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The Implications of Complex Adaptive Systems Thinking for Future Command and Control

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Outline of Presentation

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- Introduction to complexity
- Complexity and Defence
  - Why is Complexity important for C2?
- Concepts of CAS
  - Including examples
- C2 Implications
- Concluding Remarks

Introduction to Complexity
Definitions

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- **A system:**
  - Entities
  - Interactions
  - Dynamic
  - Heterogeneous
- **May be *complex* or complicated**
- **A complex system exhibits:**
  - Certain properties that can not be deduced through a study of individual components and interactions

Introduction to Complexity
Definitions continued

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- **Adaptation**
  - Change in response to feedback in order to improve fitness
  - Agents
  - Strategies
  - Interactions
  - Population distributions
- **Command and control**
  - Sense-making
  - Decision-making

Introduction to Complexity
Potted History

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- Poincaré is generally considered to be the father of complexity science
- 30 years of research
  - Condensed matter physics
  - Evolutionary theory
  - Mathematics
  - Computational sciences
  - Biological sciences
- Also being applied, as metaphor and analogy, to social systems

Complexity and Defence
Warfare

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‘The second peculiarity in war is the living reaction, and the reciprocal action resulting therefrom…reciprocal action, by its very nature, opposes anything like a regular plan’ [Clausewitz in *On War*]

‘[to overturn the role of friction]…one would need to overthrow nonlinear dynamics, the second law of thermodynamics, the fundamental tenets of neo-Darwinian evolutionary biology, and all the limiting metatheorems of mathematical logic…’ [Watts in *Clausewitzian Friction and Future War*]

Complexity and Defence
'More is different'

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- NCW and the 'energy' in the system
  - More interactions/flows
  - More information content
- A 'new' fog of war: the added dimensions of EBO
  - Socio-political
  - Economic
- Diversity of agents
  - Variety of roles
  - Coalitions
  - Non-Defence organisations and entities
- Globalisation
  - And the inherent interdependencies it introduces

Complexity and Defence
The nature of complexity in Defence

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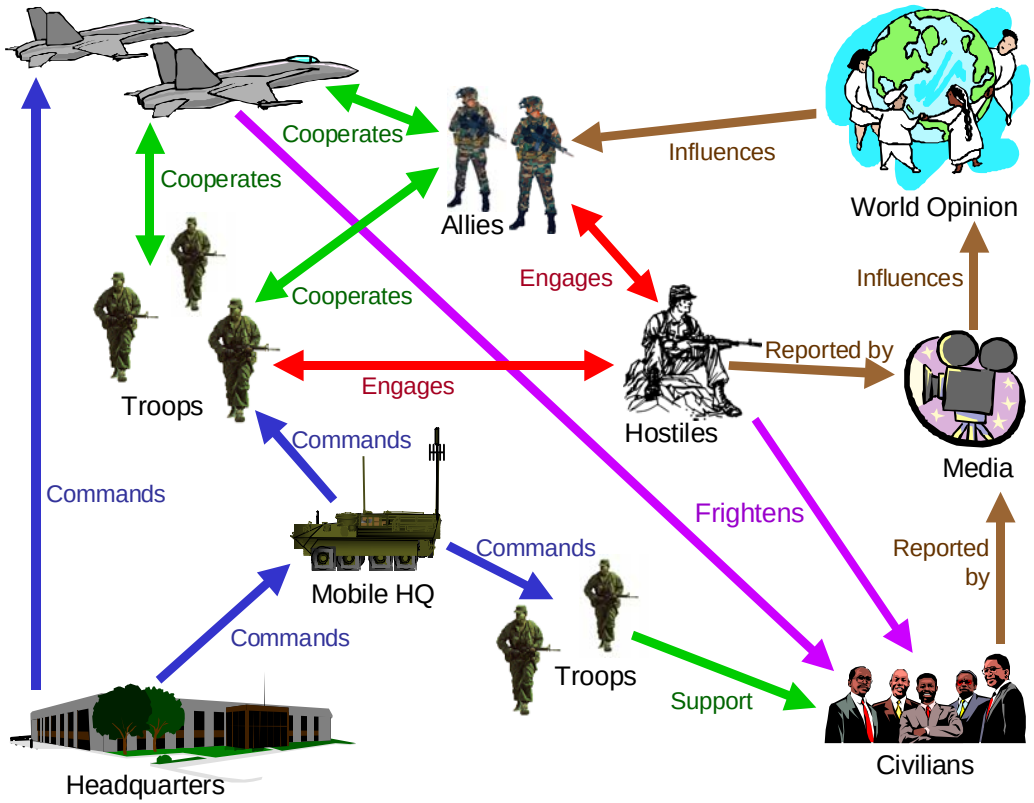

Dekker (2005 personal communication)

Concepts of Complexity
Basic Mechanisms

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- Non-linear
- Sensitive to initial conditions
- Feedback and learning

Concepts of Complexity
Overview

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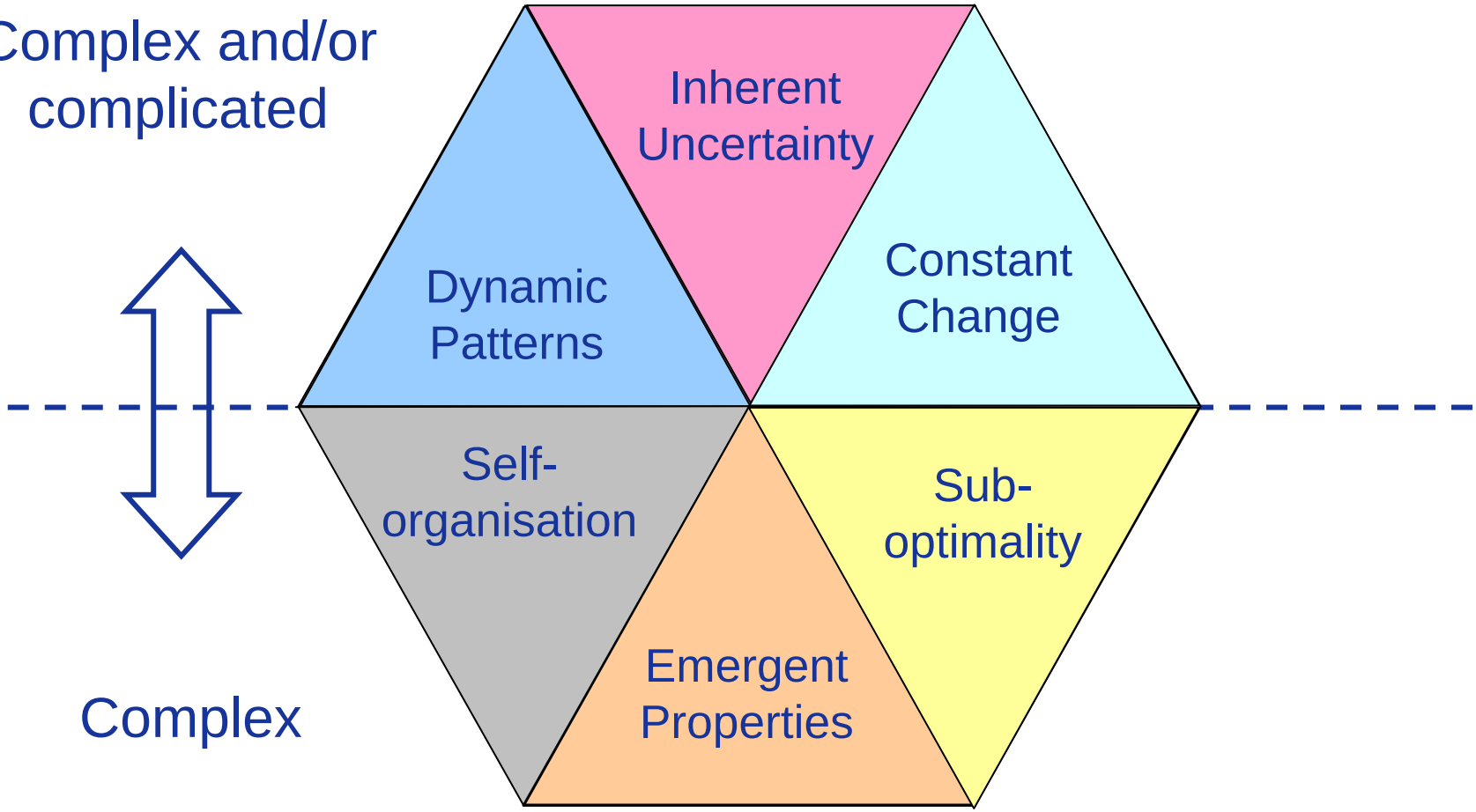

Concepts of Complexity
Emergent Properties

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- Flocking in birds
- Mind from Neuronal interactions

Invisible Hand

It can be argued that Adam Smith pre-empted modern CAS ideas when he introduced his concept of the "invisible hand" in 1776 which would now be called an emergent property. He contended that individuals acting selfishly in a free-market can produce an overall benefit for everyone. In this free-market model, the overall societal benefit emerges from interactions between self-centred individuals.

Concepts of Complexity
Self-organisation

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- Ants finding optimal paths
- Bernard cells in heated fluid
- Co-evolution of animal species

Food Distribution

The food supply in a typical city is approximately two weeks, and this is achieved without any food plan or food manager. Instead, the town self-organises in response to interactions such as demand and supply within the system.

Concepts of Complexity
Sub-optimality

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- Robustness versus optimsation

Diversification of investments

This is analogous to the principle of diversification as a strategy for investment. Diversification is the technique of spreading your investment across (and within) different asset classes (typically cash, bonds, property and shares). It is based on the notion that a poor return in one investment can potentially be offset by a better return in another investment. This is done to reduce the risk and smooth volatility of the overall investment at the expense of maximum potential performance. In other words, the optimal financial performance is traded for greater robustness in investment returns.

Implications for C2
Influence, Not Control

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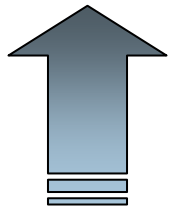
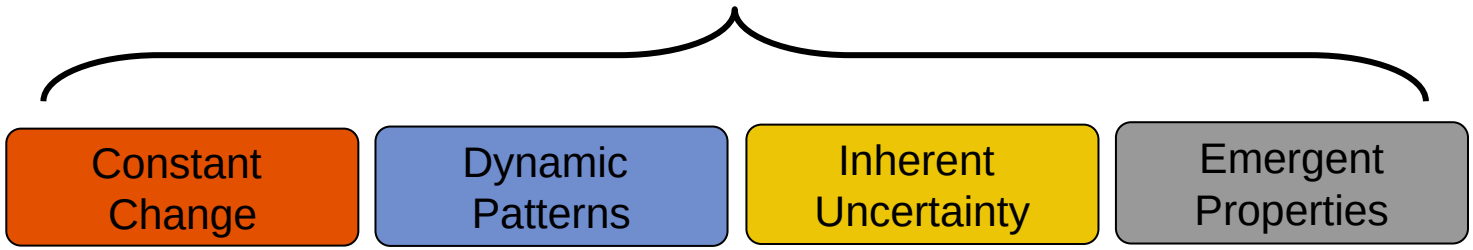
Influence, Not Control



Perfect control may be unattainable



Implications for C2
Influence, Not Control (continued)

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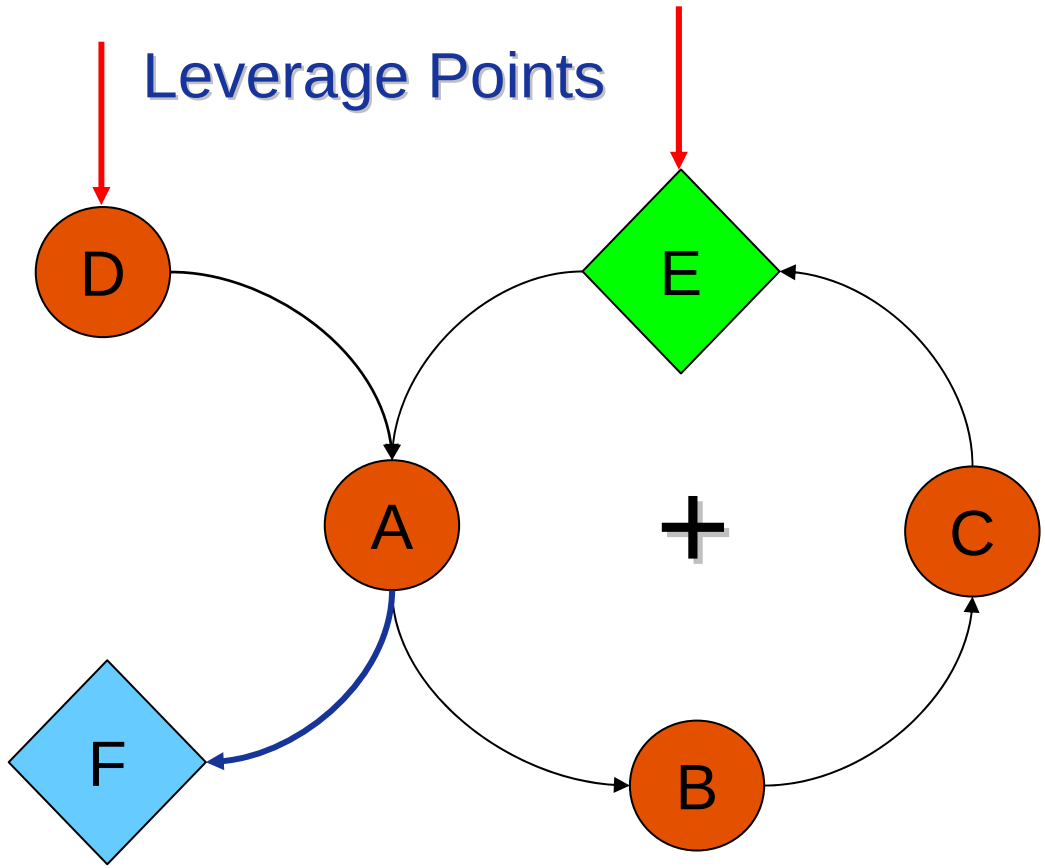

System Models
- formalised
- intuitive

Implications for C2
Variety, Not Homogeneity

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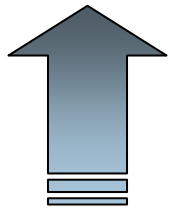
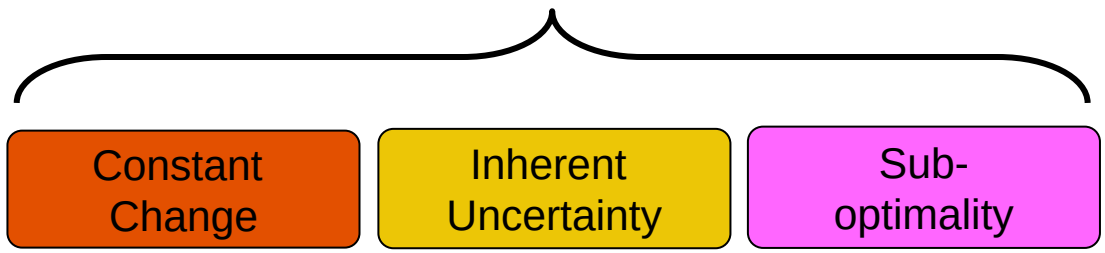
Variety, Not Homogeneity



Diversity provides robustness



Implications for C2
Variety, Not Homogeneity (continued)

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Operational Example

An example of the benefit of variety comes from recent maritime operations in the Persian Gulf in the context of a naval group conducting monitoring and interdiction tasks. An officer commanded the surface group consisting of four different coalition partners, each bringing different equipment, culture and doctrine to the group. Although this diversity brought challenges, this was outweighed by the wider range of options available to him in approaching the tasks.

Implications for C2
Agile People, Agile Organisations

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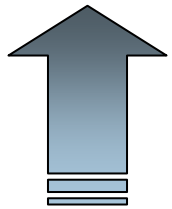
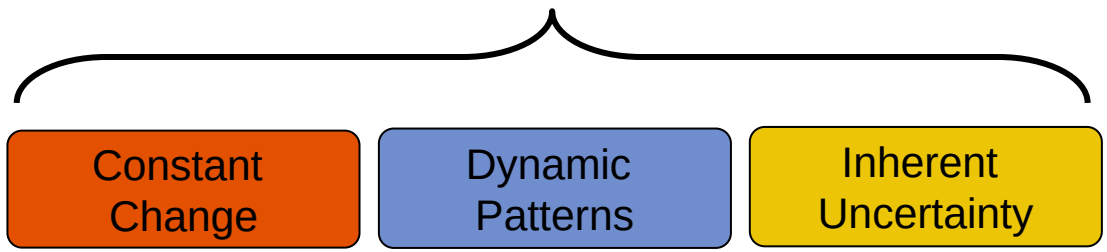
Agile People, Agile Organisations



Agility is important for success



Implications for C2
Agile People, Agile Organisations (continued)

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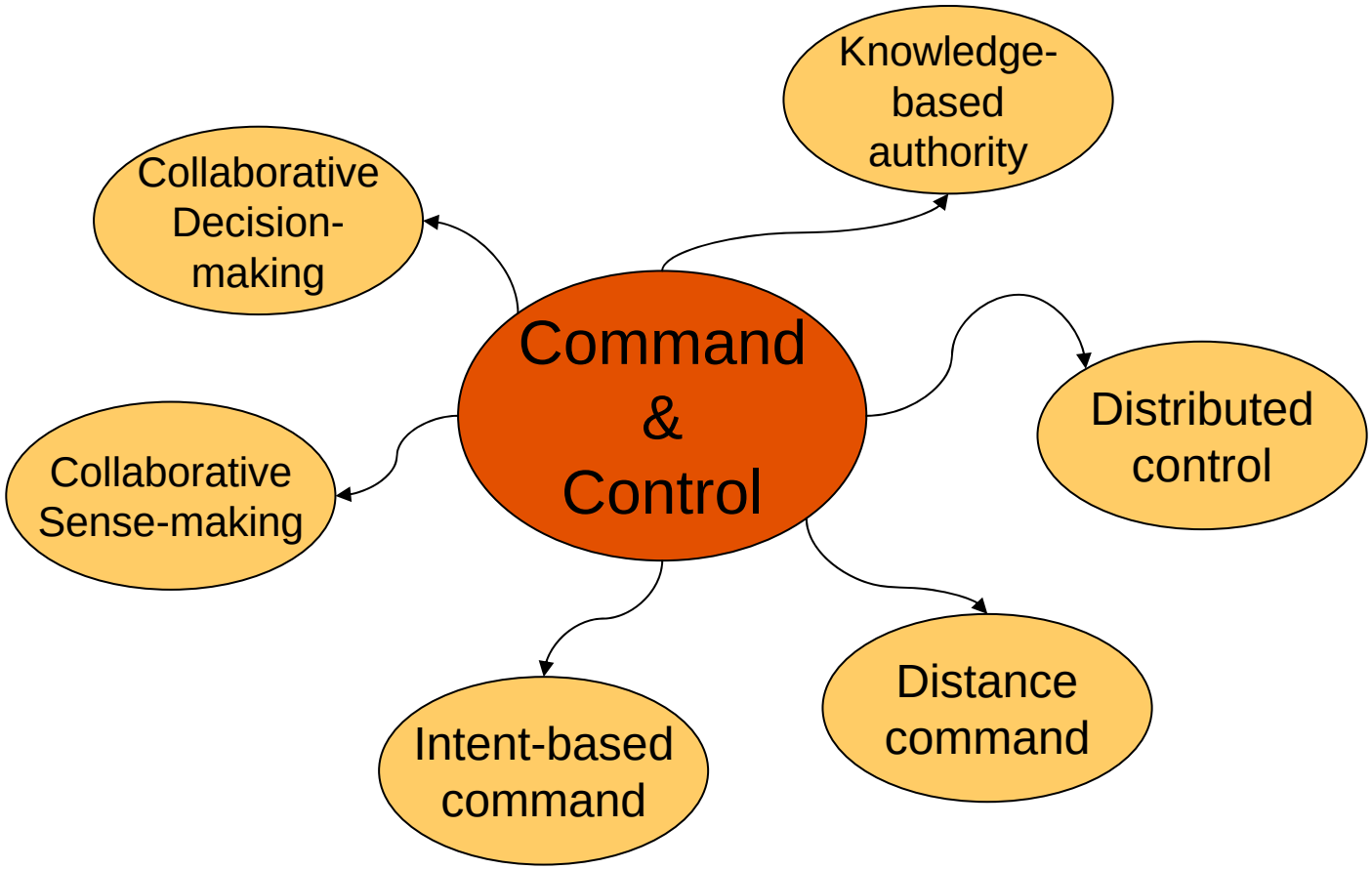

Implications for C2
No Perfect Plan

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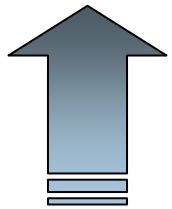
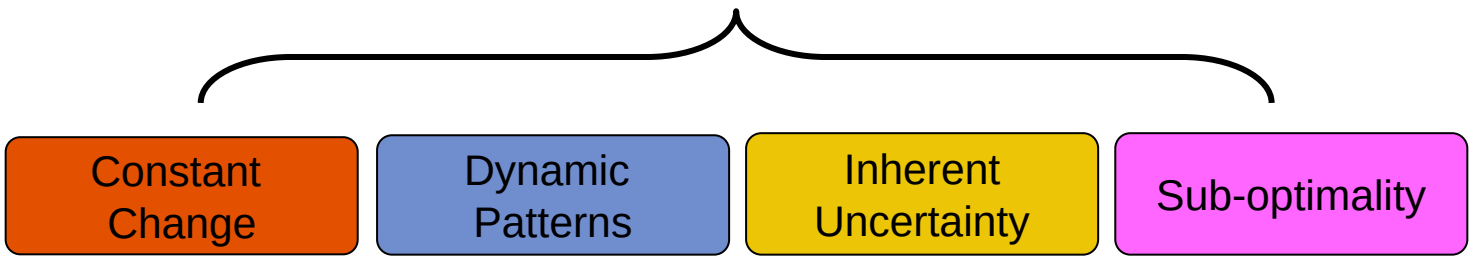
No Such Thing as a Perfect Plan (or Organisation)



Small, incremental approaches with room for adjustment



Implications for C2
C2 From the Bottom-Up

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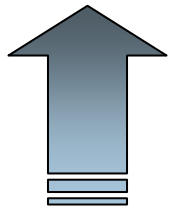
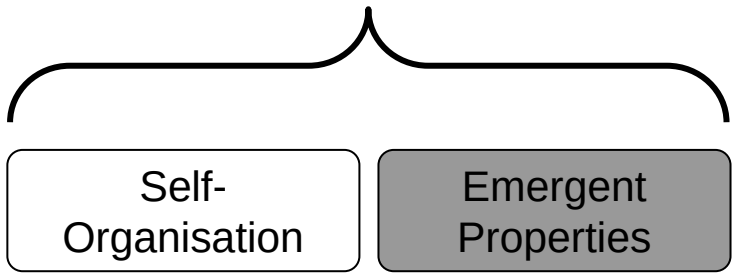
Construct C2 Bottom-Up



Self-synchronisation and the importance of local rules and interactions



Implications for C2
Metrics and Monitoring

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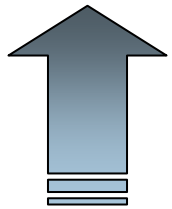
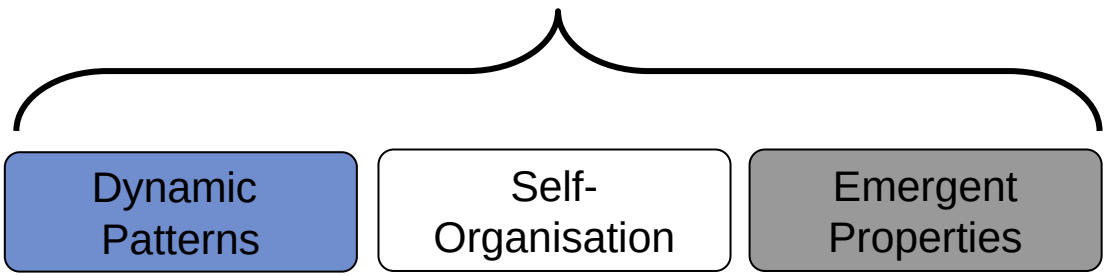
Metrics and Monitoring



New forms of measurement may be needed



Implications for C2
Training and Education

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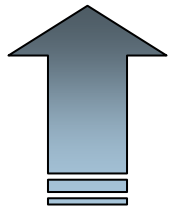
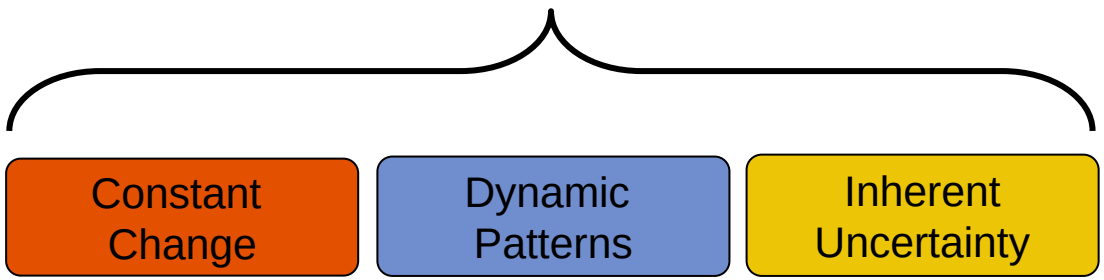
Training and Education



New forms of training may be needed



Implications for C2
Decision-maker as the Focus

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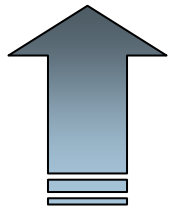
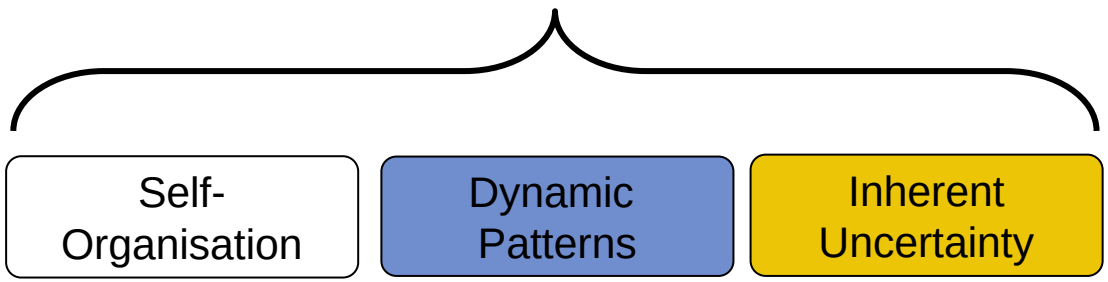
Decision-makers as the Focus



Experts are needed to make sense of the problem space



Concluding Remarks

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Complexity drives organisational shifts in systems, process, culture and values

- Formal structures in coexistence with and supporting informal structures
- Culture and process of devolving control
- Diversity in processes and capability

Complexity drives individual demands on knowledge, approach and interactions

- Individuals capable of operating in a dynamic, uncertain environment
- Diversity of knowledge, skills and experience