, 1973; Meshtaki, 1988)
    - Task environment
    - Moderating variables (e.g. arousal, motivation, emotion)

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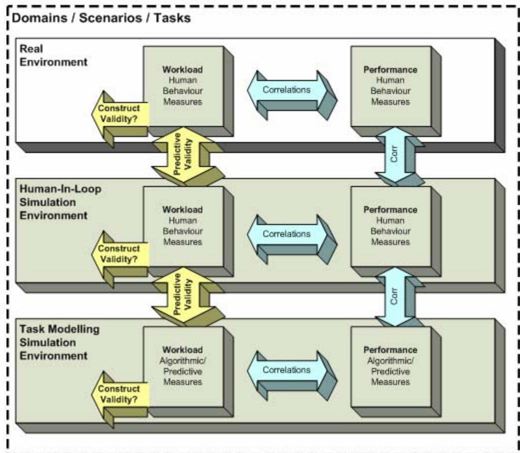
Workload Measurement Techniques

- Categories of Workload Measurement
  - Workload Assessment
    - **Measurement** of dynamic operator workload in complex system
    - Can be applied to
      - Real, Applied Situations
      - Simulated Environments
  - Workload Prediction
    - Development of computational models of workload
    - Used to **Predict** performance a priori
      - Models of Human Behaviour/Cognition
      - Synthesized Environments



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Algorithmic/Predictive Measures

- Applications
  - Diagnostic workload predictions
  - Implemented within Computational Simulations
    - Mathematical/Algorithmic
    - Task Analysis
    - Computer Simulation
- Major Categories
  - Discrete Event Simulations (Task Network Modelling)
  - Cognitive Architectures

CAE — Task Network Modelling

- General Assumptions
  - Human Behaviour Modelled as Interrelated Tasks
  - Performance Values Assigned by Developer
    - Time/Accuracy
    - Task Demands
  - Sequences managed by a discrete event simulator
    - IPME
    - IMPRINT
    - SAINT/MicroSAINT

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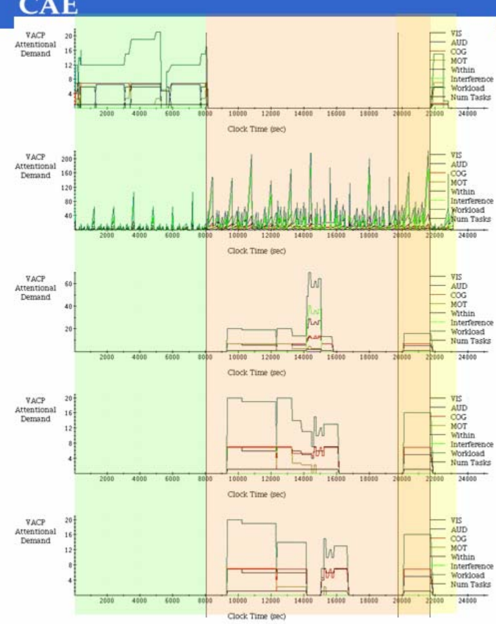
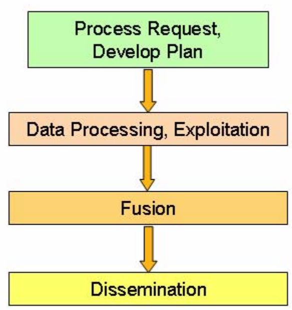


General Model



VIS – Visual
AUD – Auditory
COG – Cognitive
MOT – Psychomotor
} Attentional Demand
Within
Interference
Workload
} W/Index
Num Tasks

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Scheduler/Performance Algorithms

- Qualitatively Different than VACP or W/INDEX
  - Measure impact of task demands on task performance
  - Simulates scheduling of tasks based on demand
- Two Major Theories
  - IP/PCT
  - POP & POPIP

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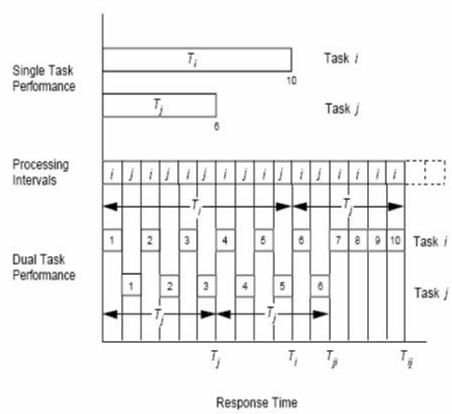
The IP Model



Time-multiplexing in concurrent task processing (Hendy, 2003)

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Cognitive Architectures

- General Assumptions
  - Theories of cognition (Keiras & Meyer, 1997)
  - Not workload specific
    - By-product of overall performance
    - Intervening variable/hypothetical construct
- Major Players
  - ACT-R (Anderson, 1993)
  - SOAR (Laird, Newell, and Rosenbloom, 1987)
  - COGNET (Zachary, Ryder, Ross & Weiland, 1992)
  - EPIC (Keiras & Meyer, 1997)

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Cognitive Architectures

- Relation to Workload
  - Functional/Task distinction
    - Task behaviour related to knowledge
      - Procedural/declarative
    - Functional components of cognition
      - Perception, Audition, Psychomotor Functions
  - Task performance
    - Inferred from operation of architecture

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Validation Overview

- Contrast of Verification & Validation

Is the model a reflection of the task environment?
(Verification)
Vs

Does the model predict reality?
(Validation)

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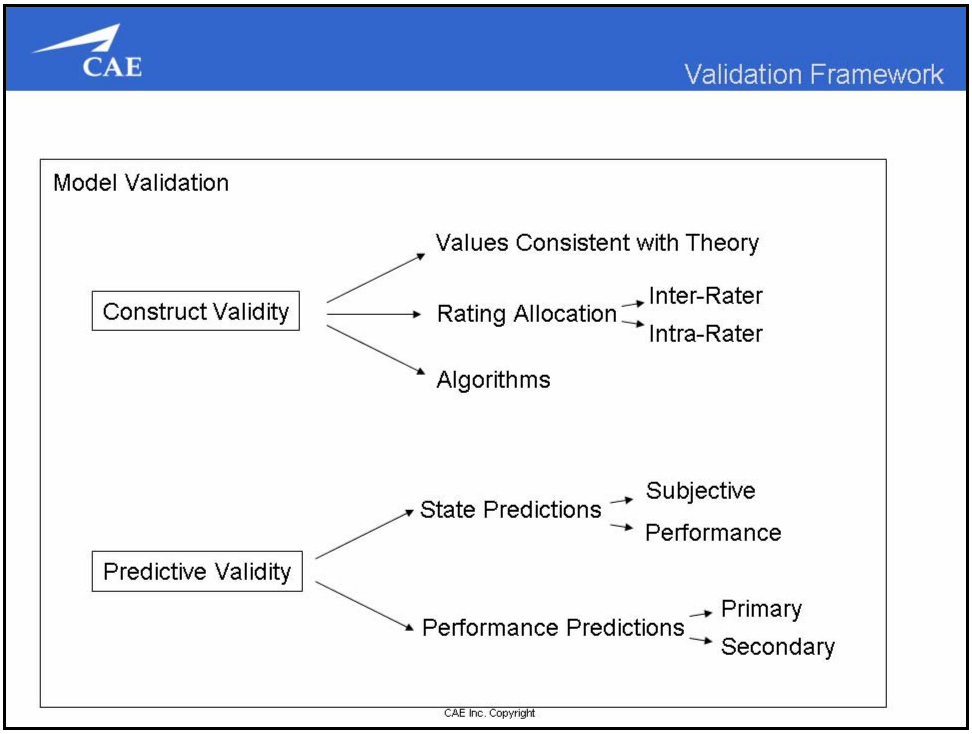
Concepts of Validation

- Criterion
  - Predictive and Concurrent (Cronbach & Meehl, 1955)
  - Task Performance vs Subjective Estimates
- Content
  - Measuring internal constructs (e.g. task performance/resource demand is a measure of workload)
- Construct
  - Computational Model = Workload Construct


CAE
Validation Framework
Model Validation
Construct Validity
Values Consistent with Theory
Rating Allocation
Inter-Rater
Intra-Rater
Algorithms
Predictive Validity
State Predictions
Subjective
Performance
Performance Predictions
Primary
Secondary
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END
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A3.8 THE CONCEPT OF MODERATORS

Concept of moderators

NATO Specialist Meeting
Toronto May 31 2007
Andy Belyavin, QinetiQ

Concept of moderators

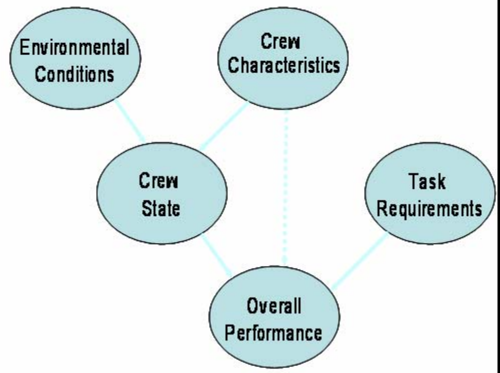
- Human performance differs from the performance of physical components in a system in that it changes with well-known effects such as fatigue or other environmental stress.
- Different individuals perform and behave differently in the same context so the full spectrum of human variability involves both inter- and intra-individual variability.
- The drivers of these differences are termed moderators

Classification of moderators

Moderators can be allocated to three groups:

- external moderators (stressors)
- internal moderators (personal attributes)
- collective moderators

Individual stressors



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Key external moderators

- Environmental impact:
  - Sleep loss fatigue/circadian effects and time on task
  - Physical fatigue
  - Thermal effects (thermal strain, dehydration, discomfort)
  - Effects of visual environment
  - Fear, anxiety, morale
  - Task demand — workload

Sample development since 1995

- Development of SAFE by DERA/QinetiQ to model the effects of fatigue, circadian rhythm and time-on-task implemented in IPME
- Development of thermal models that can be coupled to task network models.
- BAE SYSTEMS ORACLE vision model coupled to IPME
- DERA/QinetiQ developed the Prediction of Operator Performance (POP) Workload model – validated in experiments

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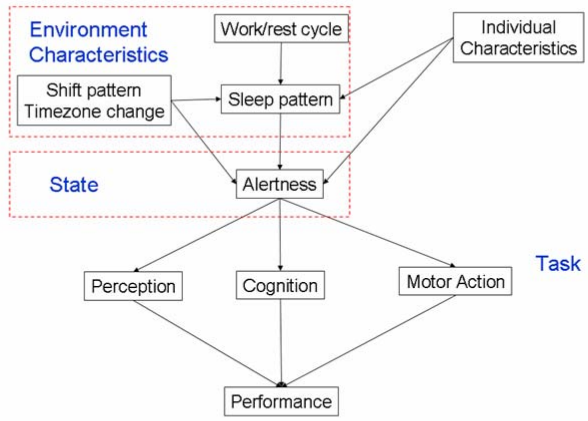
Detailed model of sleep loss



Key internal moderators

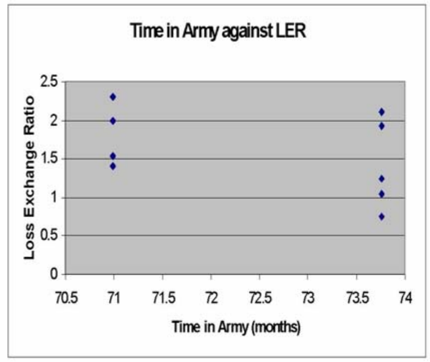
- Personal characteristics
  - Training
  - Experience
  - Personality – including coping style and culture
  - General intelligence

Sample Development since 1995

- Development of the Performance Shaping Function for Experience by QinetiQ
- Development of Performance Shaping Function for the effects of training based on standard results by Micro-Analysis and Design
- Representation of effect of skills in IMPRINT to enable allocation of roles

Key collective moderators

- Collective characteristics
  - Training
  - Experience
  - Ad-hoc team
  - Cohesion
  - Leadership
  - Culture/Organisation



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Modelling moderator effects

- Modelling the effects of external moderators is best developed area
- Many stressors have been the subject of detailed research for more than 60 years
- Can build good physiological models and model effects of stressors on state; state to performance and behaviour not as good
- Other areas not as advanced

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Problems

- Defining a minimal set of states that affect performance and behaviour is not complete
- The impact of even those states that have been identified is not well-defined
- Behavioural effects are least developed
- A data-limited area

Questions

- For what applications do we need to solve the moderator problem?
- Can we ignore moderators across a range of problems?
- How do we develop valid models if we need to?
- How do we deal with potential moderator interactions?

A word or two about moderators

or a bird in the hand…

Dr. Laurel Allender

The idea

- Take published data
- Derive general degradation factors
- Associated with different task types
- Take modeled tasks
- Denote as task type X (up to 3 task types with weights = 1)
- Apply degradation factor to modeled task
- Run model and compare with non-degraded baseline

PTS

- Personnel characteristics
  - Data collected on 9000 Soldiers, updated w/ longitudinal data
- Training
  - Recently updated
- Stressors
  - Heat + humidity
  - Cold + wind chill
  - Noise
  - Sleeplessness
  - Protective clothing

Task taxonomy

- Fine motor discrete
- Fine motor continuous
- Gross motor light
- Gross motor heavy
- Visual
- Auditory
- Cognitive – decision making…
  - (a la Berliner, see Fleishman)

The general formula *(notional data)*

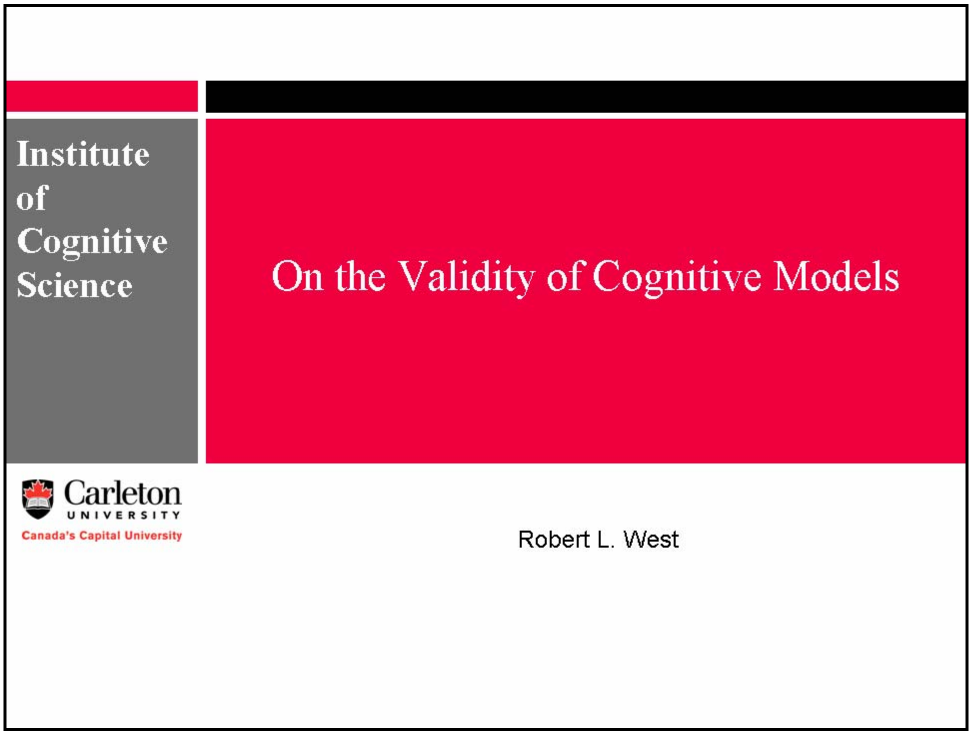
- Performance moderator effects on tasks as a function of task type
  - e.g., hours since last sleep 20 hours = performance decrease of 5% for cognitive tasks
  - derived from published data
  - % decrease applied to performance estimates attached to cognitive tasks in network model

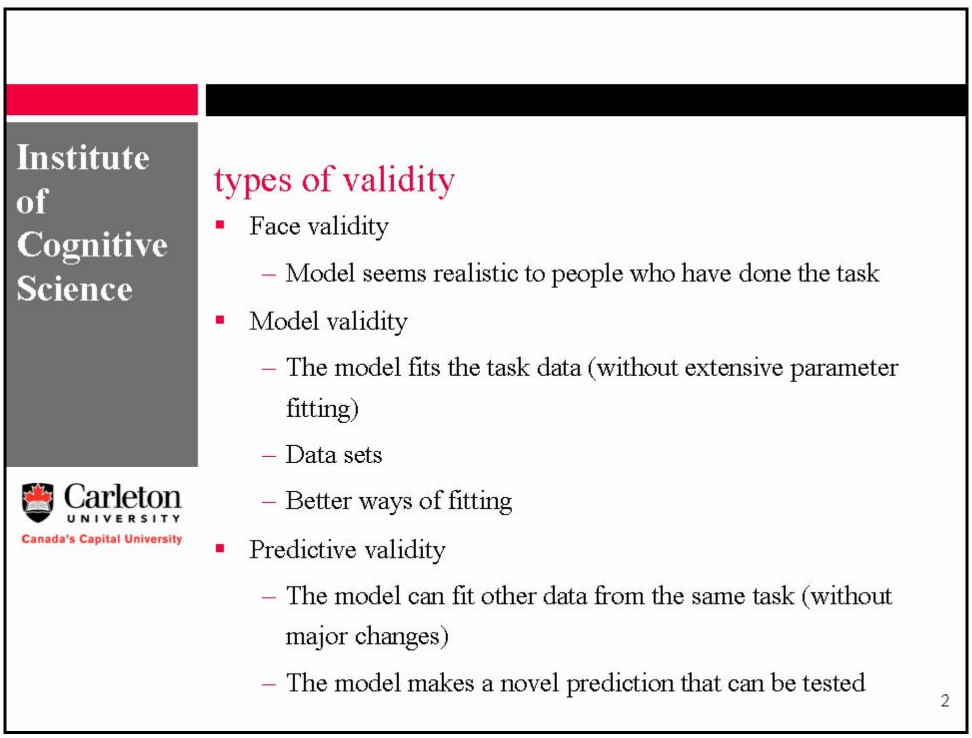
An existing modeling tool

IMPRINT
Improved Performance Research Integration Tool

- with numerous applications to Army systems

A3.9 COMPLEXITY, HIERARCHY, MODULARITY AND VALIDITY IN HBR ARCHITECTURES





Institute of Cognitive Science

Carleton UNIVERSITY
Canada's Capital University

types of validity

- Architecture validity
  - Model uses a well researched architecture (with no hidden tricks)
  - Good architecture
    - Many studies showing that it accurately predicts human behavior across a wide variety of tasks
    - Established parameter values
    - Neural correlates
  - Offloads validity onto universities
    - If the architecture is open source
      - E.g., SOAR, EPIC, LIBRA, ACT-R

3

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types of validity

- Agent validity
  - Model is consistent with other models of similar tasks
  - Goal should be to develop agents that have general skills
    - e.g., driving
- Comparative validity
  - Are other models of the same thing similar or different?
  - Is there convergence?
  - If not is there some way to compare competing models
- Publishing
  - Models need to be accessible

4


Institute of Cognitive Science
Thank You
Questions??
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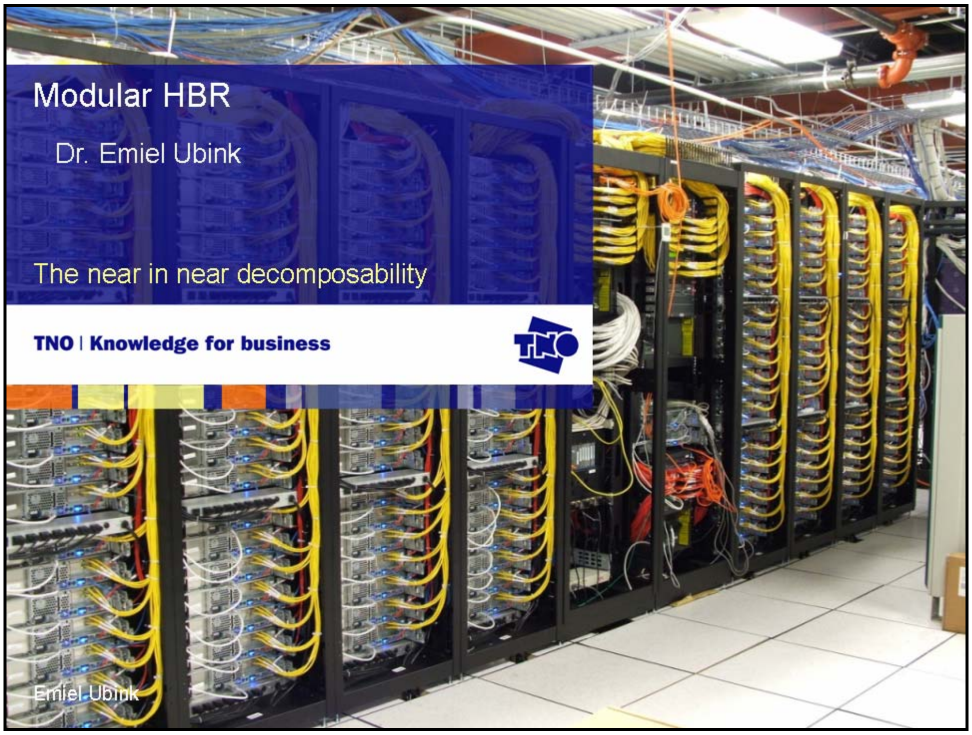
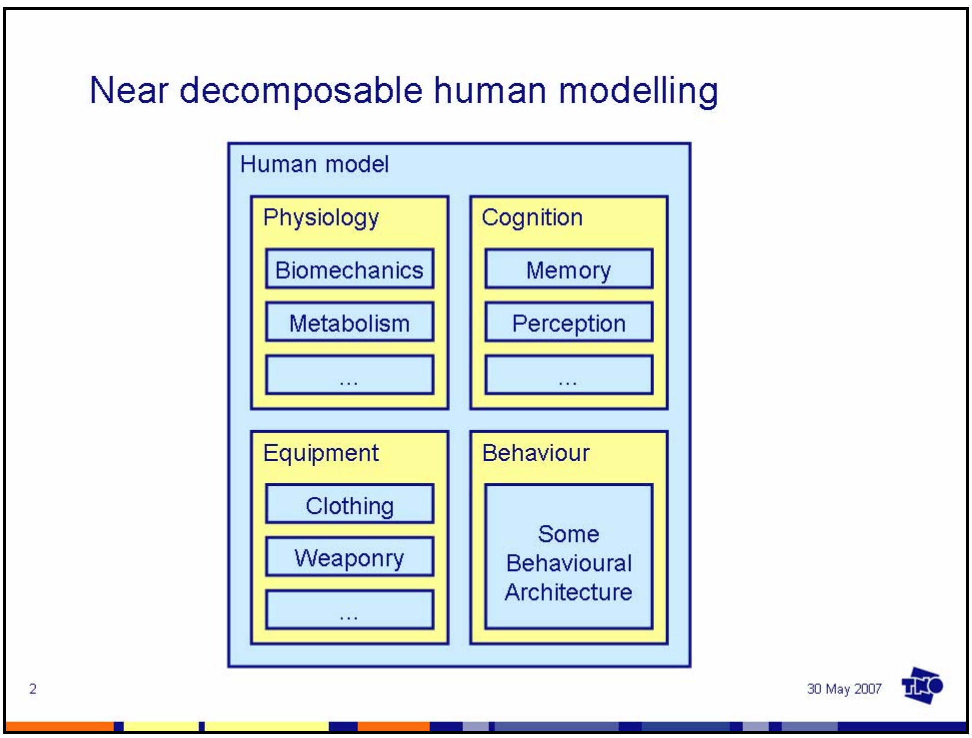
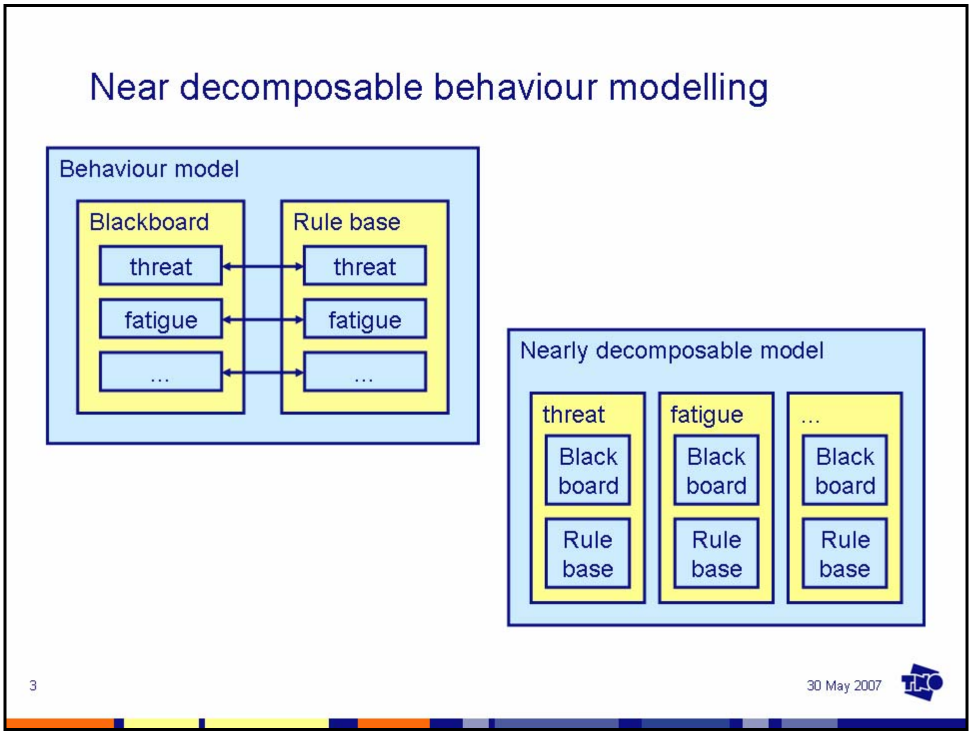
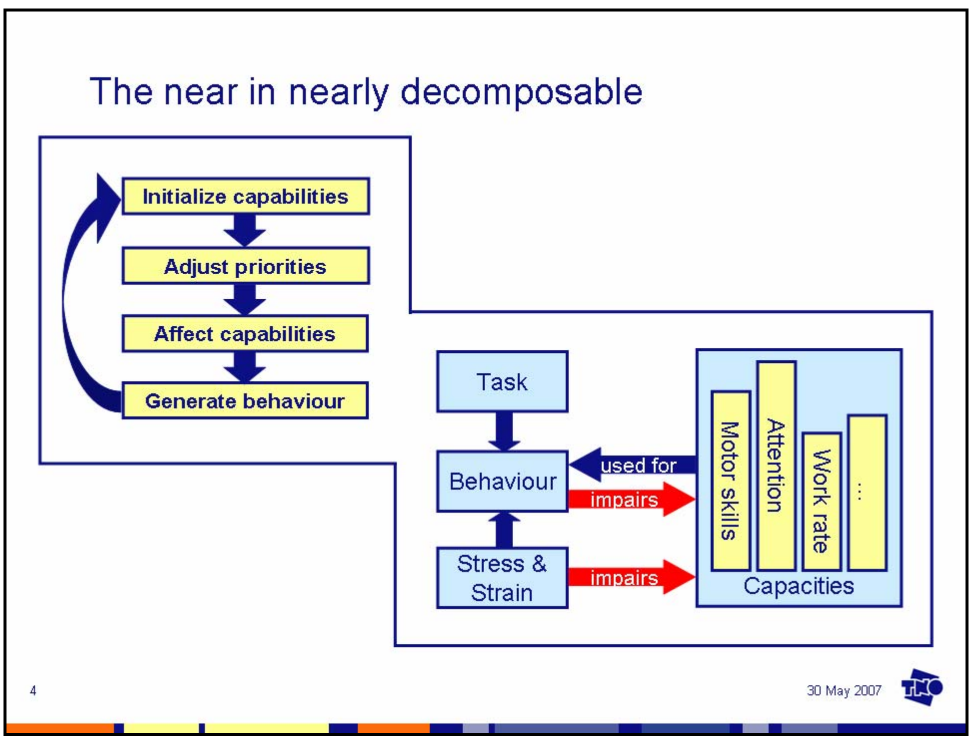
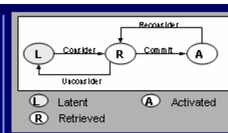

Modular HBR
Dr. Emiel Ubink
The near in near decomposability
TNO | Knowledge for business
Emiel Ubink


Near decomposable human modelling
Human model
Physiology
Biomechanics
Metabolism
...
Cognition
Memory
Perception
...
Equipment
Clothing
Weaponry
...
Behaviour
Some Behavioural Architecture
2
30 May 2007


Near decomposable behaviour modelling
Behaviour model
Blackboard
threat
fatigue
...
Rule base
threat
fatigue
...
Nearly decomposable model
threat
Black board
Rule base
fatigue
Black board
Rule base
...
Black board
Rule base
3
30 May 2007


The near in nearly decomposable
Initialize capabilities
Adjust priorities
Affect capabilities
Generate behaviour
Task
Behaviour
Stress & Strain
used for
impairs
impairs
Motor skills
Attention
Work rate
...
Capacities
4
30 May 2007



Comparative Analysis of Frameworks for Knowledge-Intensive Intelligent Agents

Randolph M. Jones

Robert E. Wray

30-31 May 2007

NATO Specialists Meeting HFM-143/RSM On

Human Behaviour Representation in Constructive Modeling

Motivations

- Software engineering principles have been applied mostly to "light" agent architectures
- Cognitive and agent architectures share more with each other than commonly recognized
  - How can we evaluate until we can compare?
  - We need a common language for intermediate components
- Better reuse would benefit applications development as well as science
  - Easier to build new models and new architectures
  - Easier to integrate models into applications
  - Easier to communicate success to broader communities

Knowledge-Rich Intelligent Agents

- Significant encodings of knowledge
  - Contrast with "Light" agents: limited, restricted capabilities
  - Intended to perform the role of one or more humans
- Integrated with non-trivial environments
  - Dynamic, unpredictable, inaccessible, continuous
  - Often require real-time response
- Situation interpretation/representation a essential part of decision making
- Long-lived ("enduring") in many dimensions
  - Execution time
  - Software life cycle

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Goals for Architectures for Intelligent Behavior

- Comprehensive
  - Explicit support of common architectural processes and representations
- Scalable
  - Engineered for efficiency and composability
  - Designed around abstract component interfaces
- Stable
  - Well-defined abstract component types
  - Well-engineered implementation
- Easy to use
  - Extensible
  - Integrated design with high-level formal abstractions (languages, libraries, tools)

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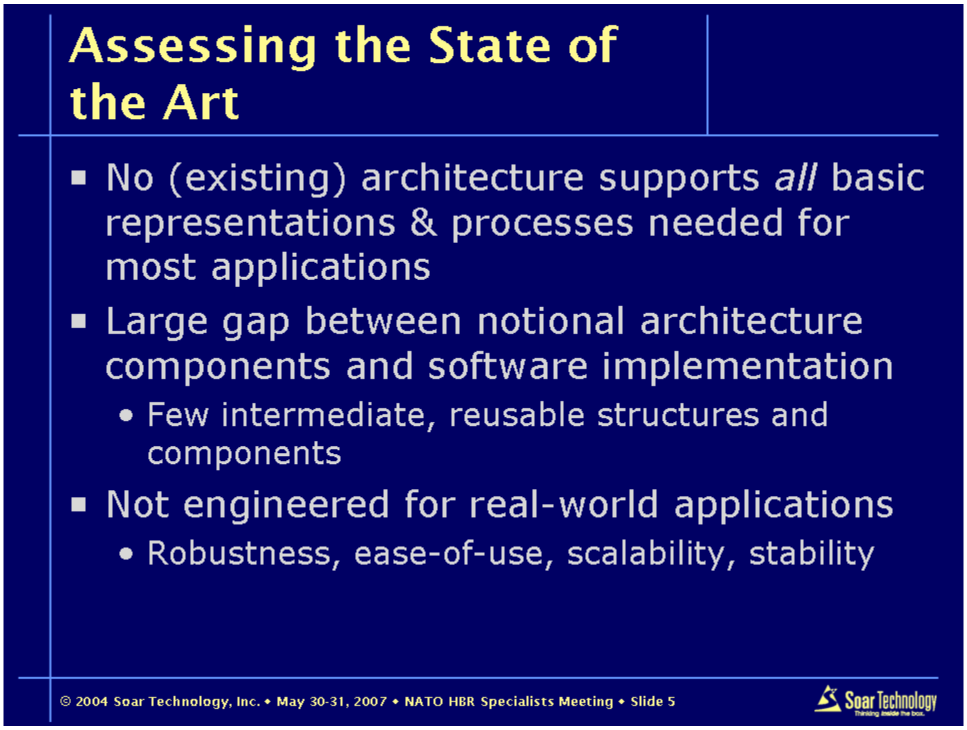
Assessing the State of the Art
No (existing) architecture supports all basic representations & processes needed for most applications
Large gap between notional architecture components and software implementation
Few intermediate, reusable structures and components
Not engineered for real-world applications
Robustness, ease-of-use, scalability, stability
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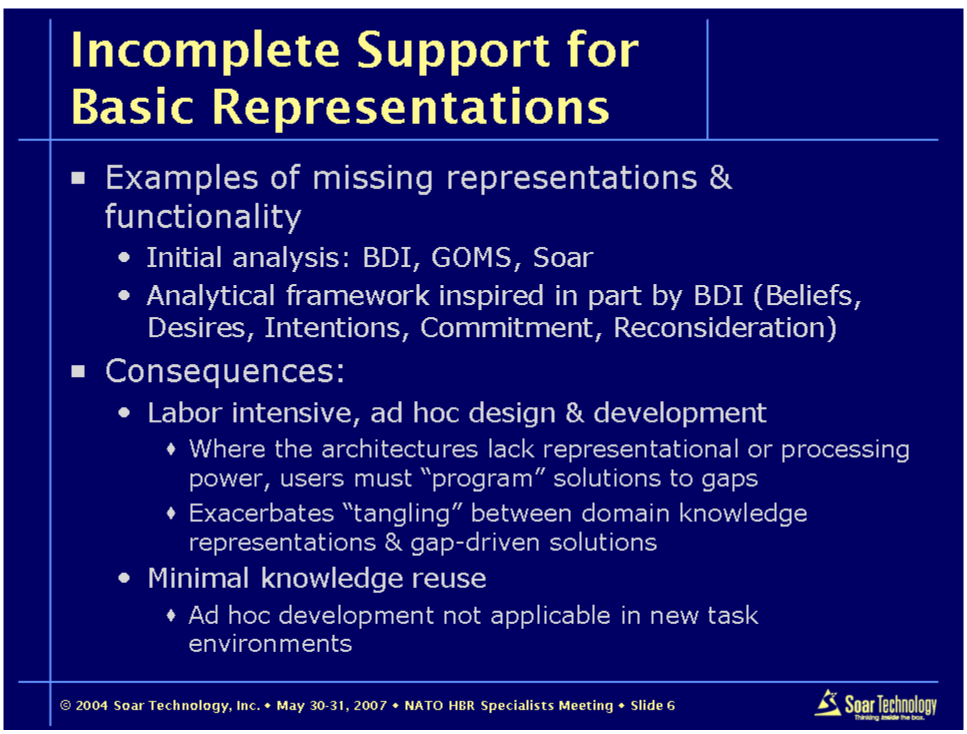
Incomplete Support for Basic Representations
Examples of missing representations & functionality
Initial analysis: BDI, GOMS, Soar
Analytical framework inspired in part by BDI (Beliefs, Desires, Intentions, Commitment, Reconsideration)
Consequences:
Labor intensive, ad hoc design & development
Where the architectures lack representational or processing power, users must "program" solutions to gaps
Exacerbates "tangling" between domain knowledge representations & gap-driven solutions
Minimal knowledge reuse
Ad hoc development not applicable in new task environments
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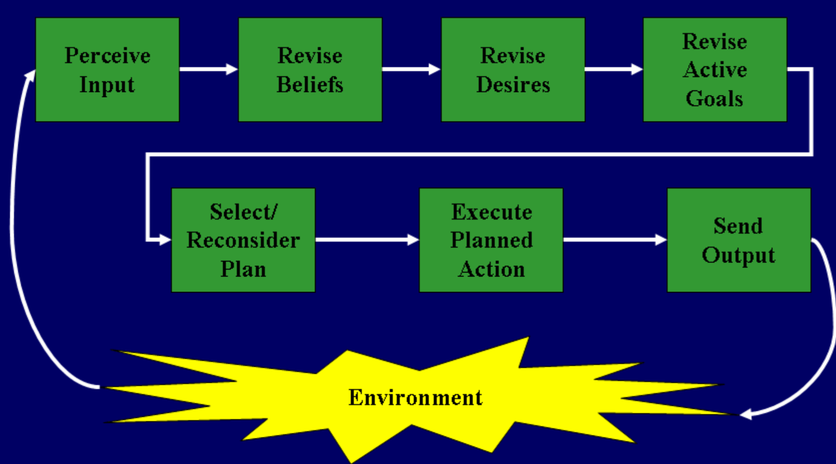
Comparative Framework

- Representational elements
  - Inputs, Justified Beliefs, Assumptions, Desires, Active Goals, Plans, Actions, Outputs
  - Superset of GOMS, Soar, BDI representations; not an exhaustive list
- Design dimensions
  - Representation formalism
    - How is each type of element represented?
  - Commitment strategy
    - Under what conditions does each type of element get selected/activated/instantiated?
  - Reconsideration strategy
    - Under what conditions does each type of element get removed/deactivated/released?

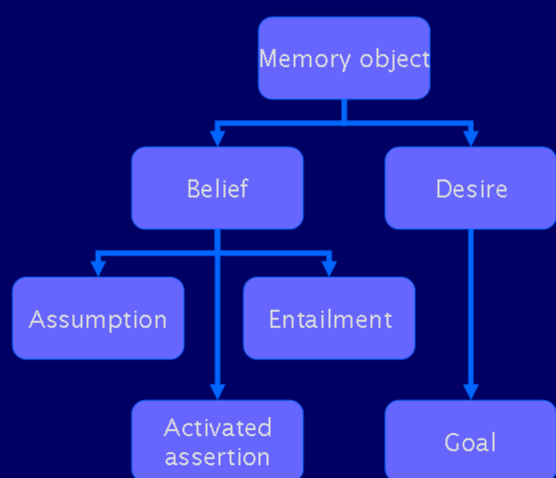
Abstract Knowledge Cycle

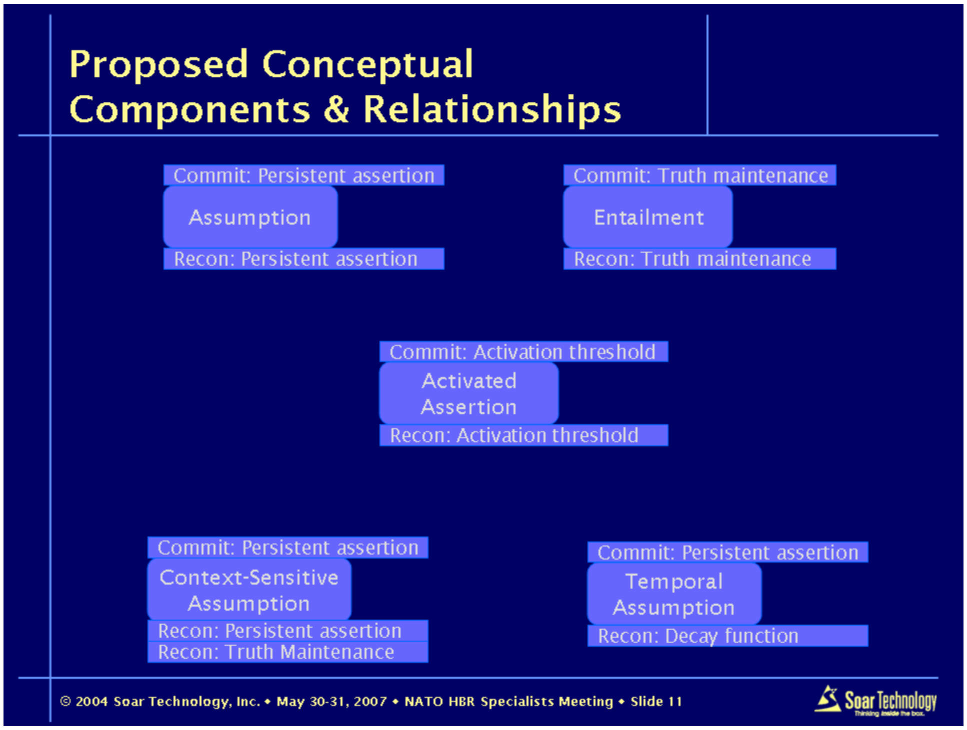


Reusable Abstract Components

- Architectures share only minimal high-level commitments/components
  - Physical symbol systems, problems space hypotheses
  - Long-term, short-term memory
  - Notable exceptions
    - Prodigy: Focus on interoperation between capability-level modules (e.g., EBL and planning)
    - PRISM: Functional, parameterizable abstractions of common architectural components
- Consequences:
  - Little transfer from one architecture to another
  - Hard to understand architecture, changes to architecture (even among user communities)
  - Difficult to investigate integration of new or alternatively designed architectural components

Proposed Conceptual Components & Relationships




Proposed Conceptual Components & Relationships
Commit: Persistent assertion
Assumption
Recon: Persistent assertion
Commit: Truth maintenance
Entailment
Recon: Truth maintenance
Commit: Activation threshold
Activated Assertion
Recon: Activation threshold
Commit: Persistent assertion
Context-Sensitive Assumption
Recon: Persistent assertion
Recon: Truth Maintenance
Commit: Persistent assertion
Temporal Assumption
Recon: Decay function
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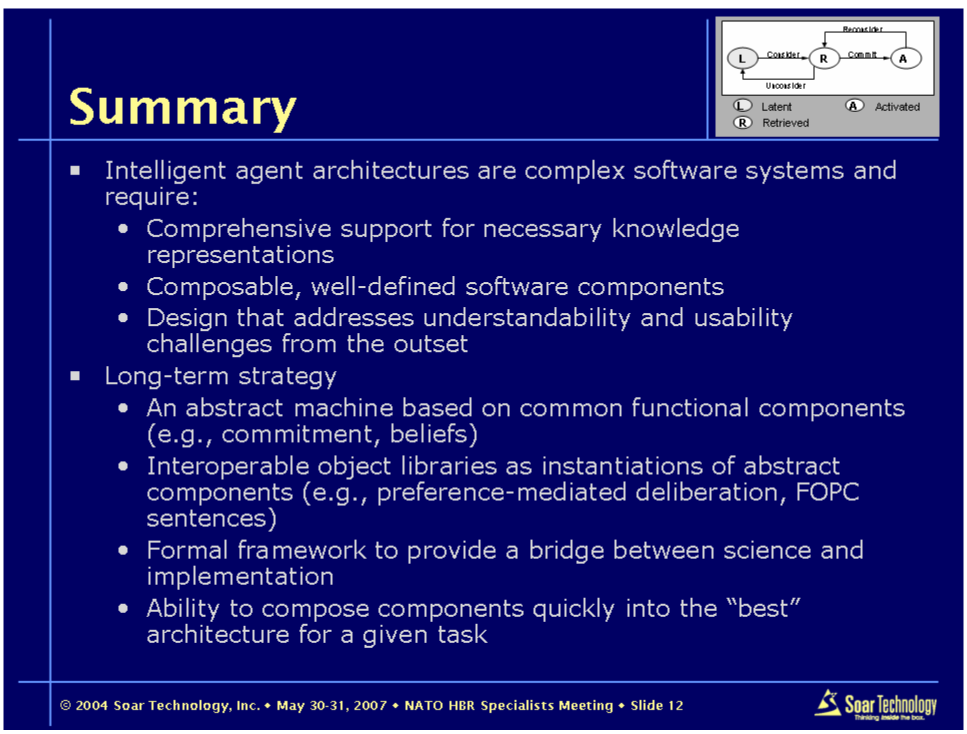
Summary
Reconsider
L
Consider
R
Commit
A
Unconsider
Latent
Activated
Retrieved
Intelligent agent architectures are complex software systems and require:
Comprehensive support for necessary knowledge representations
Composable, well-defined software components
Design that addresses understandability and usability challenges from the outset
Long-term strategy
An abstract machine based on common functional components (e.g., commitment, beliefs)
Interoperable object libraries as instantiations of abstract components (e.g., preference-mediated deliberation, FOPC sentences)
Formal framework to provide a bridge between science and implementation
Ability to compose components quickly into the "best" architecture for a given task
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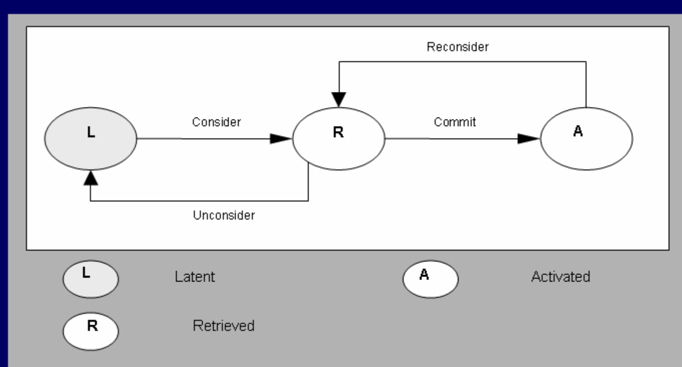
Extra Slides

Unifying View of Memory Operations



CCRU formalism for all architectural components

Review of Selected Agent Frameworks

- BDI
  - Inspired by formal logic/philosophy
  - Formal sense of rationality
  - Focus on logical consistency between beliefs and goals
- GOMS
  - Inspired by psychology
  - Explicit hierarchical task decomposition
  - Explicit pairing of goals with plans
- Soar
  - Inspired by functionality and philosophy
  - Problem-space hypothesis
  - Physical symbol systems hypothesis
  - Focus on minimal but sufficient set of principles

Comparisons

Explicitly supported
Partially supported

Base-level Representation		Representation Language	Mechanism of Commitment	Mechanism of Reconsideration
Inputs	BDI	Input Language		
	GOMS	Input Language		
	Soar	Working memory		
Justified Beliefs	BDI	Beliefs	Logical Inference	Belief revision
	GOMS	Working memory	Match-based assertion	
	Soar	Working memory	Match-based assertion	Reason maintenance
Assumptions	BDI	Beliefs	Plan language	Plan language
	GOMS	Working memory	Operators	Operators
	Soar	Working memory	Deliberation/ operators	Operators
Desires	BDI	Desires	Logic	Logic
	GOMS			
	Soar	Proposed operators	Preferences	Preferences

Comparisons

Explicitly supported
Partially supported

Base-level Representation		Representation Language	Mechanism of Commitment	Mechanism of Reconsideration
Active Goals	BDI	Intentions	Deliberation	Soundness/Decision Theory
	GOMS	Goals	Operators	
	Soar	Beliefs/Impasses	Deliberation	Reason maintenance
Plans	BDI	Plans	Plan selections	Soundness
	GOMS	Methods	Selection	
	Soar			Interleaving
Actions	BDI	Plan language	Atomic actions	
	GOMS	Operators	Operators	
	Soar	Primitive operators	Deliberation	Reason maintenance
Outputs	BDI			
	GOMS	Plan language	Plan language	
	Soar	Working memory	Conditional operators (decoding)	

Reference:

- Jones and Wray (2006) Comparative analysis of frameworks for knowledge-intensive agents. AI Magazine

A3.10 FROM INDIVIDUAL TO GROUP BEHAVIOUR

Topic 7
From individual to group behaviour

Brad Cain

Military simulation:
The early days

Lanchester models

dx/dt + ky = 0

dy/dt + mx = 0

Attrition models of Force-on-Force

Little in the way of "Human Factors"

Human elements are aggregated in the various coefficients

Small teams

- Representation
  - – Single “team” entity
  - – Collection of cooperating individuals
- Individual HF aspects may still be relevant
  - – fatigue, thermal, etc.
- Each approach has pros/cons
  - – entity: conceptually simpler but harder to validate
  - – individuals: shared understanding & comms but more detailed models required to represent interactions

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Additional team attributes

- Additional social elements
  - – communication, feedback
  - – mutual support, monitoring, task sharing
  - – morale, commitment

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OTAN

Large teams and organizations

- Social elements apply to organizations
  - Human Factors modelling requirements
    - goals, procedures, errors, social elements
    - business process models
    - elaborate Lanchester models?
  - Are there HBR requirements in organizational models?
    - perception, reasoning, performance
    - fatigue, thermal

Team models (and organizations?)

- Can we define those essential attributes of teams that require formal models that would make team entity modelling viable?
  - Are validated formal models available?
- Can we model teams of individuals at sufficient resolution and validate them for use in military simulations?
  - What can make this process affordable?
- Can we define the pros and cons of each approach sufficiently so that the military M&S community can make an informed decision about which is the more appropriate in a given context?
- How is an organization representation different from a small team?
  - Do we need to represent explicit EBO behaviours or is it sufficient to represent their “effects”?

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Modelling in Sociotechnical Systems

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Robert L. West
Gabriella Nagy

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Sociotechnical Systems

- Individuals, groups, technology, administration, command and control
- Dynamically interacting with each other and with the environment
- Includes the A space and the B space
  - If you are in B can your model work in A
  - Can A work if B is wrong
  - Can you include a link to A in B

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GOMS

- Card, Moran, & Newell
- Goals, operators, methods, selection rules
- Very representative of the type of model generally used for military simulations
- GOMS models applied to multi-agent sociotechnical systems
  - West & Yeun
  - Kieras & Santoro
- GOMS does not work well!!!!

3

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Hierarchical goal based systems

- These do not work in sociotechnical system because of:
  - Frequent interruptions
  - Frequent opportunistic task switching
- Therefore, models of individual behavior built in this way will not reflect real behavior in sociotechnical systems
- Can this be fixed?????

4

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SGOMS

- Sociotechnical GOMS
  - Augmented GOMS to cope with
    - Interruptions
    - Task switching
  - Not GOMS specific
    - Will work with any hierarchical goal based system

5

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SGOMS

- Unit tasks - cognitive level
  - GOMS - prevents overload and downtime
  - SGOMS - units of work that are not meant to be interrupted
    - If interrupted they must be abandoned or finished before moving on
- Planning unit - social unit
  - Meaningful units of work composed of unit tasks
  - Used for planning work activities
  - Used to manage interruptions and task switching

6

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Planning Units

- Planning
  - Each planning unit is associated with a set of constraints
  - Plans are made by assigning planning units to groups or individuals
- Interruptions
  - Planning units can be interrupted
  - Unit task is completed or abandoned
  - New planning unit is selected based on constraints
  - The new planning unit may have already been worked on

7

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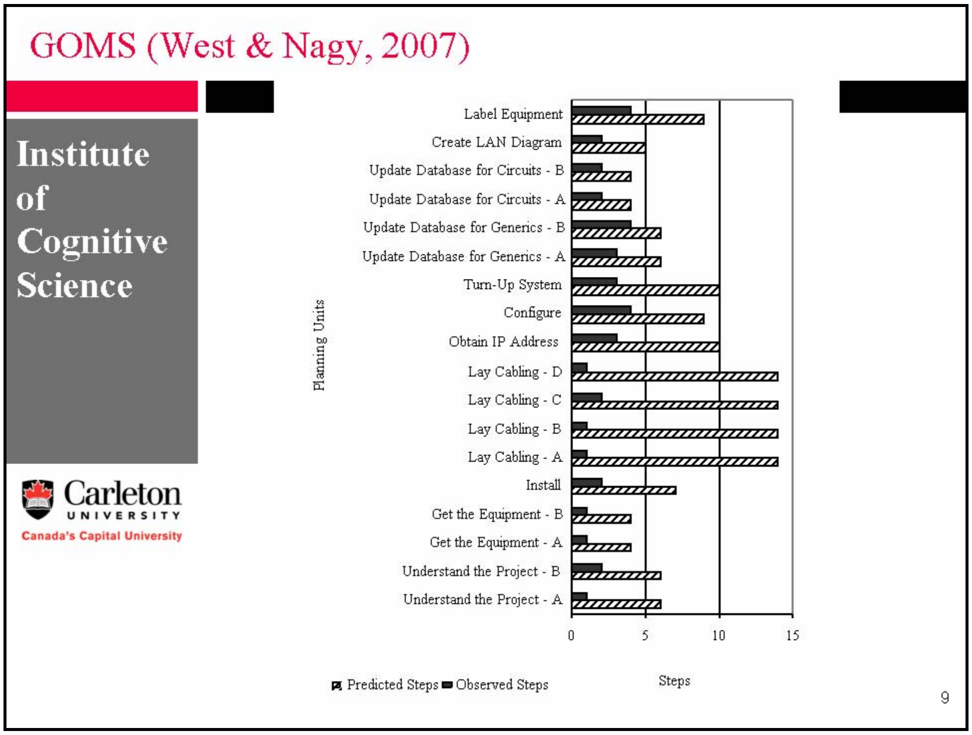
Telcom Study

- West & Nagy (2007)
  - Journal of Cognitive Engineering and Decision Making, Issue 2
  - Tested SGOMS on network maintenance teams at a large Canadian telecommunications company

8


GOMS (West & Nagy, 2007)
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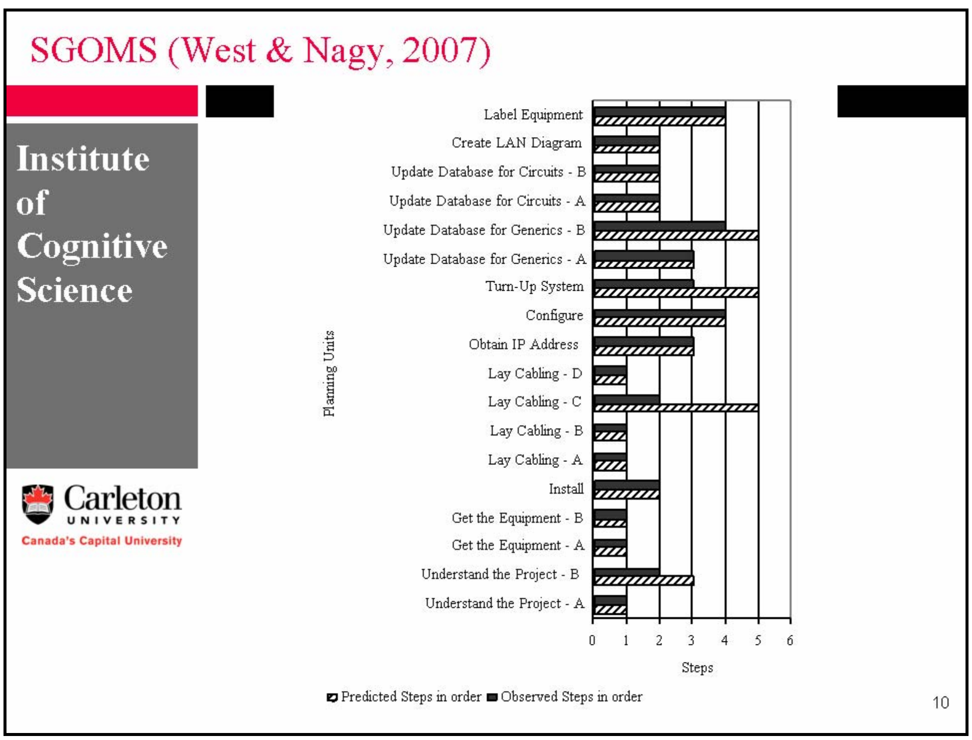
Label Equipment
Create LAN Diagram
Update Database for Circuits - B
Update Database for Circuits - A
Update Database for Generics - B
Update Database for Generics - A
Turn-Up System
Configure
Obtain IP Address
Lay Cabling - D
Lay Cabling - C
Lay Cabling - B
Lay Cabling - A
Install
Get the Equipment - B
Get the Equipment - A
Understand the Project - B
Understand the Project - A
Planning Units
0
5
10
15
Steps
Predicted Steps
Observed Steps
9


SGOMS (West & Nagy, 2007)
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Label Equipment
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Update Database for Circuits - B
Update Database for Circuits - A
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Update Database for Generics - A
Turn-Up System
Configure
Obtain IP Address
Lay Cabling - D
Lay Cabling - C
Lay Cabling - B
Lay Cabling - A
Install
Get the Equipment - B
Get the Equipment - A
Understand the Project - B
Understand the Project - A
Planning Units
0
1
2
3
4
5
6
Steps
Predicted Steps in order
Observed Steps in order
10

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Conclusions

- Hierarchical, goal orientated task models do not predict human behavior in sociotechnical system
- These models are not wrong, just incomplete
  - They seem correct to workers because they map onto how they think about the task

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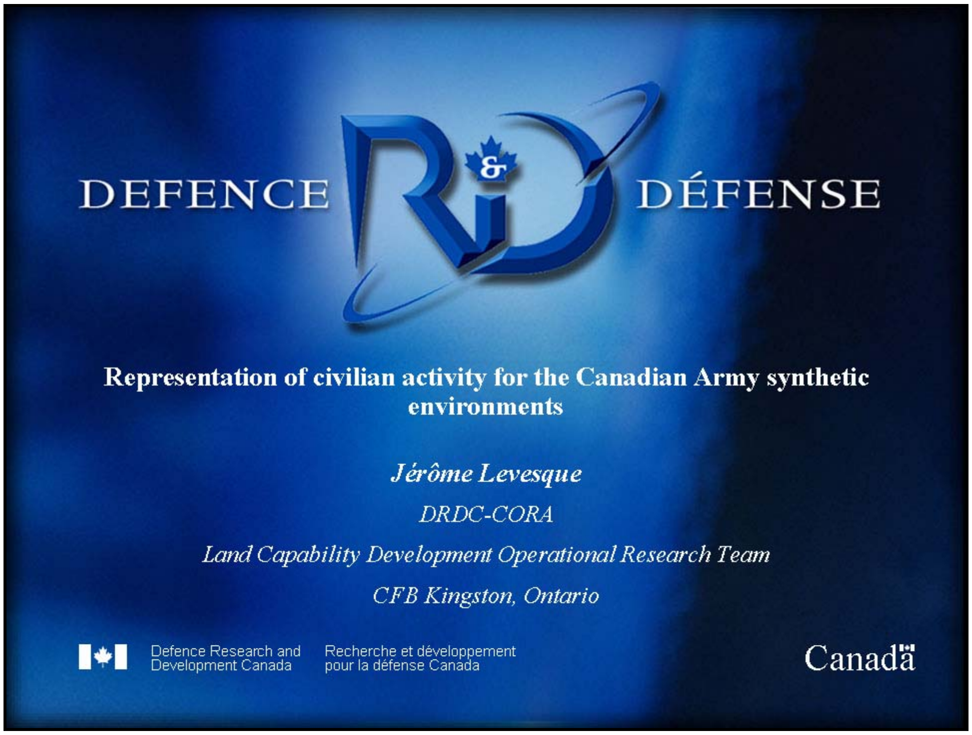
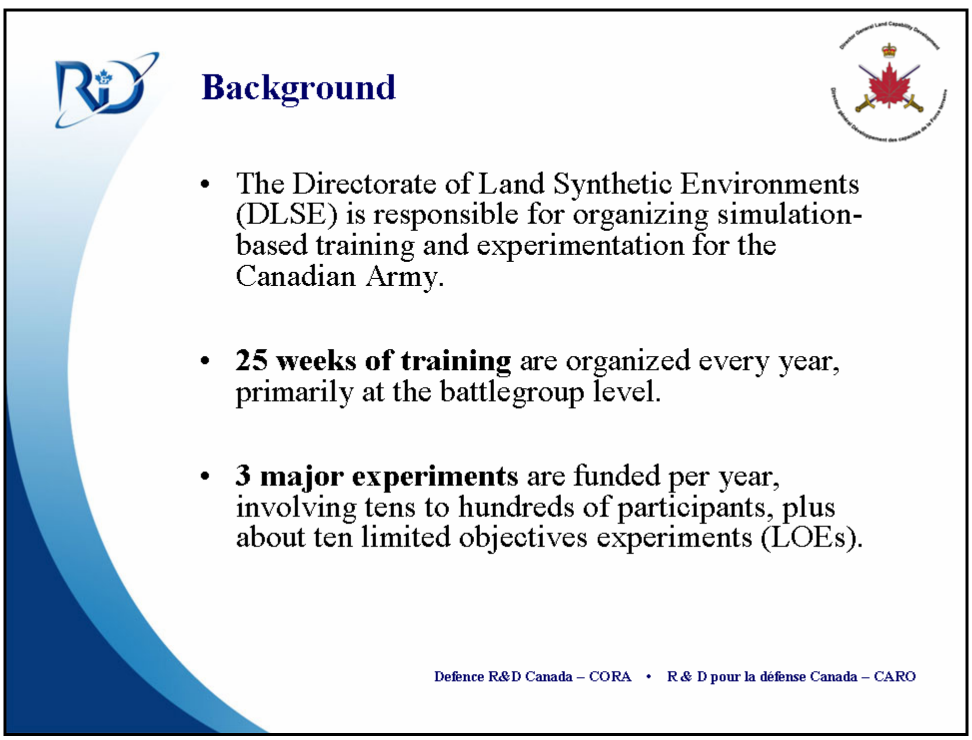
Thank You
Questions??


DEFENCE
DÉFENSE
Representation of civilian activity for the Canadian Army synthetic environments
Jérôme Levesque
DRDC-CORA
Land Capability Development Operational Research Team
CFB Kingston, Ontario
Defence Research and Development Canada
Recherche et développement pour la défense Canada
Canada


Background
• The Directorate of Land Synthetic Environments (DLSE) is responsible for organizing simulation-based training and experimentation for the Canadian Army.
• 25 weeks of training are organized every year, primarily at the battlegroup level.
• 3 major experiments are funded per year, involving tens to hundreds of participants, plus about ten limited objectives experiments (LOEs).
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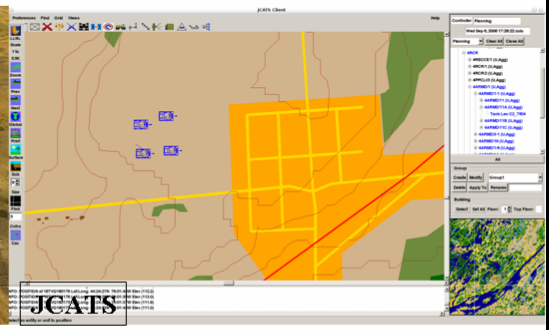
Constructive simulation software

- **JCATS**: Interactive land combat simulation war game
  - Top-down view
  - Units are represented by icons
  - Interactors decide their actions (with *lots* of left/right clicks)
  - Main differences between this war game and RTS:



Simulation of urban environments

- Urban environments involve *civilian activity*:
  - Circulation of persons
  - Urban traffic
  - Formation of crowds, disperse to dense, passive to aggressive.

  NOTE: crowd dynamics is but one aspect of civilian activity…

- Before a model is built we need to:
  - Lay down the training/experimentation objectives.
  - A software platform must be chosen.

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Designing a civilian activity model requires the assessment of several human factors

- From an experimentalist's perspective:
  - Of all the important features an actual population exhibits, which ones can reasonably be represented by an agent-based simulation?
  - Which simulation outcomes are predictive and which are not?
  - ...
- From a trainer's perspective:
  - How can we teach real-world skills using a 2D representation?
  - Which features should the 2D model exhibit to maximize the training payoff?

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The civilian activity modelling project in a glimpse

- 1 OR scientist
- Collaboration with the Royal Military College:
  - Prof. **Greg Phillips** (Comp. Eng.)
    - 1 undergrad student for 2007-2008
  - Prof. **Robert St-John** (Psychology)
  - Prof. **Allister MacIntyre** (Psychology)
    - 1 undergrad student for 2007-2008

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[dstl]

STORM

Socio-cultural Teamworking for OR Models

HFM-143: 30-31 May 2007

Carol Cooper Chapman

POC: Dr Beejal Mistry
bmistry@dstl.gov.uk

STORM

- Impact of social and cultural factors
- Coalition NEC context
- Investigate issues of agility
- Able to integrate with C2 models.
- Support investment decisions

[dstl] 30-31 May 2007

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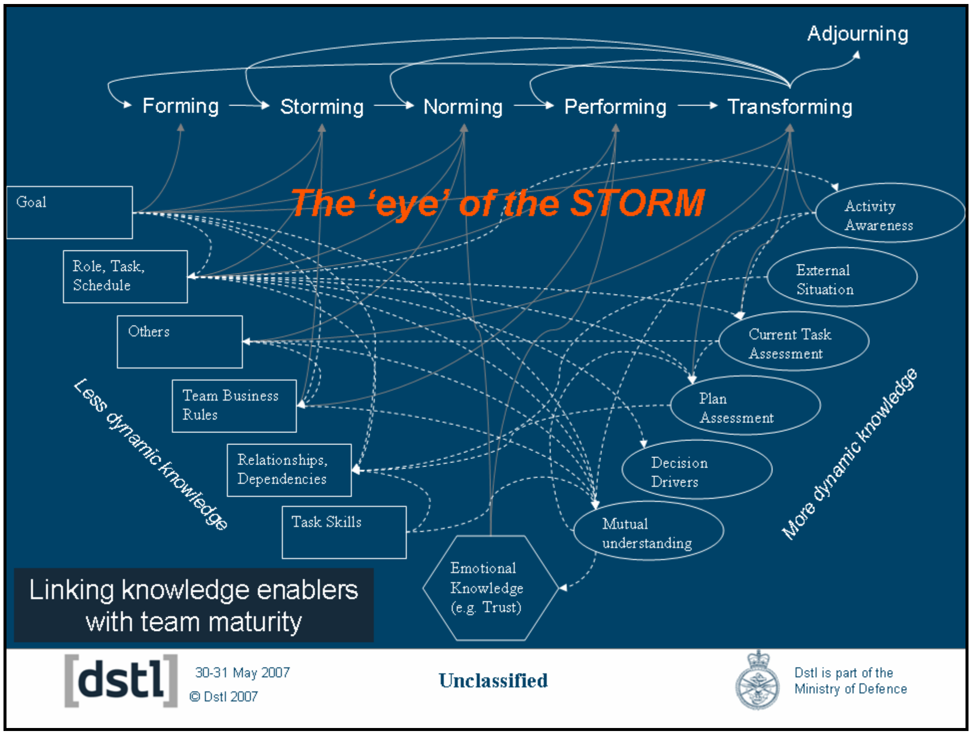

Requisite modelling

- Even if modelling human behaviour and its antecedents is difficult, **this is not an adequate reason not to.**
- Even though we may know little about the inter-relationships between key variables. **This is not an adequate reason to omit them.**

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Uncertainty in relationships

Uncertainty about relationships between variables handled through:

- Generic parametric functions
- Default: half-period sine wave.
- Substitute other functions based on evidence from sensitivity analysis or empirical validation.

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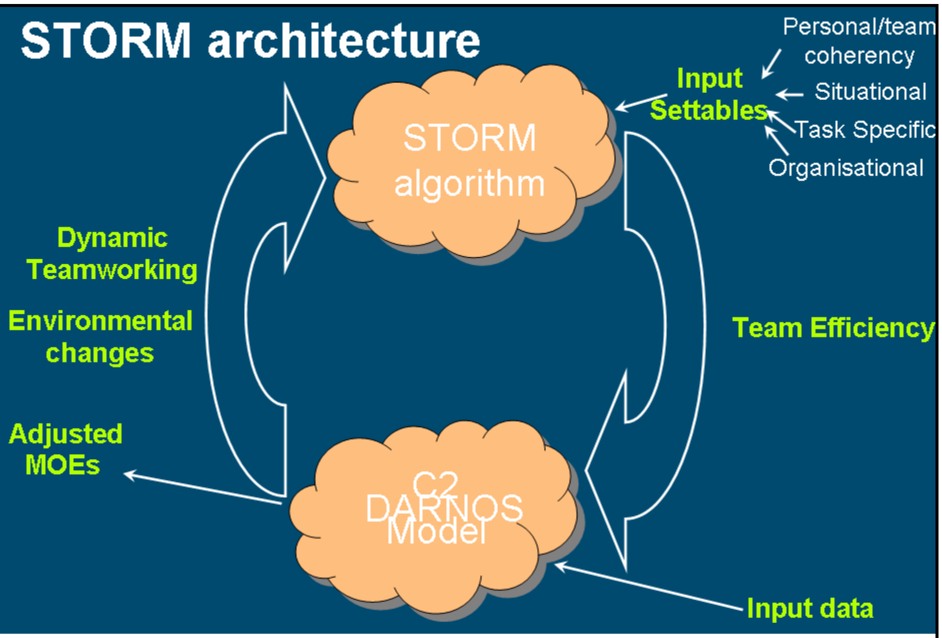
STORM architecture



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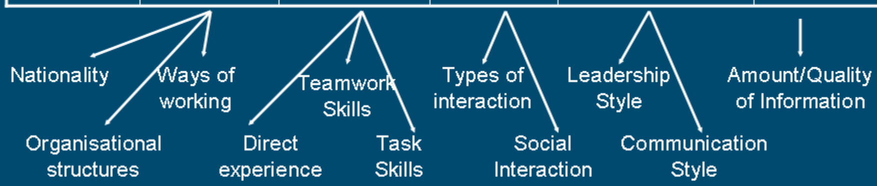
Consider 2 Teams

	HQ - Composition	Prior Exercise	HQ - Location	Commander – Leadership Style	Situation Information
Well Performing Team	UK/Aus	Considerable exercising together	Co-located	Well suited to coalition ops	Good
Poorly Performing Team	UK/Aus/ Host Nation	No exercising together	Distributed	Not suited to coalition ops	Patchy



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Results

- Well Performing Team
  - Coalition HQ well integrated
  - Collaboration timely – able to take out the threat.
- Poor Performing Team
  - Coalition HQ not well integrated well
  - Collaboration delayed – missed opportunity to take out the threat, resulting in attacks on refugee camps.

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Achievement

Move towards dynamic representation of the impact of social and cultural factors affecting performance.

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bmistry@dstl.gov.uk

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