

Managing Complexity Sellafield - a Case Study

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Context

The views presented here are the authors and cannot be attributed to Sellafield or any of the organisations I have worked for. This presentation is informed by 40 years working on complex civil nuclear and defence programs.

Focus - 7 year working in the **100 year long** Sellafield Decommissioning Program

UK Nuclear Program Legacy at Sellafield

- The race to atomic weapons.
 - The MAUD Committee (1940)
 - The USA Atomic Energy Act (1946).
 - UK High Explosives Research program.
 - Windscale (now Sellafield) UK Plutonium Production
 - The Windscale Piles. The Windscale Pile 1 Fire in 1957.
 - 1ST MAGNOX reactor – Calder Hall – Connected to grid 1956
 - Initially fuel reprocessing developed at Sellafield to separate the plutonium for Weapons use.
- The race to cheap electricity and energy security - “Too cheap to meter”
 - UK focus on efficiency of carbon moderated gas reactors
 - Fleet of Magnox reactors (each evolving and different) then AGRs – each evolving and different.
 - Drives UK development of world leading fuel reprocessing at Sellafield
 - Thermal Oxide Reprocessing plant (THORP) a huge export opportunity for UK for its fuel reprocessing technology.
- Fission products and other wastes from lifetime of MAGNOX fleet operations and most of the Advanced Gas Reactors stored at Sellafield

Sellafield

- Nuclear Decommissioning Authority (NDA) Ownership (UK Gov)
- 24/7 operation
- Permanently armed Civil Nuclear Constabulary
- Highest hazard facility in UK and possibly the world.
- 11000 Staff + Contractors
- Dominant employer in Northwest Cumbria.



Sellafield's legacy

- Windscale Piles (Reactors). Including damaged Pile 1
- Numerous silos containing cladding from reprocessed fuel
- Highly Active Liquors containing fission products from the reprocessed fuels - require continuous cooling
- Special Nuclear Material storage and maintenance from the reprocessing activities
- Calder Hall Nuclear power station (4 MAGNOX reactors)
- Prototype Advanced Gas Reactor (AGR). The Windscale AGR (WAGR)
- MAGNOX fuel reprocessing line
- Thermal oxide reprocessing Line
- Numerous Fuel reprocessing facilities
- Fuel storage ponds with radioactive sludges from fuel corrosion
- Fission Product Vitrification
- Active laboratories
- Etc
- Over 1000 building and facilities
- **Remediation Programme will take over 100 years to complete**



Some Factors Driving Complexity.

- Political
 - Imperative for new nuclear power – energy security and carbon reduction
 - Value stream for radioactive waste split between licensees. Each driven to So Far As is Reasonably Practicable within its own area of responsibility.
 - International concerns – Irish Government
- Local economy distortion
- Social Licence for Nuclear Power
 - Impact on political decisions – Geological Disposal Facility, Plutonium disposition.
- Technological
 - Silo contents – uncertainty. Material condition of facilities.
 - Loss of knowledge. Silo contents, buried services
 - New technologies needed for unique challenges
- Legal
 - Public procurement regulations
 - Highly regulated (Office Nuclear Regulation, Environment Agency)
 - Nuclear Safeguards
- Environmental
 - Radioactive waste inventory
 - Deteriorating facilities



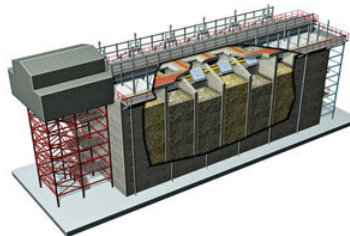
Simplifying a Complex Programme. Example 1 The Magnox Swarf Storage Silo (MSSS)

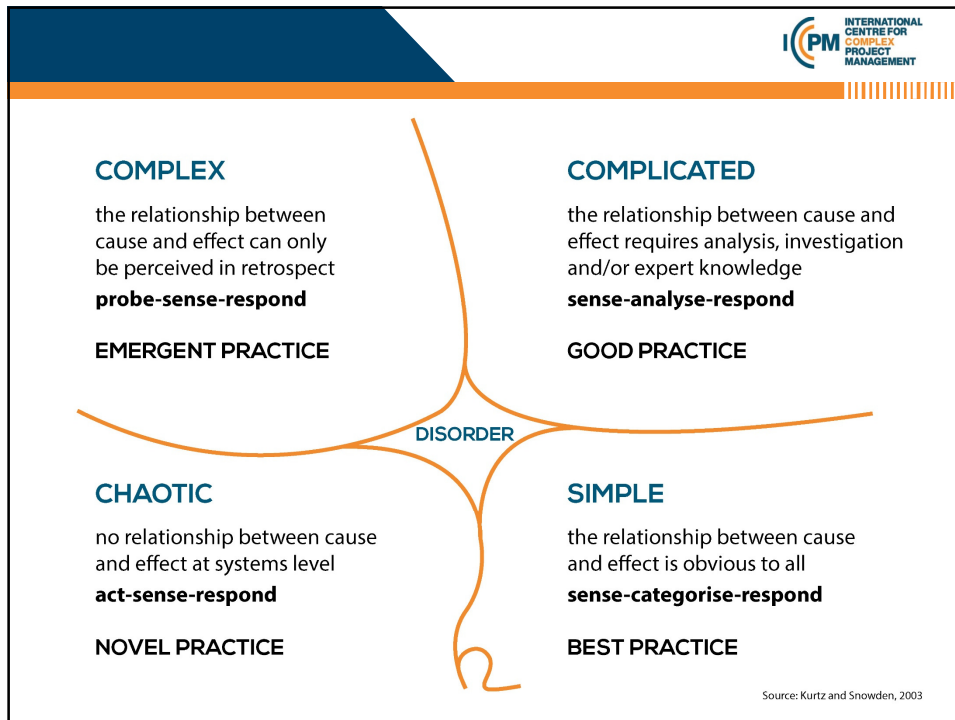
- <https://youtu.be/qQwky909RVO>
- Programme decision calendar
- No1 Regulatory priority
- Silo Direct Encapsulation Plant (SDP)
- Public Procurement Regulations
- 4 year R&D Programme to characterise waste properties
- G6 formed. Office Nuclear Regulation, Environment Agency, Sellafield Ltd, NDA, Radioactive Waste Management Ltd, Department of Energy and Climate Change.
- Contract let for SDP Dec 2014.
- Raw Waste Storage approach agreed December 2015.
- SDP project terminated December 2015. Cost £120m



Simplifying a Complex Programme. Example 2 Pile Fuel Cladding Silo

- Initial project to gain access and empty silo for waste encapsulation escalated in cost and duration during design phase.
- Decision made to halt and rescope simpler phase 1 (Early retrievals) project
- Phase 1 project completed to time and cost
- Knowledge from Phase 1 reduced uncertainty for Phase 2 (Full retrievals)
 - Reduced complexity of retrievals end effectors.
 - Project now proceeding well.





ICPM INTERNATIONAL CENTRE FOR COMPLEX PROJECT MANAGEMENT

Lessons in Portfolio, Programme and Project Management

- Cynefin matrix - Simplify, Simplify
 - Complexity as a badge of honour
 - Fire fighting/Fire starting
- Programme Decision Callander - (Sellafield has a 100 year programme)
 - Its never to early.
 - Make assumptions and manage the risk with mitigations (R&D and Studies portfolio).
 - Model scenarios
- Programmes – define the scope of projects. Keep them simple.
- Develop long term industry engagement and collaboration. (PPP Later)
- Look for smaller simpler scopes. Over ambitious initial capability = increased complexity = increased risk
- Beware of optimism bias in scoping and estimating projects. (Reference Class Forecasting (later))

The Programme and Project Partners Project Delivery Model

- Why?
 - Public Procurement Regulations drive competition for each project scope
 - Long procurement process
 - Late industry engagement
 - Same people different hats
 - Industry not motivated to invest
- What ?
 - All major projects at Sellafield over 20 years
 - Four industry partners. Integrator, Engineer, Civil Construction Manager, Process Construction Manager
 - Value £7Bn
 - Competed on capability and collaborative behaviours – not scope.
 - 4 individual contracts with Sellafield and an Aligned Incentive agreement
- Result
 - Long term supply chain engagement
 - Innovation
 - Supply chain investment
 - Early industry collaboration to ensure project success.

Reference Class Forecasting

- Optimism Bias
- We don't now what we don't know. So we cant estimate it.
 - What will be acceptable to the politicians?
 - Once its going they will keep funding it.
- Databases of over 10K projects exist
 - Statistical distributions so likely outcomes for classes of projects
 - Data broken down by cost breakdown structure allows tailored reference classes for unique projects
 - Increasingly complex projects have long tailed distributions
- Decision Making
 - Long tailed distributions indicate high uncertainty. – Is this project too ambitious?

Questions?