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Generic Feasibility Assessment
– a methodology for assessing nuclear energy technologies

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IDM
integrated decision management

Shortcut

Popular media coverage of nuclear power tends to concentrate on two areas:

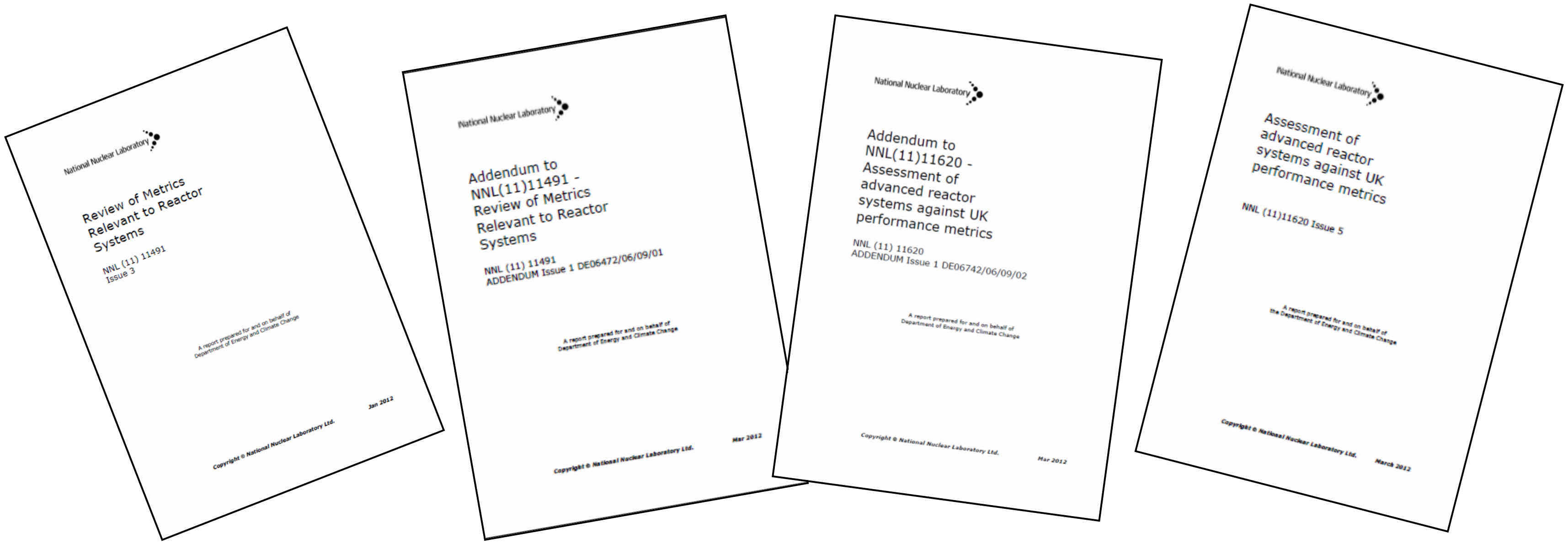
- **“Disasters”** whose newsworthyness is often only coincidentally proportionate to their actual significance
- **“Miracle cures”** – “new” systems which are invariably
  - Absolutely and passively safe
  - Produce no long-lived waste
  - Burn any and all fissile material
  - Will produce power at a fraction of current costs, for ever

That these claims gain traction stems, at least in part, from the absence of a transparent, understandable system to evaluate reactor systems: making sure that the **“good”** is balanced by a consideration of the **“bad”** and the **“ugly”.**

With the UK back in the nuclear new build business after a 20-year gap, it has attracted a range of propositions of varying provenance and urgently needs assessment methodologies to assess reactor systems for the various “pathways” being examined by (and for) the UK Government

There are well-proven systems like IAEA’s INPRO Project which provide ways of analysing futures with closed and open nuclear cycles, but while these detail **‘what’** happens for a given scenario, they generally give little information as to **‘why’** any particular scenario should be preferred

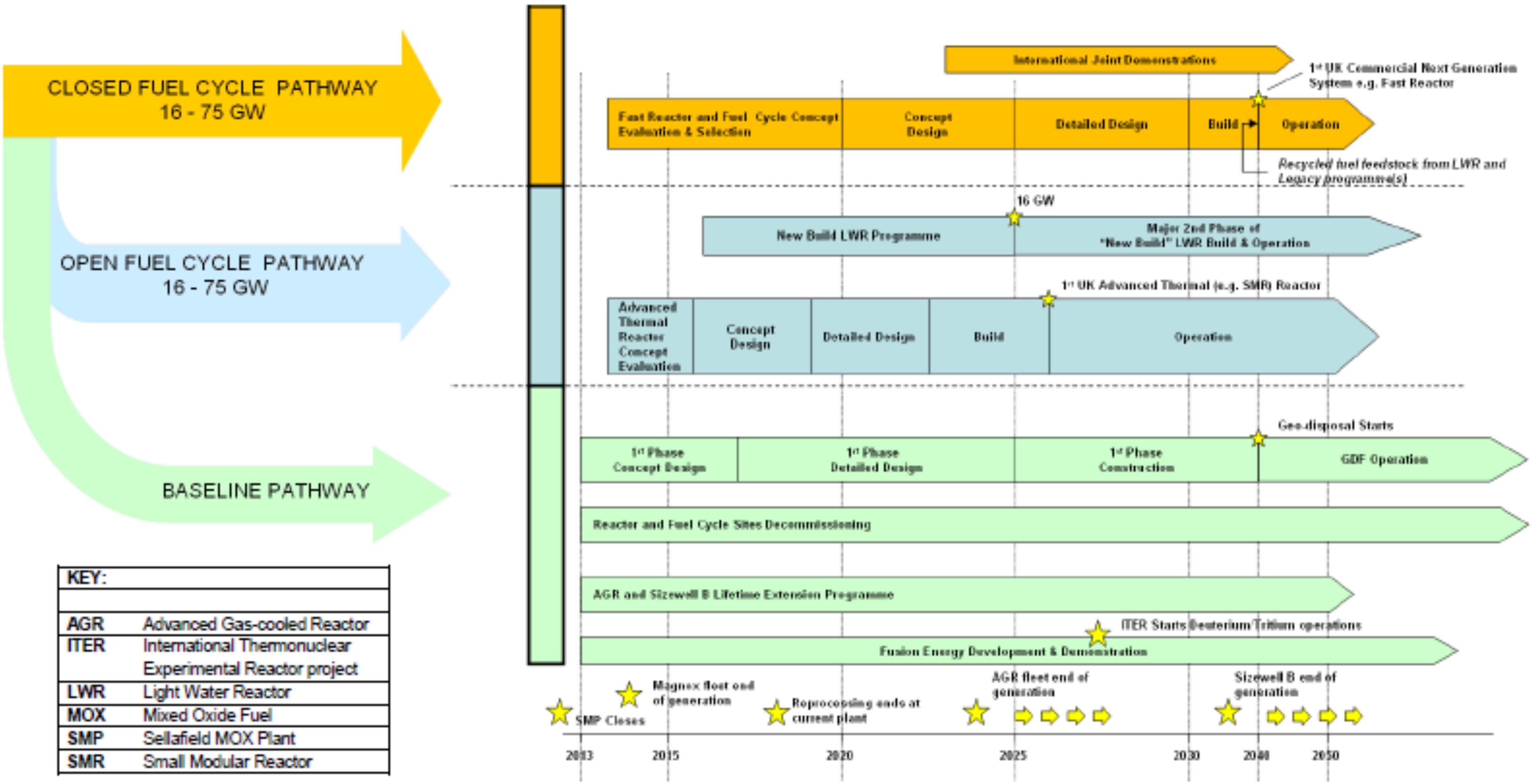
- DECC is examining future energy scenarios including nuclear component ranging from 16 – 75GWE as part of a commitment to reduce greenhouse gas emissions by 80% from 1990 levels by 2050
- DECC commissioned NNL and Dalton to assess different New Build ‘pathways’ looking for ‘*tipping points*’
- NNL did extensive work based on 42 metrics covering the 26 attributes derived for the GEN IV project – all the papers are on the DECC Website



- NNL and Dalton used the ORION fuel cycle model to analyse different futures with different systems
- ORION is a powerful tool, enabling all the inputs (uranium, thorium, enrichment, plant throughputs etc) and outputs (spent fuel, reprocessing products and wastes, waste/fuel radiotoxicity/heat output/ volume etc)
- As for other such tools, ORION essentially gives all the information of **WHAT** happens if a given future is pursued, it does not ask or answer the question **WHY?**
- And there has been some extensive examination of **WHAT** we could do . . . .

Nuclear Energy Research and Development Roadmap: Future Pathways , DECC, March 2013

Nuclear Energy Technology Pathway Options



KEY:	
AGR	Advanced Gas-cooled Reactor
ITER	International Thermonuclear Experimental Reactor project
LWR	Light Water Reactor
MOX	Mixed Oxide Fuel
SMP	Sellafield MOX Plant
SMR	Small Modular Reactor

Thanks to ORION and a lot of scrutiny, these scenarios do actually 'work', but which one would you want and why???

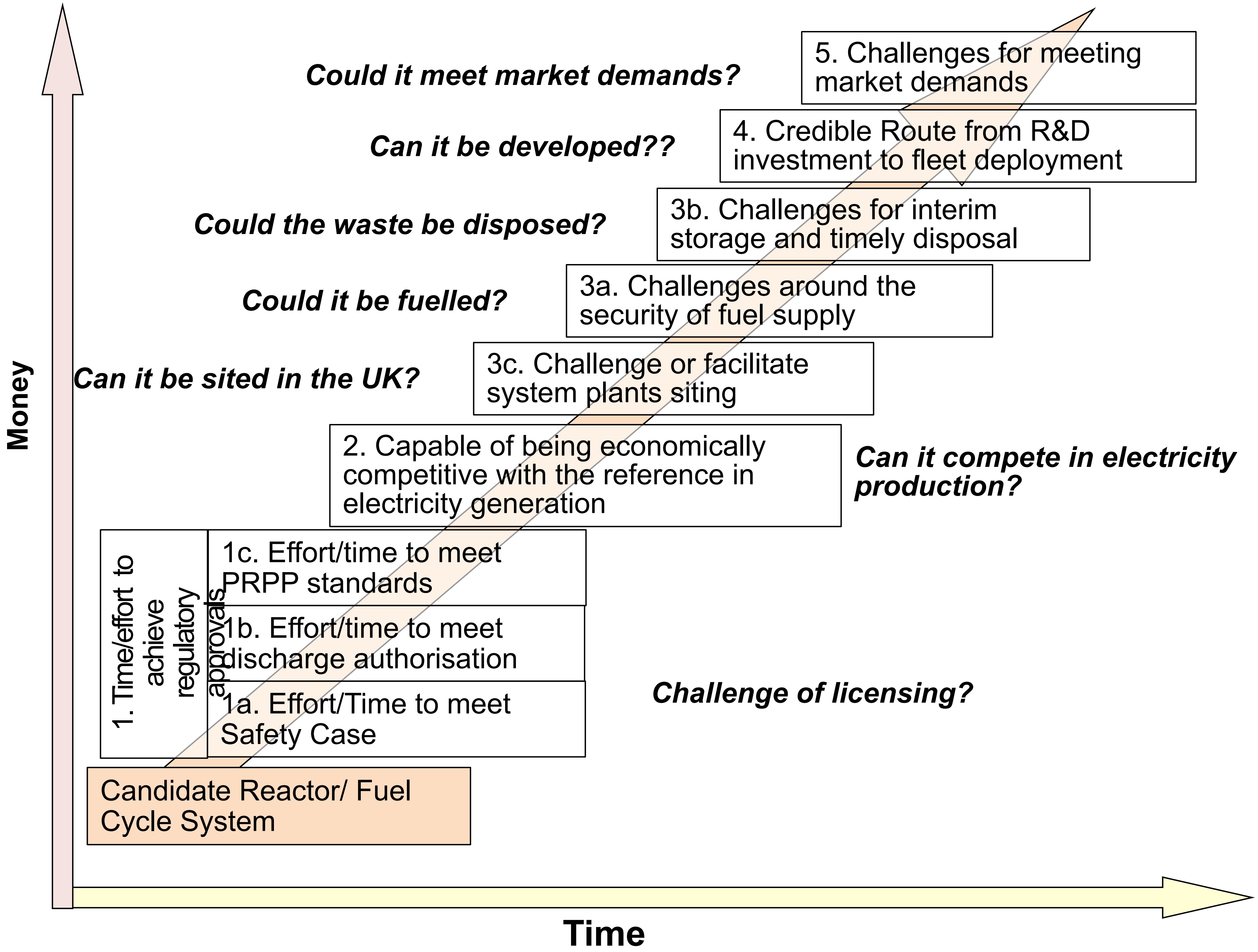
- The **Generic Feasibility Assessment** methodology attempts to address the ‘why’, and poses the question

  “What are the attributes of a nuclear energy system which would justify investment in its future development with view to deployment in the UK?”

- In the UK context, safety environmental and proliferation/security are all covered by well-developed regulatory regimes – so that reactor system deployment is not about “*how safe, secure, and environmentally benign*” a system is, or “*whether it can be licensed or not*” – but how much ***time*** and ***effort*** must be expended to allow the system to conform with regulation.
- This leads to a process with five High Level Discriminators

1. ***How much time and effort will be required to achieve regulatory approvals to deploy this reactor system?***
2. ***Is it likely that the reactor system is capable of being economically competitive with the reference (once-through LWR) system?***
3. ***If this system was deployed . . . . . ? (covers fuel supply, waste disposal and reactor/fuel cycle siting issues)***
4. ***Is there a credible path between state R&D investment now and private reactor system deployment then?***
5. ***Can the system meet market demands***

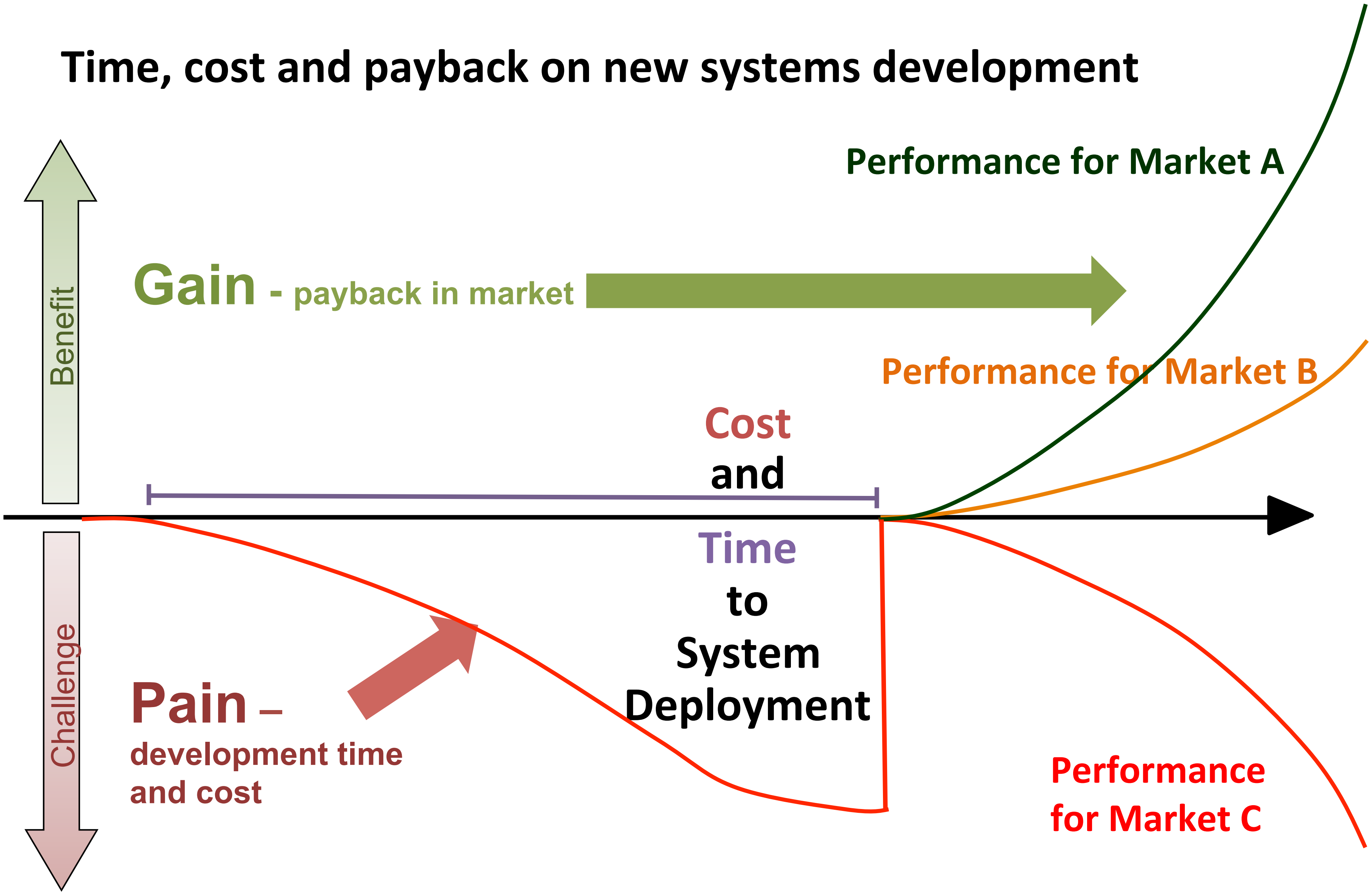
This in turn gives a process which can be represented as . . .



Money
Time
Candidate Reactor/ Fuel Cycle System
1. Time/effort to achieve regulatory approvals
1a. Effort/Time to meet Safety Case
1b. Effort/time to meet discharge authorisation
1c. Effort/time to meet PRPP standards
Challenge of licensing?
2. Capable of being economically competitive with the reference in electricity generation
Can it compete in electricity production?
3c. Challenge or facilitate system plants siting
Can it be sited in the UK?
3a. Challenges around the security of fuel supply
Could it be fuelled?
3b. Challenges for interim storage and timely disposal
Could the waste be disposed?
4. Credible Route from R&D investment to fleet deployment
Can it be developed??
5. Challenges for meeting market demands
Could it meet market demands?

Though the process is **NOT** sequential, but the activities of licensing, deploying and operating a reactor system can be represented as initial spend "**PAIN**" leading to ultimate success in the energy market – "**GAIN**"

Time, cost and payback on new systems development



Investment ('pain') must deliver a commercially acceptable payback ('gain') after deployment - will it do this in the current market situation (low U price, no flexibility requirement etc) or is it aimed at a different future?

- NNL/Dalton analysed the ORION data for different systems using a Multi-Attribute Decision Analysis (MADA) technique based on the 42 metrics it had derived based on those used in the GENIV programme
- MADA gives giving ‘marks’ and ‘weights’ to each attribute, before combining all the marks and weights to give an “overall system score”
- The use of a MADA with the large number of 42 metrics makes the result very difficult to communicate meaningfully, even to committed stakeholders – there is often a shared understanding by ‘*those that were in the room for the analysis*’, which fails to be transferable to others.

- Also the ‘weights’ (i.e. how important is this ‘score’) depend on the future being examined: low uranium usage may be crucial if uranium shortages are predicted, but largely irrelevant if an abundant, low-priced uranium future is predicted.
- ‘The winner’ is a complex concept prone to misunderstanding – and is critically dependent on which ‘future’ is being considered

  “It uses 50x less uranium” – *but what if uranium stays below $50/lb U_3O_8 for 100 years?*

  “It produces less waste” – *but are we* really *going to be limited by the availability of* ***geology*** *for Geological Disposal?*

  *“*It makes the waste shorter lived*”* – *but has anyone thought to tell the 131I, 36Cl, 14C etc etc – which seem to drive most GDF safety cases?*

The Generic Feasibility Assessment (GFA) Approach . . .

- Rather than use MADA, GFA assesses a smaller number of ‘Strategic Attributes’ by comparison to a ‘reference system’, initially taken as ‘once-through PWR’, whose characteristics are already well known.
- The comparisons made are based on published data which can be referenced, linked, and made publically available. It is expected that as the body of assessments build up, it will provide a significant and easily accessed database on reactor systems and their attributes.
- It does not use ‘scores’, but asks the question “*does the system being examined offer benefits or challenges (compared to the reference system) on the attribute being considered, and how significant are these challenges/ benefits*”

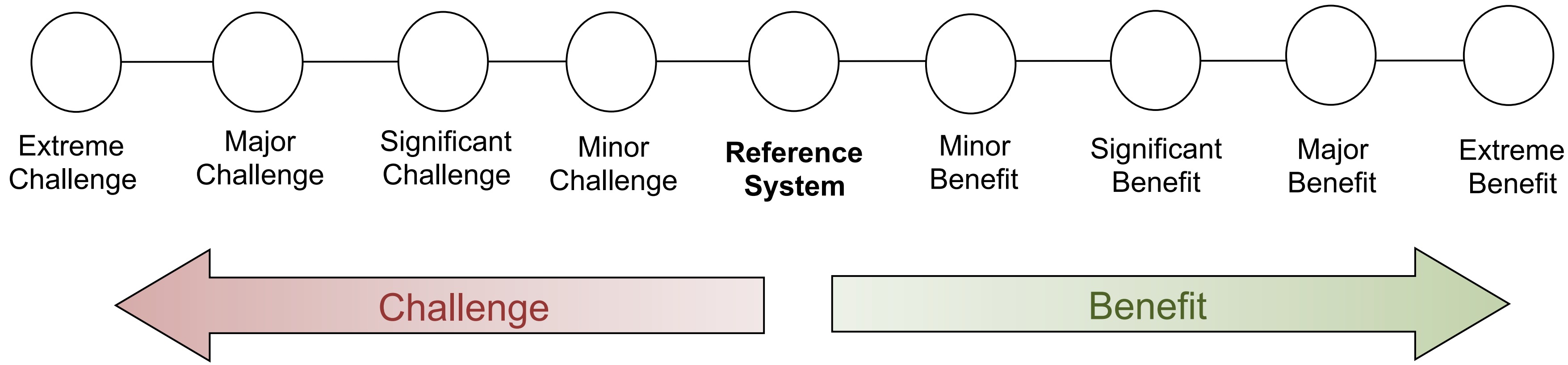
The Generic Feasibility Assessment (GFA) Approach

From the five High Level Discriminators, 12 Strategic Attributes have been developed, which map onto the original 26 GENIV attributes and the 42-metric detailed work by NNL/Dalton

High Level Discriminators and Strategic Attributes

High Level Discriminator		Strategic Attribute		Metrics
1	Regulatory Challenges and Timescales	a. Safety Licenseability	1	10
		b. Environmental Authorisation	2	1
		c. PRPP Acceptability	3	4
2	Competitiveness	a. Economic Competitiveness	4	9
3	Viable Deployment	a. Fuel Security	5	2
		b. Waste Storage and Disposal	6	6
		c. Siting	7	3
4	Development Route and Timescale	a. Access to International Programmes	8	0
		b. Time and cost to Deployment	9	3
		c. Enable UK Supply Chain	10	0
5	Meets Market Requirements	a. Flexibility	11	1
		b. Process Heat	12	2

The detailed NNL work, supplemented by additional work and/or additional information searches where less familiar systems are involved, seeks to assess the performance of the ‘Subject System’ against that of the ‘Reference System’ in terms of the challenge of benefit it represents, and a system with four points of ‘challenge’ and ‘benefit’ on either side of the Reference System, has proved to be useful



When the 12 attributes of the ‘Subject System’ have been assessed against that of the ‘Reference System’, the presentation in the next slide has been found very useful to bring out key points and support debate

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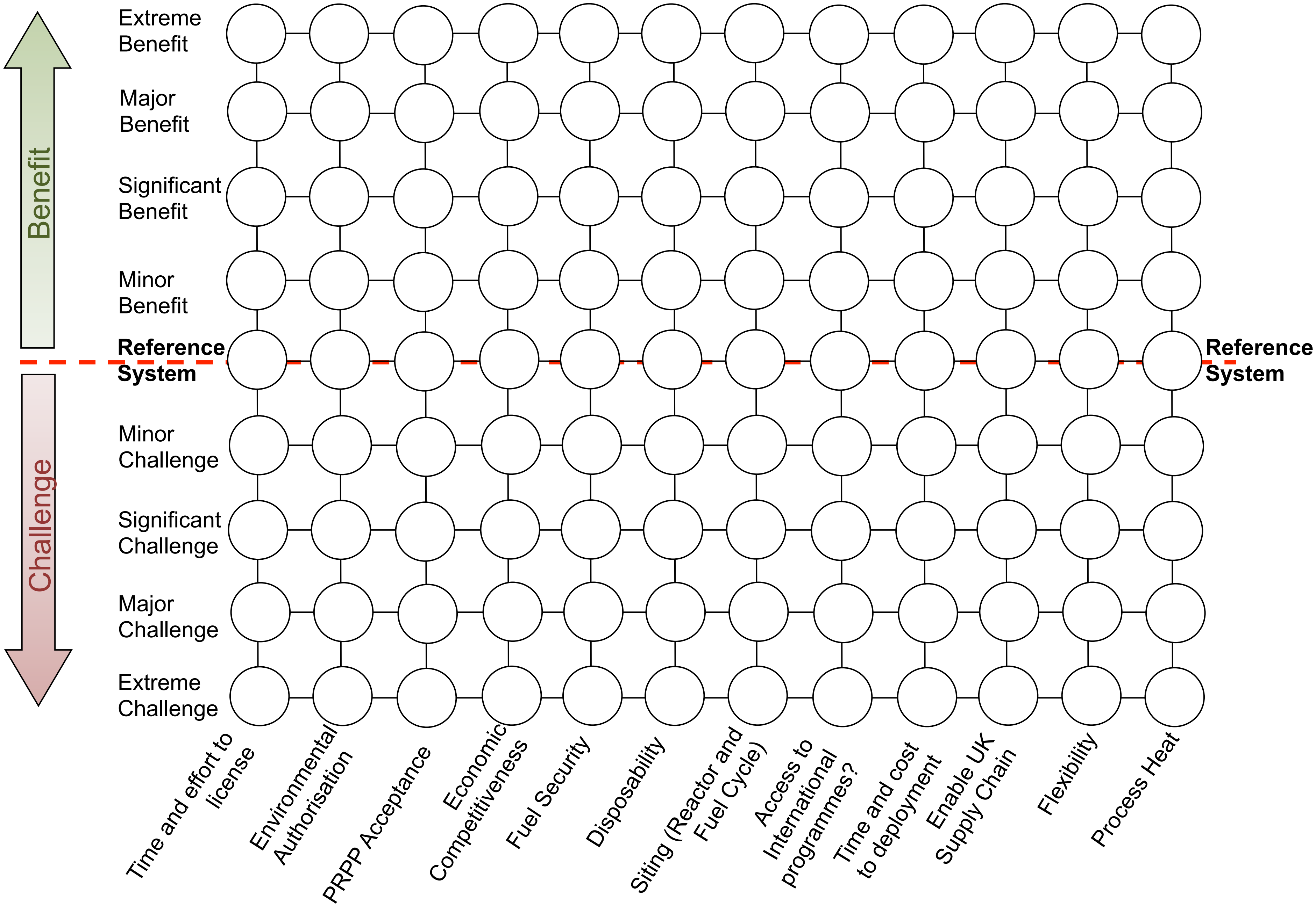
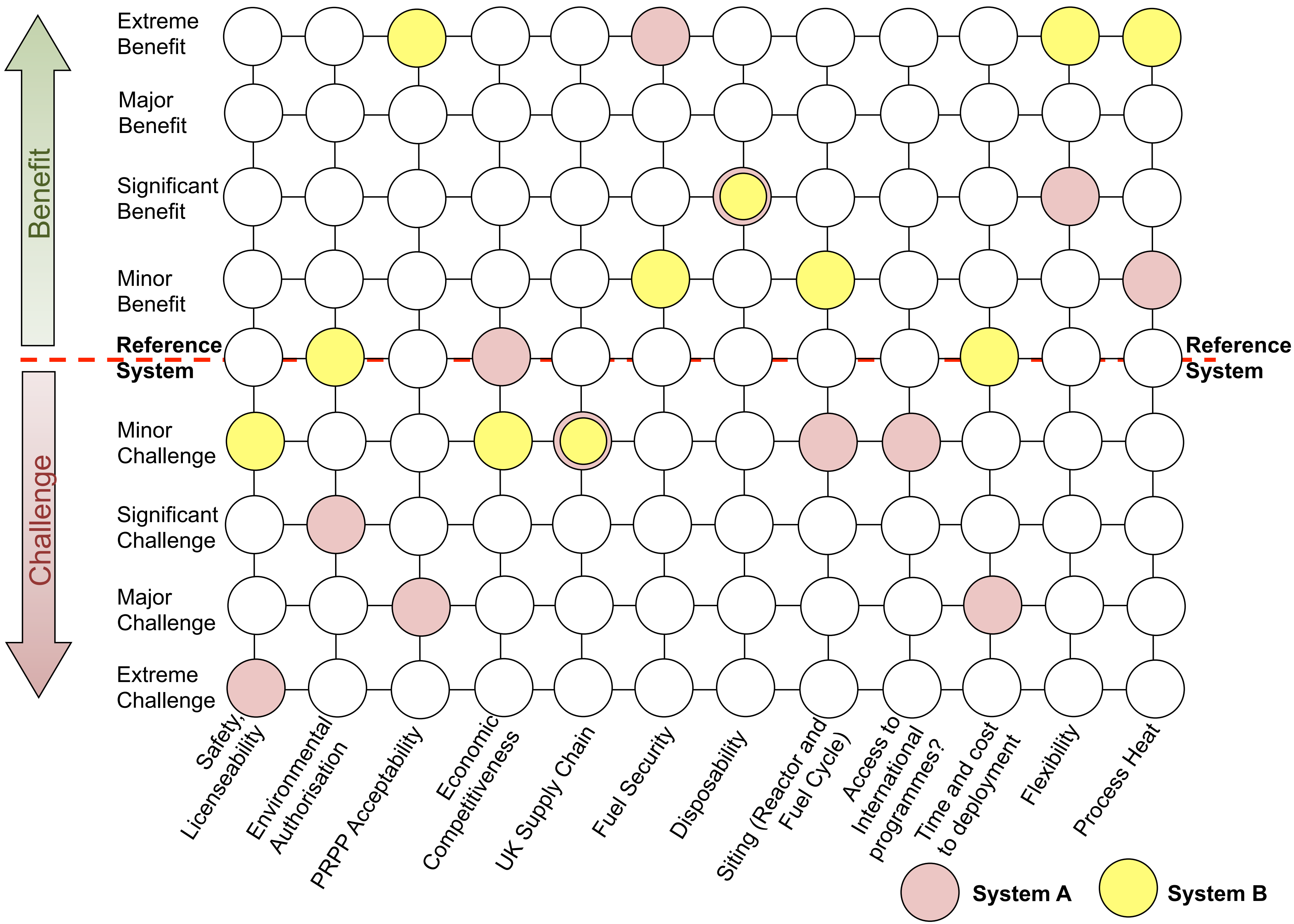
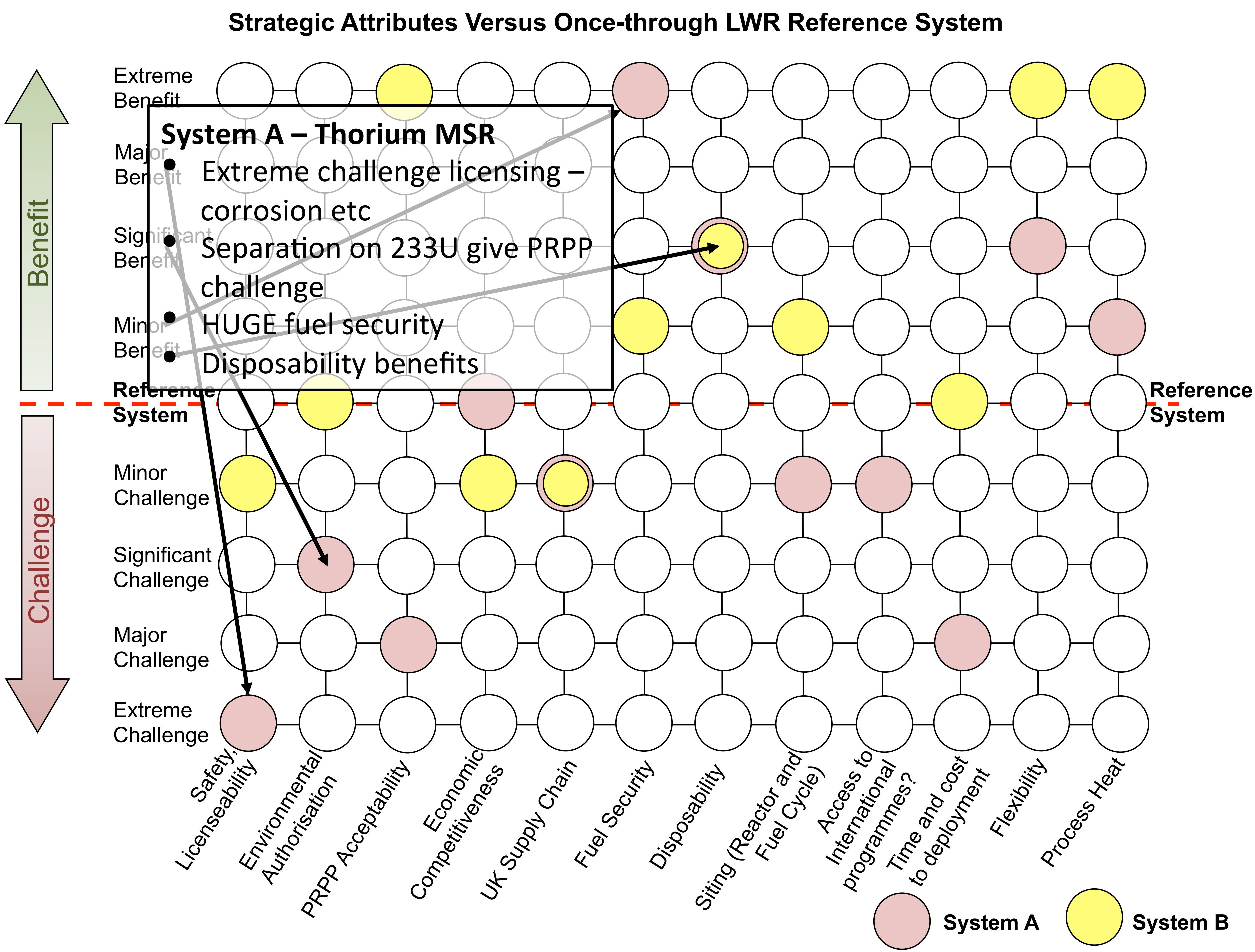
Strategic Attributes Versus Reference System



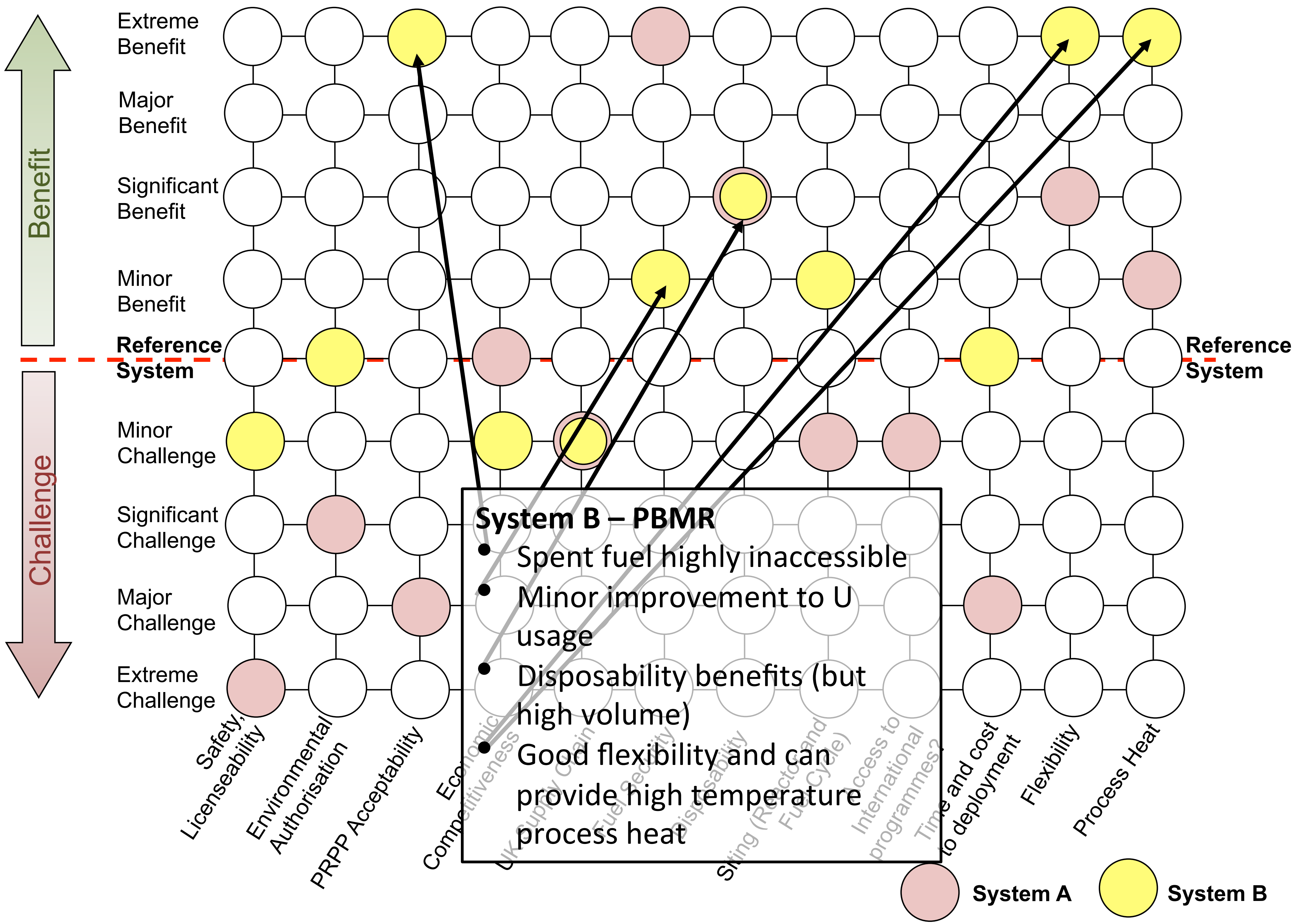
Strategic Attributes Versus Once-through LWR Reference System





Strategic Attributes Versus Once-through LWR Reference System
Benefit
Challenge
Extreme Benefit
Major Benefit
Significant Benefit
Minor Benefit
Reference System
Minor Challenge
Significant Challenge
Major Challenge
Extreme Challenge
Reference System
System A – Thorium MSR
Extreme challenge licensing – corrosion etc
Separation on 233U give PRPP challenge
HUGE fuel security
Disposability benefits
Safety, Licenseability
Environmental Authorisation
PRPP Acceptability
Economic Competitiveness
UK Supply Chain
Fuel Security
Disposability
Siting (Reactor and Fuel Cycle)
Access to International programmes?
Time and cost to deployment
Flexibility
Process Heat
System A
System B

Strategic Attributes Versus Once-through LWR Reference System



Now a quick look at the current "GFA Methodology State of Play"

Note: these are NOT finalised assessments – for illustration and discussion purposes only

RUN

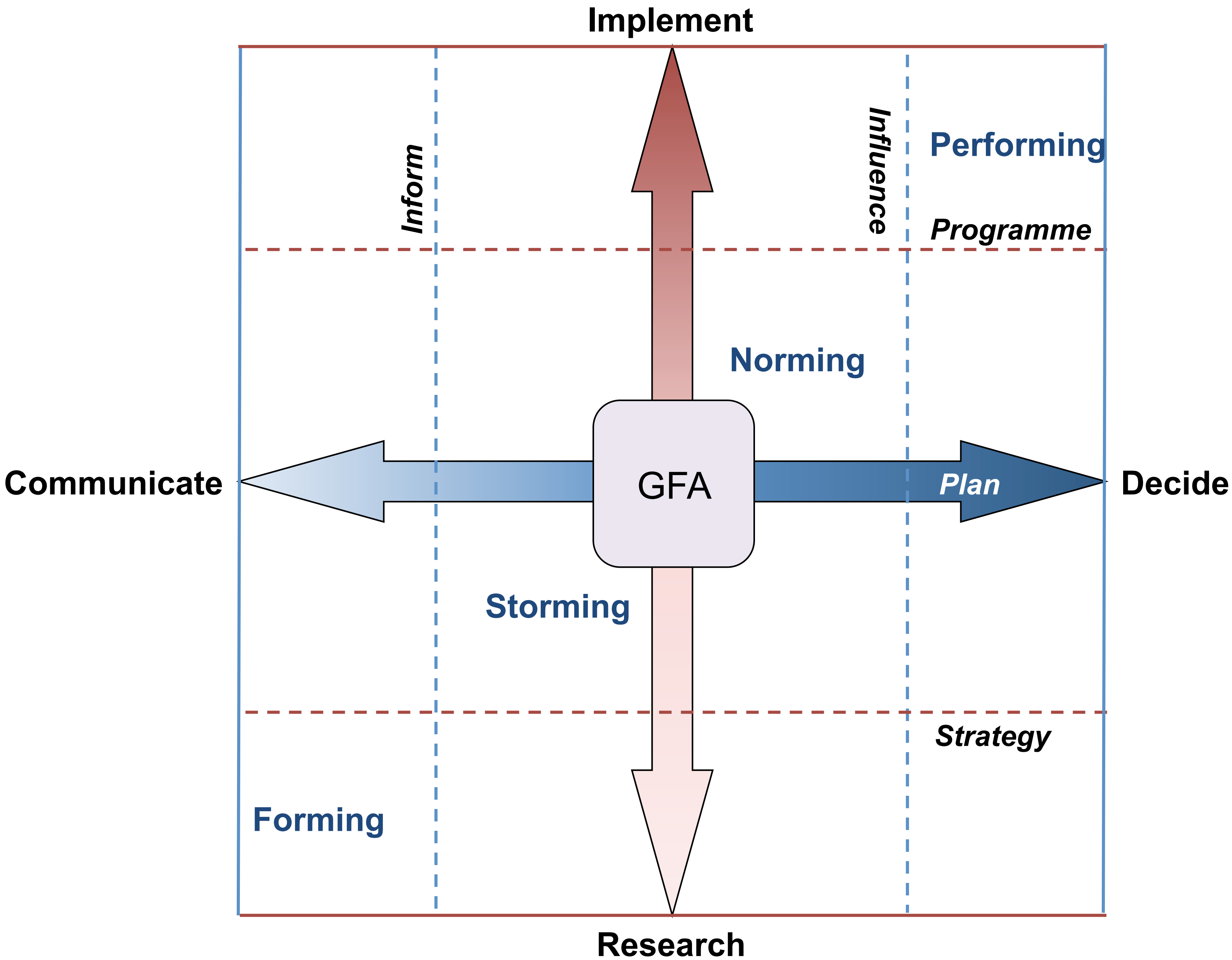
Some ongoing work

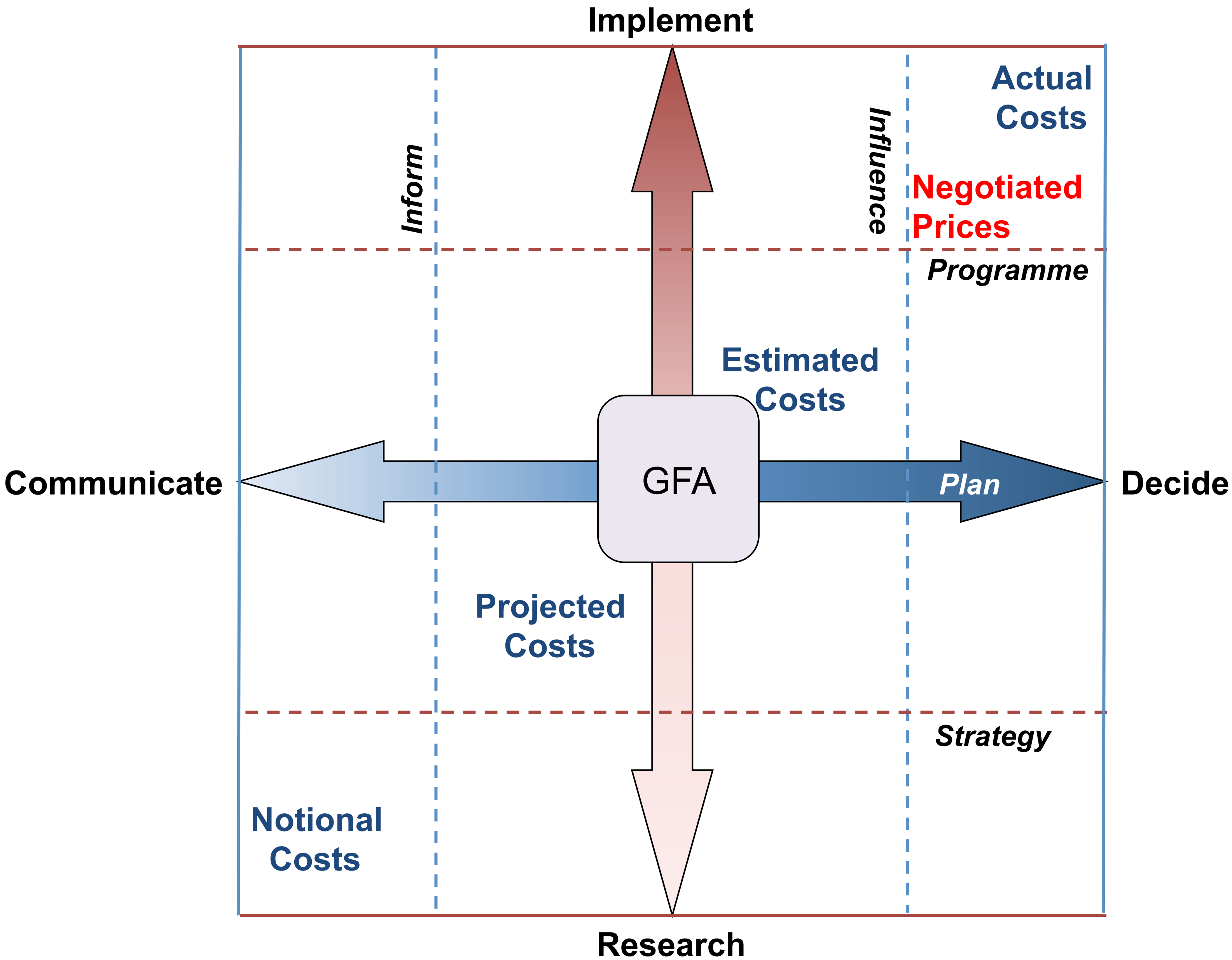
- *Uranium availability and economics* – top-down and bottom-up assessments. Very little recent top-down assessment work, but many advances in the knowledge of uranium mineralisation
  - *Uranium from sea water* – USDOE quote $140/lb – if so what drivers for advanced systems?
- *Isotopes driving safety cases* – most assessment methodologies use radiotoxicity as the main yardstick, but though this (via heat output) may drive repository volume, it is the mobile long-lived fission products (^{129}I, ^{36}Cl, ^{14}C etc) which generally drive doses and hence safety cases. What is the variability of these isotopes between reactor systems?

In Summary – What GFA is

- GFA can help to clarify choices for the role of nuclear systems and to test what kind of energy future is required
- GFA focuses on reactor and fuel cycle systems, it looks at benefits and challenges, relative timescales and costs
- It is NOT a tool for *“choosing between these 2 PWRs”*

So where *does* it fit?


Implement
Inform
Influence
Performing
Programme
Norming
Communicate
GFA
Plan
Decide
Storming
Strategy
Forming
Research



Implement
Actual Costs
Inform
Influence
Negotiated Prices
Programme
Estimated Costs
Communicate
GFA
Plan
Decide
Projected Costs
Strategy
Notional Costs
Research

In Summary – What GFA is

- GFA can
  - help prioritise research needs;
  - provide a focus on innovation opportunities;
  - improve accessibility to information
  - identify information gaps which need to be filled.
- GFA can
  - highlight the difficult questions and uncertainties (Challenges) relating to a system, and
  - show the conditions under which the system might be successfully deployed and the Benefits that might accrue.

In Summary – What GFA is

- GFA works on public domain information – it says ‘given what we know, these are the benefits and detriments’
- If more information is made available, the assessment will change, it is a ‘work in progress’
- GFA is the mortal enemy of ‘marketing by assertion’

In Summary – What GFA is NOT

- GFA ***helps*** decisions, it doesn’t try to ***make*** them
- It examines ***relative*** challenges and benefits – it is not directly trackable to monetary values or exact timescales
- It clarifies the issues and assesses the ‘fit’ of systems into UK energy futures.

In Summary

- GFA has been developed as an alternative to MADA-based decision making tools
- It aims to clarify drivers for different energy futures, and how different nuclear systems can complement these
- It doesn’t seek to give all the answers, but does seek to surface all the questions!