



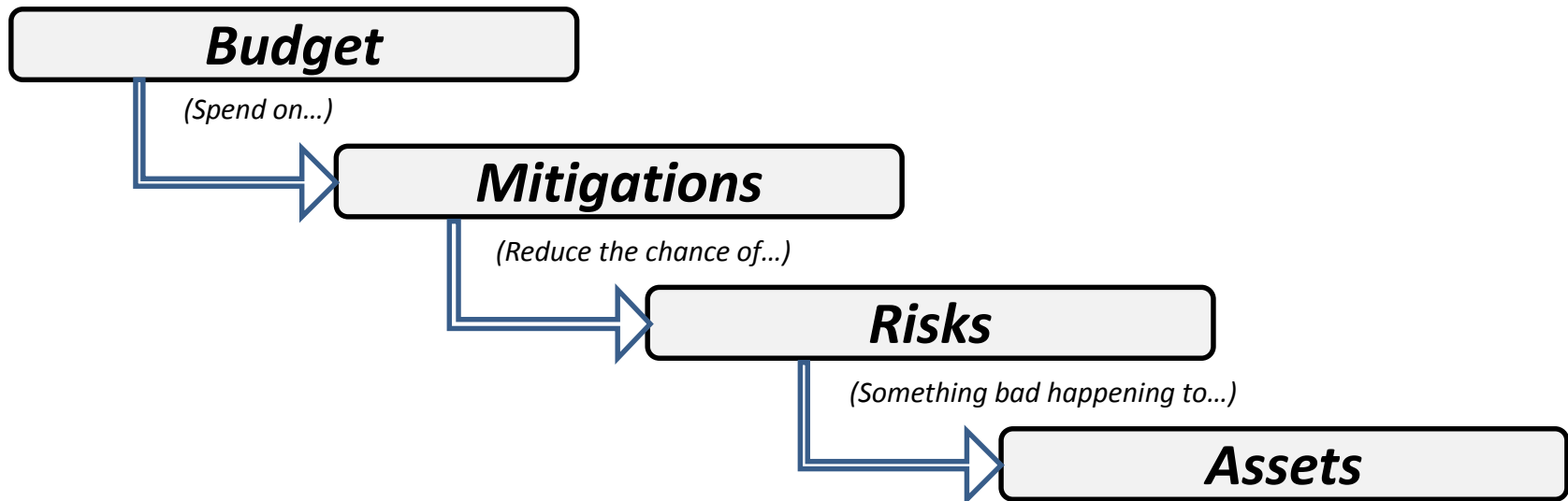
Strategic Cyber Cost-Effectiveness Analysis

Robin Smith

- Arke → Cost analysis, cost effectiveness and cost benefit
- Aim to present our thinking...
 - *Cost-Effectiveness/Cost-Benefit analysis of Cyber security...*
 - Different to the norm?
 - Interesting challenges?
 - How to address challenges?

To keep track:





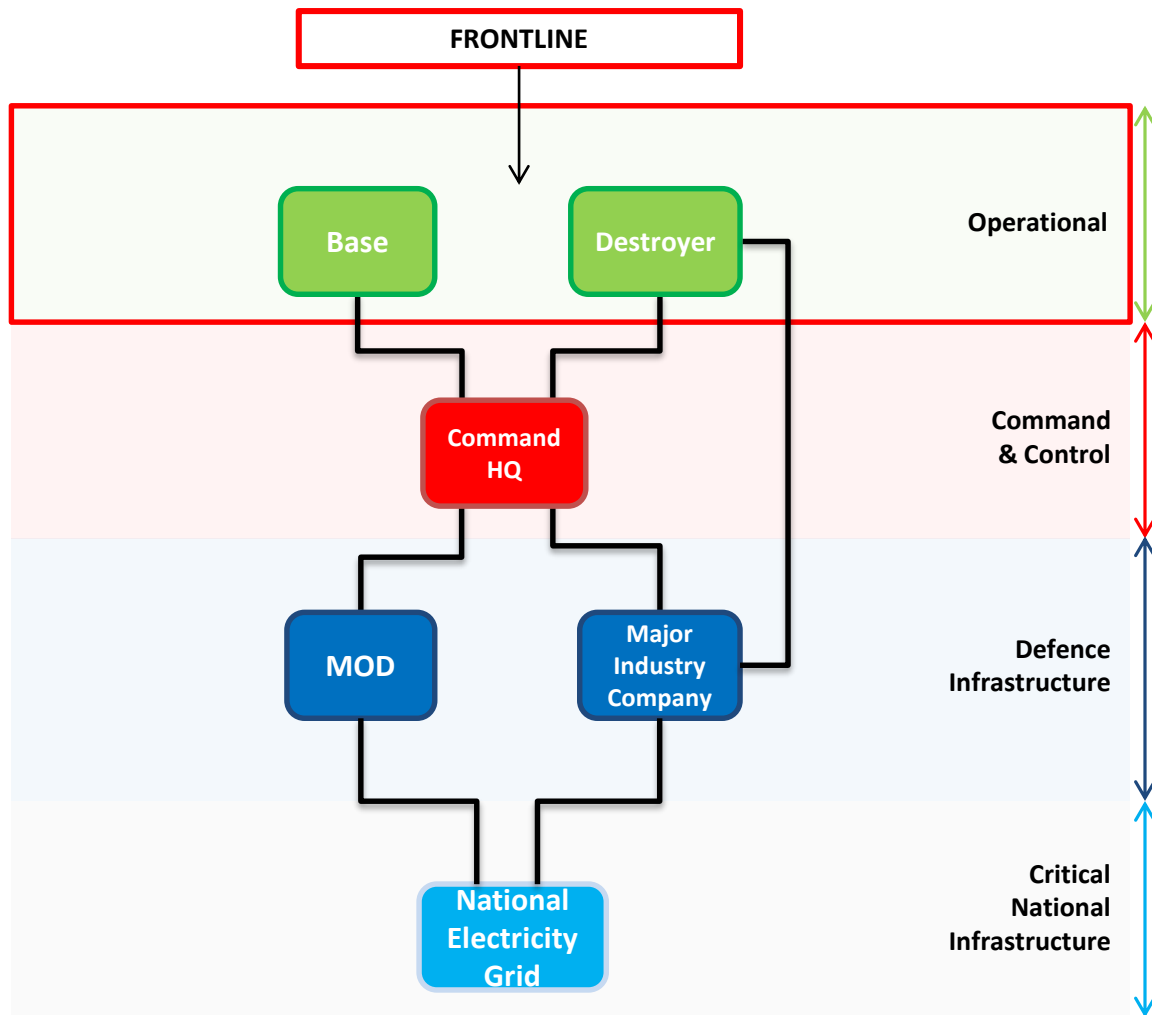
Key aspects for usual cases...

- Cost-Effectiveness directly related → **value for money** for taxpayer
 - Through defence perspective
- Assets → Entirely defence
- Assets → Not necessarily interconnections/interdependencies



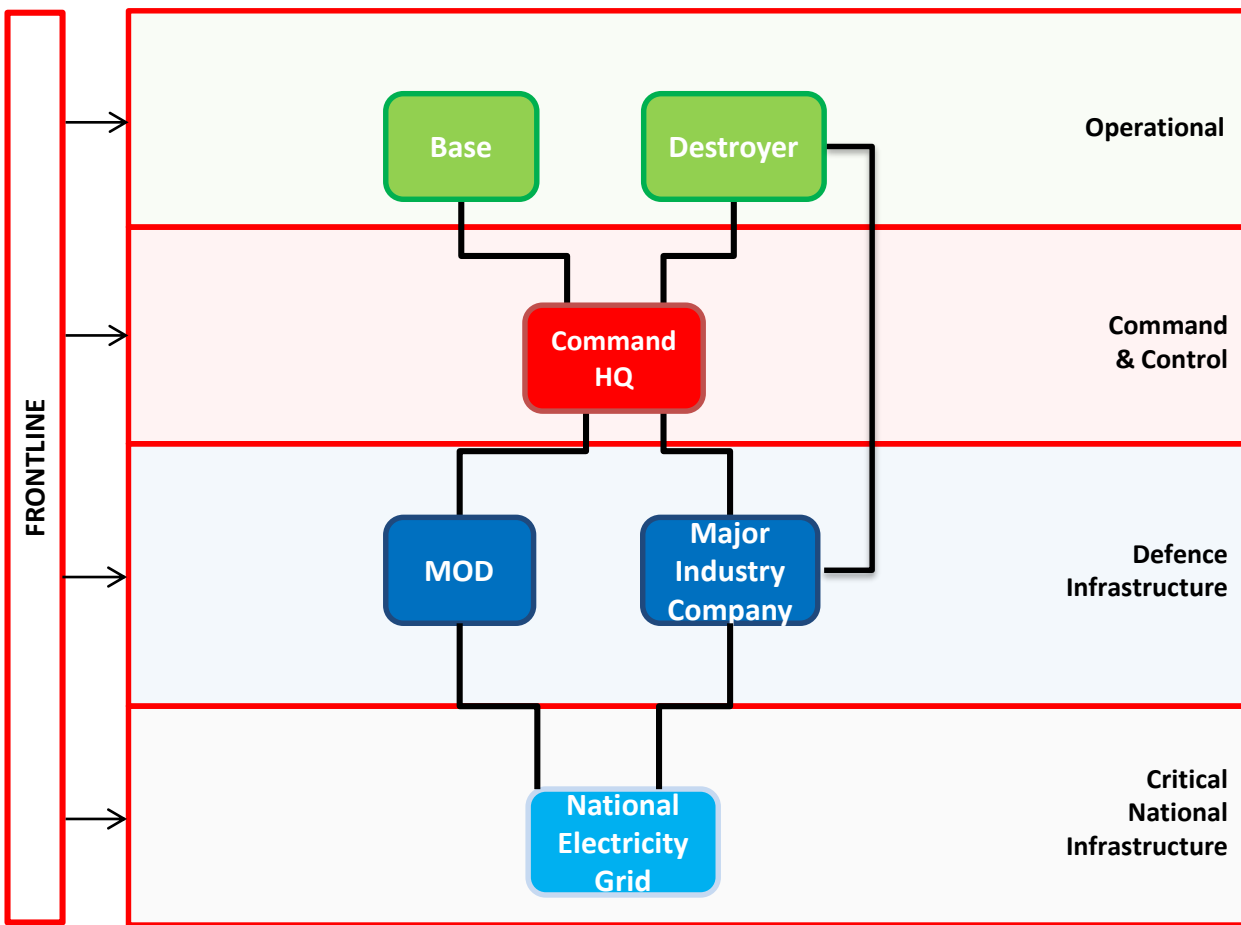


Assets and Infrastructure: Strategic Level

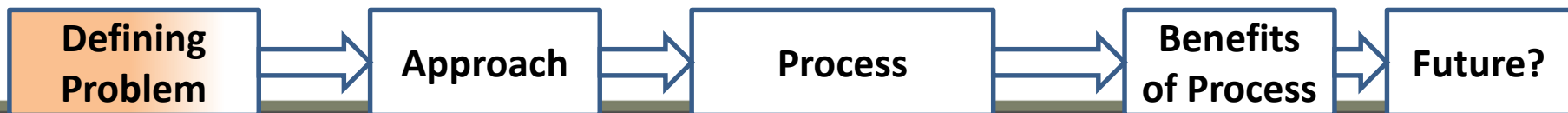


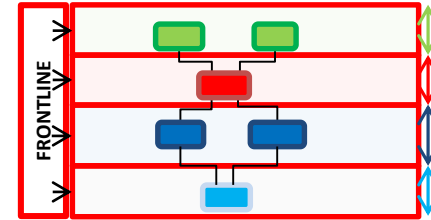
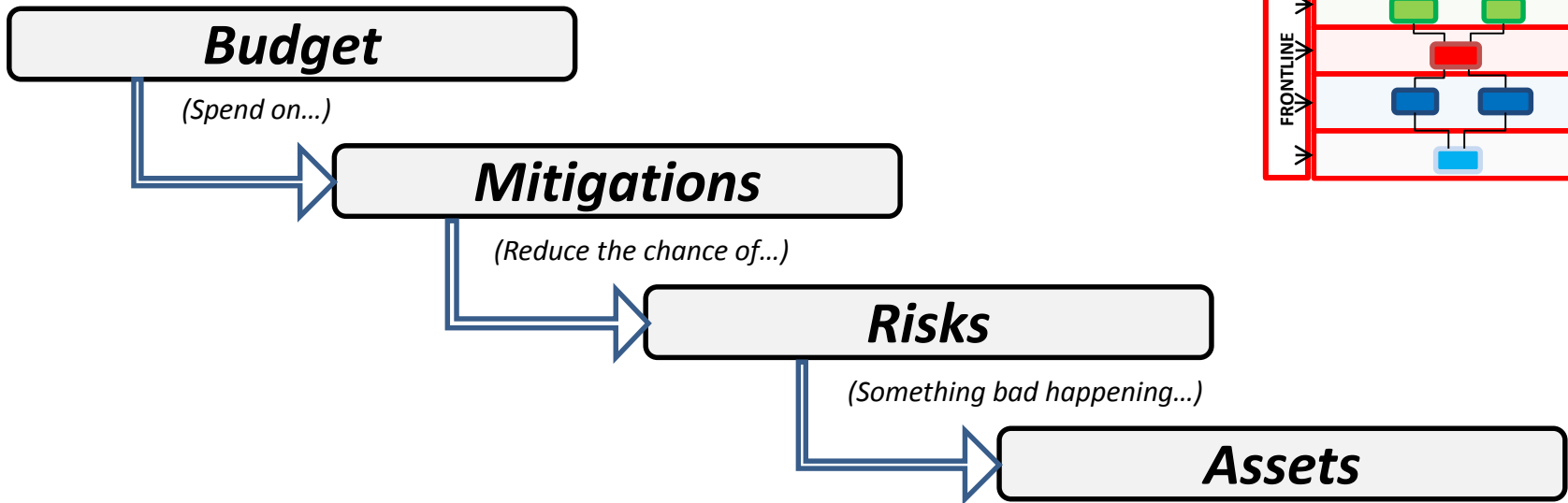
- Representation:
 - Network of nodes
- Nodes layered from the fighting end to the infrastructure that it depends upon in the long term
- Usually, risk of 'attacks' considered at the operational end.





- Representation:
 - Network of nodes
- Nodes layered from the fighting end to the infrastructure that it depends upon
- Communication with each other and some might depend on others to function
- Usually, risk of attacks considered at the operational end.
- All exposed to cyber security risks





Key aspects for cyber security...

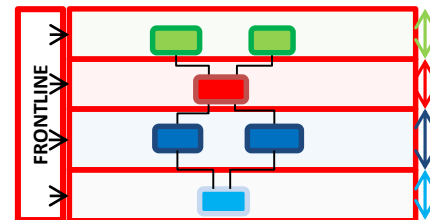
- Cost-Effectiveness directly related → **value for money** for taxpayer
 - Through defence, **trade, energy.. Etc.**
- Assets → Not all entirely Defence
- Assets → Have interconnections/interdependencies





New problems with cyber security

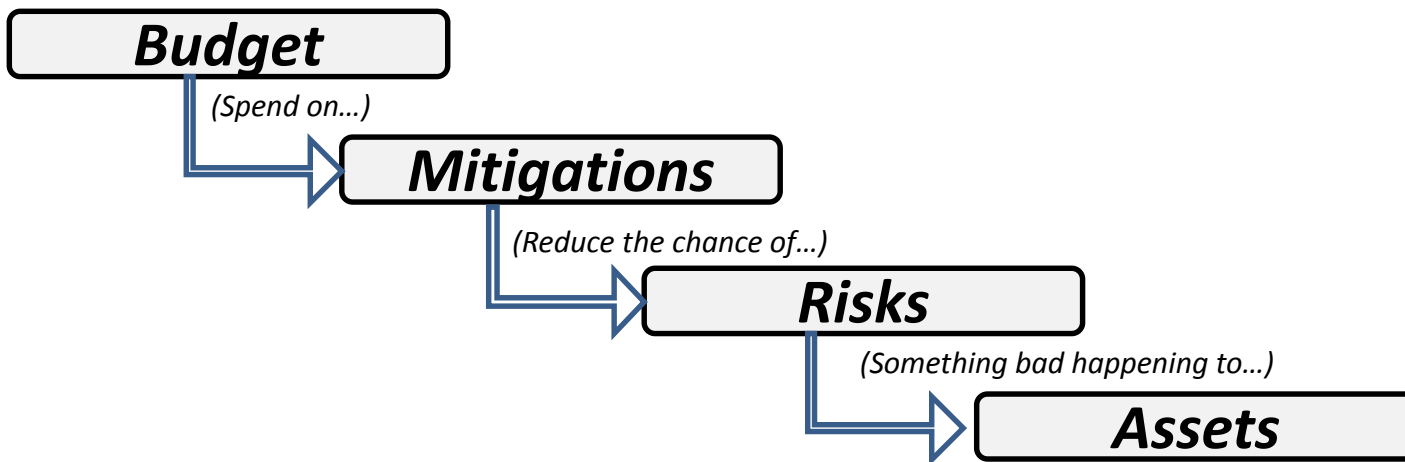
1. Wider Impacts (than just defence)
2. Risks propagate (between nodes)





High-level understanding → Best way to spend money?

- On reducing chance of successful cyber attacks



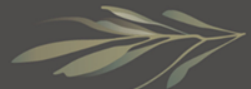
Challenges

- Wider Impacts (than just military)

Influencing our approach

- Reflect principles of assessing risks to information systems in the UK
- “HMG Information Assurance Standard 1 – Technical Risk Assessment” (Government Standard) for information system risk assessment
- Assess core goals of Information Assurance separately
 - *Confidentiality* -> Loss of privacy
 - *Integrity* -> Loss of trust
 - *Availability* -> Loss of presence
- Assess relevant impact categories separately (‘Business Impact Levels’) e.g.
 - *Military Operations*
 - *Trade*
 - *Energy... etc.*





- ① • **Quantifying Risks**
 - ⓐ ○ *CHANCE* of a successful attack
 - ⓑ ○ *IMPACT* of a successful attack

- ② • **Effectiveness of mitigations**
 - Highest ***reduction in probability*** of successful attack
 - (want to reduce risks where they have a ***high impact***)

- ③ • **Cost**
 - ⓐ ○ Estimated costs of ***implementing mitigations***
 - ⓑ ○ Estimated costs of ***risks affecting nodes***



1 Quantifying Risks

① CHANCE of a successful attack

- Probability of successful attack – based on...
 - different parameters for different risks
- Example *Risks* could be quite different

Indicative Parameters

1. <i>Compromised Hardware</i>	->	<i>quantities procured, percentage compromised</i>
2. <i>IP Theft</i>	->	<i># of people security cleared, percentage threats</i>
3. <i>DOS attack – national scale</i>	->	<i>SME judged /work-shopped quantities?</i>

- Parameters may have different values for each node in the network



1 Quantifying Risks

① CHANCE of a successful attack

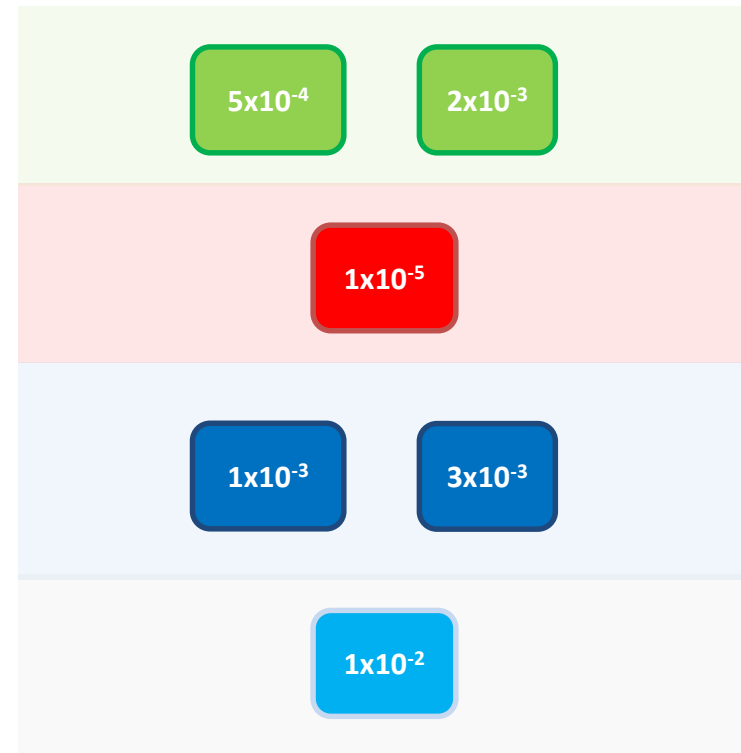
- Uncertainty – MUST capture the ‘error margins’
 - Three point estimating
 - E.g. ‘Best Case’, ‘Most Likely’, ‘Worst Case’ → Weighted mean value
 - Manually set distributions – eliciting uncertainty
- Range of inputs
 - Background work → through to → best judgement
- Identify and engage relevant Subject Matter Experts



1 Quantifying Risks

① CHANCE of a successful attack

Nodes: Risk 1



Risk Propagation - problem

- For Risk x
 - Mean probability of occurrence at each node
- **Usually**
 - (unmitigated) probabilities of occurrence
 - 'at risk' assets not connected
- **Cyber**
 - consider propagation of risks
 - 'at risk' assets are connected

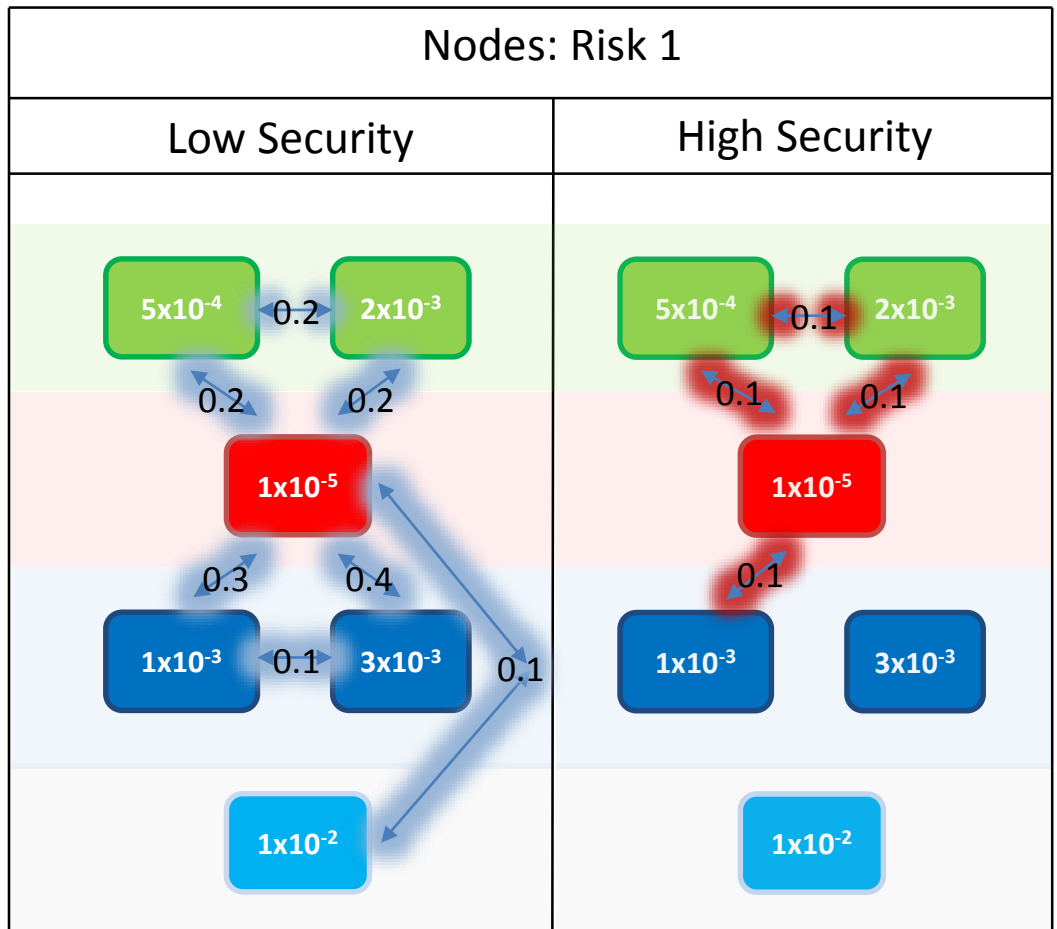


1 Quantifying Risks

(a) CHANCE of a successful attack

Risk Propagation - treatment

- Two connection types?
- **Conditional probabilities**
 - Per risk per connection?
 - Two-way value, or one-way values?
- Implications
 - Simulation/modelling of probability
 - Triggers an impact at the node





1 Quantifying Risks

① CHANCE of a successful attack

- **Summary** – CHANCE of a successful attack
 - Detailed/not detailed info on risks
 - Capture uncertainty
 - Probabilities of Propagation
 - Use Subject Matter Expert judgement (where needed)



1 Quantifying Risks

(b) IMPACT of a successful attack

Impact

- How bad is the loss of an asset?

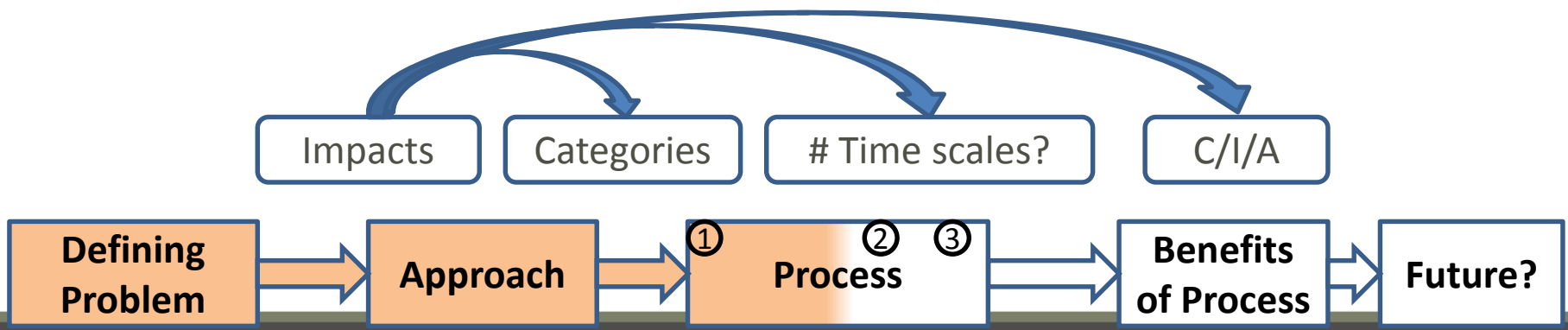
1. **Categories** e.g. ...

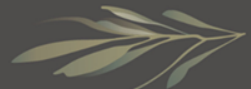
- Military Operations
- Trade
- Energy

2. **Time scale**

3. **Confidentiality, Integrity or Availability**

(loss of privacy, loss of trust, loss of presence)

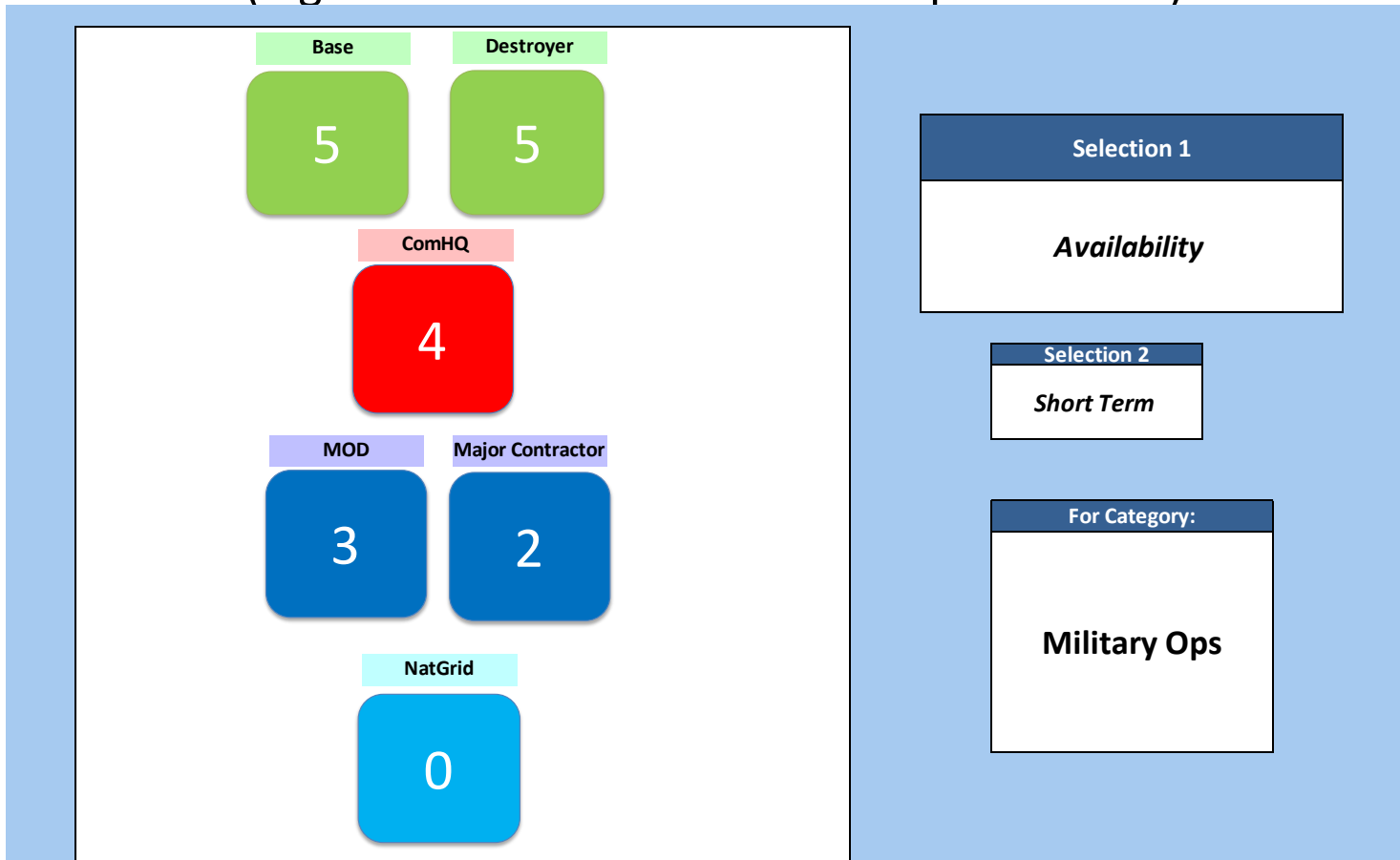


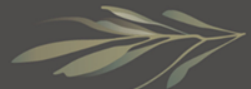


1 Quantifying Risks

- What is the impact of a successful attack?
- Score 0→6 (e.g. consistent with 'Business Impact Levels')

② IMPACT of a successful attack

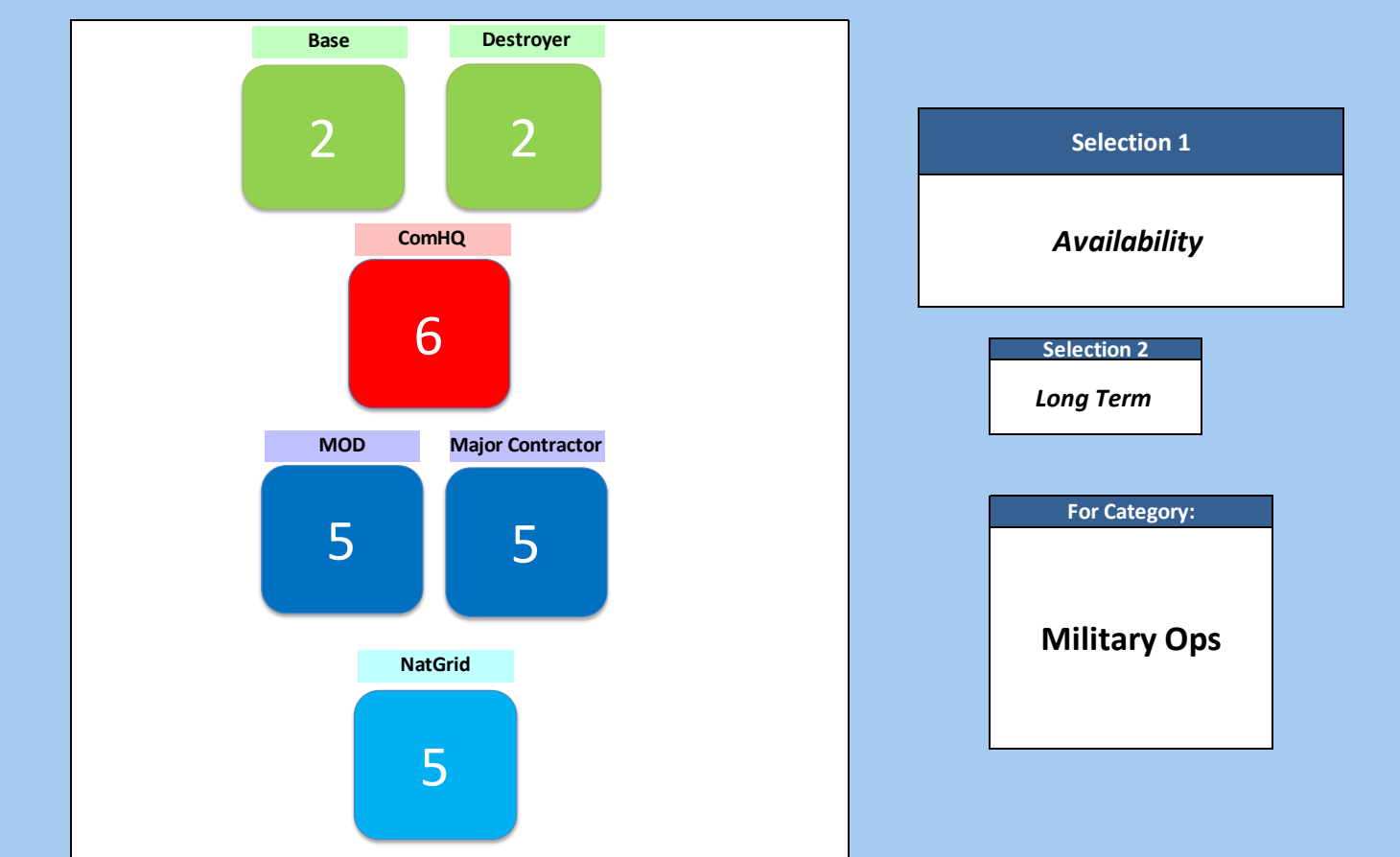




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ⓑ IMPACT of a successful attack

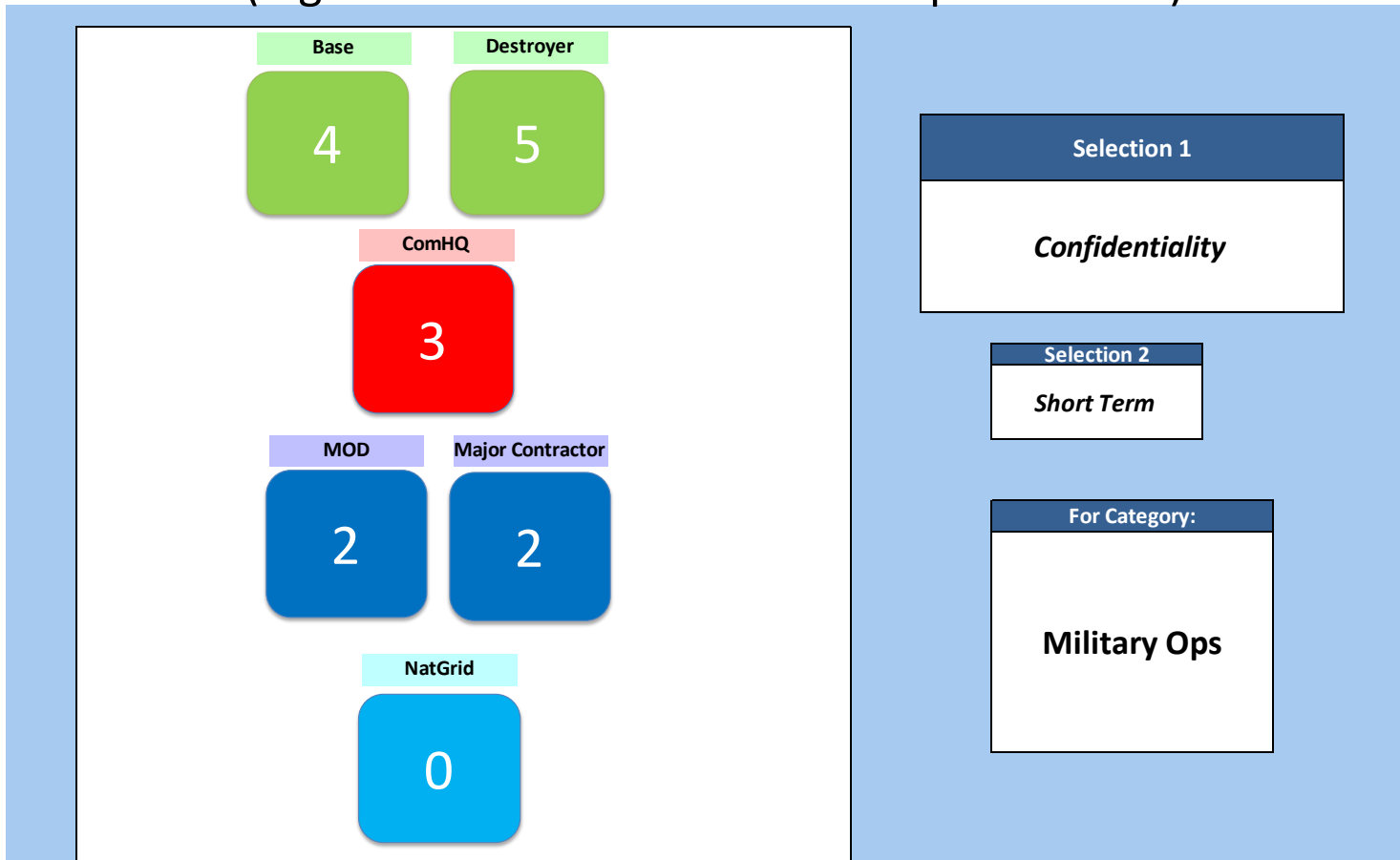




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ⓑ IMPACT of a successful attack



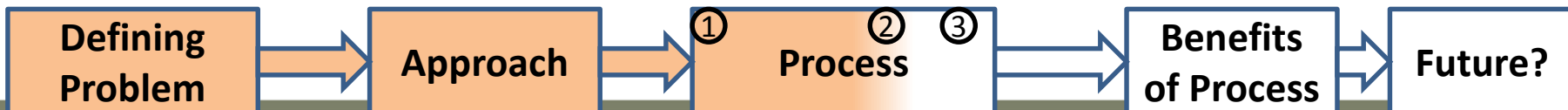
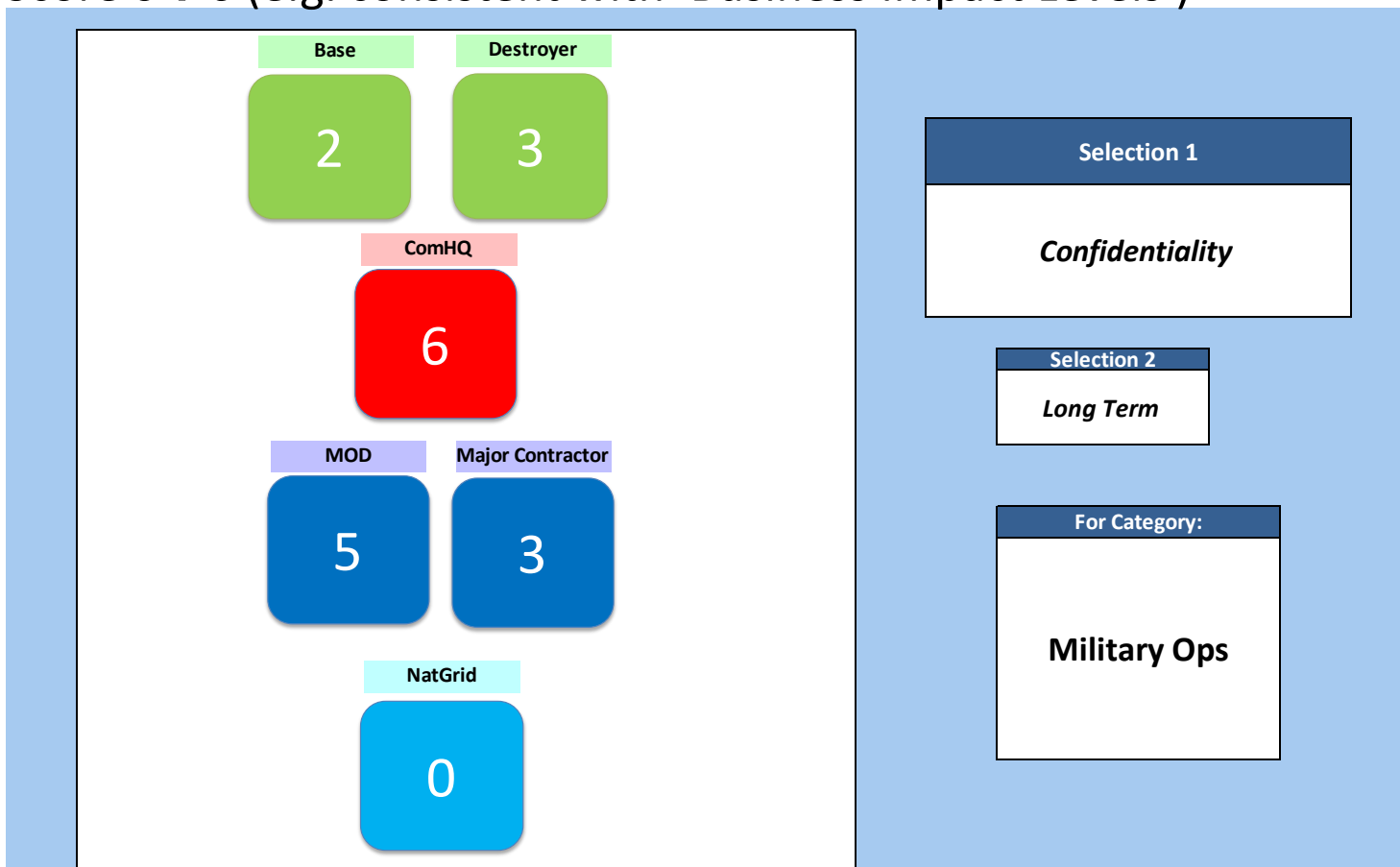


1 Quantifying Risks

- What is the impact of a successful attack?

ⓑ IMPACT of a successful attack

- Score 0→6 (e.g. consistent with 'Business Impact Levels')





1 Quantifying Risks

ⓑ IMPACT of a successful attack

- **Summary** – IMPACT of a successful attack
 - Minimum information to capture wider impacts:
 - Categories
 - Time Scales
 - Confidentiality, Integrity, Availability



- 2 • **Effectiveness of mitigations**
 - How much does **CHANCE** of a successful attack **decrease**?
 - (how high an impact might there be if attack is successful)
- Similar to assessing **CHANCE of a successful attack...**
 - **Summary –**
 - Detailed/not detailed info on mitigations
 - Capture uncertainty
 - Probabilities of Propagation
 - Use Subject Matter Expert judgement (where needed)





- ③ • **Costs**
 - ① ○ Estimated costs of *implementing mitigations*
 - ② ○ Estimated cost impact of *risks affecting nodes*

- **Q. How complex might the estimating be?**



① Mitigations

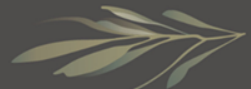
e.g.

1. Reduce chance of an Edward Snowden?
 - *Interview all personnel with security clearance X, every 5 years*
2. Reduce chance of buying compromised hardware?
 - *Set up and run an organisation to scrutinise imports*

Estimate cost of implementing

- Not too difficult
- Based on people and effort?





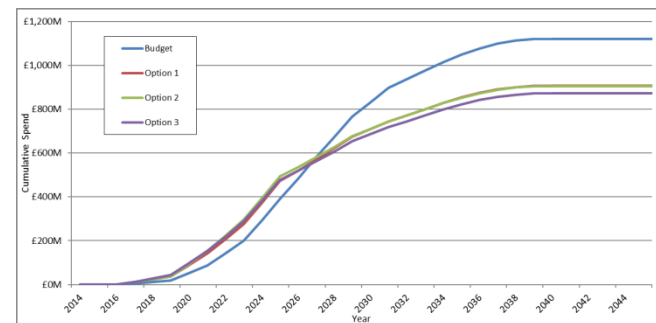
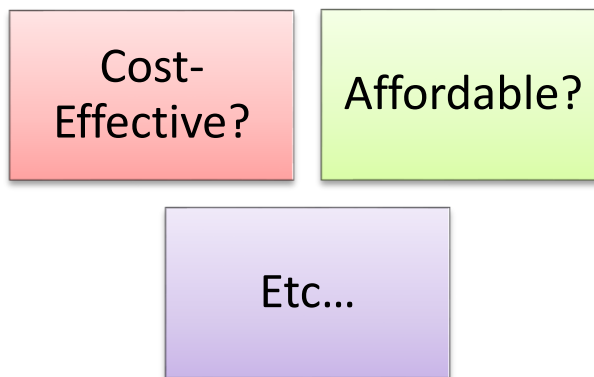
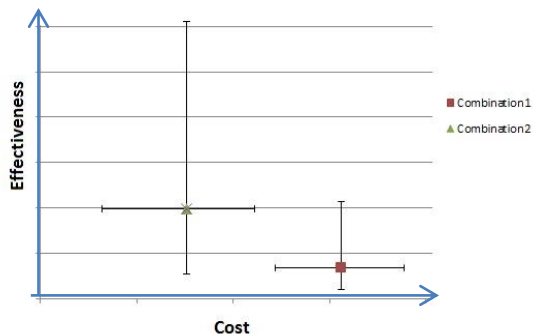
- ② • **Cost ‘impacts’ of a successful attack**
 - **What is the cost of losing an asset (for each ‘C/I/A’ property)**

CIA	Data Sources		Issues
	Military	Non-Military	
Availability (loss of presence)	Country Force Structure Cost Model, military accounts (e.g. UINs)	Overheads from company accounts	Time-related Short and Long term costs of running the asset (inc. existing response information system staff etc.)
Confidentiality (loss of privacy)	!	!	Loss of profit, re-development costs of exposed research, very uncertain
Integrity (loss of confidence)	!	!	E.g. Battlefield pictures untrustworthy. Difficult to define, proportion of availability/confidentiality?



- **Summary of Process**

- Describe Assets (at high level) – network of nodes
- Quantify Risks
- Quantify Mitigation Actions
- Quantify Costs
- Feed information into a tool → assess most cost-effective combinations of mitigations



- ***Same outputs for cyber security, by the approach discussed?***



- **Benefits**
 - Audit trail for the evidence
 - Quickly assess alternative combinations of mitigations
 - Engage stakeholders – buy-in?
 - A Tool allows: Evolving Threat, Learning Curves in Mitigation
 - Assess at different levels of detail
 - Run strategic-level ‘attack’ scenarios
- *Applicable to cyber security, by the approach discussed?*



- **Future Effort**

- Risk Propagation
 - Test methods of simulation
- Cost Impacts
 - Estimating ‘loss of trust’, ‘loss of privacy’
- Example framework
- Example tool
- Scalability?
 - Easy/fast to add risks?
 - Easy/fast to add nodes (to the network of assets)?

