Fixing the power cuts: Resolving Type 45 power and propulsion problems

The ground-breaking Integrated Electric Propulsion system fitted to the Royal Navy's Type 45 destroyers has hit the headlines for all the wrong reasons. Richard Scott examines the issues that have driven plans to upgrade the ships' electrical generation capacity.

Innovation invariably comes with a level of financial and operational risk. The challenge has always been to understand the complexities and interdependencies associated with introducing new technologies and concepts of operation, and so take the appropriate steps to quantify, qualify, and retire the attendant risks ahead of introduction to service.

Yet there are frequently occasions where, despite prior investment in demonstration and de-risking, the robustness of new technology - particularly where embodied in a complex 'system of systems' - has not met expectations. In the case of the UK Royal Navy's (RN's) six new Type 45 destroyers, it is the adoption of an all-electric power and propulsion architecture, coupled with the introduction of the new WR-21 advanced cycle gas turbine (ACGT) prime mover, which has caused major headaches.

Numerous instances of total electrical failure have been reported during the class's first three years of operations, and it is now recognised that some initial 'teething troubles' in the Type 45 Integrated Electric Propulsion (IEP) system are in fact more systemic in nature.
While these issues were an open secret within the RN, it is only more recently that they have come under parliamentary and public scrutiny. Much negative media attention has followed.

So what are the underlying causes of this situation? To understand these, it is first necessary to review the rationale for the IEP, and also the circumstances that led to the selection of a gas turbine alternator (GTA) using the complex cycle Rolls-Royce WR-21 intercooled and recuperated marine gas turbine. Going back to the 1990s, the UK Ministry of Defence (MoD) and the RN's marine engineering community had set a course - guided by a Marine Engineering Development Strategy - to adopt an 'Electric Ship' architecture for future warships on the grounds of improved survivability, improved operating efficiency, reduced costs of ownership, and an ability to meet the needs of future pulsed-power weapon systems. The same strategy also advocated the adoption of high-efficiency, power-dense ACGT technology on the basis of the through-life benefits accruing from significantly improved fuel efficiency at part load.

The Type 45 is the first frontline warship in the world to introduce an all-electric power and propulsion architecture. Yet, there is no denying that IEP in a warship application - demanding much higher power densities and shock standards compared with existing commercial designs - was a 'system of systems' still at the very cusp of realisation when the decision was taken in 2000 to adopt such an architecture for Type 45. In fact, at the outset of the programme in 1999 the initial preference was to adopt with a hybrid Combined Gas and Electric (COGAL) machinery arrangement; IEP was ruled out because of the lack of suitably compact and power-dense motors.

However, this decision was reviewed in early 2000 after testing performed at the US Navy's Integrated Power System land-based testbed in Philadelphia demonstrated the performance of a 20 MW Advanced Induction Motor (AIM) of sufficient volume and weight to fit inside a destroyer hull. The baseline COGAL option was dropped, and the decision made to instead opt for direct drive IEP with fixed pitch propellers on the basis it represented the best option in terms of through-life costs, performance, and risk.

The Type 45 IEP was shore-tested using the Electric Ship Technology Demonstrator (ESTD). These de-risking trials tested a subset of the Type 45 power and propulsion plant in a variety of regimes and modes so as to give confidence in function and performance.

At the outset, the design intent was that the IEP system would typically run on one WR-21 GTA in a single-island mode, with the second GTA brought on line only in 'high risk' operating regimes; the two 2 MW diesel alternators were to provide power for harbour services and 'blackout' recovery, and not foreseen to perform as true back-up generators in the event of GTA failure. In fact, current operating practice tends towards one WR-21 and one auxiliary diesel in single-island mode.

However, the reliability of the IEP system in service - including numerous operating casualties leading to shipwide power outages - has revealed a series of shortcomings in specific equipments, and fragility in the overall system architecture. These issues have variously been exacerbated by changed operating profiles (notably extended low-speed loiter periods in high ambient temperature environments) and shortfalls in crew operating experience.

Also, while the ESTD de-risked the functional integration of the IEP design, it was a cost-constrained programme. There is today a general acceptance that it did not achieve sufficient running hours to provide adequate equipment reliability assurance.
In a 3 February written parliamentary answer, minister for defence procurement Philip Dunne acknowledged that around 50 minor design alterations for the Type 45 IEP system had been identified up to 2010. He added, "A report was commissioned in 2011 to examine the reliability of the power and propulsion system in greater detail. This work was re-assessed in 2013 to examine the extent to which the issues identified in the report had been dealt with, (by changes to operating procedures and training) and establish which were not simply the problems associated with a new complex system."

For the longer term, the plan is that a diesel generator upgrade will be embodied towards the end of the decade so as to add greater resilience to power and propulsion by increasing electrical-generation capacity. The feasibility phase for this work, co-funded by BAE Systems and the MoD, concluded at the end of March 2015. Last year's Strategic Defence and Security Review confirmed the intention to take this plan forward.

The diesel generator upgrade is now in its assessment phase, with three options and a variety of delivery models currently being investigated with a number of industrial partners. *IHS Jane’s* understands that the objective is to provide sufficient additional electrical generation capacity such that the IEP system can make cruise speeds (covering the major part of the Type 45 operating profile) on diesels alone. The WR-21 GTAs will remain to provide boost power as necessary, but will be used much less often.

The expectation is that the MoD will determine its preferred technical solution by the end of the second quarter of 2016. The total cost and timetable of implementing the diesel generator upgrade will be determined at the main investment decision point.

Whichever option is selected, the diesel generator upgrade will present its own risks given the space constraints in the Type 45 machinery spaces, and the attendant physical and functional integration of additional prime movers. However, there is a clear understanding that an upgrade of such scale and invasiveness is now necessary to ensure that Type 45 can achieve the levels of availability demanded by the RN.

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