Modelling Human Reasoning in Dynamic Time-Constrained Environments:

The Pros and Cons of Folk Psychology

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Bottom Line

We will try to convince you of the following thesis:

Technologies and methods *grounded in folk-psychology provide excellent approaches to modelling human behaviour for military operational research.*

(with a couple of caveats)

Overview

- We'll set the scene and give examples of the OR problems with which we are concerned
- We'll endeavour to answer the following questions – or at least sketch an outline of what an answer might look like:
  1. What is folk psychology?
  2. Why folk psychology is useful?
  3. How folk psychology is integrated into modelling and simulation?
  4. The benefits and limitations of such an approach

The Kinds of OR of Interest to us

- Uncertain environments
- Experts acting in their field of expertise
- Time-sensitive decisions
  - Better to make a satisficing choice *now* than an optimal one later
- Want to know *why* outcomes are reached, not just what outcomes are reached
- Where outcomes hinge critically on the human element – or are at least believed to be
- Where the human reasoning of importance is governed by tactics, procedures, recipes, plans, rules or other descriptions that can be explained – or is at least believed to be
- Where modelling and simulation is required to answer the question

What to buy or how to fly

PACAUS

SWARMM

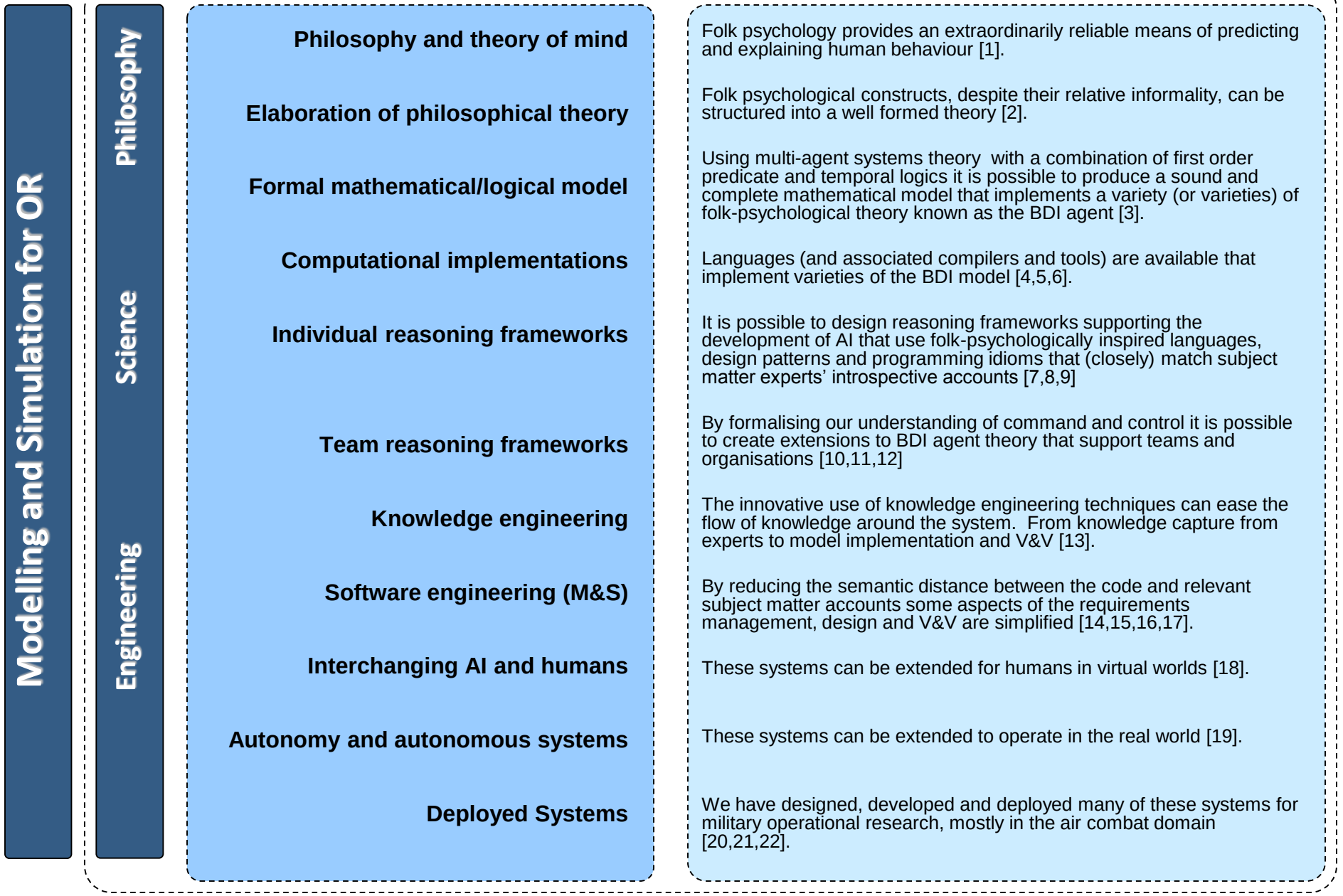
BattleModel

ARTEMIS

ACE
AIR COMBAT ENVIRONMENT

Folk Psychology

- **Folk psychology is "*the way we think we think*"**
- **Typically used to generate explanations or predictions for the actions of others**
  - **"He only did that *because he was tired and wasn't thinking clearly.*"**
  - **"She *didn't know that he'd already been told*, otherwise she wouldn't have tried to do that."**
- **Folk psychology as a theory of mind typically refers to either:**
  - **A theory-theory**
  - **A simulation-theory**
- **We are more interested in explanation and description**
- **Not the way the mind works**

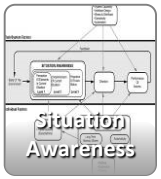

Modelling and Simulation for OR
Philosophy
Science
Engineering
Philosophy and theory of mind
Elaboration of philosophical theory
Formal mathematical/logical model
Computational implementations
Individual reasoning frameworks
Team reasoning frameworks
Knowledge engineering
Software engineering (M&S)
Interchanging AI and humans
Autonomy and autonomous systems
Deployed Systems
Folk psychology provides an extraordinarily reliable means of predicting and explaining human behaviour [1].
Folk psychological constructs, despite their relative informality, can be structured into a well formed theory [2].
Using multi-agent systems theory with a combination of first order predicate and temporal logics it is possible to produce a sound and complete mathematical model that implements a variety (or varieties) of folk-psychological theory known as the BDI agent [3].
Languages (and associated compilers and tools) are available that implement varieties of the BDI model [4,5,6].
It is possible to design reasoning frameworks supporting the development of AI that use folk-psychologically inspired languages, design patterns and programming idioms that (closely) match subject matter experts' introspective accounts [7,8,9]
By formalising our understanding of command and control it is possible to create extensions to BDI agent theory that support teams and organisations [10,11,12]
The innovative use of knowledge engineering techniques can ease the flow of knowledge around the system. From knowledge capture from experts to model implementation and V&V [13].
By reducing the semantic distance between the code and relevant subject matter accounts some aspects of the requirements management, design and V&V are simplified [14,15,16,17].
These systems can be extended for humans in virtual worlds [18].
These systems can be extended to operate in the real world [19].
We have designed, developed and deployed many of these systems for military operational research, mostly in the air combat domain [20,21,22].

Research

PhD Studies

THE UNIVERSITY OF MELBOURNE

TODD MANSELL Planning Under Uncertainty	**GIL TIDHAR** Organisation Oriented Systems: Theory and Practice	**DAVID MORELY** Semantics of Actions, Agents and Environments	**DAVID KINNY** Fundamentals of Agent Computation Theory: Semantics	**CLINT HEINZE** Modelling Intention Recognition for Intelligent Agent Systems		
MICHAEL PAPASIMEON Modelling Agent-Environment Interactions in Multi-Agent Simulations with Affordances	**SUSANNAH SOON** Multi-Agent Coordination: A Graph Based Approach to Intention Recognition	**RAYMOND SO** Situation Awareness in Software Agents: Theory & Practice	**DON PERUGINI** Agents for Logistics: a Provisional Agreement Approach	**SAMIN KARIM** Acquiring Plans Within Resource Bounded Agents	**EMMA NORLING** Modelling Human Behaviour with BDI Agents	



Programming Languages

THE AUSTRALIAN ARTIFICIAL INTELLIGENCE INSTITUTE

dMARS

PRS
AgentSpeak
dMARS-R
dMARS-C2

AOS™ Autonomous Decision-Making Software

JACK™ AUTONOMOUS SOFTWARE

CoJACK™

SimpleTeams
JACKTeams
OKRA

Methods and Models

OODA
Cognitive Work Analysis
JACK-UML extensions
"The Four-Box Model"
AOSE
Intention Oriented Analysis and Design
Naturalistic Decision Making
Recognition Primed Decisions

Simulation Frameworks

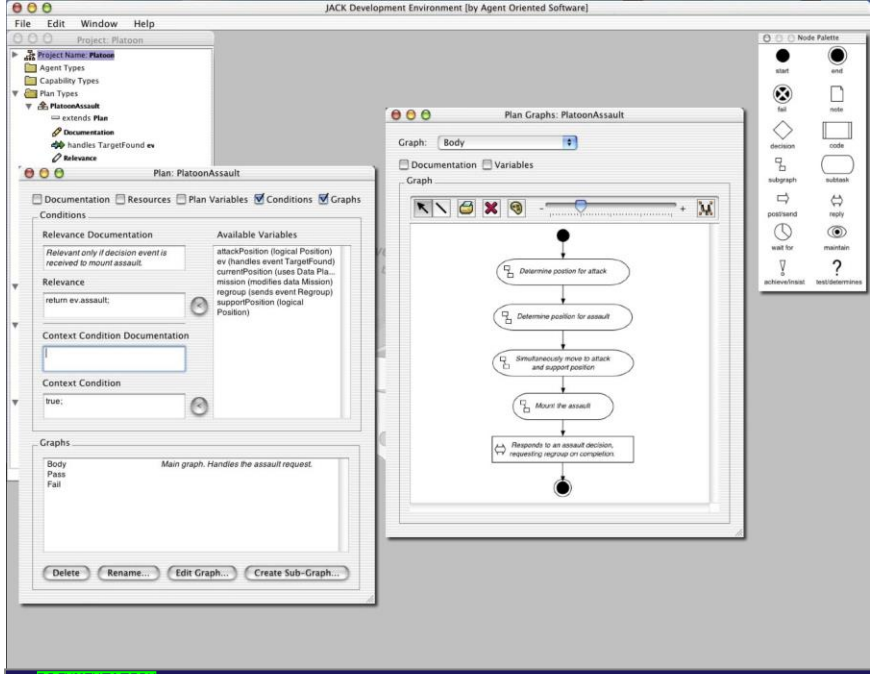
KESEM INTERNATIONAL

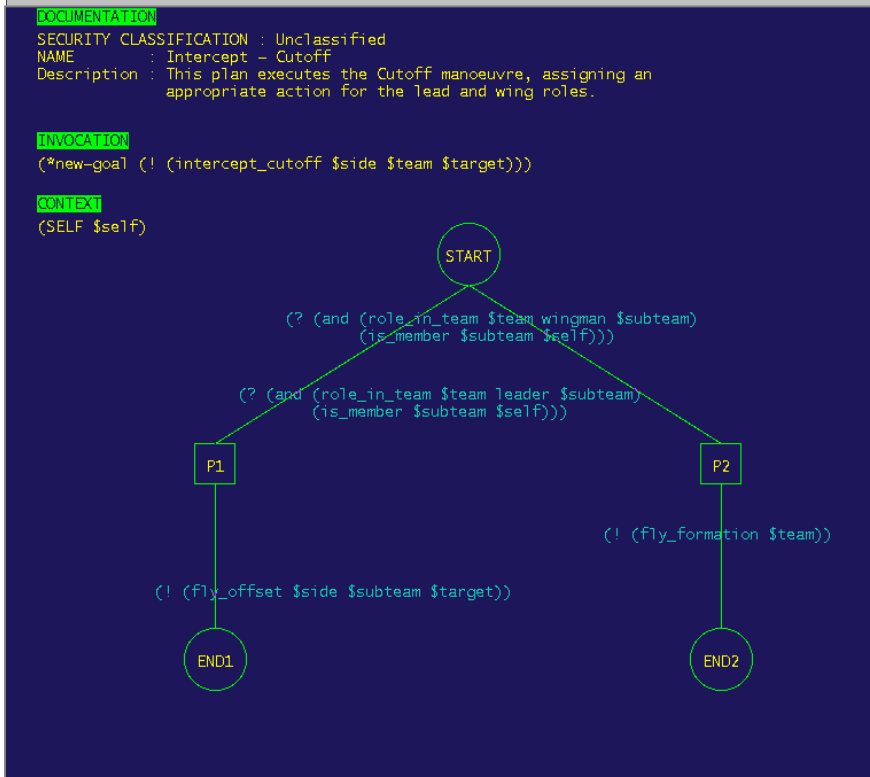
CAE

AVT Advanced VTOL Technologies

The Benefits

- Because the agent's reasoning is based in folk psychology, traces of the reasoning look like plausible explanations.
  - Experts (the subjects being modelled) can easily identify flaws in implementation, which can be quickly adjusted within the models
  - Particularly good at highlighting where lack of knowledge (information flow) can lead to poor decisions



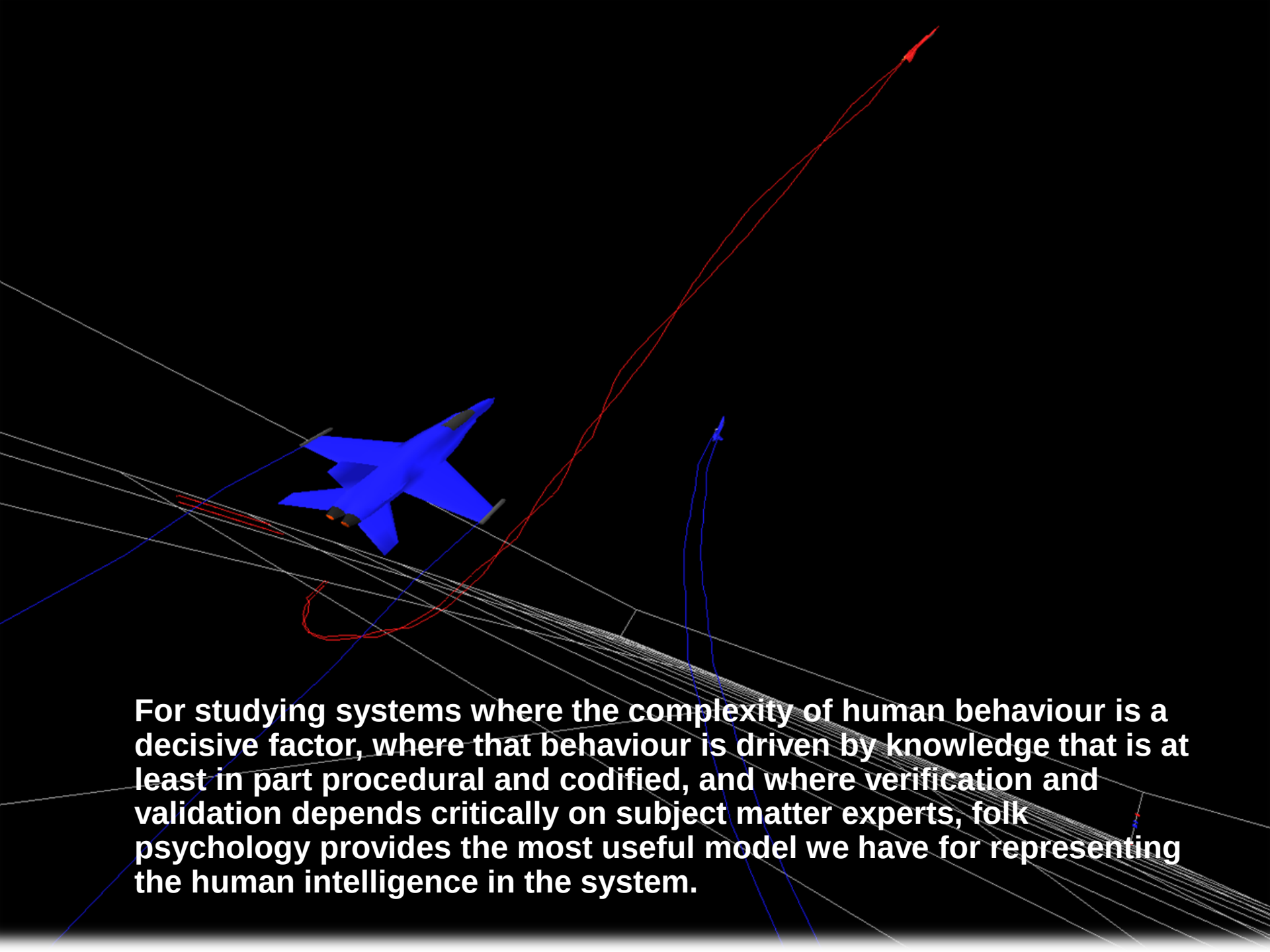


The Limitations

- Folk psychology only goes so far
  - Good for the “natural” explanations of behaviour that we use every day, not so good if we want “deeper” models of cognition, e.g. models of memory
    - However some work has been done on integrating “cognitive overlays” with folk psychological models – COJACK
    - Naturalistic decision making and recognition primed decisions
- Better at explaining expert behaviour than novice
- Experts don’t really think the way experts think that they think
- Understanding the impact of the assumptions entailed by folk psychology is not easy

The Future

- Modelling *social intelligence*
  - Facilitating more natural human-agent and agent-agent interactions
  - Building ad-hoc teams and coalitions
  - Teams composed of human and artificial entities
- Generating real-world artificial intelligence and autonomy
- Automated reporting and analysis



For studying systems where the complexity of human behaviour is a decisive factor, where that behaviour is driven by knowledge that is at least in part procedural and codified, and where verification and validation depends critically on subject matter experts, folk psychology provides the most useful model we have for representing the human intelligence in the system.