



Rolls-Royce

Management of Key Technologies in the UK Naval Nuclear Propulsion Programme.

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History of the UK NNPP

- Key Dates
 - 1954 – UK NNPP formed
 - 1957 – DS/MP construction commences
 - 1958 – US/UK MDA signed
 - 1960 – HMS DREADNOUGHT launched
- HMS VALIANT (1966) used first all-UK plant & core design.
- PWR1 reactor plant design implemented in VALIANT, CHURCHILL, RESOLUTION, SWIFTSURE and TRAFALGAR Classes (1966-present, 23 vessels).
- PWR2 reactor plant design implemented in VANGUARD and ASTUTE Classes (1993-present, 10 vessels).

History of the UK NNPP

- Philosophy of Continuous Improvement applied within each plant design.
- 5 generations of reactor core design implemented.
- The latest Core H design represents a ten-fold improvement in core life over the first US and UK core designs and avoids the need to refuel the submarine during life.
- The installed core population to date represents an energy capacity of approx 70,000 GW hr.
- Estimated that over 30m nautical miles steamed under nuclear power since HMS DREADNOUGHT launched in 1960.

History of the UK NNPP

PWR1 REACTOR PLANT															PWR2 REACTOR PLANT																			
DECOMMISSIONED															IN SERVICE					IN BUILD														
		V & C		RESOLUTION			V & C		SWIFTSURE				TRAFALGAR							VANGUARD			ASTUTE											
HMS DREADNOUGHT	DS/MP1 PROTOTYPE	HMS VALIANT	HMS WARSPITE	HMS RESOLUTION	HMS RENOWN	HMS REPULSE	HMS REVENGE	HMS CHURCHILL	HMS CONQUEROR	HMS COURAGEOUS	HMS SWIFTSURE	HMS SOVEREIGN	HMS SUPERB	HMS SCEPTRE	HMS SPARTAN	HMS SPLENDID	HMS TRAFALGAR	HMS TURBULENT	HMS TIRELESS	HMS TORBAY	HMS TRENCHANT	HMS TALENT	HMS TRIUMPH	STF PROTOTYPE	HMS VANGUARD	HMS VICTORIOUS	HMS VIGILANT	HMS VENGEANCE	HMS ASTUTE	HMS AMBUSH	HMS ARTFUL	HMS AUDACIOUS	HMS ANSON	HMS AGAMEMNON
CORE A	B/F	ORIGINAL FIT																																
CORE B		BACKFIT										ORIGINAL FIT																						
CORE Z	B/F											BACKFIT				ORIGINAL FIT																		
CORE G																							ORIGINAL FIT											
CORE H																							BACKFIT					ORIGINAL FIT						

Future developments in the UK NNPP

- SSBN Successor platform recently announced to be powered by PWR3 reactor plant.
 - PWR3 presents a significant design evolution for the UK NNPP.
 - PWR3 selected over PWR2 derivative design based upon demonstration of safety improvement and total-life cost reduction.
 - Additional benefits in terms of exercising of UK NNPP design, validation and build capability.

RR Role & Capabilities

- Rolls-Royce have been central to the UK NNPP since its inception in 1954.
- RR Submarines employs c. 2000 employees in Derby, HMNB Clyde & Devonport, Barrow-in-Furness, Bristol and Thurso.
- RR operates and maintains the Naval Reactor Test Establishment (HMS VULCAN) at Thurso.
- RR is licensee for 2 nuclear licensed sites in support of the UK NNPP in Derby.

Example Key Technologies

- ‘Key Technologies’ considered as those being unique or specific to the UK NNPP design and not accessible in the wider supply chain, e.g.
 1. Reactor core design and performance analysis
 2. Reactor plant performance analysis
 3. Reactor core and plant validation & verification
 4. Major plant component design
 5. High integrity electrical design

In-Programme Technologies

- A number of key technologies have been managed by proactive maintenance within the NNPP.
 - Typically ‘crown jewels’ technologies
 - E.g. core/plant design & performance analysis
 - Requires technology to be realistically exercised in order to retain capability
 - Dedicated infrastructure
 - Naval Reactor Test Establishment (DS/MP, STF)
 - NEPTUNE (Zero Energy Reactor)

Strategic Technology Partners

- A key technology requirement supplied by an organisation external to the UK NNPP
- NNPP involvement/commitment in sustaining capability to ensure its availability
- Strategic Technology Partners include:
 - Electric Power Research Institute (EPRI)
 - Multiple research areas
 - National Nuclear Laboratory
 - Post-irradiation examination capability

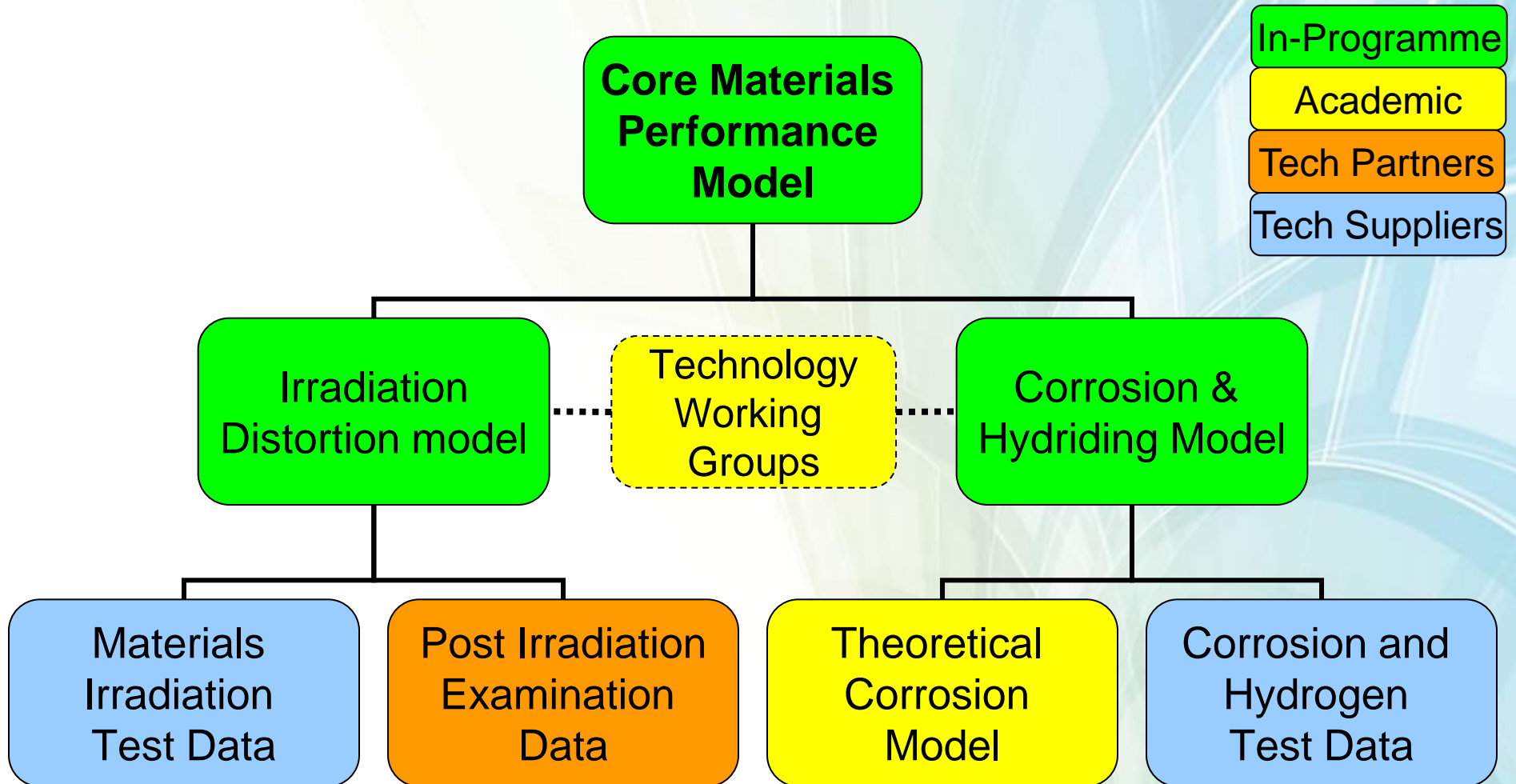
Strategic Technology Suppliers

- A key capability required by the NNPP but procured on a commercial basis.
- Capabilities managed under Strategic Technology Suppliers include:
 - Materials irradiation, testing & characterisation
 - Analytical codes to support physics analyses
 - Electronic card and component detail design

Academic Engagement

- Academic institutions have been engaged to support both research and training needs:
 - Nuclear University Technology Centres (UTCs) established with Imperial College and Manchester University.
 - Masters courses and Engineering Doctorates at Manchester, Imperial and Birmingham Universities directly supported by the NNPP (by funding, students and industrial placements).
 - Bespoke technology training courses developed and delivered by Sheffield, Loughborough, York and Surrey Universities.

Technology Management Example



Management of nSQEP & Training

- Maintenance of nSQEP resource is a critical requirement for the NNPP; a programme level body reviews and directs efforts in this area.
- A wide range of nSQEP training is delivered on an enterprise basis, from basic NSRP acquaint through to MSc level.
- A number of relevant masters level courses are supported by the NNPP.
- A programme-wide graduate development programme is in place – interfacing with the NuclearGraduates industry programme.

Potential Impact of UK Civil Renewal

- In medium to long term, renewal of the UK civil industry will benefit the UK NNPP:
 - Increased depth, capability and resilience of UK nuclear supply chain.
 - Presents a more attractive career prospect to the engineering profession.
 - Early effect being seen through popularity of NuclearGraduates programme.
- In short term, a rapid expansion of the UK civil industry may precipitate short-term competition for SQEP resources and key facilities.
- UK NNPP is actively planning to manage impacts arising from UK civil renewal in the 5-10yr timescale.

Summary

- For over 50yrs, the UK NNPP has developed, maintained and delivered nuclear propulsion to the Royal Navy flotilla.
- A range of approaches to managing key technologies has evolved, engaging both industry and academia.
- Nuclear SQEP training and development is delivered on a broad enterprise basis.
- Renewal of the UK civil nuclear sector presents both risks and benefits to the NNPP.