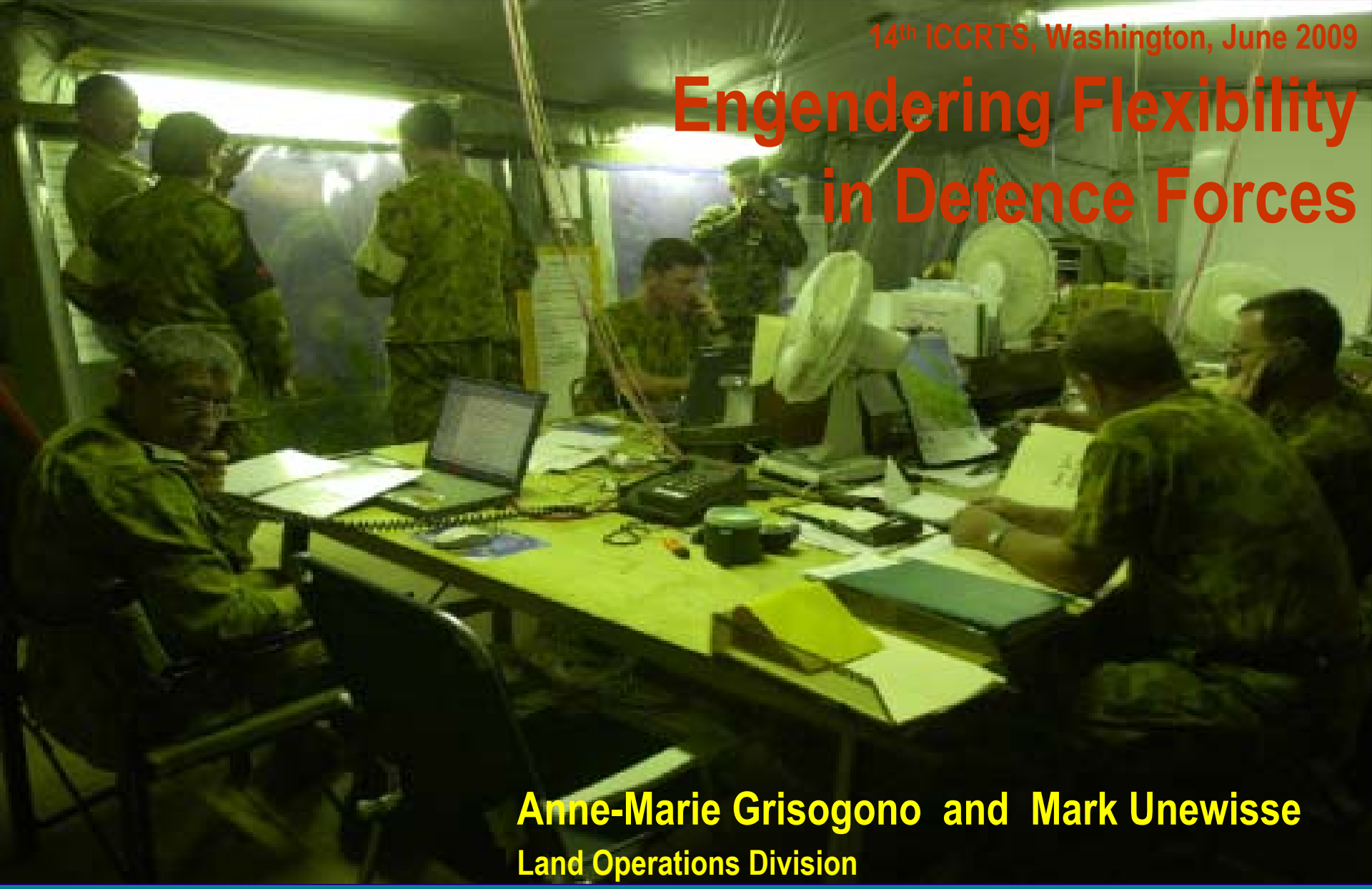

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Engendering Flexibility in Defence Forces

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Overview

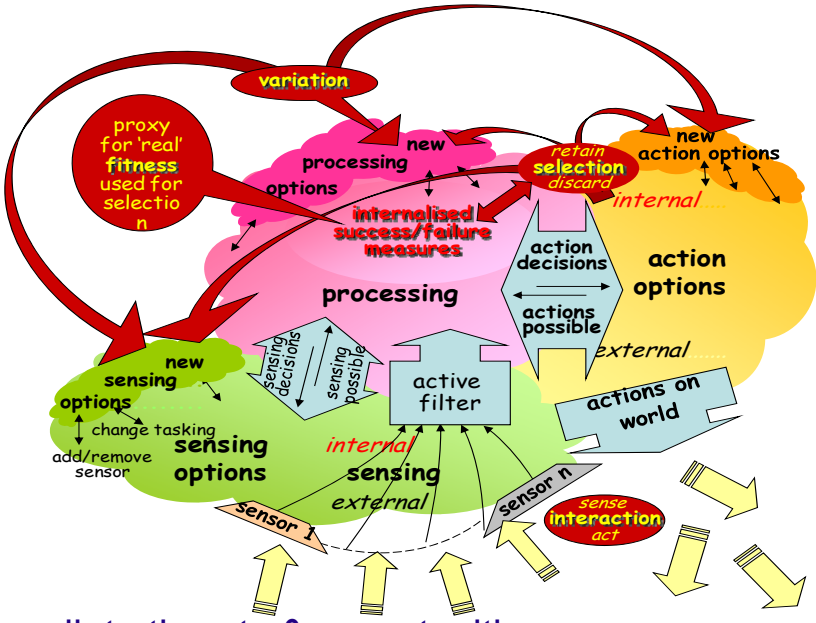
- Adaptation and Flexibility – basic concepts
- Duality of Systems and Operations
- Domains of Adaptive Action
- Improving Flexibility at Different Scales
- Design Factors for Flexibility
- Trade-offs and Meta-Decision Space
- Adaptation Architecture

Adaptive Systems

- **Complex systems which are adaptive – i.e. structure and behavior of the system changes over time in a way which tends to increase its 'success'.**
- **Being adaptive requires**
  - concept of 'success or failure', or 'fitness', for system in its context
  - a source of variation in some internal details of the system
  - way of evaluating impact of a variation on fitness
  - a selection process, i.e. the system preferentially retains/discards variations which enhance/decrease its fitness

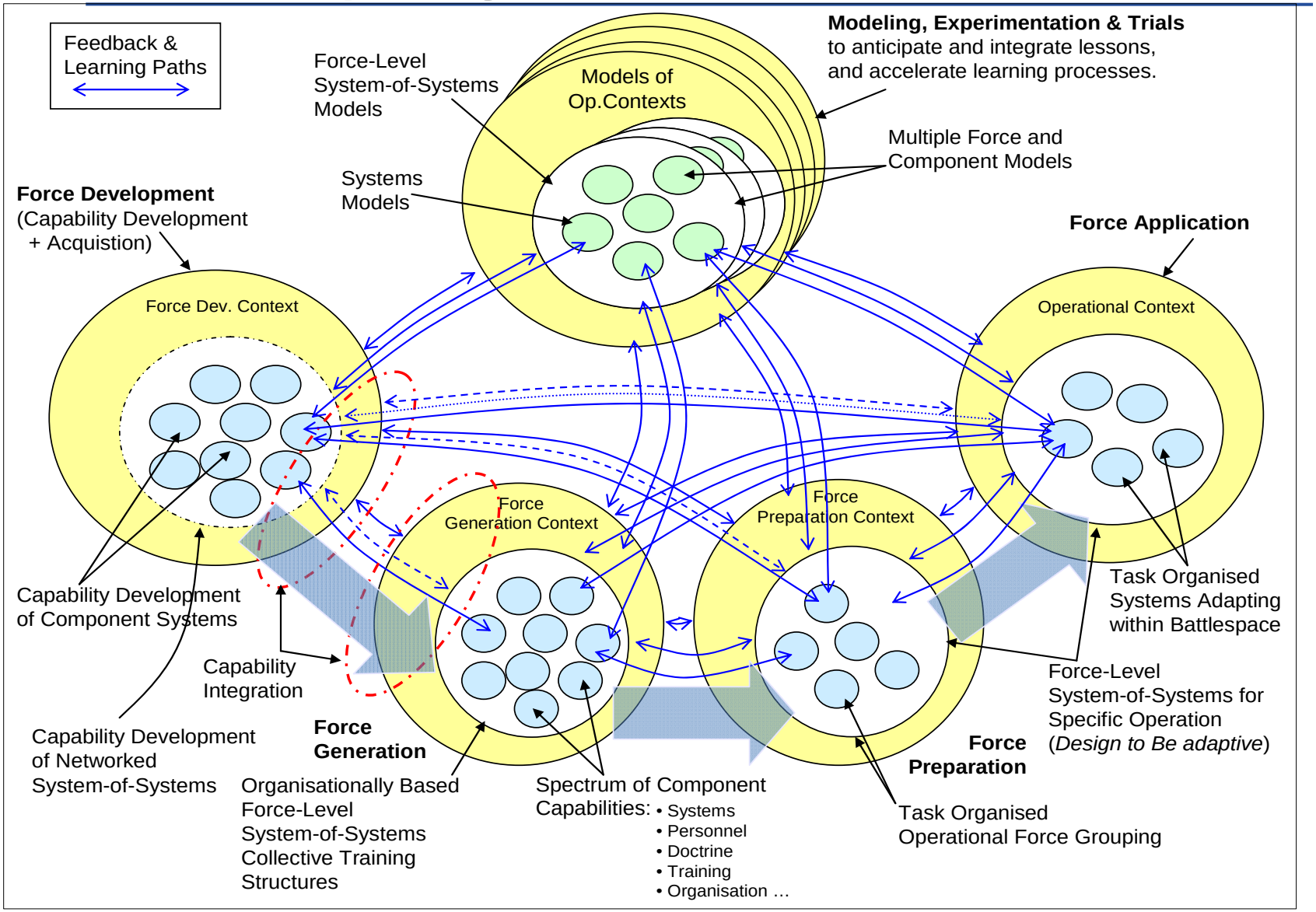
Conceptual Framework for Adaptation

- **Structured generic framework form adaptivity in complex systems**
- **Levels of Adaptivity**
  - Level 1: Action-in-the-World
  - Level 2: Learning
  - Level 3: Learning-to-learn
  - Level 4: Defining Success
  - Level 5: Co-Adaptation
- **Classes of Adaptivity**
  - Responsiveness: ability to respond to immediate threats & opportunities
  - Resilience: ability to cope with shocks or harm to the system
  - Agility: ability to implement changes in approach within a context
  - Flexibility: ability to deal with new challenges and divergent contexts
- **Scale –** Ranging from individual to enterprise

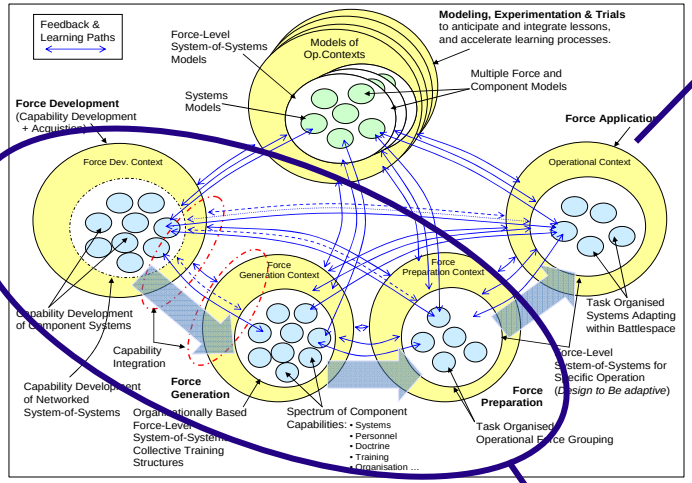


capacity of a force to modify itself so as to be able to rise effectively to continuously evolving challenges, both within the range of what is expected, and not.

Defence Capability Creation Model



Defence Capability Creation Model



Operations are systems in action

Design and execution of complex operations ➔ What kind of complex system is needed

DUALITY

Design and build of complex systems ➔ what kind of operations are possible

systems are means by which operations can be implemented

- vast number of possibilities

components of operations systems (capability elements) and how they are put together (operational stratagem; SoS design))

- complex interdependent multi-dimensional and multi-scale MoS/F
- complex Causal and Influence Networks (C&INs)

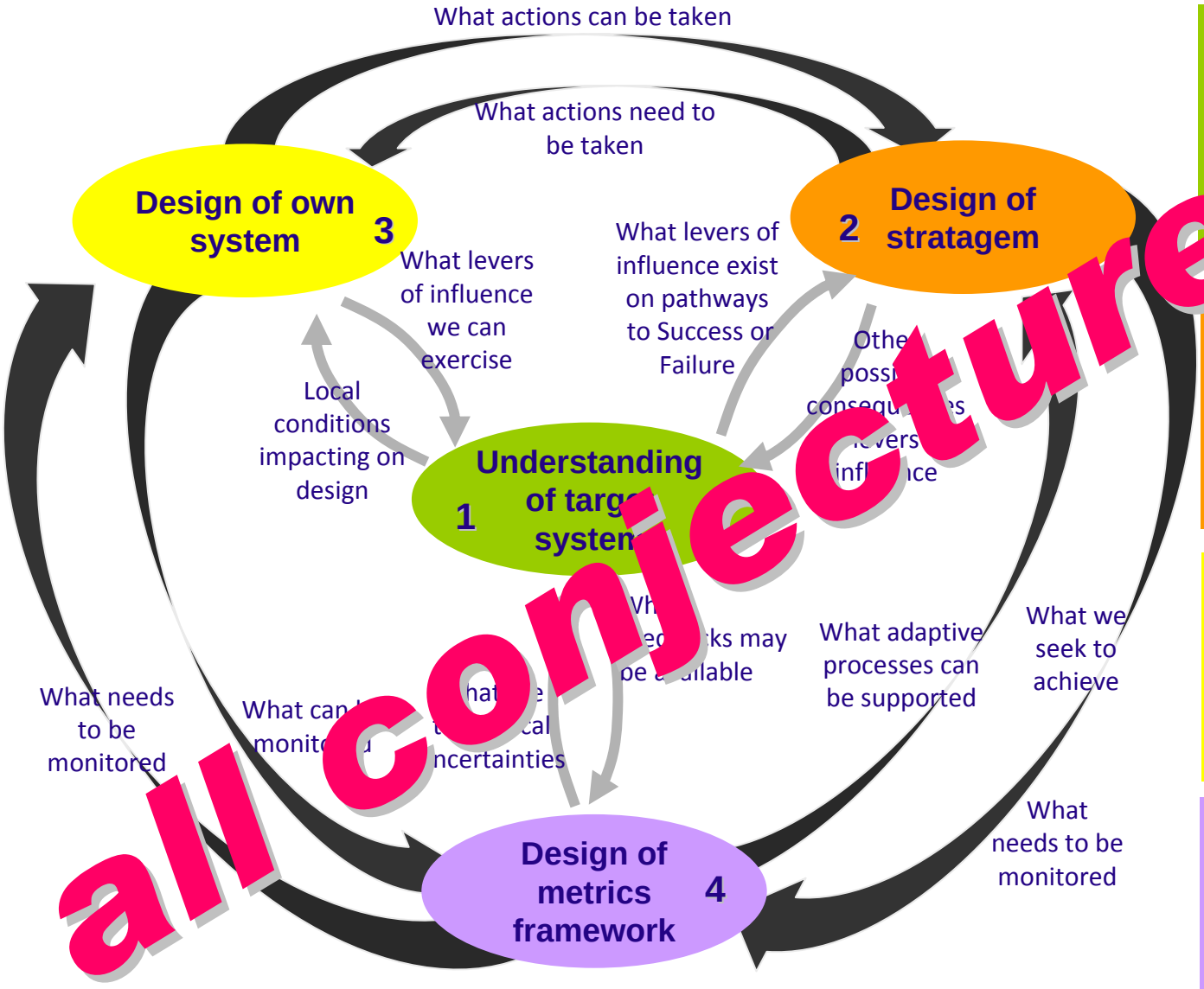
➔ Both present complex problems to design and manage.

Domains of Adaptive Action

- **Structure and functions of systems**
  - → kinds of outcomes they can generate in a given context.
- **Adaptive properties of systems**
  - → their ability to understand themselves and their context well enough to determine:
    - what outcomes they should generate,
    - when they should change what they're doing,
    - how they need to change themselves in order to do so, and
  - → their ability to make those changes smoothly and quickly enough

Continuous Co-evolution of Understanding and Design

Multi-scale Structures



Situation Understanding
- wide-scope bi -picture dynamics,
- ...
- det ... mapp ... of roles, relat ... ist ... es, causal ... ors ... ific local areas

perational Design
- overall stratagem,
- CoA (Course of Action),
- plans,
- tasks
- ...
- detailed execution

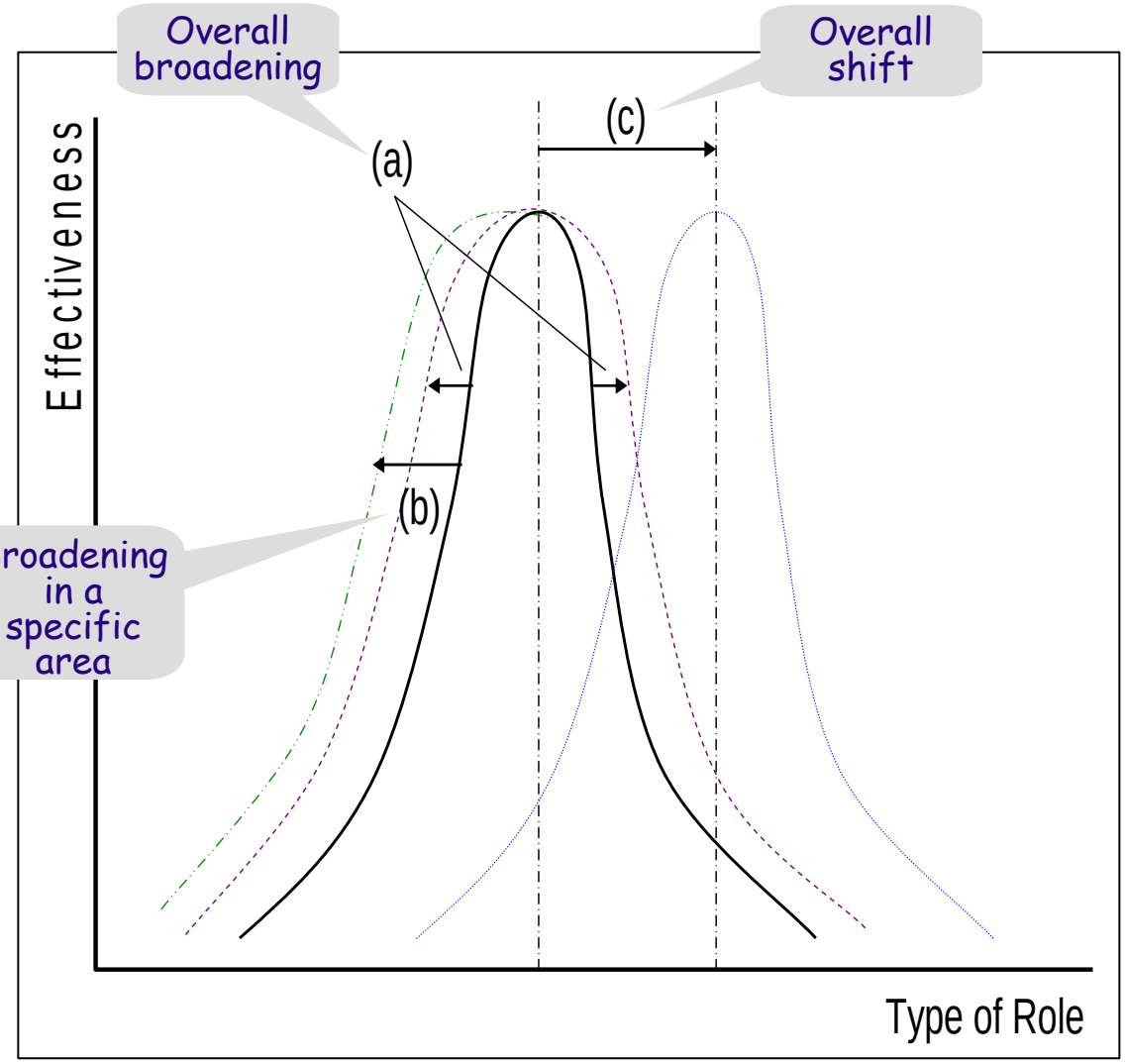
System Design
- SoS design
- Major systems
- ...
- teams
- individual components

Metrics Framework
- high-level success and failure,
- proxies for success and failure,
- indicators,
- contingent factors and
- measures of performance

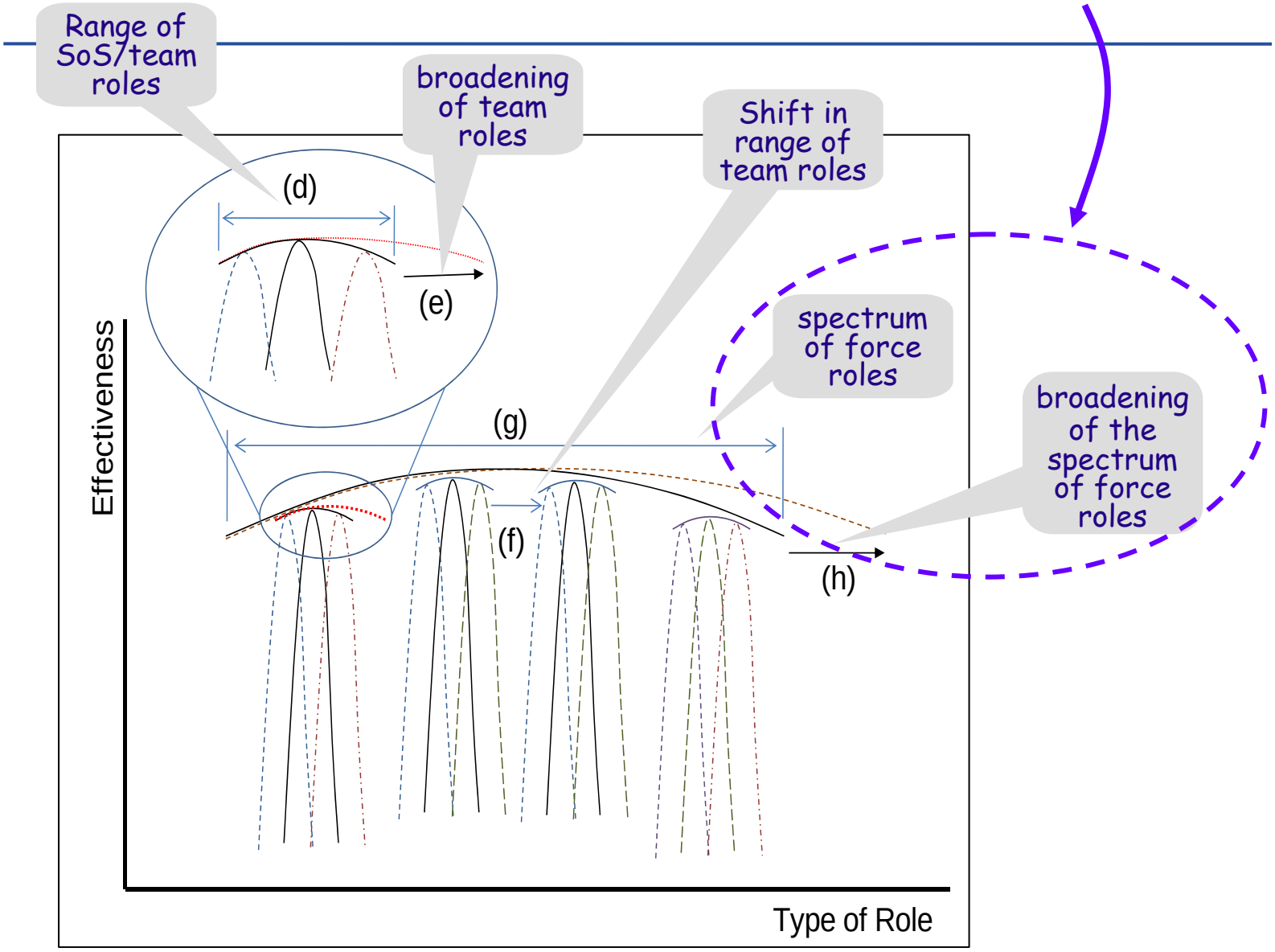
Importance of Flexibility

- As situation develops, and understanding grows
  - **many adaptive changes called for**
  - **at various scales of both situational understanding and operational design, and**
  - **hence also to the metrics framework which represents a distillation of both, and**
  - **therefore also to the system that implements the changes in the operational design and**
  - **the collection plan.**
- These adaptive changes may relate to
  - *responsiveness* **to changes in the threat and opportunity landscape,**
  - *resilience* **in the face of incapacitation of elements of capability, or**
  - *agility* **in recognition that the current stratagem or CoA is no longer the best feasible option.**
- But changes to operational design and metrics to be monitored can only be made if the deployed system is capable of determining what changes would be effective and implementing them in a timely way.
- Therefore *flexibility* of the force is paramount in determining the extent of its other adaptive properties beyond what is in reach of its current configuration.

Level 2: Improving Component Flexibility



Level 2: Improving Flexibility at the SoS and Enterprise scales



Level 3: Improving How Flexibility is Improved

- **Level 3 changes can be introduced at every scale, by**
  - examining how Level 2 changes are made,
  - measuring how effective they are at achieving the desired changes in flexibility, and
  - seeking ways to do it better,
  - supported by experimentation and feedback.
- **As with all design drivers the goals of enhancing flexibility need to be balanced with other conflicting goals.**
- **Greater flexibility does not always provide increasing benefit since there can be significant associated costs and impacts on overall component and SoS effectiveness, including:**
  - down time,
  - material cost (financial, equipment, personnel) to keep multiple options open and due to increased implementation costs; and
  - providing decision-makers with too many options, variable and elements that need to be pulled together to enable the right change decisions to be made.

Design Factors for Flexibility

SIFs: first discussed by Herbert Simon in *The Sciences of the Artificial*, MIT. 1996. They have since become widely appreciated as a key design pattern of complex systems

- Exploit self-organising processes to facilitate fast smooth implementation of selected changes;
- Use Service Oriented Architectures (SOA), standardised interfaces where feasible, cost-effective;
- broker services to mediate interactions between components;
- Exploit Stable Intermediate Forms (SIFs) to accelerate speed and success of evolutionary searches – i.e. modular composable components at every practical scale;
- Appropriate use of structure – hierarchical SoS composition with adaptive selection at every scale = multilevel selection + extra reqts on relations bet. adaptive processes to avoid chaotic regimes;
- Cultivation of 'hot swap' capabilities;
- Adaptive approach to managing the trade-off between multifunctional and specialized components to provide sufficient diversity and capability;
- Biologically-inspired techniques such as recombination, facilitated variation which comprises conserved core processes, weak regulatory linkages and exploratory processes, and so on to enable faster, wider and more useful generation of options;
- Adaptive approach to managing trade-off between increasing the flexibility of the components operating within the SoS, and the ease of combining them into novel configurations; and
- Adaptive approach to managing the trade-off between trying to equip a component with as much flexibility as it is expected to need, and giving the component more ability to evolve its flexibility in response to emerging requirements.

Kirschner, M.W. and Gerhart, J.C. *The Plausibility of Life*,

See eg p144 'exploratory behaviors … generate many… specific states in the course of their function, and provide a mechanism for selecting among these states those that best meet the particular physiological need', p 219 for a discussion of facilitated variation, p 109 for weak regulatory linkages etc.

Designing for Flexibility

- **Flexibility requires**
  - ability to generate and evaluate innovative SoS designs,
  - ease of integration, or federation, of component systems into many different combinations,
  - as well as components that can play many different roles within a SoS.
- **Design factors that support these requirements include**
  - avoiding hardwired solutions, and
  - preserving degrees of freedom in system designs.
- **Need a more nuanced view of interoperability**
  - mandating formats, interfaces, or technical systems = one solution strategy, but needs central authority to enforce and resource the mandate.
  - ability to work together needs less – ability to establish agreements and provide and receive services, whether through direct or indirect (eg via a broker) interaction.
  - enlarges the scope of potential flexibility in environments with a great diversity of players, such as feature in most of our current and expected future operations.

INTEROPERABILITY = ability of diverse systems and organisations to work together

HOW decisions get made about

WHAT design decisions get made,

and WHEN, WHERE and by WHOM those decisions are made.

Trade-offs and the Meta-Decision Space

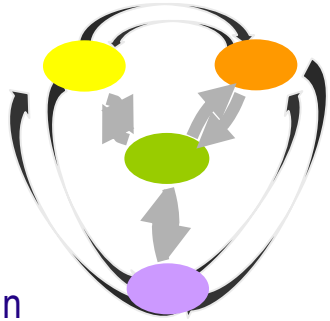
1. ↑ flexibility → efficiency ↓ in particular tasks, and ↑ decision burdens on deployed force
   - Handling this trade-off depends on expected complexity and dynamic properties of environment.
2. make design decisions at last possible moment vs costs and risks incurred
   - PROS: keep options open to increase adaptive range
   - CONS: greater decision burden on operational domain, risks of poor decisions, and greater cost of extra sense, process and act options needed to take advantage of adaptive range etc.
3. .. to maximize force's adaptive properties for complex endeavors, .. need:
   - *necessary design degrees of freedom are left open in preceding stages, and*
   - *necessary adaptive processes are facilitated by the design choices made in those stages.*
   - .. Force Development domain.. should only determine those design features that meet.. conditions .. of being costly to build or of having many other design decisions dependent on them.

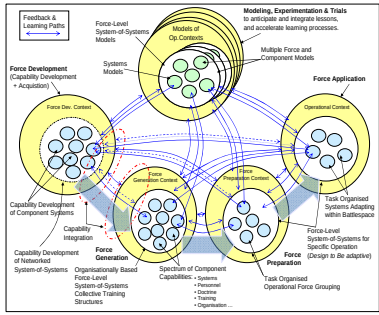
- Our meta-decision architecture is largely accidental by-product of decisions made for reasons of local efficiencies, tradition, administrative convenience, short-term cost-cutting etc
- justifiable within frame of decisions, but don't necessarily combine to produce most effective use of resources to address overall goals and higher objectives.
- structures and processes developed to implement them become costly and difficult to modify,
- complexity of existing enterprise too great for pure top-down restructuring to be effective.
- Changing meta-decision architecture must be addressed adaptively as structural and business process design issues at all scales of the enterprise.

Adaptive Approach to Creating Flexible Capability

- **Apply Conceptual Framework for Adaptation to fostering necessary changes in meta-decision architecture at enterprise scale**
- **Apply Domains of Adaptive Action to Enterprise level Capability Creation:**
  - **Situational context** = wider context within which situations requiring defence interventions arise, (including some aspects of our own political and social systems)
  - **System design** = overall enterprise SoS that creates and applies defence capability in response to those requirements (schematic process view represents one high-level view of our 'own system' design)
  - **Operational design** = concept of how to deliver effective defence interventions as required, meta-decision architecture is one aspect.
  - **Metrics framework** captures logic of operational and systems designs by relating:
    - MoS/F at highest scales
    - MoS/F (or proxies for them) at next more detailed scales,
    - down to MoPs for tasks and
    - indicators to be monitored in both our own systems and the target system,

  in order to support continual posing and answering of questions, within adaptive processes at every relevant scale…





How metrics support asking key questions within adaptive processes

- **MoS and F (in providing effective defence interventions as required)**
  - Are we succeeding or failing?
- **Proxies (for MoS and F i.e. measures which we conjecture are on the path to achieving success and avoiding failure, and vice versa)**
  - Are we on a path towards success or towards failure?
  - Is our stratagem working as we expect?
  - Are there undesirable consequences emerging from outcomes we produce that need to be mitigated?
  - … or desirable consequences to be nurtured?
  - Does the stratagem need to be adapted?
- **MoO (of our CoAs which we conjecture will contribute to achieving proxies for success and avoiding proxies for failure)**
  - Are our courses of action delivering the outcomes expected?
  - Do we need to adapt our plans?
- **MoP (of our tasks which we conjecture will contribute to achieving the CoA outcomes)**
  - Are we performing our tasks well enough?
  - Do we need to adapt how we perform them?
- **Contingent factors & indicators**
  - What is going on in the complex situation ?
  - Does our understanding of it make sense in the light of what we are observing?
  - Do we need to change our unerstanding?
  - Is there an opportunity or threat to take adaptive action on?

Adaptation Architecture

- **enterprise responsiveness, agility, and resilience supported by:**
  - continual monitoring of these questions
  - flexibility in generating appropriate responses, and
  - ways in which adaptive processes are put together in an *adaptation architecture*
    - adaptive processes in a complex system are not independent
    - may interact in myriad ways eg → synergistic or antagonistic effects on particular elements, one may indirectly modify the impact of another, they may interact temporally to produce oscillations or other patterns etc.
    - So appropriate relationships need to be established (and adaptively refined) between them.
  - *meta-decision and adaptation architectures* are closely related,
  - together form a significant aspect of stratagem and
  - determine how enterprise is able to evolve over time.
  - So, as environments and social and organisational contexts all change over time, the enterprise can keep learning and adapting itself to achieve and maintain high levels of effectiveness in eyes of its stakeholders

enterprise task: enable deploying forces to develop own meta-decision and adaptation architectures

→ keep learning about own complex changing environments,

→ adapt own operational and system designs, and metrics to support.

Summary and Conclusions

- outlined a conceptual basis for flexibility
- interpreted implications for the design and operation of
  - deployed forces and
  - the enterprise that produces those forces.
- identify and discuss factors that contribute to flexibility, and
- how could be better enabled through every phase of the defence capability creation enterprise.
- → recognition of importance of the meta-decision and adaptation architectures of the enterprise, and of the forces they produce.
- Many details remain to be worked out and explored, in particular the impacts for the structures, processes and relationships in the Force Development

QUESTIONS