15th ICCRTS: The Evolution of C2

Quantifying the Need for Force Agility

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Aim

- To study the agility and adaptability of the force development process

- From a Complex Adaptive Systems perspective
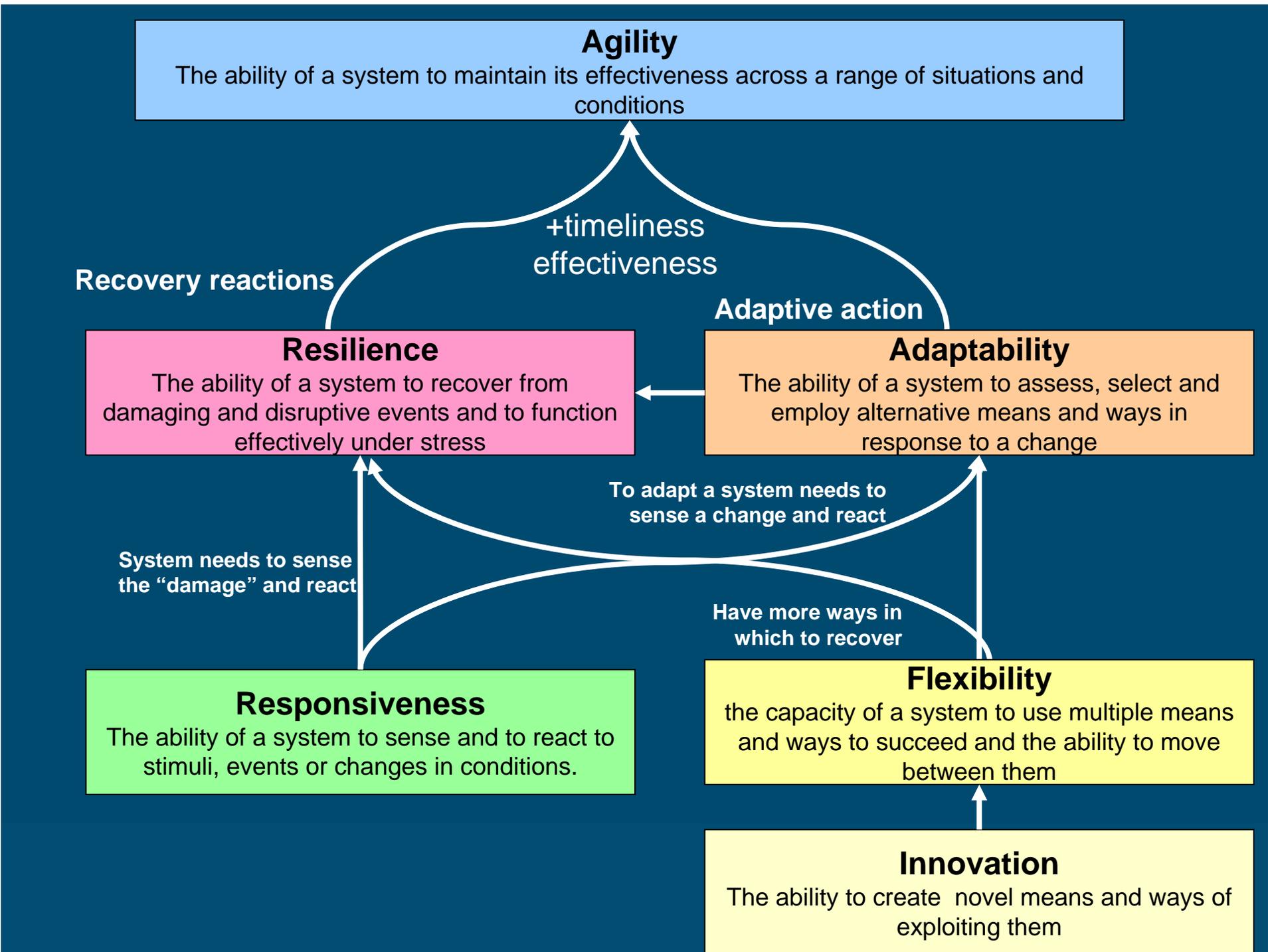
Overall Approach to the Analysis

Agility
The ability of a system to maintain its effectiveness across a range of situations and conditions

+timeliness
effectiveness

Recovery reactions

Adaptive action

Resilience
The ability of a system to recover from damaging and disruptive events and to function effectively under stress

Adaptability
The ability of a system to assess, select and employ alternative means and ways in response to a change

To adapt a system needs to sense a change and react

System needs to sense the "damage" and react

Have more ways in which to recover

Responsiveness
The ability of a system to sense and to react to stimuli, events or changes in conditions.

Flexibility
the capacity of a system to use multiple means and ways to succeed and the ability to move between them

Innovation
The ability to create novel means and ways of exploiting them

Agility – An agile system is capable of delivering effective forces in dynamic threat environments across time.

Resilience – A resilient system can recover from damaging or disruptive events and function effectively under stress. It can recover functionality to a minimum specified level of effectiveness within a desired time frame.

Adaptability - the ability of the process to create, select and employ alternative ways and means that maintain or improve its effectiveness under changing conditions.

In order to adapt, the force development process must have a concept of fitness against which to continually assess its performance.
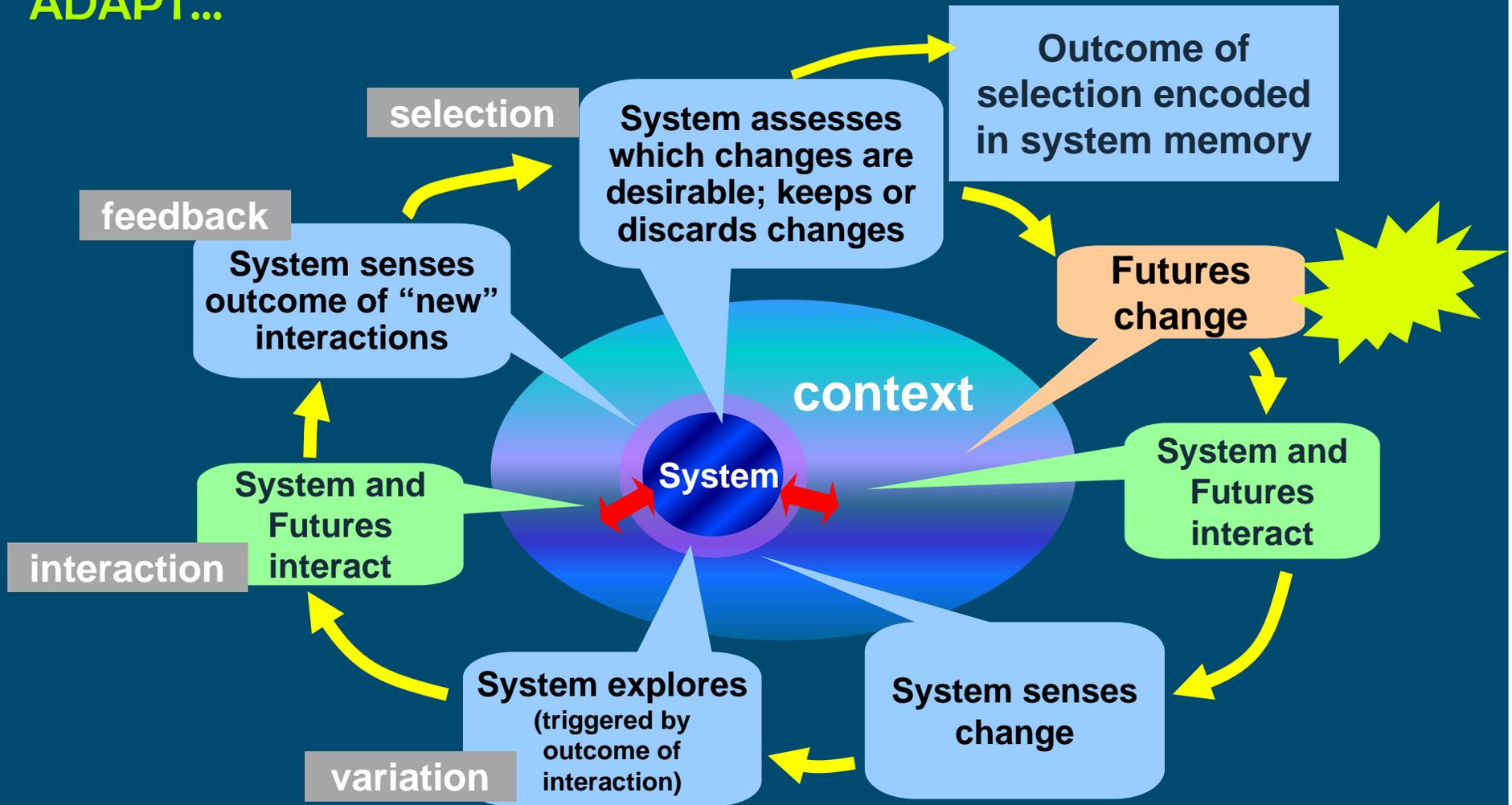
Responsiveness – the ability of the process to sense the current environment, to determine the range of potential future worlds and respond to that by developing interventions that maintain or improve effectiveness.

Flexibility - the capacity of the system to use multiple means and ways to deliver effective capability and the ability to move between them.
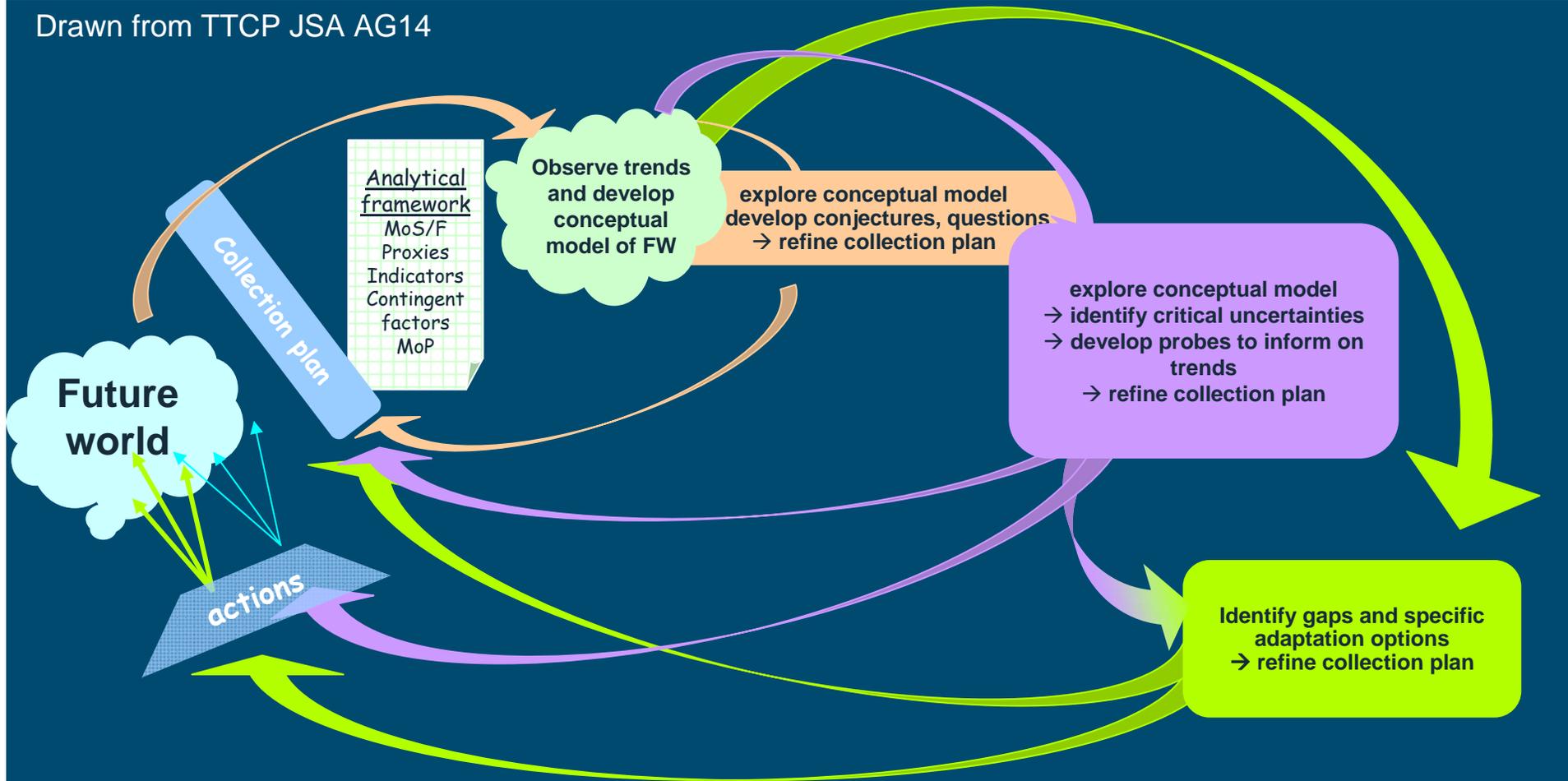
A high degree of diversity should lead to agility in the face of the unexpected.

Innovation - the ability of the system to create novel means and ways of developing force structures and compositions, and methods of exploiting them.
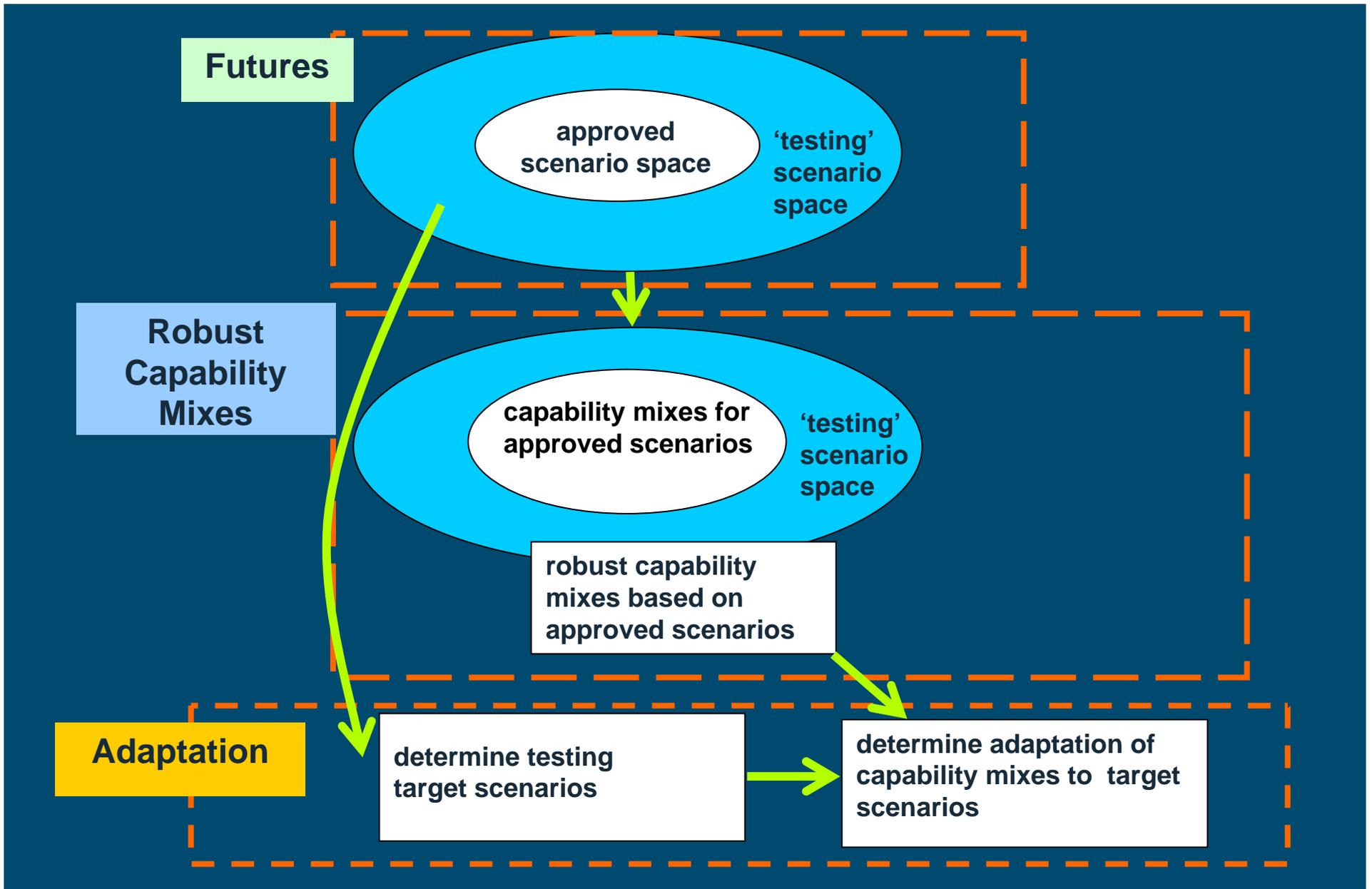
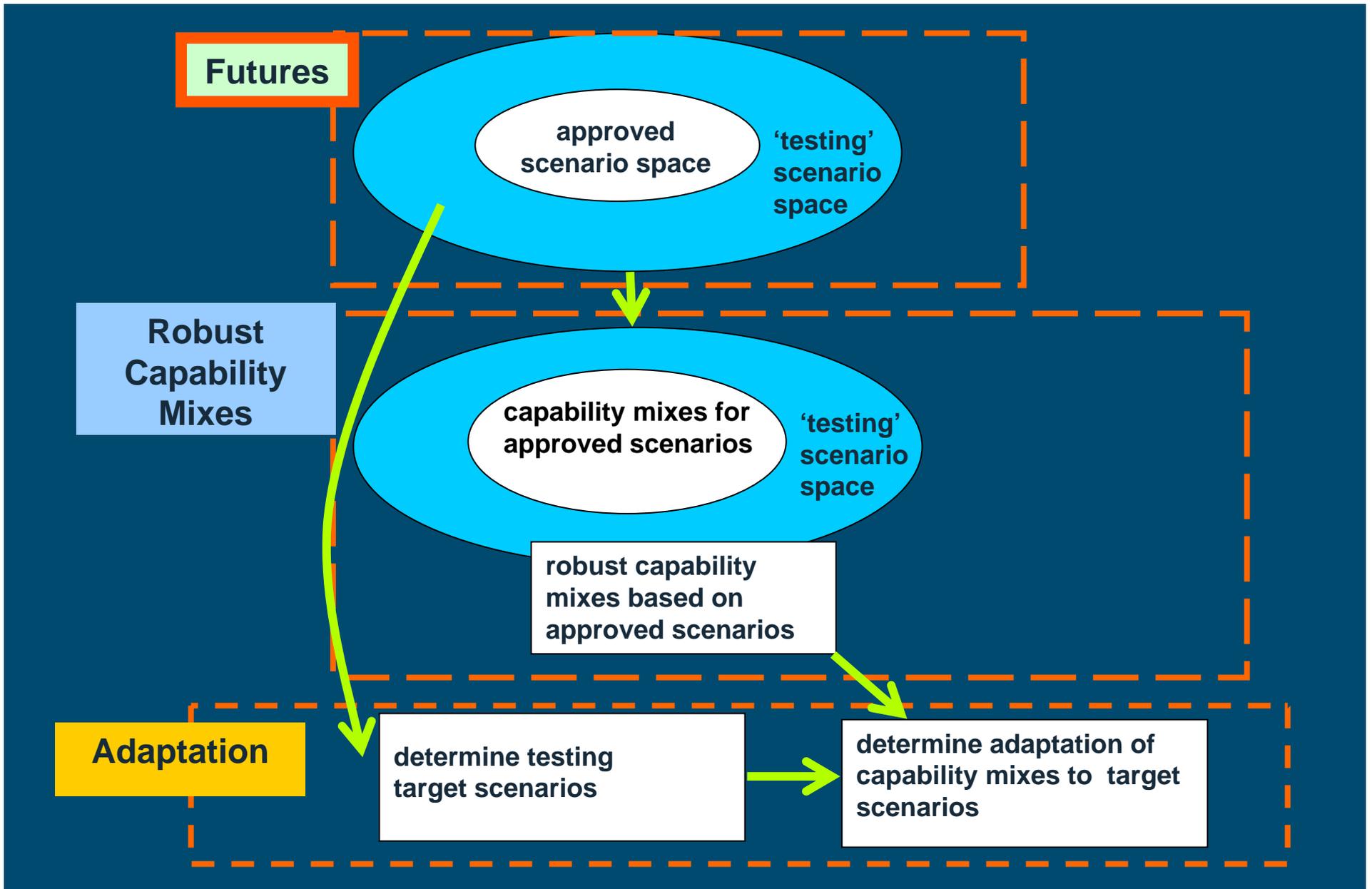# One of the most important characteristics is the ability to ADAPT...

selection

feedback

System assesses which changes are desirable; keeps or discards changes

Outcome of selection encoded in system memory

System senses outcome of "new" interactions

Futures change

context

System

System and Futures interact

System and Futures interact

interaction

System senses change

System explores (triggered by outcome of interaction)

variation

Dstl is part of the Ministry of Defence

Drawn from TTCP JSA AG14

Analytical framework
MoS/F
Proxies
Indicators
Contingent factors
MoP

Collection plan

Future world

actions

Observe trends and develop conceptual model of FW

explore conceptual model develop conjectures, questions → refine collection plan

explore conceptual model
→ identify critical uncertainties
→ develop probes to inform on trends
→ refine collection plan

Identify gaps and specific adaptation options
→ refine collection plan

1. **Evolving conceptual model of the Future world** (orange loop) – represents the range of possible future operational environments and is based on observations of the current environment and historical trends**– Futures**

2. **Evolving intervention strategy** (lilac loop) –capability of the planned force structure is assessed and any shortfalls identified **– Robust Capability Mixes**

3. **Evolving implementation plan** (green loop) – adaptive interactions aimed at dealing with the shortfalls **– Adaptation**
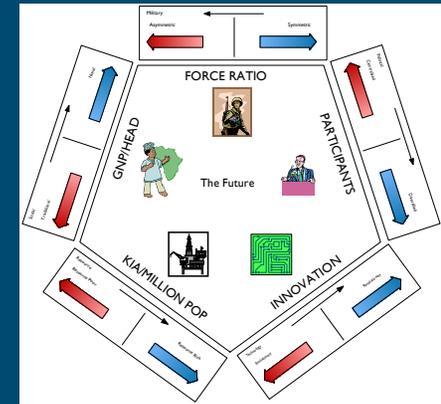
Futures

approved scenario space

'testing' scenario space

Robust Capability Mixes

capability mixes for approved scenarios

'testing' scenario space

robust capability mixes based on approved scenarios

Adaptation

determine testing target scenarios

determine adaptation of capability mixes to target scenarios

Futures

approved scenario space

'testing' scenario space

Robust Capability Mixes

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Adaptation

determine testing target scenarios

determine adaptation of capability mixes to target scenarios

Five Key Strategic Trends Constraining 'Futures' (UK Doctrine and Concepts)

- Military

- Resource

- Political

- Technology

- Social

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Quantitative Indicators of these Strategic Trends

- Military – Force ratio

- Resource – Military killed in action per million population

- Political – number of participating states/actors

- Technology – mean age of equipment employed

- Social – GDP per capita of conflict zone

K Conflicts from WW2 to Present
og-log scales)

Military vs Resource - UK Conflicts since 1945
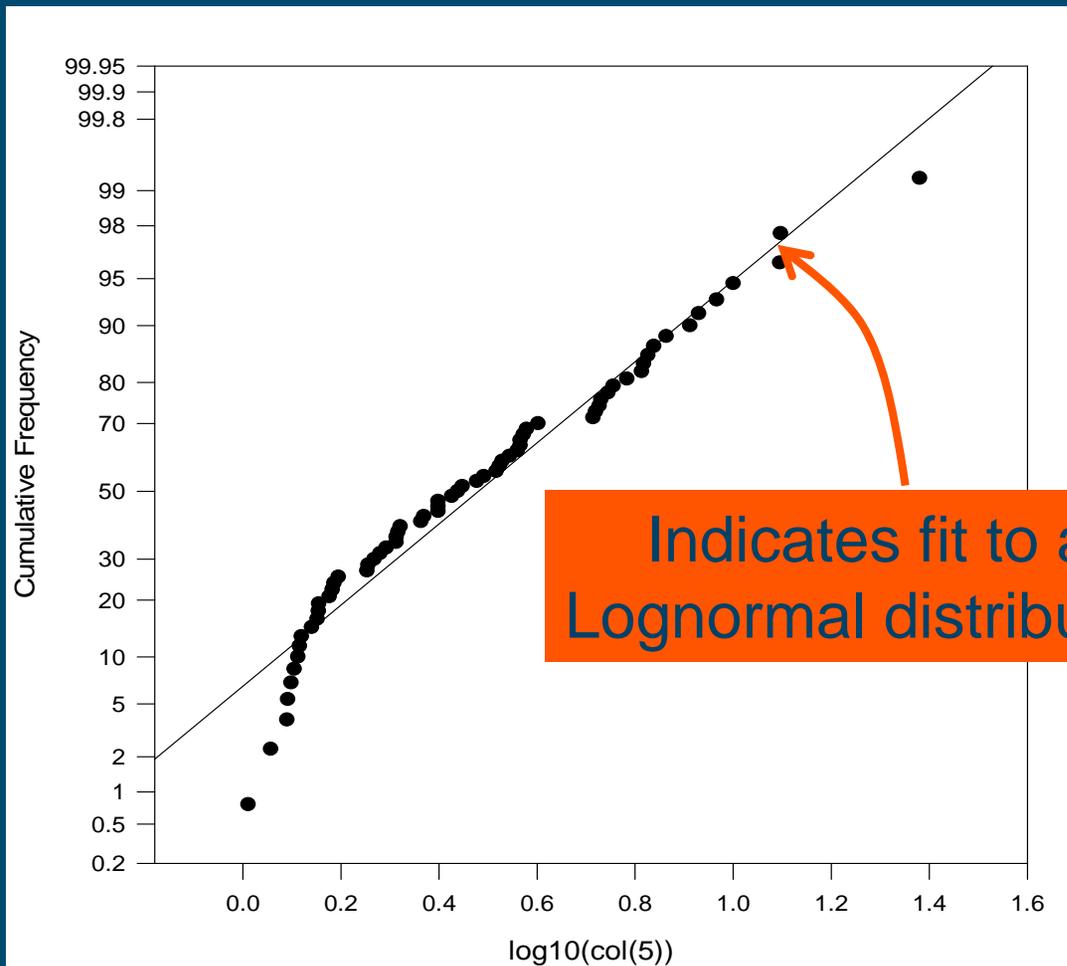**Force Ratio versus Total KIA per Total Million Population of Participants**

Force Ratio (UK and Allies/Opponents)
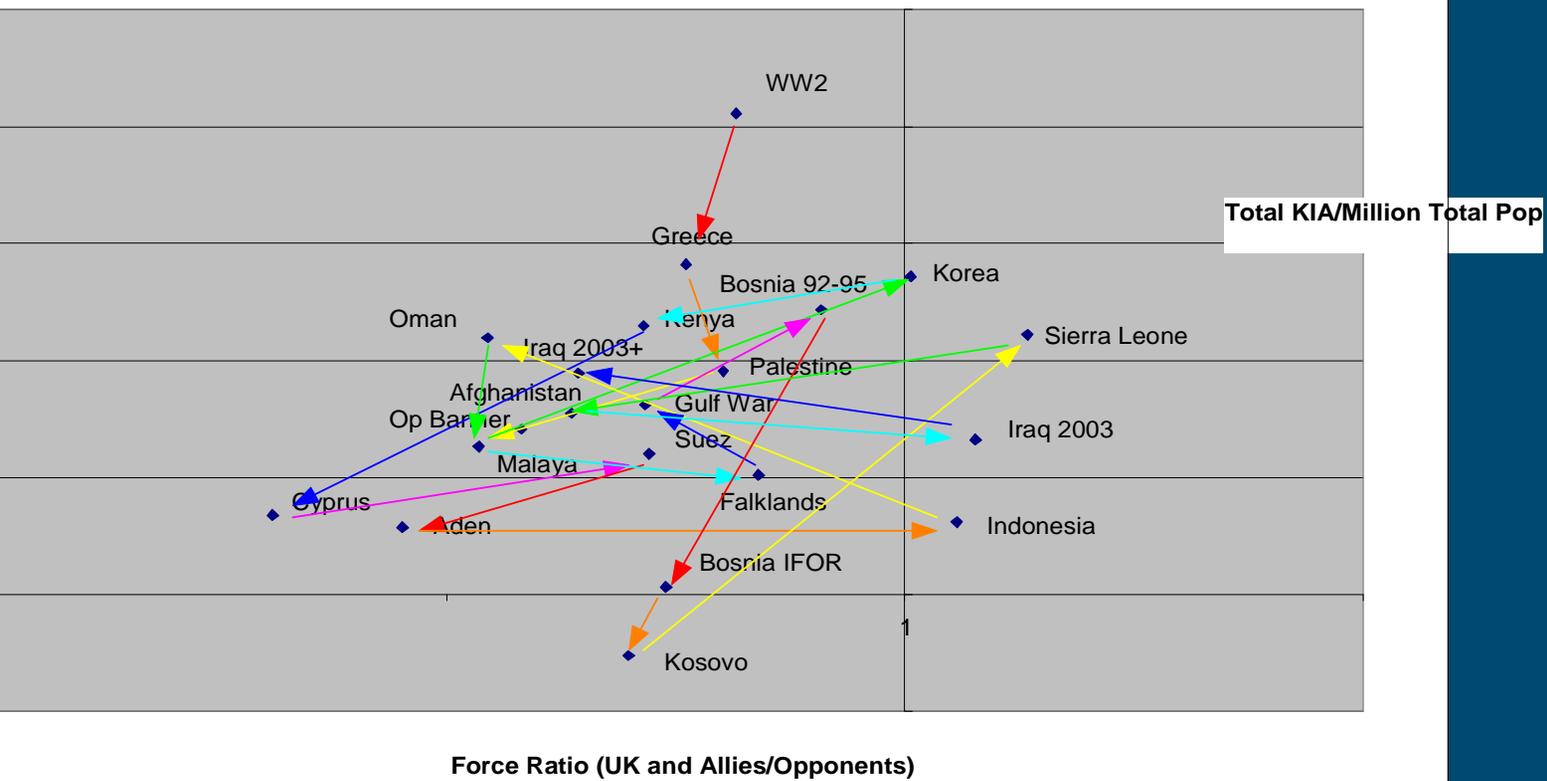
Walking through Futures Space

Have similar datasets for US, France and Israel

All show the same pattern, of large and irregular jumps in the Futures dimensions

The lengths of jumps and position in the scenario space are largely similar for all the powers – all seem to be drawing from the same population
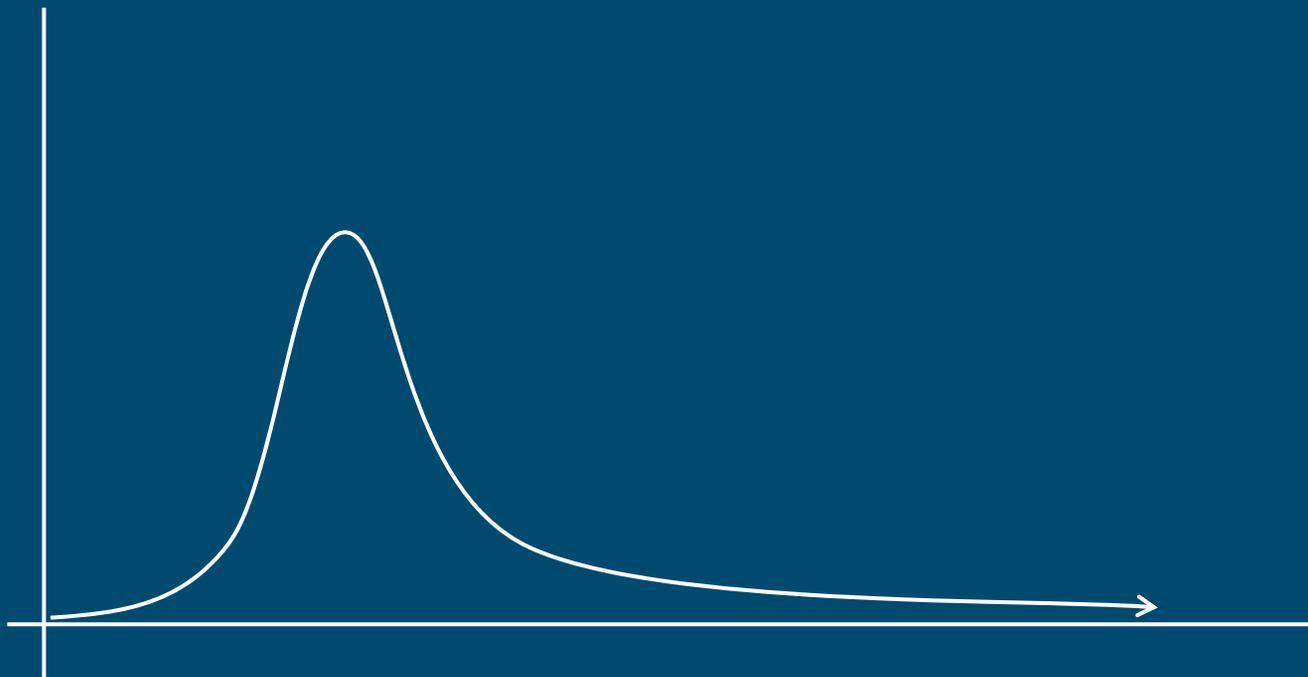
Allows us to do some analysis on the 'pooled' data
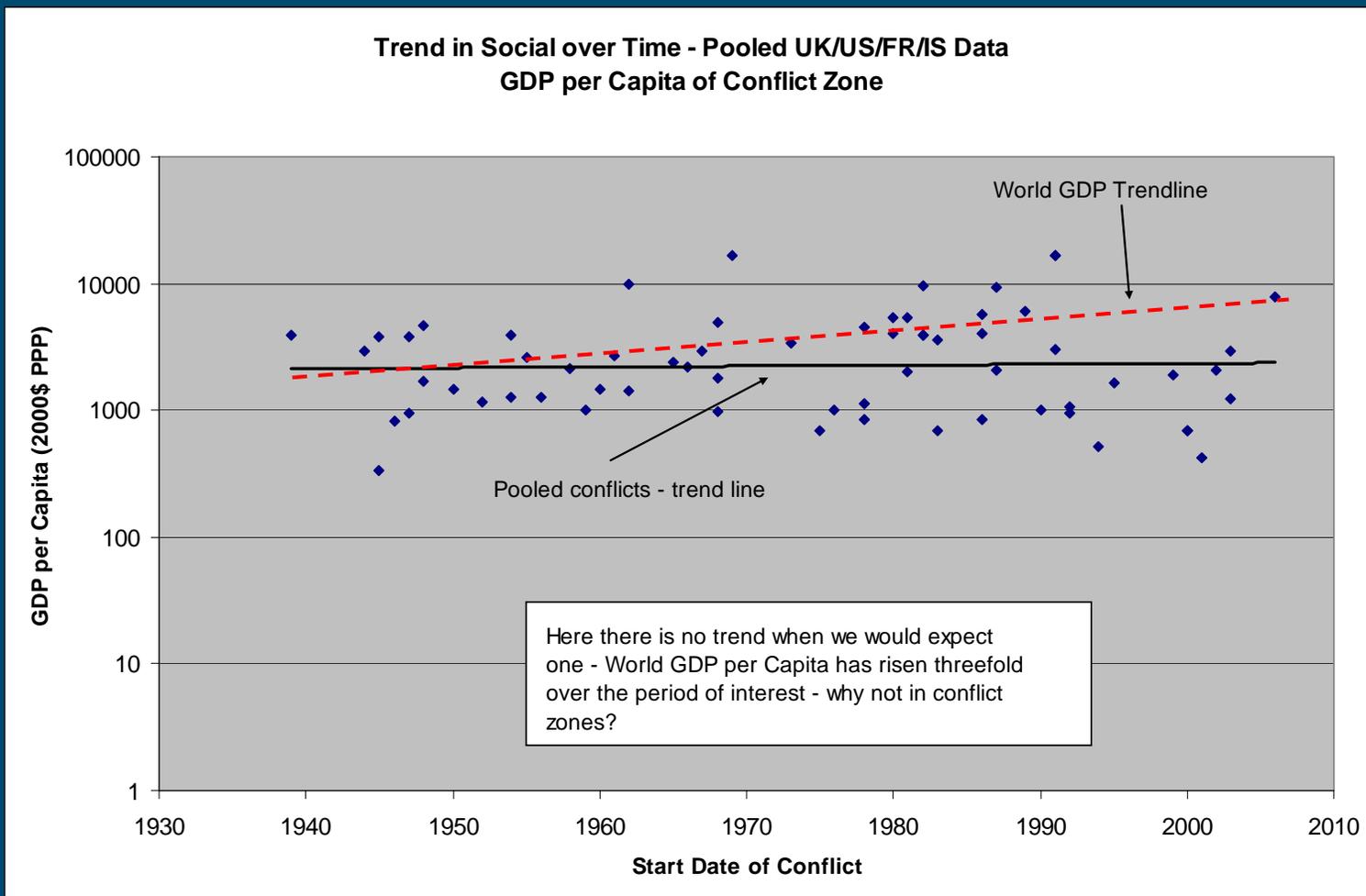
ooled **Military Dimension- Force Ratio**

mergent Behaviour – a random walk

Business as usual   Extreme excursions ('shocks')

Trend in Social over Time - Pooled UK/US/FR/IS Data
GDP per Capita of Conflict Zone

World GDP Trendline

Pooled conflicts - trend line

Here there is no trend when we would expect one - World GDP per Capita has risen threefold over the period of interest - why not in conflict zones?

GDP per Capita (2000$ PPP)

Start Date of Conflict

Futures

approved scenario space

'testing' scenario space

Robust Capability Mixes

capability mixes for approved scenarios

'testing' scenario space

robust capability mixes based on approved scenarios

daptation

determine testing target scenarios

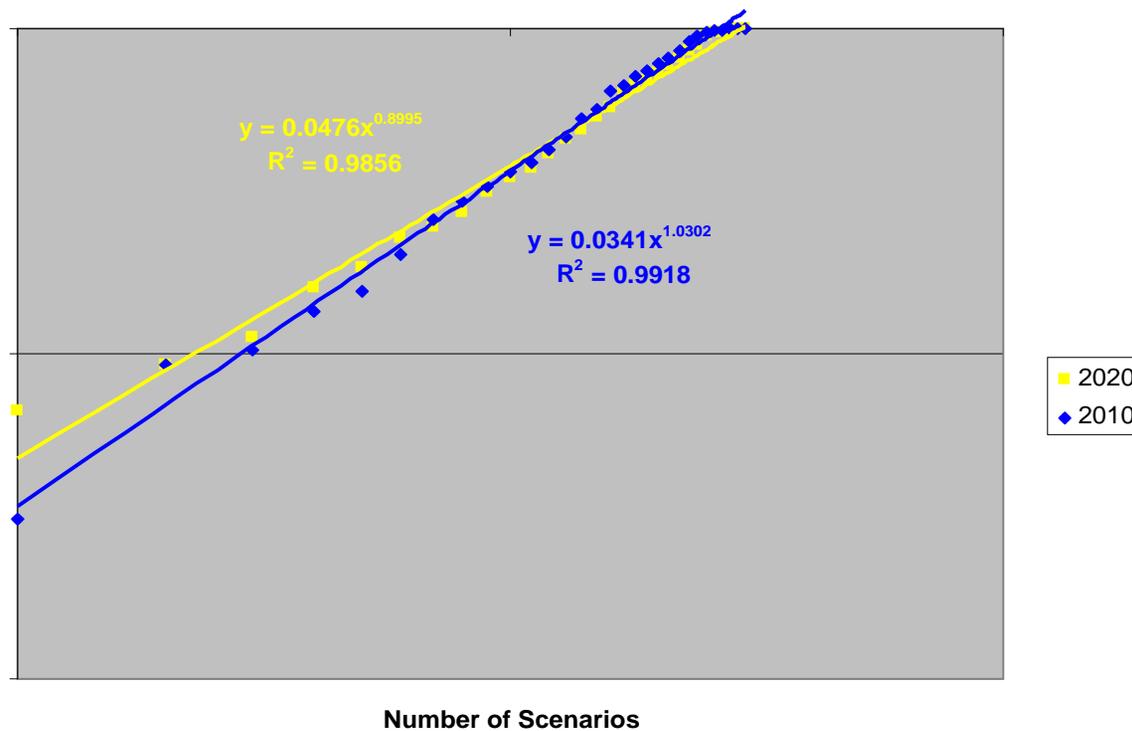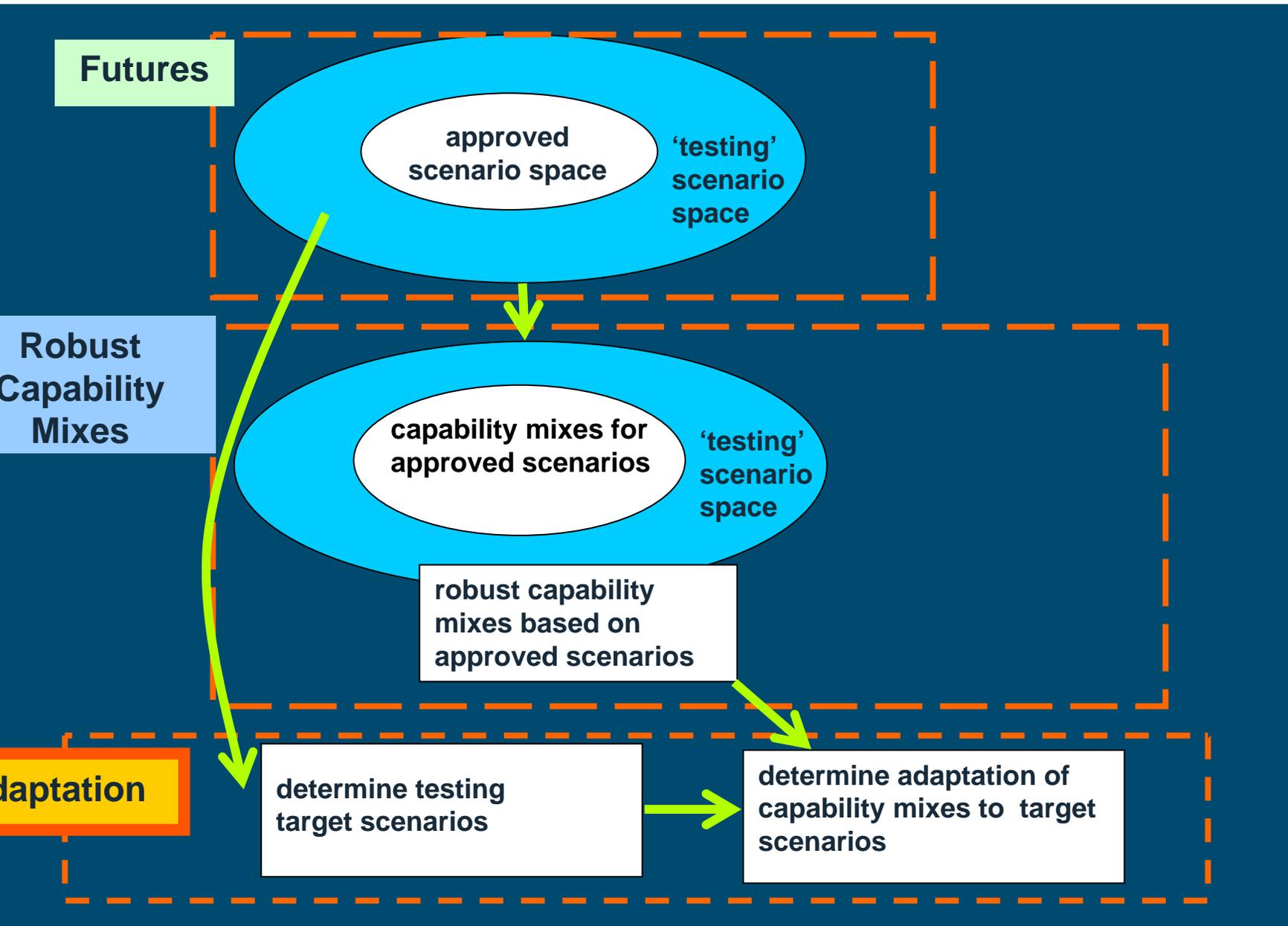determine adaptation of capability mixes to target scenarios

Allocation of Force Elements to Scenarios
(illustrative example only of power law fits)

Proportion of Force Elements Used in Fewer than X Scenarios
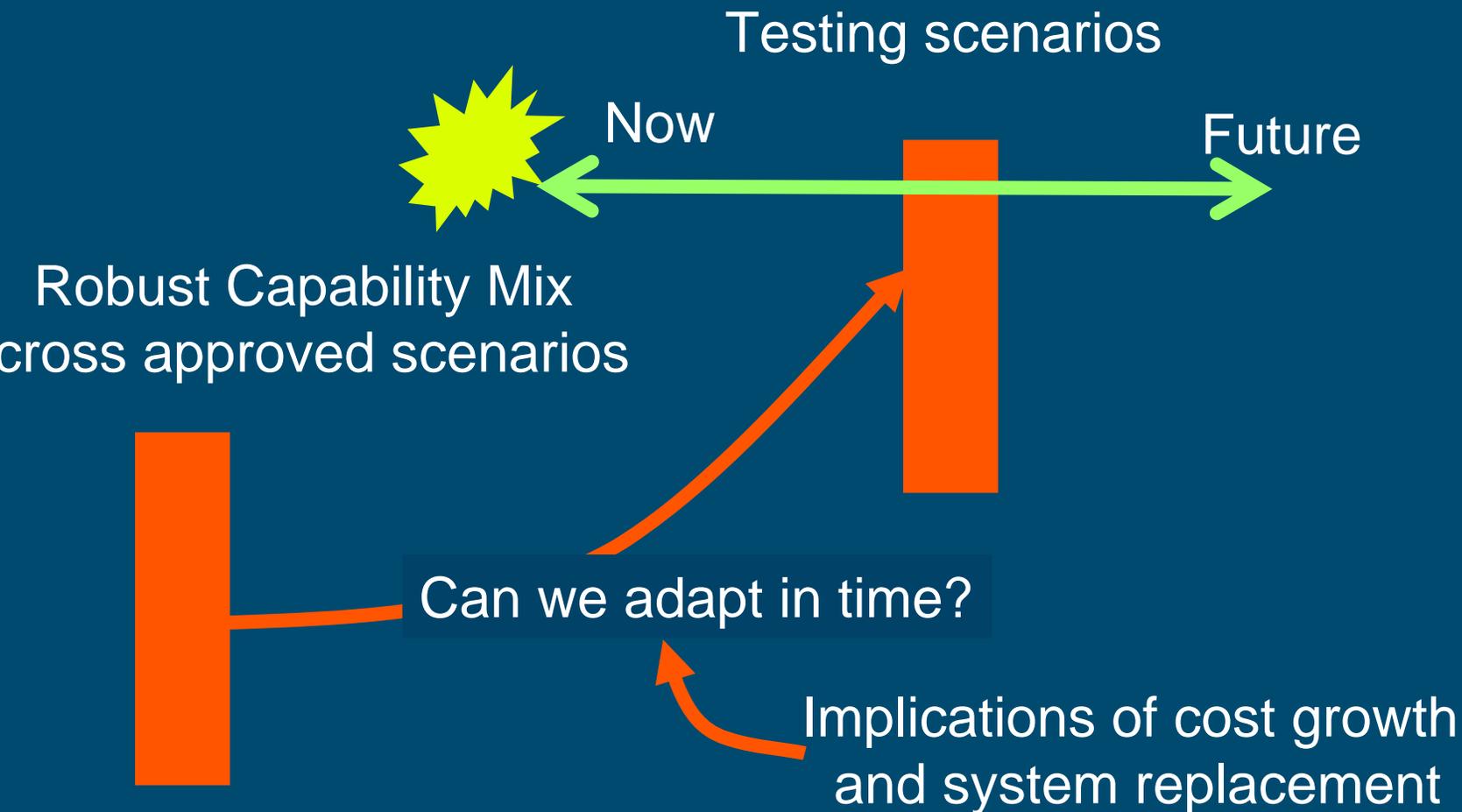
Proportion used in this many or fewer

$y = 0.0476x^{0.8995}$
$R^2 = 0.9856$

$y = 0.0341x^{1.0302}$
$R^2 = 0.9918$

- 2020
- 2010

Number of Scenarios

pproach to Adaptation

Testing scenarios

Now

Future

Robust Capability Mix
cross approved scenarios

Can we cope?

pproach to Adaptation

Testing scenarios

Now

Future

Robust Capability Mix
cross approved scenarios

Can we adapt in time?
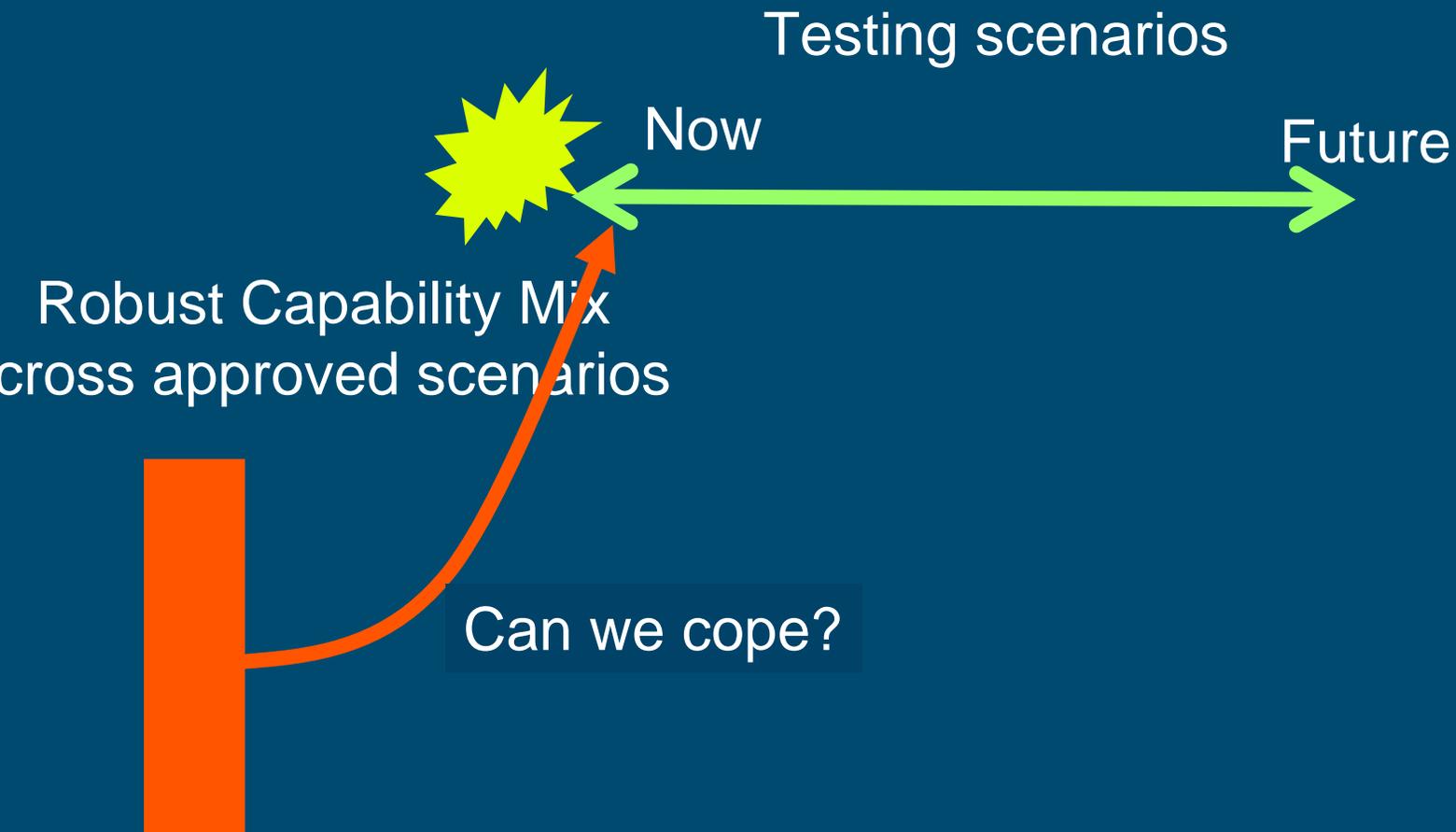
Implications of cost growth
and system replacement
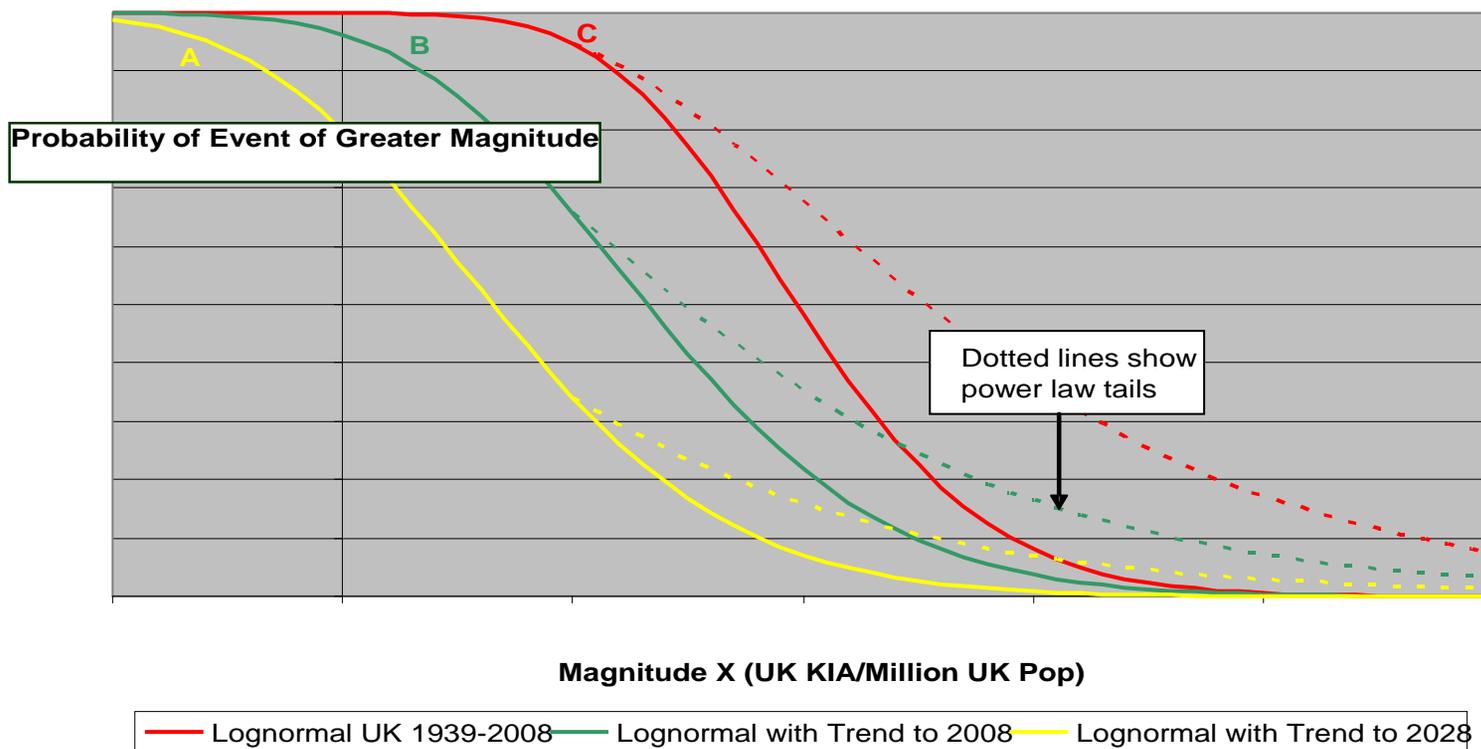
he Future Risk Profile (illustrative example
hly)

Probability of Event Greater than Magnitude X before 2035
- Lognormal Distribution with Power Law Tails

A B C

Probability of Event of Greater Magnitude

Dotted lines show power law tails

Magnitude X (UK KIA/Million UK Pop)

—— Lognormal UK 1939-2008 —— Lognormal with Trend to 2008 —— Lognormal with Trend to 2028

Dstl is part of the

Summary

'Futures' have the statistical structure of a random walk

- Assuming recent historical trends continue
- Quantifies high impact low probability events ('shocks') across strategic trends
- Consistent with Complex Adaptive Systems emergent behaviour

An agile force structure is required to deal with such high and random variability

Questions ?