

# Exploiting CAS as a Force Multiplier - Its Application to Policy, Acquisition, Assessment and Operational Employment

A presentation to: Complex 07, Brisbane

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Systems Concepts and Assessments

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# Agenda

- Background
- The Drivers - Uncertainty, Agility and CAS
- Current Approach to Provision of 'Capability'
- The Design, Assemble and Run-time (DART)
- Exploiting CAS within the DART Framework
- Summary / Way Ahead

## Background

- DRA / DERA:
  - Air / Land Agile C2 (Cellular automata / HiLoCa) with 32 AOG, Ramstein
  - 1998 - Study on exploiting emergence as force multiplier
  - 1999 - Uncertainty in command and control  
[http://www.dodccrp.org/html4/events\\_past.html#1999](http://www.dodccrp.org/html4/events_past.html#1999)
- With Institute of Human and Machine Cognition
  - 1999 - DARPA work on Coalition interoperability (CoAX)
    - autonomous agents / distributed systems in complex uncertain context  
<http://www.aiai.ed.ac.uk/project/coax/index.html>
- Santa-Fe Institute - ARCS (Adaptive and Resilient Computing Security):
  - 2002: <http://discuss.santafe.edu/defense/agenda>
  - 2003: <http://discuss.santafe.edu/bnadaptive/>
  - 2004: <http://www.arcs-workshop.org/>

# Background

- QinetiQ:
  - Military workshops: Command Agility and Intelligence
  - 2004 - DoD Complex Systems / Agility in 'Edge Organisations'
  - 2006 - DSTO / DSTL collaboration on Complex System Engineering
- Some common themes / realities:
  - Humans are active problem-solvers, not dumb process-followers
  - Higher-level abstractions are used - hypotheses / 'abstract i2'
  - Boundaries (self / non-self) are blurred - interdependencies complex
  - Adversaries and the environment must not be 'simplified' away
  - 'Always-on' **federations** - can't be optimal, diversity is essential
  - Uncertainty, heterogeneity and the unexpected - are a certainty

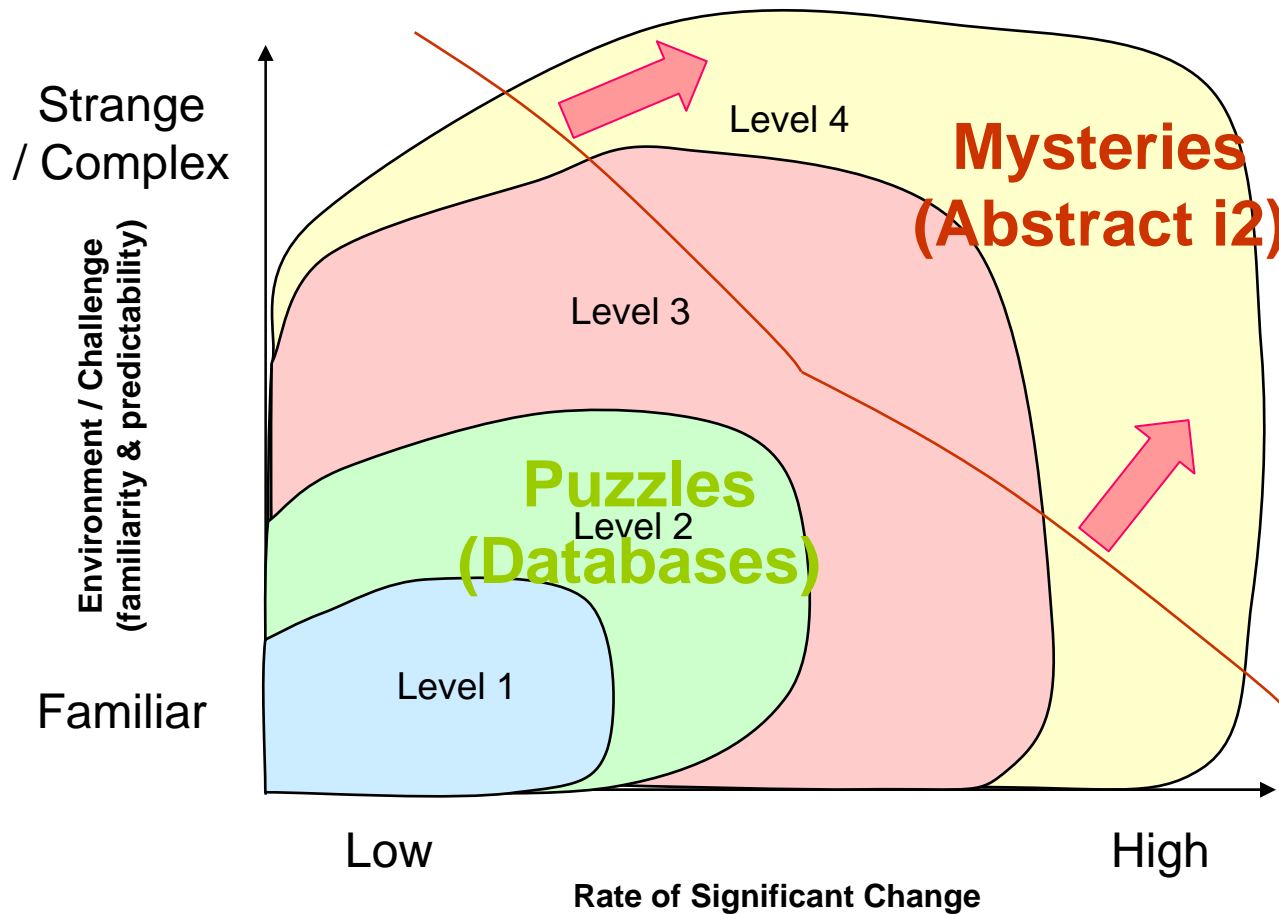
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## Operational context for CAS - Uncertainty

- We have trouble 'finding adversaries'- we look in our pictures and 'they' are not there. Why? Probably because they are:
  - Not on a defined battlefield - not where we expect them to be
  - Not constrained by notions of boundaries - they act wherever / whenever
  - Not part of a western-style 'fighting force' - asymmetric:
    - anything is a 'weapon' to be used to exert decisive influence
  - Not commanded 'from the centre' - instead, use resilient social networks
- From our point of view, they are probably:
  - Culturally 'strange' - different motivations, allegiances, values etc
  - Not necessarily part of 'them', 'out there' ... they are "**Among the People**" ... and able to mimic apparently 'harmless' behaviours:
    - subvert our assets, mindsets, ways of working etc to their purpose

**Level 3 / 4, abstract i2, is decisive in conflict and includes: hunches, intentions, hypotheses, weights of evidence, networks of relationships and other advanced abstractions that cannot be represented and manipulated as if they are facts**



Any pre-defined 'sensor grid' is predicated on Level 1 / 2 and is useless against opponent who operates in the 'mysteries' region.

Level 4 - Bizarre - where ability to reason about non-things is vital. The data you don't have is significant etc. Hence is cognitive mind-game - you can't search databases for non-things!

Level 3 - eg Fallujah. Is as much about absence of signal as presence of signal.

Level 1 / 2 - Conventional Western warfighting. We can be structured - presumption is that things are easy to sense and identify, ie the 'object' has significance (not the background)



## Starting Points - Agility and CAS

- To operate purposefully and effectively in a changing real world enterprises must be able to adapt, be agile:
  - Enterprises must be agile enough to generate novelty / deceive
  - Novelty cannot be defined a-priori, it must be generated at run-time
  - Enterprises use novelty to generate 'option spaces' / wiggle room
- Enterprises employ various aspects of CAS to:
  - Self-organise, regulate (autopoiesis), maintain / sustain (autonomic)
- What is self in CAS? Taking a perspective:
  - Human self: defined by cognitive, endocrine, immune system, possessions?
  - Systemic Self: System, System-of-systems, Federation
  - Acknowledging concurrent scales (time, extent of effect etc)

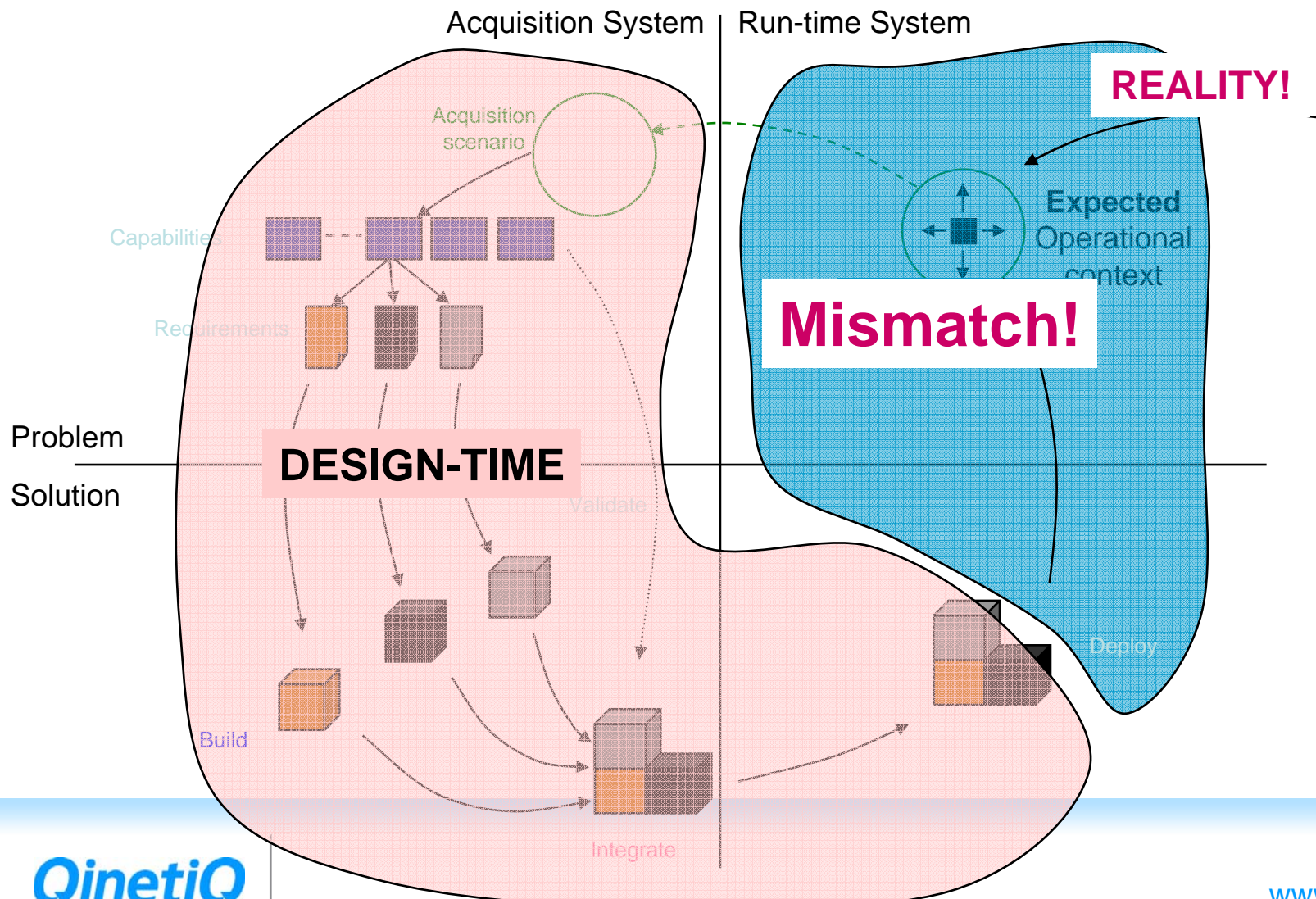
## Exploiting CAS Purposefully

- Three aspects of influence:
  - Top-down - by the 'directing mind', shaping and tuning
  - Self-adjustment - through regulatory mechanisms
  - Bottom-up - emergence and spontaneous-organisation
- Factors to consider to enable 'influence-able enterprises':
  - 'Design-time' precursors that need to be in place
  - Assembling / 'growing' the necessary structures or letting them emerge
  - Opportunities and mechanisms available to be influenced
  - Run-time exploitation of the many levels at which interactions take place and the degrees of 'coupling' between these levels - federation dynamics
- How do these map to the wider environment?

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# Industrial Age - How it Used to be (is!)



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# Design, Assemble and Run-time (DART)

## Design Time

Concepts and  
'Design'



Building Blocks

Design  
Techniques

## Assembly Time

Assemble and  
Deploy  
integrated  
building blocks

Assemble  
Mechanisms

## Run Time

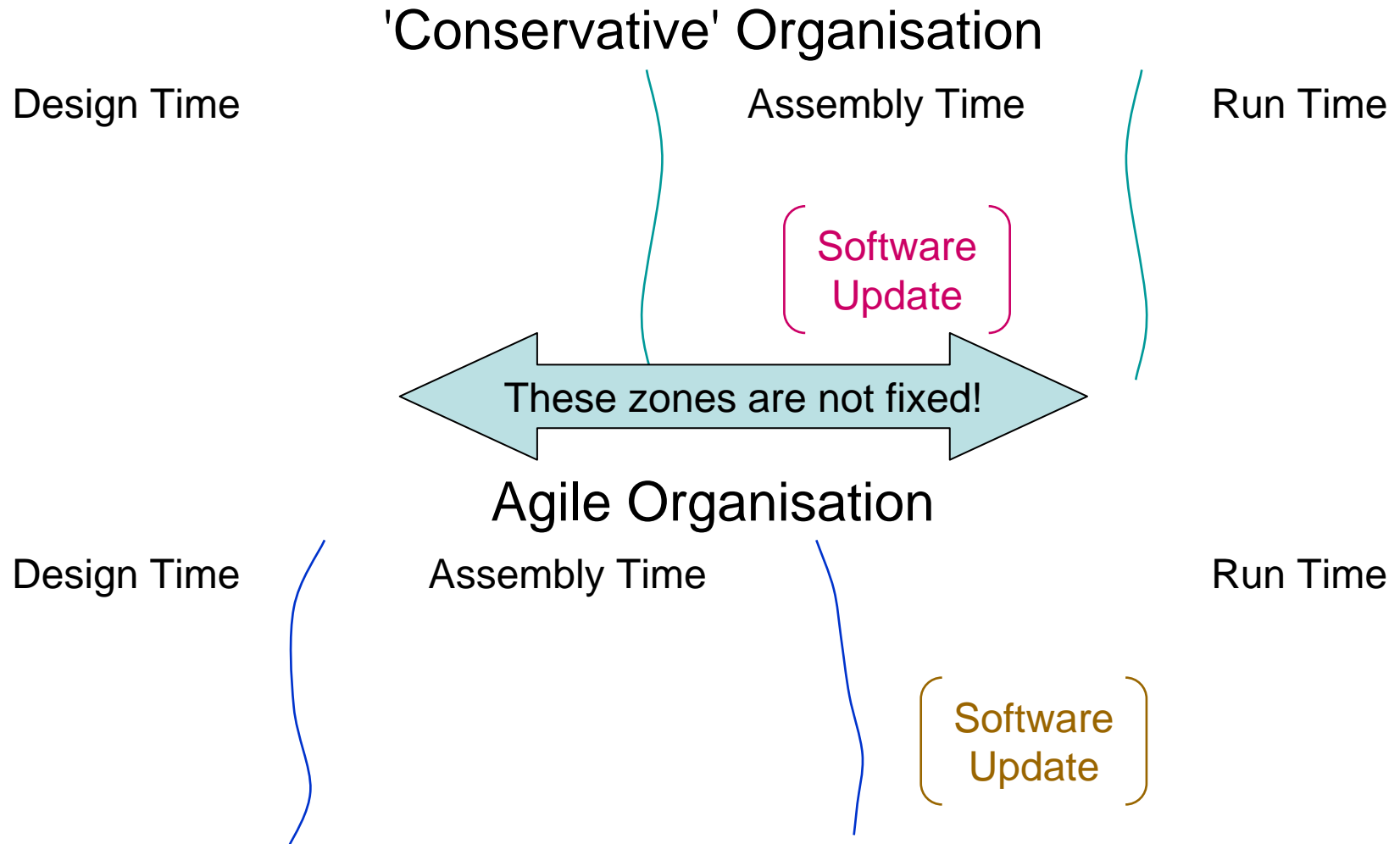
Dynamic re-  
configuration of  
"behaviour"



If not enough

Adaptation  
to  
Operational  
Imperatives

# Design, Assemble and Run-time (DART)



# DART Mechanisms

Design-time  
[Engineer]

Assemble-time  
[Build / Structure]

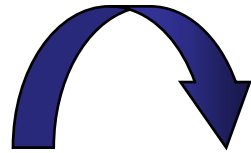
Run-time  
[Evolve / Influence]

Instantiate

Activate

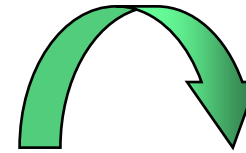
'Building Blocks':

- Devices
- Equipment
- Procedures
- Basic units



'Functional Units':

- Systems
- Structures
- Interfaces
- Services

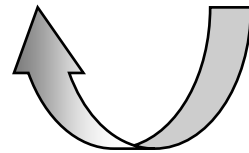


'Enterprises':

- Communities
- Networks
- Interdependencies
- Agents and actors

Features:

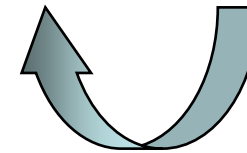
- Component level
- Objects
- Bounded
- Closed
- Dormant
- Designed



Decompose

Features:

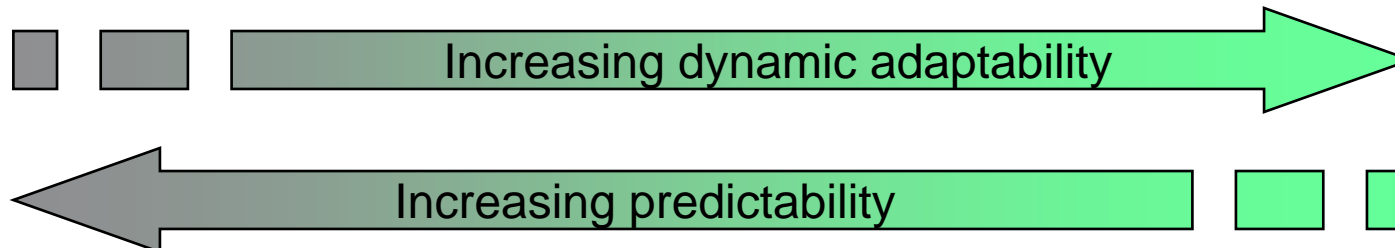
- Individual level
- Capabilities
- Nascent connections
- Open
- Model-able
- Built



Reconfigure

Features:

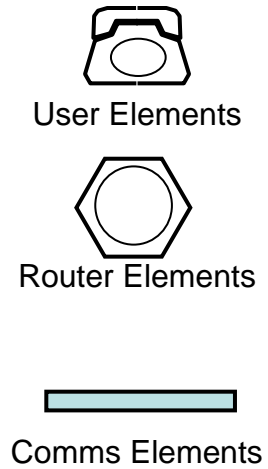
- Social level
- Ecosystems
- Adaptive
- Dynamic
- Purposeful
- Grown



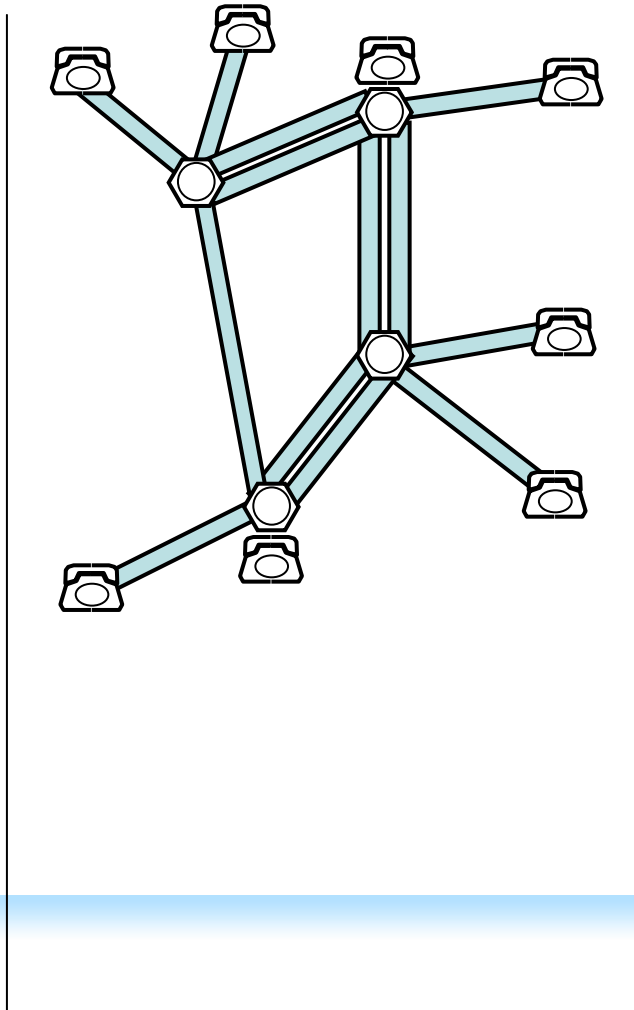


# Comms Networks

Design Time



Assembly Time



Run Time

Primary Means

- Dynamic network management

Secondary means

- Re-building (going back to assembly-time)

# Applications and Services

Design Time

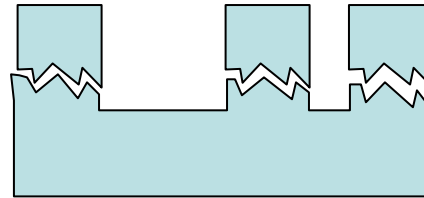
Application



Application Server



Assembly Time



Run Time

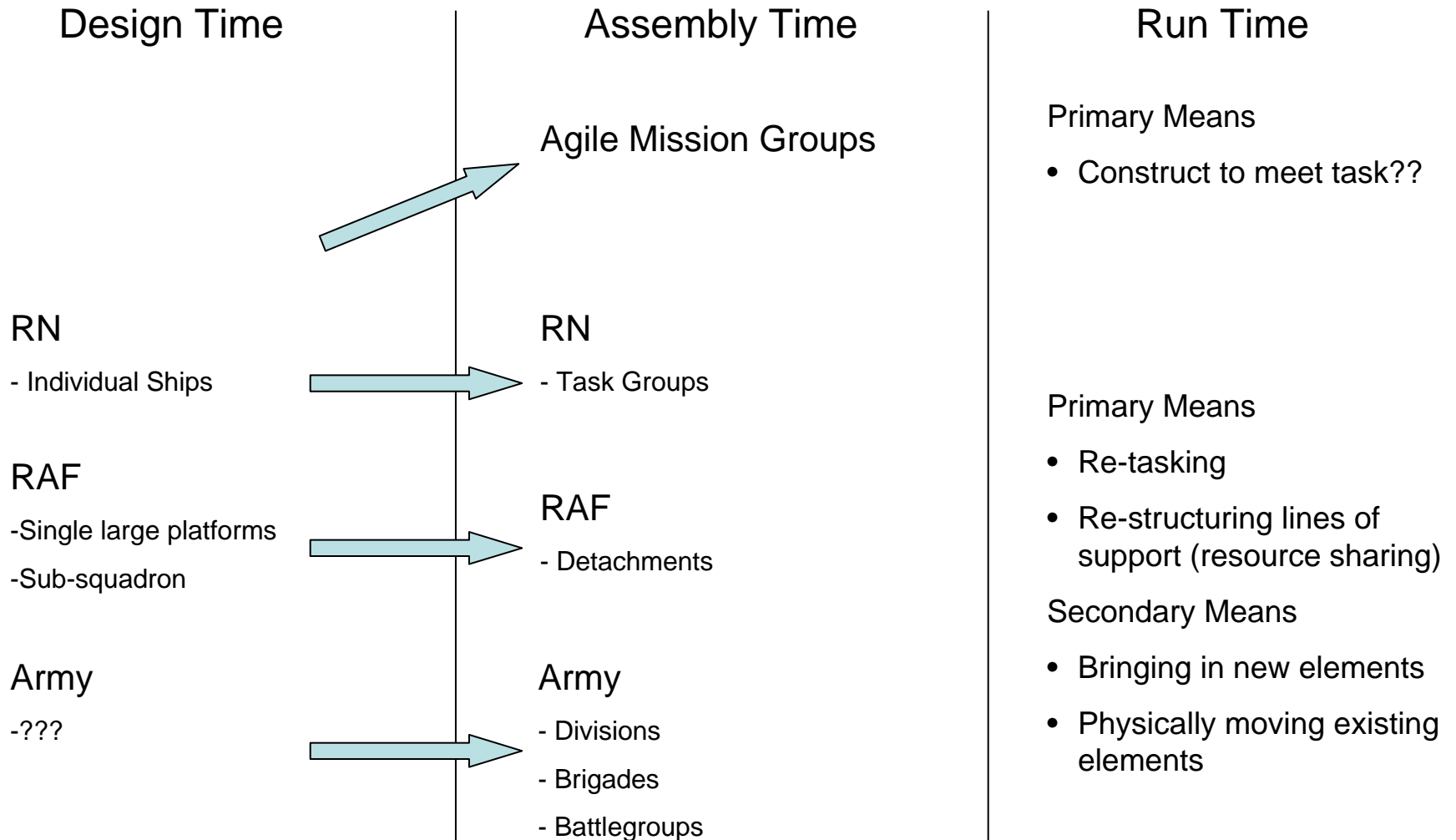
Primary Means

- Dynamic reconfiguration

Secondary means

- Plug and play (Plug and play needed for software upgrade more than agility)

# Organisational Networks



# Social Networks

## Design Time

- Trained commanders
- Liaison officers

## Assembly Time

- Command networks/structure
- Communities of interest
- Informal Groups
- Lines of support

## Run Time

### Primary Means

- Dynamic COI's
- Dynamic lines of support

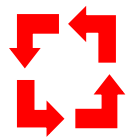
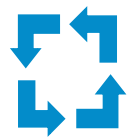
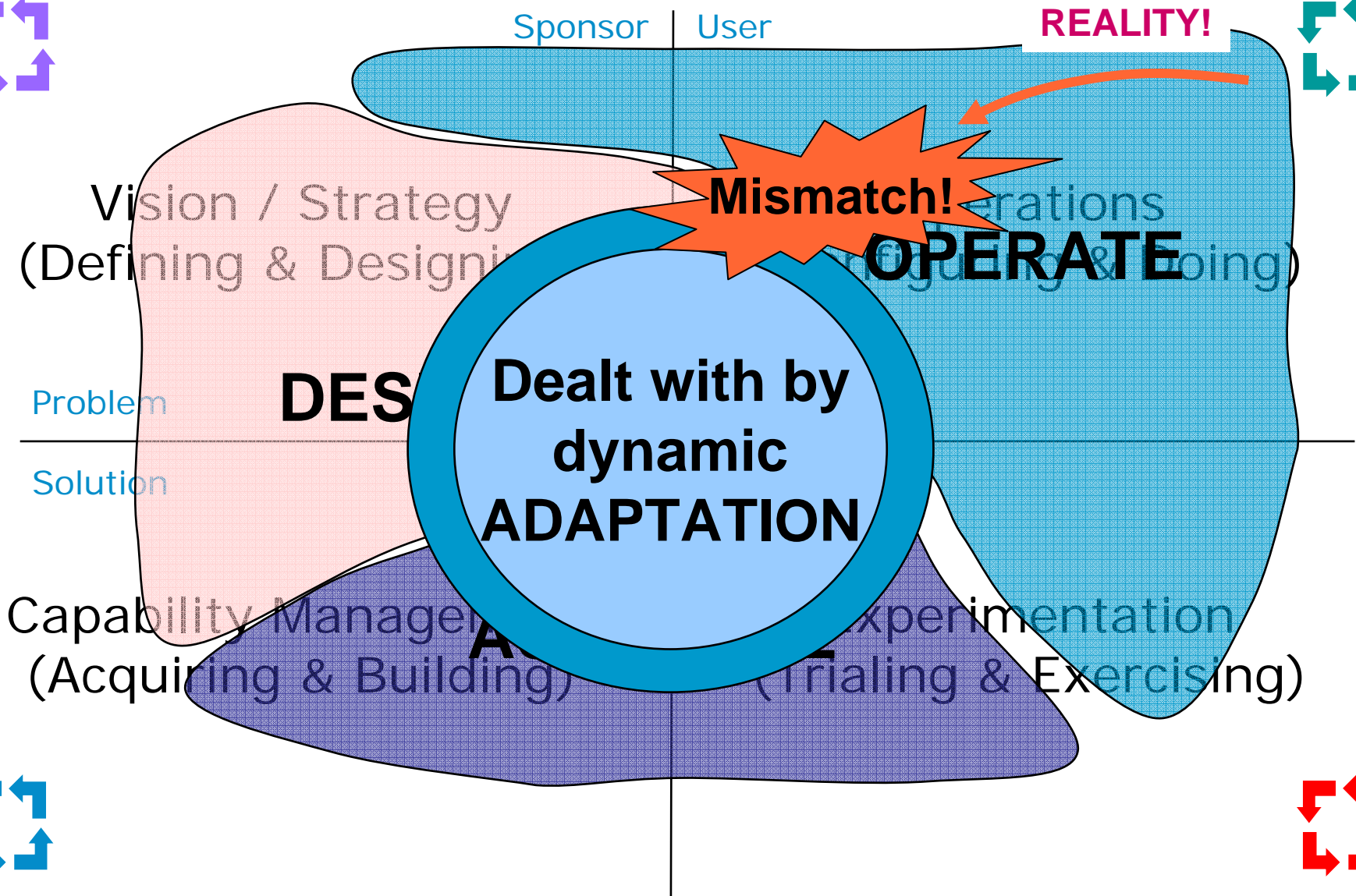
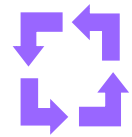
### Secondary Means

- Change to command networks / structures

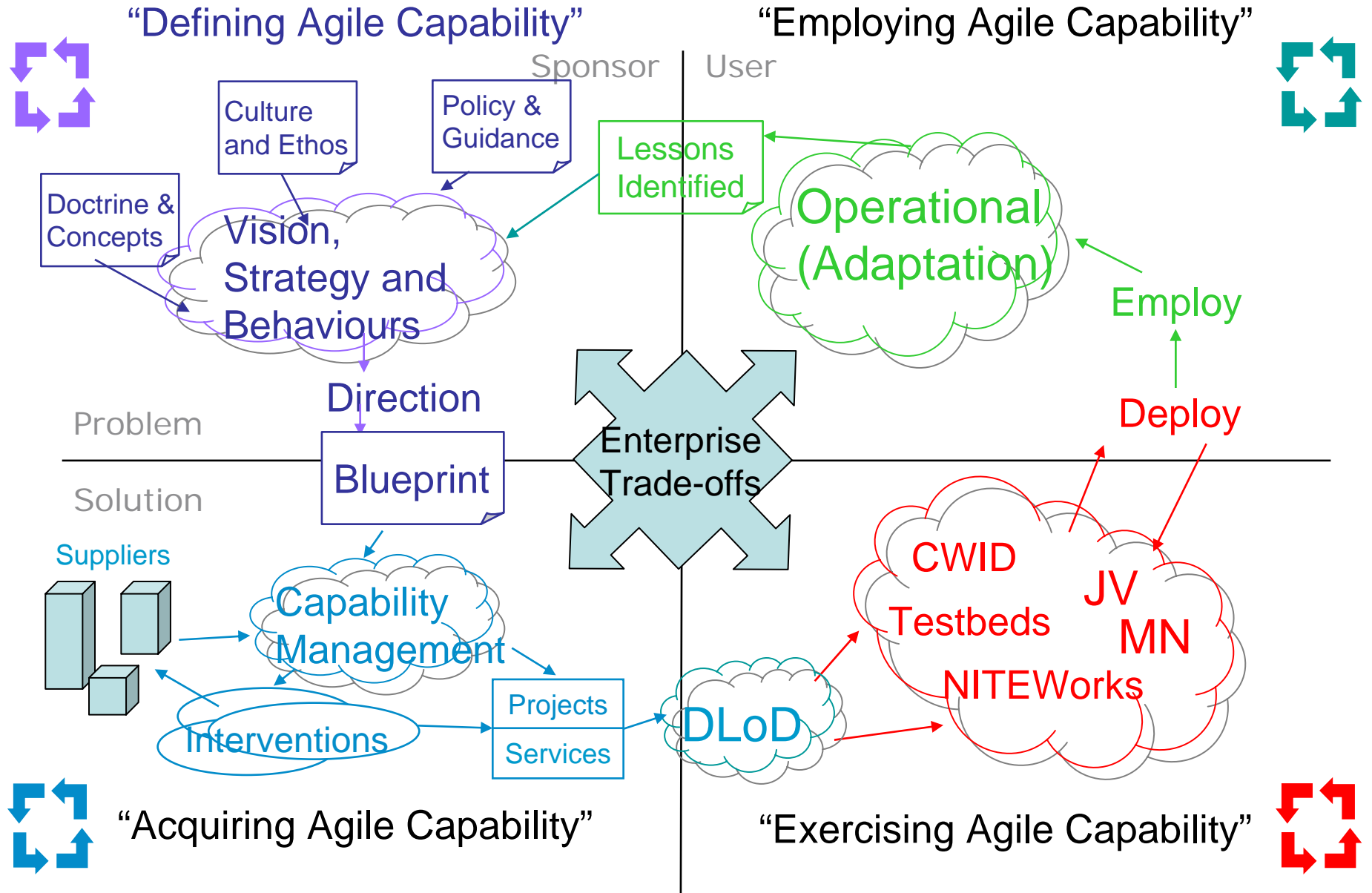
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# The DART Framework



# The DART Framework



## Exploiting DART - Vision / Strategy



- Nature of complexity: (Defining and Designing)
  - Accommodating the range of possible future challenges
- Appropriate approaches and mechanisms:
  - Design: From 'ethos', develop statements of policy and guidance
  - Assemble: Develop capability strategy and plans
  - Run-time: Use leadership and / or satisficing to hone policy / adjust plans
- Nature of outcomes:
  - Coherent and consistent guidance (blueprints) to acquisition
  - Provision of success values / metrics to experimentation
  - Provision of operational capabilities consistent with national aims



## Exploiting DART - Capability Management



- Nature of complexity: (Acquiring & Building)
  - No single Project - managing diverse federations
- Appropriate approaches and mechanisms:
  - Design: Identify federate characteristics across DLoDs\*
  - Assemble: Build / acquire and configure capabilities in line with blueprint
  - Run-time: Through-life management support
- Nature of outcomes:
  - Provision of capability to support vision and strategy - national confidence
  - Interaction with experimentation - 'predator / prey' strengthening
  - Trade-off project risks with operational agility benefits

## Exploiting DART - Experimentation

- Nature of complexity: (Trialling & Exercising)
  - Complex, open-ended and unbounded experimental context
- Appropriate approaches and mechanisms:
  - Design: Define CAS-appropriate simulations / models experiments
  - Assemble: Configure federations of operational tools and simulations
  - Run-time: Experiments are plug and play in an 'always-on' environment
- Nature of outcomes:
  - Indicate policy constraints / inconsistencies, flawed assumptions, unreasonable expectations
  - Challenge and 'stress' acquisition / component providers / recruitment
  - Provision of adaptation-ready capabilities



## Exploiting DART - 'Operations'



- Nature of complexity: (Configuring & Doing)
  - Uncertainty, concurrency and wide scope of 'operational' environments
- Appropriate approaches and mechanisms:
  - Design: Conceive relationships, authorities, possibilities and constraints
  - Assemble: Form 'agile mission groupings' - be adaptation-ready
  - Run-time: Employ CAS interventions: eg, influence via tuning gradients, changing delegation of authority, force mix, environmental changes
- Nature of outcomes:
  - Robust operational outcomes in-line with national aspirations
  - Provision of credible insights to capability provision, doctrine etc
  - Hardened experimental context - the 'looser' learns the most (employ deception and countermeasures)

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## Summary / Way Ahead

- Agility\* is essential to enable operational adaptation:
  - The world is increasingly 'joined up' in federated structures - boundaries between 'us' and 'them' are blurred - *we need optimisation*
  - 'Competition' is more diverse and dynamic - the unexpected should be expected - *we need to actively develop adaptive capabilities*
- We should increase our understanding of the demands and benefits of agility and its systemic operational aspects:
  - Characterise, Design, Assemble, Run-time concepts and mechanisms
  - Identify and employ appropriate CAS toolsets / methods (mindset)
  - Provide education in complex systems engineering
  - Purposefully employ DART to enable CAS to be exploited as a Force Multiplier (including deception, vulnerabilities and counter-CAS)

**Complex system engineering enables federated 'adaptive enterprises'**

## Associates and Partners

- QinetiQ:
  - Anthony Alston, Patrick Beautement, Lorraine Dodd
  - Neil Briscombe / Mike Kirton - D3C (Dynamic, Dependable Distributed Computation)
  - David Allsopp - DIF DTC (Data and Information Fusion DTC)
- DoD: Use Strong Angel as a test case?
- DSTO: Anne-Marie Grisogono
- DSTL: Niki Jobson / Jim Moffat
- EU: Exystence Complex Systems network
- BT: Robert Ghanea-Hercock
- Institute of Human and Machine Cognition: Jeff Bradshaw
- Santa-Fe Institute: Business Network members
- Southampton University: Nick Jennings
- Warwick Business School: Yasmin Merali

# Questions?

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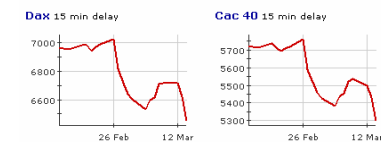
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