Uncertainty: Some Principles?
DSTL Futures Community of Practice
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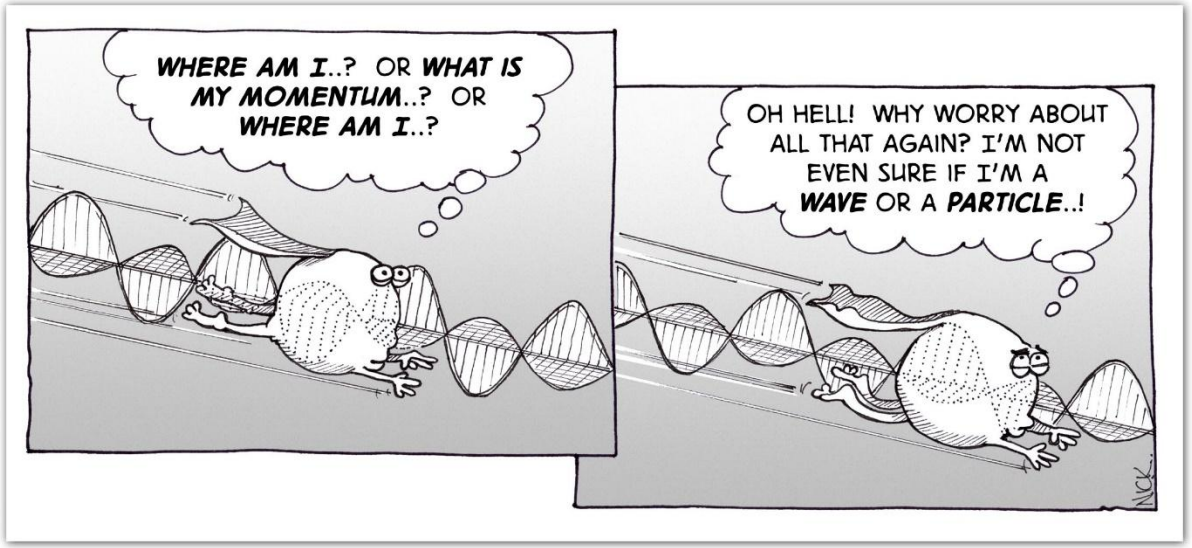
https://crimeframeworks.com

Coming up

- Uncertainty in hard and social science
- Uncertainty as risk
- Defining risk
- Complexity and Complex Adaptive Systems
- Handling complexity
- Uncertainty, ignorance and knowledge
- Giving structure to knowledge – for gaps you need maps
- How to cope with uncertain future
- Future proofing
- Questions for discussion

Hard Science and Uncertainty

- Estimation/combination of measurement errors
- Information theory/ Entropy?
- Randomness and nature of probability
- Chaos – tiny variations in initial conditions
- Fuzzy concepts
- Quantum uncertainty



Photon self-identity issues

- Computer science
  - How does a Machine Learned algorithm work?
  - Will it always act as predicted?
  - How does a world full of such algorithms, interacting, work?

Social Scientists and Uncertainty

- Traditionally, social science uncertainties seen as relating to **here-and-now** – but in fact, they all relate to the **future**
- **Statistical/measurement** uncertainty
  - Survey **sampling error/reliability**
  - **Statistical significance**/ confidence intervals
  - **Validity** – do measurements reflect real world?
- **Perceptual** uncertainty – is it a bird, is it a plane? **Signal detection**
- **Causal** uncertainty
  - **Correlation** not causation
    - **Direction of causality** – does A cause B or vice-versa?
    - **Risk and protective factors** – from medicine to crime prevention (offenders, places, products, services prone to crime)
  - **Alternative explanations** – what caused the crime drop in the first part of this century? Hence what to **expect**?
  - **Evaluation** – how far was the fall in crime due to the intervention, or to background trends and coincidental events?
- **Contextual** uncertainty – if we transplant this security intervention from Belgium to UK, will it still work?
- **Implementation** uncertainty – if we roll out this local success story as a scaled up national programme, will it still work? Huge history of implementation failure in crime prevention
- **Decision** uncertainty – **risk**

Defining risk and related concepts

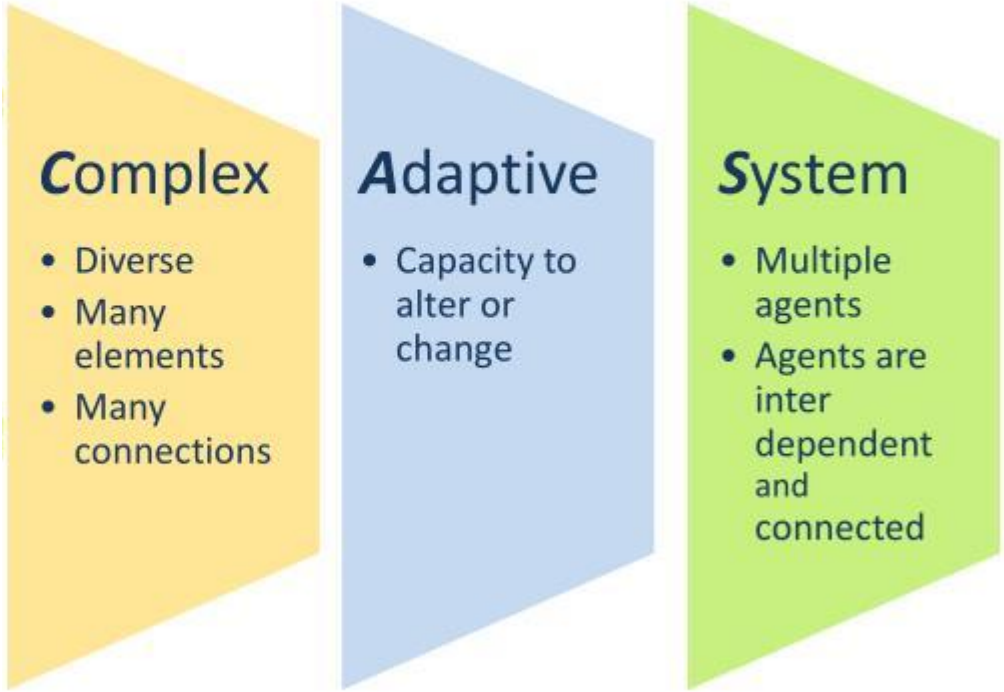
- '**Risk**' in crime science used in diverse senses – risk to offender, 'at risk' of offending, risk to victim… risk of failed criminal attempt or preventive intervention
- **ISO 31000** – Risk as the **effect of uncertainty on objectives** – could be **positive** (opportunity) as well as **negative**
  - Risk **sources**
    - **Natural hazard**
    - **Accidental** human action/inaction
    - **Deliberate** human action – threat – something specially concerning about **intended** harm, and particular **practical** difficulties of handling goal-directed threat
  - Potential **events** – what we do/don't want to happen
    - **Likelihood** of event
    - **Consequences** of event
- **Threat** and **Opportunity** (one person's incoming threat = adversary's opportunity)
  - **Intent/purpose** – to do/achieve what?
  - **Capability/resources**
  - **Presence/access to target**
  - **Environment supportive** of the action/exploitation and target vulnerable/attractive/provocative
- Risk **management**, risk **appetite**

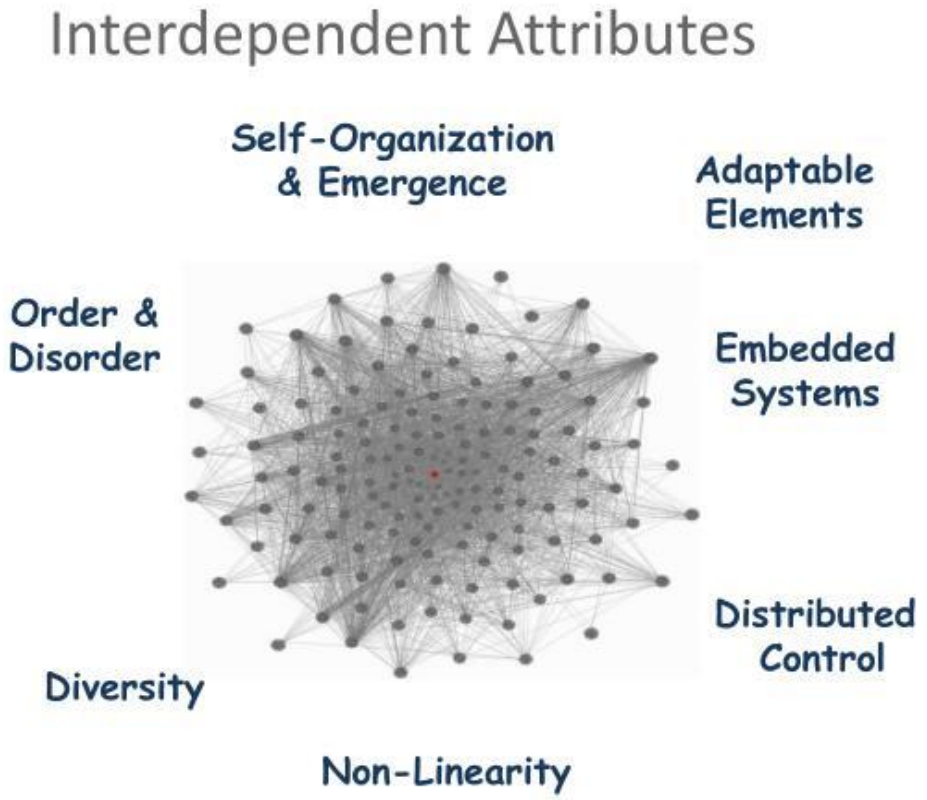
Complexity

- Human problem-solving capabilities and practice emerged to tackle problems that are **simple, obvious, tangible, clearcut, linear**
- We increasingly face problems which incorporate **uncertainty** (in approximately ascending order) about nature of problem, and what to do about it
  - **Complicated** – many components, albeit quite tightly coupled
  - **Complex** – highly interactive, loosely coupled components, non-linear
  - and even **Chaotic** – cause and effect are unclear, no knowledge-based response available
  - **Wicked** – hard to solve because of incomplete, contradictory and changing requirements
  - **Deep uncertainty** – when parties to a decision don't know/can't agree on, the system model that relates action to consequences, the probability distributions to place over the inputs to these models, which consequences to consider and their relative importance; often involves decisions made over time in dynamic interaction with the system
- The more that problems are **uncertain**, the harder it is to forecast into the **future**
- The further forecast problems are in the **future**, the more they are **uncertain**

Complex Adaptive Systems

- Diverse **agents** (individuals, organisations, intelligent software) acting, reacting and anticipating each others' moves against a changing social and technological background that favours first one side, then the other, often with **lags**





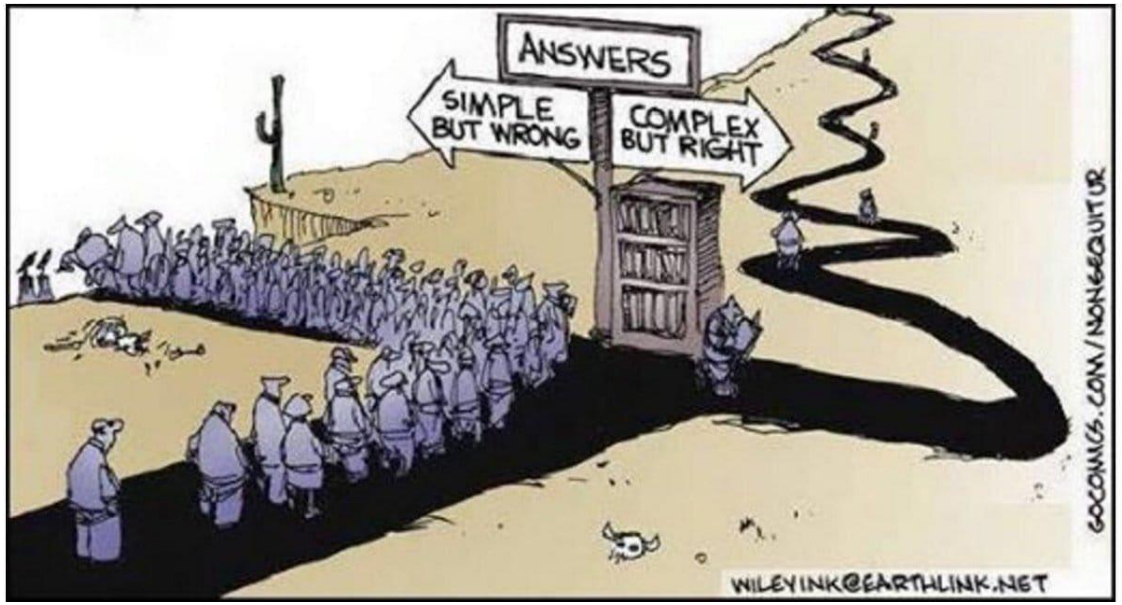
- **CAS** multiply uncertainty, and shorten the timescale to uncertain future, e.g. through **arms races**
- **System failure** occurs when interventions targeted to perturb one component of a CAS have unpredicted/undesired effects on other components or system as a whole

https://www.slideserve.com/charlize-vaughn/flirting-with-uncertainty-and-surprise-thriving-on-change-in-complex-systems-powerpoint-ppt-presentation

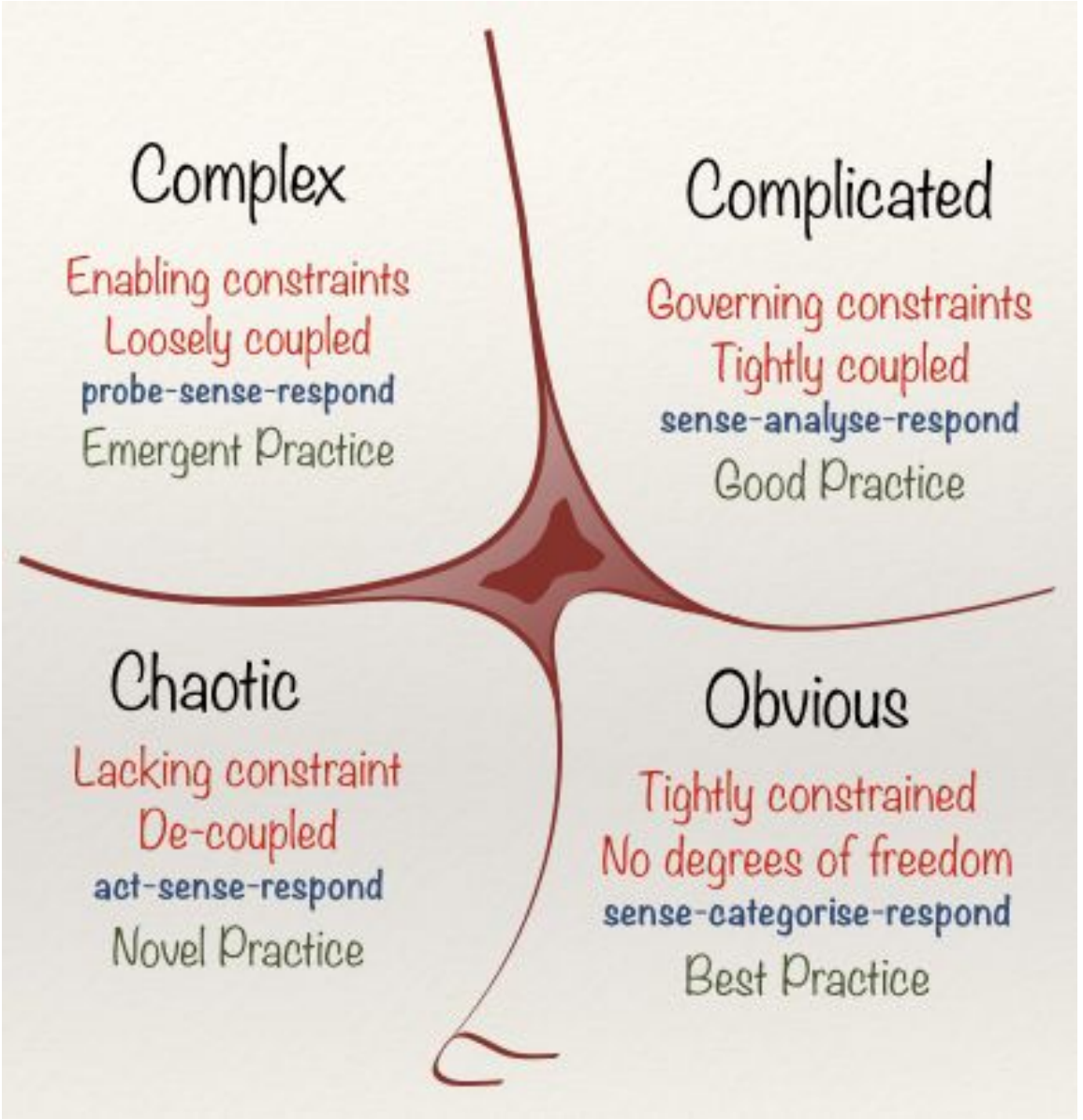
https://www.demos.co.uk/files/systemfailure2.pdf

Handling Complexity

- Use Ashby's **Law of Requisite Variety**
  - Oversimplified approaches may be easier to understand/communicate but fail to tackle problem
  - Our **models** of the real world must be sufficiently complex in themselves, to handle the vastly greater complexity **out there**



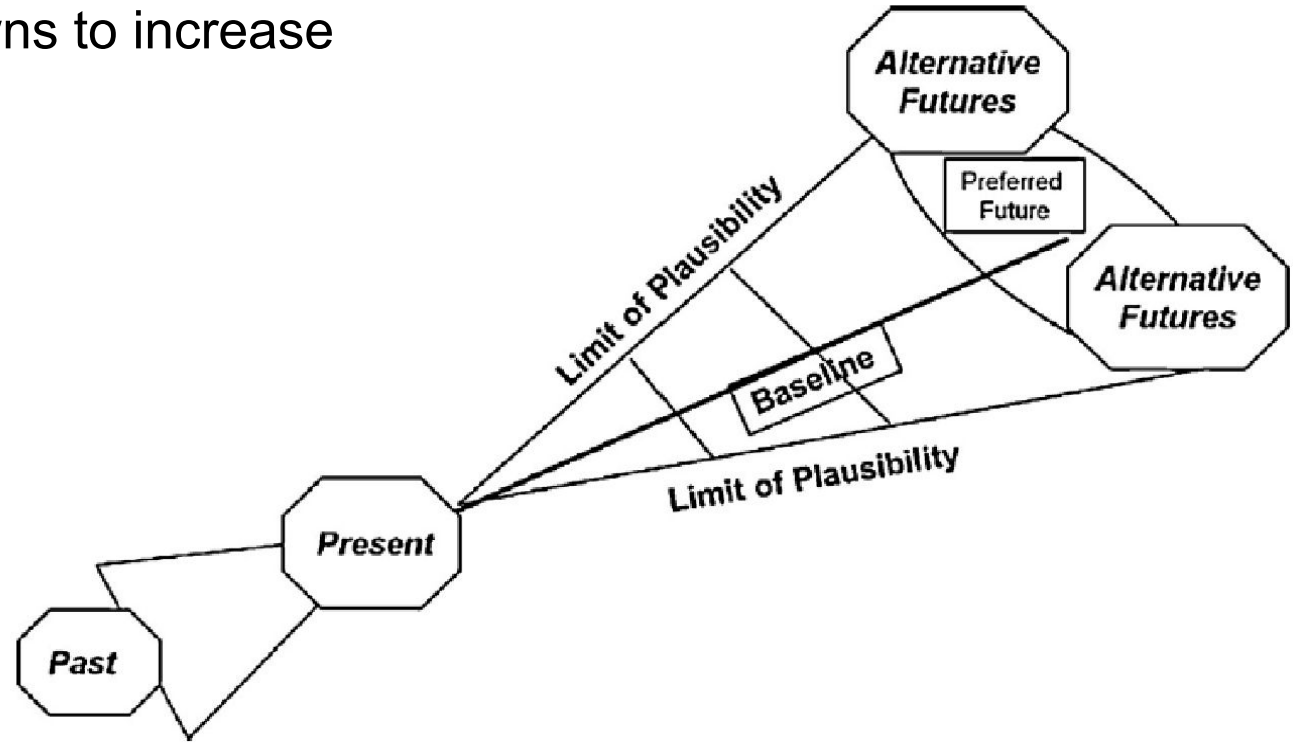
- Use **Cynefin** – put complexity in its place by characterising the nature of the problem/s and responding appropriately



https://en.wikipedia.org/wiki/Cynefin_framework

Uncertainty, Ignorance and Knowledge

- How are **uncertainty, ignorance and knowledge** related?
- How does this relationship play out over the short, medium and long-term future?
  - **Quantitative** – **cones of uncertainty** widen as more (and rarer) events have time to happen, and trends to strengthen, fade or change
  - **Qualitative** – as context changes, novel factors have time to appear, new combinations to emerge with unexpected properties, unknown unknowns to increase



Reducing Uncertainty: Knowledge – Purpose and Structure

- The **Purpose** of Knowledge: Improving, Extending, and Sustaining **Performance**
- Purposeful performance is about transforming inputs into desired outcomes, i.e. achieving **goals**
  - **Principal** goals e.g. security, defence
  - **Adjunct** goals e.g. legitimacy/acceptability of actions, inclusiveness, low-carbon footprint – these may compete, conflict or synergise with principal goals
  - **Meta** goals e.g. responsiveness, resilience and adaptability
- But (understatement) there's much we don't know about the future – huge **knowledge gap**
- To identify and structure **gaps**, we need **maps**
- The following **frameworks** supply very broad-brush maps – don't supply specific answers but at least divide up the uncertainties into **manageable questions**

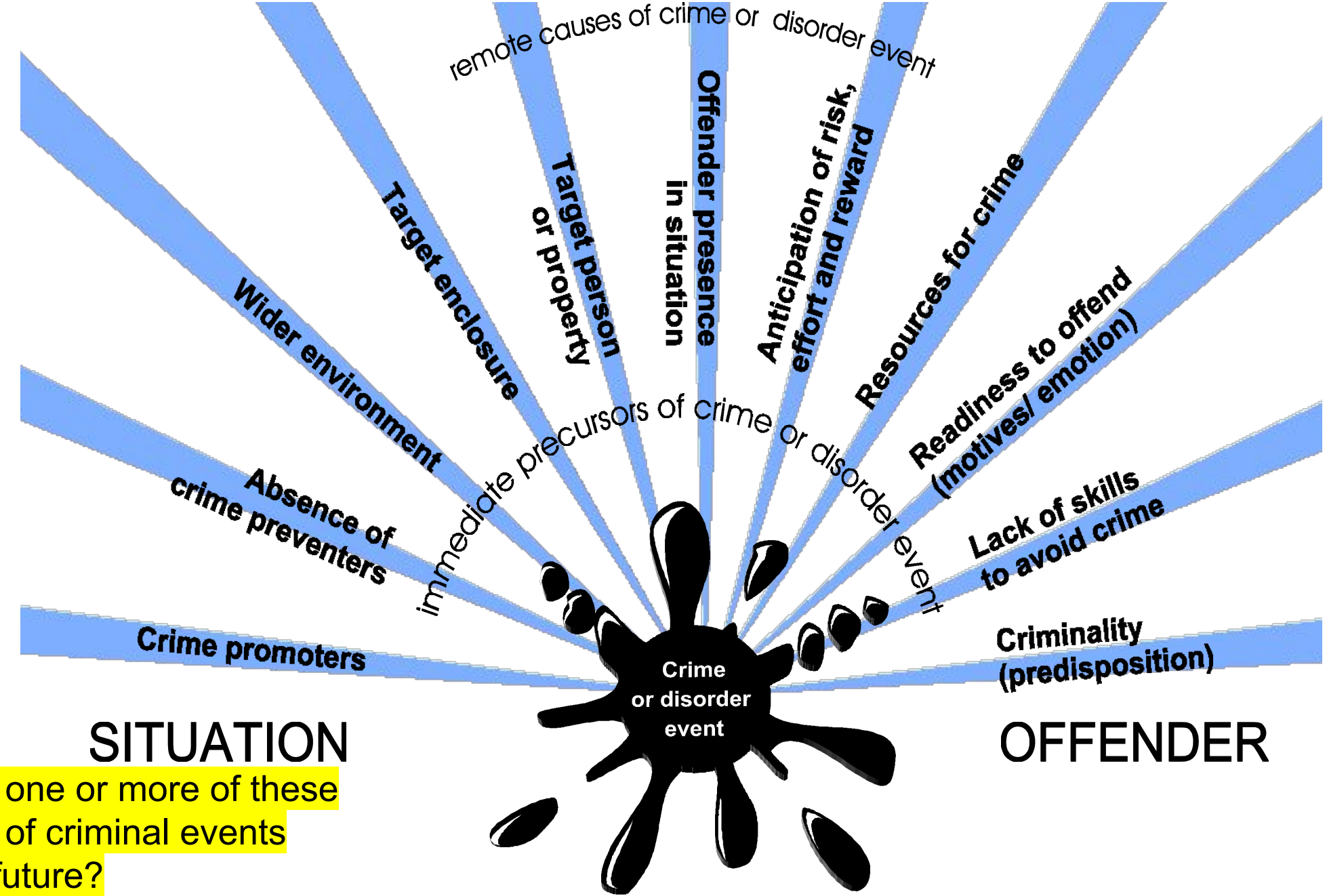
What Kinds of Knowledge do we Need for Good Performance in Security?

- **Know crime** – offence definitions
- **Know-about** crime problems and offenders
- **Know-what works** to reduce crime
- **Know-who** to involve
- **Know-when** to act
- **Know-where** to distribute resources
- **Know-why** – symbolism, values, politics, ethics
- **Know-how** to put into practice

- Hard enough assembling these kinds of knowledge for operational use in the **present**, but how might each change over various timescales in the **future**, as the **PESTELOMI** context changes and adversaries react?
  - Eg What Works is a wasting asset

Political, Economic, Social, Technological, Environmental, Legal, Organisational, Media, Infrastructure

Know-About: The Conjunction of Criminal Opportunity – Causes



How might one or more of these precursors of criminal events change in future?

Know-About Offender Actions/ Affordances – Misdeeds & Security Framework

- CCO covers crime risks in general
- But we can focus on more specific risks too, taking the POV of offenders and their **affordances**

Mistreatment (damage/ harm)

Misappropriation (theft)

Mishandling (e.g. fraud)

Target of crime

Misuse (as tool/weapon)

Misbehaviour (nuisance, conflict)

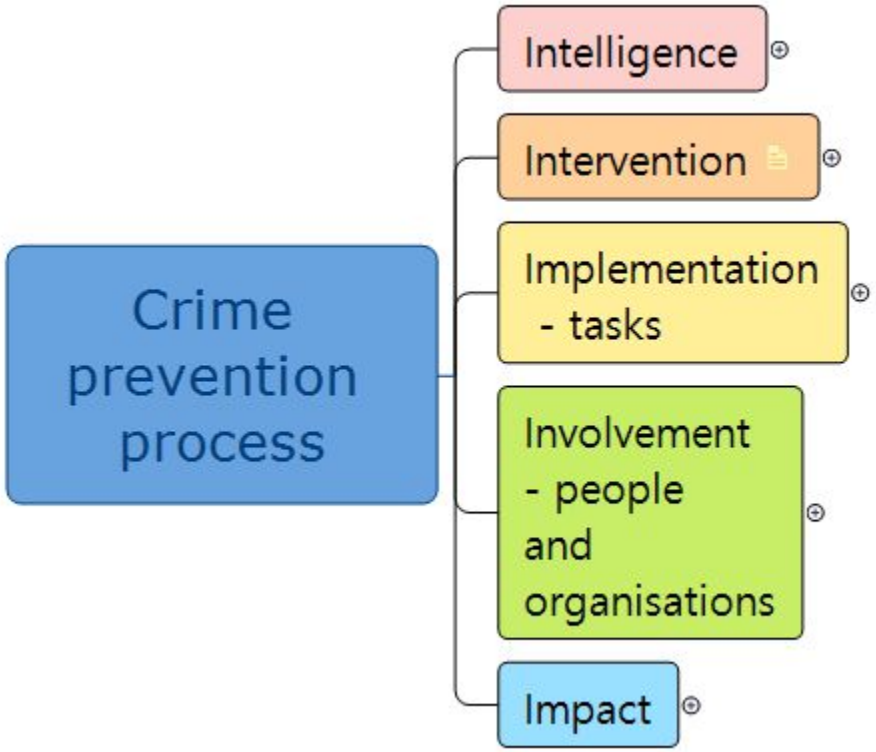
Contributor to crime
eg **resource** or **readiness** (provocation)

Mistake (e.g. false alarm)

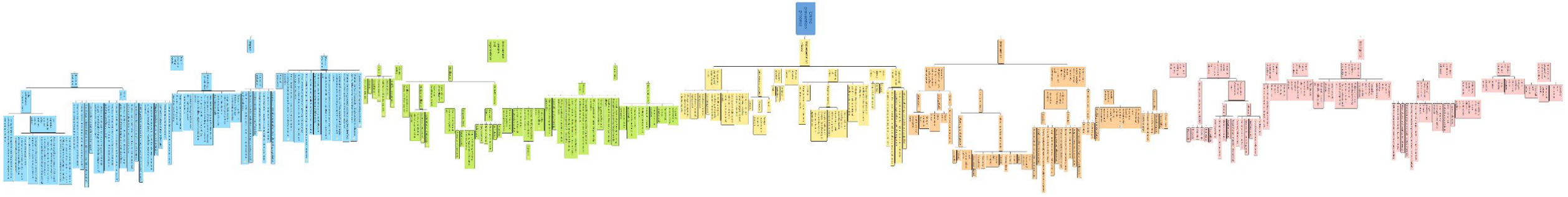
Downside of prevention

How might this new product, process or societal change, be Mistreated, Misappropriated, Misused etc?

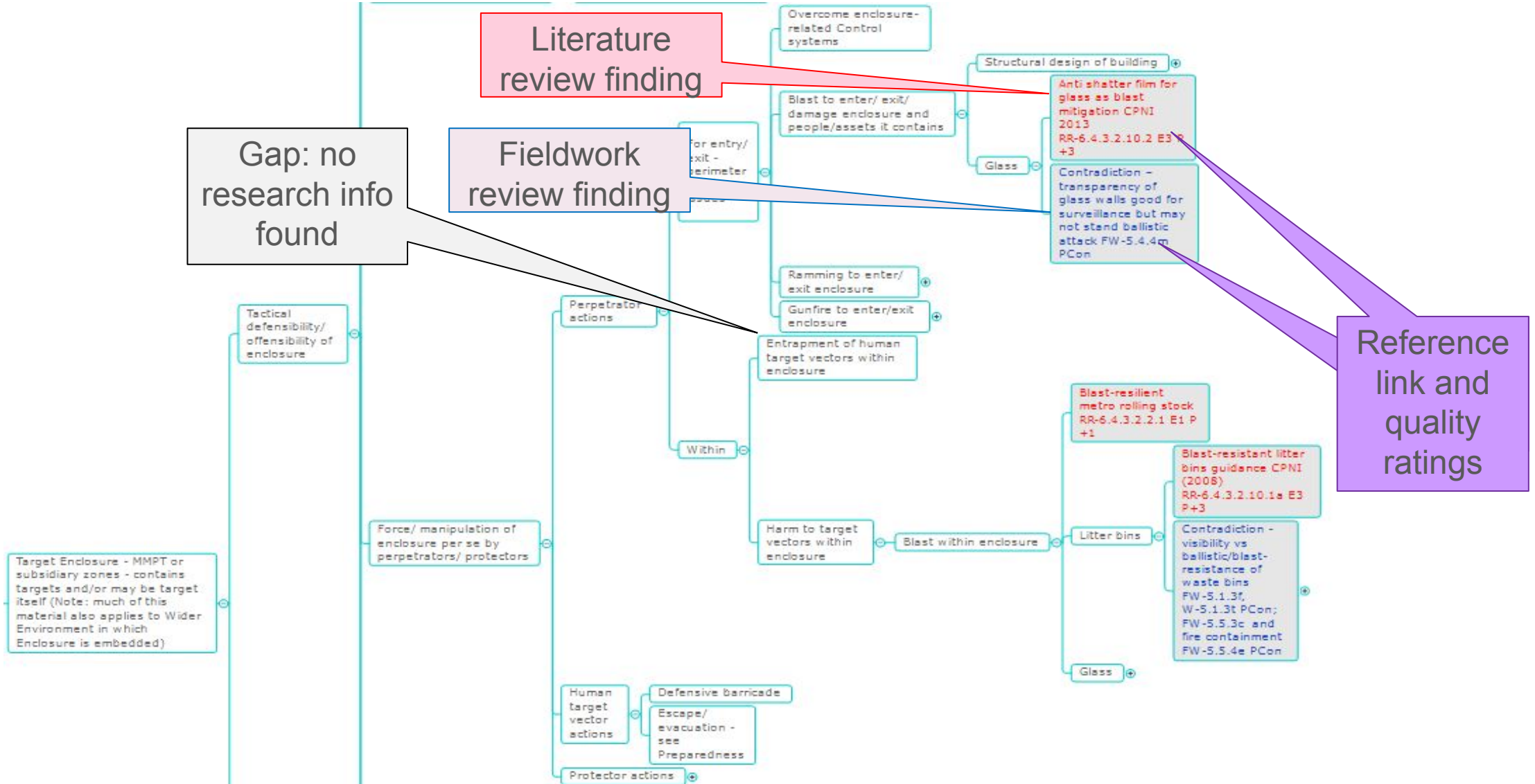
Know-How – 5Is Process Model



How might each of these tasks, and their operating environments, change?



Consolidating Research Findings on the 5Is Security Knowledge Tree



Strategies for Coping with an Uncertain Future

- **Spare Capacity** – more of the same operationally
- Developing and Disseminating **Innovative Capacity**
- **Scanning for emergent problems** – rapid feedback loop for when security fails
- **Future-Proofing**
- **True anticipation**
  - Empirical
  - Theoretical
  - Complex modeling/simulation
  - Moves/countermoves

Future-Proofing – Evolution of Evolvability

- Make interventions **adaptable** to social and technological change and to adversaries' countermoves and hence as **sustainable** as possible
- **Monitor for obsolescence** and **weed out** those practices which no longer work and have run the course of modifications to keep them going
- Make products/places/procedures **upgradeable** and capable of 'learning'
- Develop '**pipeline**' of new security systems (as with satellite TV, banknotes and credit cards) so old methods can immediately be replaced as they become defunct
- Make interventions **varied** – so adversary can't quickly 'crack one, crack them all'
- Make that variety **theoretically and practically plausible**
- Make interventions **unpredictable** and **obscure** to adversaries
- Support **Design Freedom** (specify functional requirements not structure/materials)
- Anticipate **adversaries' future resources**

Eternal Principles underlying Change – e.g. Tactical Script Clashes

- Sometimes, beneath the constant Heraclitean flux, we can identify **eternal principles**
- E.g. we can identify **tactical clashes** between offenders and security at key stages of their scripts

Wield force v resist (Damage v protect, Injure v keep intact)	Take v keep	Snoop v maintain privacy
Act at will v control misbehaviour	Confront v avoid	Pursue v escape
Conceal traces and tracks v detect	Surprise/ ambush v be alert	Trap v elude
	Challenge suspect v give plausible response	Conceal criminal intent v detect
	Surveill v conceal	

- These clashes
  - Influence **criminal plans and outcomes**
  - are **generic and perennial** – will always need to be faced
- Innovations can **disrupt the balance** of these clashes, and favour one side over other
- In future, which side will gain from a sudden breakthrough?
- How can we design things to **advantage the good side**?

Evolving faster – boosting inventiveness to cut crime whilst respecting the tradeoffs

- **TRIZ** – a theory of inventive principles
  triz-journal.com
- Based on analysis of **oodles** of patents
- 40 generic **Inventive Principles**
- 39 **Contradiction Principles** (e.g. strength v weight) – the sharper-expressed the contradiction or tradeoff, the easier the problem to solve
- **Lookup tables** – what inventive principles solved what contradictions in past?
- Analysis of **evolutionary trends** of invention (solid > segmented > flexible > field) – look for what's likely to be next, to limit search for next solution

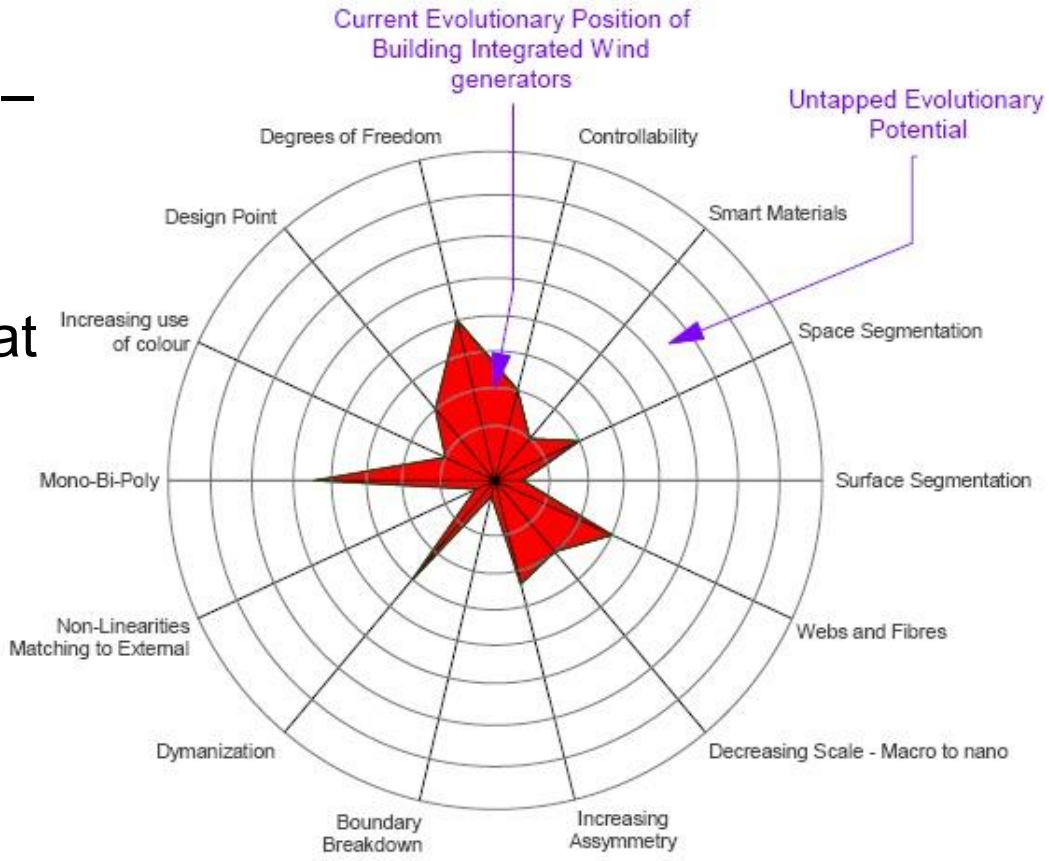


Fig. 4. Untapped Evolution Potential in integration of Wind Energy into Buildings (reproduced from McGee 2005 with permission).

Using Uncertainty to our Advantage

- Security through obscurity
  - Tactically, protect passwords etc
  - Strategically, don't let the adversary find out how our security works – or at least slow discovery down
- **Deter-unknown** (may be better than Deter-known), **Disconcert** (from the 11Ds)
- Variety and obscurity together mean the adversary has to keep guessing, carry wide range of tools and develop many skills

Foresight – and Hindsight!

Worm with eyes in head and bottom found off Shetland

18 June 2019 Share

The worm was found during a survey of a protected area off Shetland

A new species of worm which has eyes in its head and also in its bottom has been discovered in the sea off Scotland.

Scientists found the animal during a survey of the West Shetland Shelf Marine Protected Area.

Measuring only 4mm (0.2in) in length, it was discovered in a previously unexplored part of the seabed of the large protected area.

The worm has been given the scientific name *Ampharete oculicirrata*.

- **New survey of cheesy-bottoms sponge belt**

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Questions for Discussion

1. Is it meaningful to rank sources of uncertainty in order of their importance for a given issue, decision or plan?
2. How would we consider the ranking of uncertainty if we are seeking to ensure that any mistakes we do make in the future are fully survivable?
3. How are uncertainty, ignorance, information and knowledge related?
4. How can the security services or the military gain advantage over an adversary by making better use of uncertainty ?
5. Are there different types of uncertainty which become more salient or important over different future timescales?
6. What are the special properties of uncertainties involving complex issues such as human intentions or those in the natural world?
7. How should we (from a governmental perspective) respond when the decisions people take under uncertainty turn out to be the wrong ones?
8. How best can we surface areas of unseen uncertainty?