Overview of Systems Thinking: what it is, its development in the history of science and why it is important.

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Science as philosophy

Brief history

Ecological, economic & social applications (systems dynamics)
- World1 and World2 (Forrester)
- Limits to Growth (1972) – World3
- Resource constraints: sharing a finite world (IFoA) (2013)...

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Systems thinking and scientific methods

Brief history

Science as Philosophy

Disciplinary science

‘Real world’ challenges

Specific optimization issues
Systems Thinking
Underlying principles

• Holistic
• Linkages and interactions between elements
• Disciplinary applications
  - social systems theory
  - systems biology
  - systems dynamics
  - systems ecology
  - systems engineering
  - systems psychology

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• Non linear complex systems
  - Small perturbations approximated using linear thinking
  - Large perturbations dominated by complex multi-interactions
• ‘Divisibility’ of the system
• *(all pre-dating computers/models)*
Systems models
Fundamentals

- Stocks and flows
- Negative feedback (dampen)
- Positive feedback (magnify)
- Emergent behaviours (out of the aggregate rather than individual)
- What it isn’t…
  - Near equilibrium
  - Deterministic
  - Single agent
Systems models
Limitations

- Sensitivity to initial conditions
- Sensitivity to connecting functions (how does ‘A’ impact ‘B’)
- Sensitivity to impacts of perturbation (e.g. limits)
- Massively complex systems are massively complex
Systems models
Applications

• Explore patterns & behaviours (not predictions)
• Non-divisibility of the system
• Explore larger perturbations away from equilibrium
• Emergent behaviour (financial cycles/crashes, civil unrest, ecology)
• Adaptive and learnt behaviours (inc. herding)
• Predictability – small perturbations can cause large deviations

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Colour palette for PowerPoint presentations:

- Dark blue: R17 G52 B88
- Gold: R217 G171 B22
- Mid blue: R64 G150 B184
- Light grey: R220 G221 B217
- Pea green: R121 G163 B42
- Forest green: R0 G132 B82
- Bottle green: R17 G179 B162
- Cyan: R0 G156 B200
- Light blue: R124 G179 B225
- Violet: R128 G118 B207
- Purple: R143 G70 B147
- Fuscia: R233 G69 B140
- Red: R200 G30 B69
- Orange: R238 G116 B29
- Dark grey: R63 G69 B72

Secondary colour palette:

- Color names and corresponding RGB values are listed.
Systems thinking today

• **Model types**
  - Systems dynamics
  - ABMs
  - Chaos theory
  - Fuzzy logic
  - Genetic algorithms

• **Model applications**
  - First model use for GE manufacturing
  - Industrial management
  - Optimising fuel consumption
  - Spread of epidemics

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Systems thinking tomorrow

- Model development and use becoming mainstream
  - UK & EU research funding (e.g. CECAN, MEDEAS)
  - Economic risk (esp. herding and emergent risk)
- Model applications
  - Financial crisis
  - Stock markets and equity/commodity valuations
  - Social interactions (e.g. terrorism)
  - The weather…

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