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A GENERIC FRAMEWORK FOR GENERATING AND EXPLORING C2 CONCEPTS

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Overview

- The transformation agenda
- Needles in haystacks
  - – the seven problems of the “fitness landscape”
  - – a solution strategy
- Phase 1: Understanding Defence Effectiveness
- Phase 2: Creating the Space
- Phases 3 & 4: Planning and Executing a Mission in the Space of Possibilities
- Concluding Remarks

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The transformation agenda

"Find new domains of force effectiveness"!!

- But what **is** 'effectiveness'?? .. Elusive, but you know it when you see it
- Why? exponential growth in technological capabilities & in threats
- pit one vs other? → RMA/IS …NCW/NEO/NEC…EBO/MDM/EBP

"Transformation"? … suggests:

- Sweeping changes in structure, function, process – not just local improvements
- Do different things or play different role in bigger picture – not same things better
- Force → leaner, more powerful, aware, anticipatory, flexible, better able to deal with complexity, better able to work in diverse partnerships…

… begs many difficult questions:

- If we are moving goalposts, how do we know in what direction to move them?
- If making radical change in some aspects, how can we be confident of necessary complementary changes in other aspects? And can they be implemented in parallel?
- How can we undertake profound transformation without taking force offline?

Common thread … in each case we're looking for needles in haystacks

- Pick a direction out of a hyperspace..
- Select from astronomical no. of possible combinations
- Find viable path through vast no of intermediate possibilities

c.f. **problem or task complexity =** $\frac{\text{number of ways of performing the task incorrectly}}{\text{number of ways of doing it right}}$

i.e. we have a complex design problem! → Experimentation & Co-evolution

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Experimentation & Co-evolution

Experimentation

- ***Good for research about how things <u>are</u> in the world***
- ***But in defence, often misguided in attempt to apply scientific methodology to what is essentially a complex design challenge,***
- ***<u>crucial difference</u>:***
  - ***science looks for enduring and universal principles by <u>attempting to refute</u> hypotheses through experimentation designed to test all their consequences,***
  - ***whereas in a design problem we are first looking for ways to <u>make things work</u>.***
- ***vast number of ways of doing things wrong, and relatively few of getting it right – the challenge is to find the latter.***
- ***naïve experimentation that results in 'breaking' a new concept hasn't proved anything except that the experimenter hasn't been smart enough to figure out how to take advantage of the potential utility that might reside in the concept.***

Co-evolution - *multi-dimensional exploration of the 'effectiveness landscape' to find (co-evolve) combinations of characteristics with acceptable levels of utility.*

- ***Measurement of the utility clearly requires experimentation, but what is less widely appreciated is that the design process itself in the form of constructive exploration also requires experimentation.***

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Needles in Haystacks

the seven problems of the fitness landscape

A more accurate picture…

1. How to define fitness? Notoriously difficult…
2. How big is the space? Notoriously astronomical
3. How does fitness depend on design choices (parameters)? Not smooth or single-valued, also depends on many uncontrollable factors
4. How can we ‘see’ the peaks? We cant… only laboriously explore tiny bits… So how can we know where to look?
5. What search trajectory to take? What to vary? But must tune interdependent factors to find potential value – so cant keep ‘everything else fixed’!
6. What to do at each point? Estimate fitness!… but how? Requires co-evolution I.e. some kind of exptn.
7. But the space is not static! **OUCH!!**

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A Solution Strategy

1. How to define fitness?
2. How big is the space?
3. How does fitness depend on design choices (parameters)?
4. How can we 'see' the peaks?
5. What search trajectory to take?
6. What to do at each point?
7. But the space is not static!

→ **Phase 1**: Understand what constitutes effectiveness

→ **Phase 2**: Understand dimensionality and structure of concept space

Focus on C2 here ..

→ **Phase 3**: develop ways of rapidly scanning and segmenting the space

→ **Phase 4**: develop accelerated forms of co-evolution & effectiveness evaluation

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Phase 1
Understanding Defence Effectiveness

The most important problem to solve!

- Effectiveness defined externally
- But strategic guidance generally vague..→ use scenario-based capability goals..
- … but danger in glib jump to specific! → lose sight of bigger picture
- Effectiveness must be developed in concert with other agencies.

- Explore the "Space of Possible Futures" and assign 'values' to different regions.
- 'very d… … costs'
- Identify roles that defence can play in the wider context
- Identify outcomes defence should produce or avoid in its contribution to generation of desirable futures, or prevention of dangerous futures

Belongs to broader forum to which defence is answerable

Defence business!

"goal is to … deter … compel … rapidly and …

Outcome space seems discouragingly complicated:

- Vast number of parameters
- all interactive
- multiple domains:: Physical, Cognitive,Social, Informational

But can simplify!:

"Ultimately armed conflict is about a clash of wills"

What kinds of crises?

At what acceptable cost?

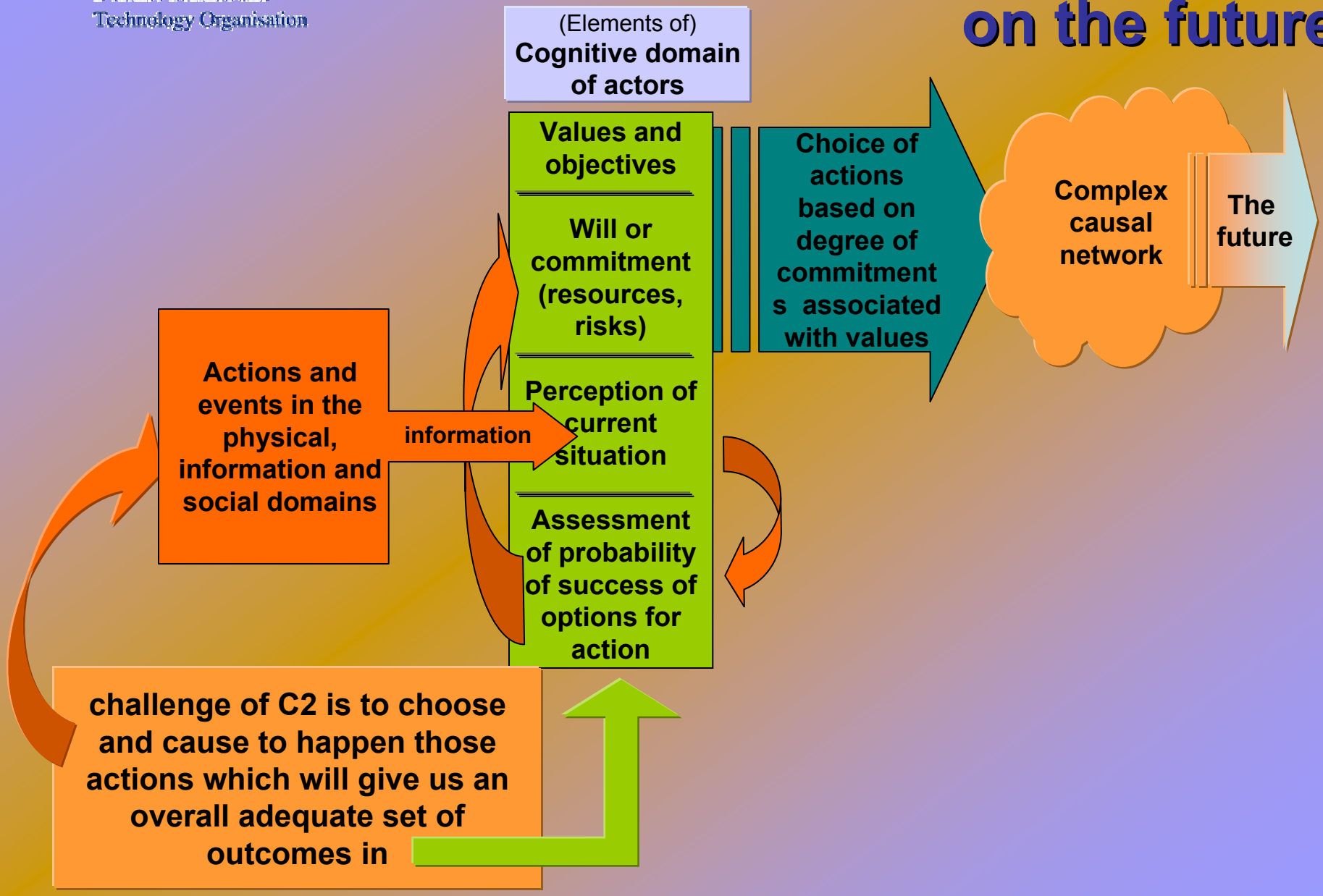
What constitutes defeat?

How to judge how decisively defence acts?

What are the implicit goals?

eg don't solve one crisis by actions that ultimately cause a more serious crisis later?

Phase 1: Will as a locus of influence on the future



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Phase 1
→ Effectiveness measures

- In <u>actual ops</u> planning issues are clear (even if hard...)
- In <u>capability</u> planning don't know types of crises, timescales, extent and concurrency requirements, and possibilities wider than ever
- → even if not sure what kinds of operations will have to perform, can be sure of one thing:

  realtime dynamics of deciding what defence is going to do and raising an appropriate force package to do it will be of comparable importance to ability to produce / prevent particular outcomes.
- essentially a C2 issue at level above operational C2
- → need force not optimised for known things, but flexible force construct to negotiate with range of stakeholders, and rapidly mount specialised operations in partnership with other agencies.

effectiveness measures of the force must embrace both:

- conventional measures of mission outcomes, and
- dynamical properties of how higher level decisions about what missions to undertake are made and implemented

Phase 2
Creating the Space: a Generic Framework for C2

eg Outcome:
- *defence (alone or in cooperation) causes adversary to perceive checkmate for every dangerous CoA*
- *Conversely, we always have freedom of action to achieve our objectives*

Suppose now have clear set of effectiveness measures describing
- **the outcomes by which defence will be judged, and**
- **hence the roles and functions which it must perform, and**
- **the dynamical properties of the defence enterprise**

explore space of possible ways we might address C2 aspects

Discussed in Phase 1

what exactly is C2 about?

1. **negotiate defence role in implementing higher strategic intent in space of possible futures**
2. **determine outcomes defence must produce/avoid, alone or with others**
3. **choose defence actions to undertake**
4. **cause those actions to happen, and**
5. **monitor and continuously re-assess all above in light of unfolding events**

Recursive – applies at any scale

Look at next

<u>Planning</u>: understand causal network, benefits, feasibility, costs and risks

Dont build in any constraining assumptions about how roles are performed and interact !

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Phase 2: Conditions for Action

Also recursive – applies at any scale

1. Objective (for action)
2. Will to act
3. Opportunity to act
4. Capability to act:
   - Authority to act
   - Physical Means
   - Information required
   - Competence

C2 roles in 'causing' actions:

1. Determine objective (for action)
2. Foster will to act
3. Seek, shape, recognise opportunity to act
4. Build capability to act:
   - Delegate authority & constraints

Allocate (realtime); develop (slow time)

   - Physical Means
   - Information required
   - Competence

Complex Adaptive Systems also offer other approaches – DONT exclude!!

Plus need interaction and collaboration to

- achieve coherence of actions in big picture
- rapidly id/resolve conflicts in whole context
- negotiate objectives, resources, constraints responsibilities, authority and information between various elements.

→ free C2 parameters in framework:
- Extent to which functions are performed + …
- Where, how, when and by who

Choosing values of parameters
→ specifies C2 structure & approach
→ how these C2 functions are performed, distributed and linked.

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Phase 2: Meta-parameters

Where C2 aspects are variable → must choose:

- **hardwired, uniform throughout force, enduring in time? or**
- **dynamic, local, temporary?**

These meta-decisions → dynamical properties of the force, and

→ requirements on how force is organised, equipped, trained, supported.

C2 Role 5 -- 'Control' function

- **because 'ballistic' behaviour isnt successful in complex enterprises**
- **control provides feedback necessary for adaptive action**
- **degrees of freedom for generic model are parameters of adaptation:**
  - **selection of indicators to monitor,**
  - **how well they correlate with likelihood of producing preferred outcomes,**
  - **frequency of monitoring relative to the timescale of change in indicators,**
  - **how tight the control loops are**

+ Role of information and its parameters – refer written paper

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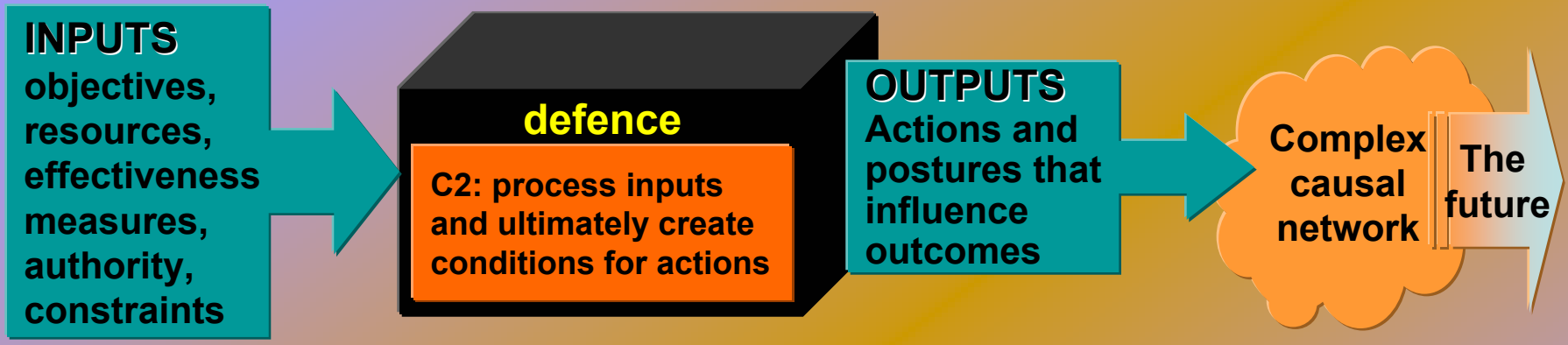
Phase 2: Summary



Have sketched out a generic framework describing essential features of C2 with two classes of free parameters, and ranges wide enough to cover all conceivable choices about how C2 could be handled.

1 How inputs → conditions for actions.

How, information, access to resources, responsibilities for objectives and authority, are processed and distributed throughout the force, and what types of interactions exist between the nodes of the network

2 Dynamical meta-properties of C2:

which parameters are not fixed, ranges, how values are chosen, how long they endure, how homogeneous, under what conditions they change and what indicators are monitored to trigger such changes.

THIS IS A VERY LARGE SPACE INDEED!!

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Phases 3 & 4:
Planning and Executing a Mission in the Space of Possibilities
- some initial and immature thoughts …

Two problems: Need ways to

- rapidly scan or segment the space to mark potentially interesting regions
- reduce number of regions to be explored or complexity and dimensionality
- estimate force fitness at a point in the space.
- rapidly estimate outcomes in a region without slow costly experiments

Key principle operating:

- Exploit building block hierarchy of natural CAS
- then searching for useful new features at one level of complexity is much simpler
- look for patterns at each level → become entities of next level. Search is then always tractable.
- Fitness function and estimation simpler too!
- eg success of Brooks' Subsumption Architecture

"the cut and try of evolution isnt just to build a good animal, but to find good building blocks that can be put together to make many good animals."
(Holland)

Reminiscent of other needle-in-haystack problems:

- How has evolution thrown up such dazzling variety of lifeforms?
- How does human mind leap to insightful algorithm-defying chess moves?

Existence of solutions in natural world is an existence proof → hope…

To Do List

Lots to do to establish feasibilty, let alone productivity, of this strategy.

- **further structural analysis of the outcome space, and its relationship with the futures space,**
- **defining useful measures of defence effectiveness,**
- **mapping out the causal networks operating on each side of the cognitive domain of the major players,**
- **better understanding cognitive domain**
- **further development of the C2 parameter space and its extension to cover other defence functions,**
- **structural analysis of that space into a generic building block hierarchy,**
- **corresponding decomposition of the effectiveness measures into a hierarchical structure,**
- **development of techniques for their rapid assessment,**
- **application of the subsumption principle to spawning promising concepts for a more targetted search through the space of possibilities.**
- **remaining challenge of dealing with a dynamic reactive context**

Any takers??