1 November 2016

QUEEN ELIZABETH CLASS AIRCRAFT CARRIERS

Flagship for the Future

Andrew Matters, Support Delegated Design Authority - Aircraft Carrier Alliance (ACA)

This project, first defined in 1998 (but with roots in studies for an 'Invincible Class' aircraft carrier replacement traceable much further back) is due to reach fruition as a vessel sailing under its own power in 2017, and in service with a complement of aircraft in 2020. There will be two carriers, called 'HMS Queen Elizabeth' and 'HMS Prince of Wales.'

This class is the largest warship ever built in the UK, and is being developed with four main contractors working in the Aircraft Carrier Alliance (ACA): these are BAE Systems, Thales, Babcock, and the UK Ministry of Defence. The speaker was a BAE Systems spokesman whose role involves him in a wide range of integration activities related to the configuration and detailed design of the vessels. Construction is divided into major 'blocks,' (built in six different UK shipyards, and assembled at Rosyth in Scotland), and systems – of which some are integral to the blocks prior to arrival for assembly, and others are installed later in the completed hull, much of this 'fitting out' being conducted in dock. Systems range from propulsion to crew accommodation and facilities, and numerous role-dependent elements. Through the design stages the application of technology has led many innovative solutions to the meeting of the operational requirements. The first completed hull has been floated and is now being fitted-out, with the second ship 'Prince of Wales' following with a gap of only a year or so.

Describing a large-scale and significant military development, the speaker, representing the suppliers, avoided being detailed on aspects of operational role, and set out to assure the audience of the capabilities, expressed in wide-ranging requirements, that had been devised within the combined design and operator team over 20 years. These were frozen when it was essential to preliminary design proceeding, and at the same time were configured to allow the greatest possible opportunity to review and replace elements in the current and future stages of the life-time. It has been recorded widely that the greater the scale of a project, the less successful has been the outcome of such requirement-led military programmes, but in this case the speaker spoke only of the experience within their relatively unique and wide-ranging team, and stressed his clear belief that on the QE-class carrier a very successful balance has been struck that has achieved goals constrained by physical design, technology-readiness and evolution issues, and budget and timescale constraints.

There was no reference to political interference as such, but he had to address one example, and that was the desire expressed in 2010 by the UK Government that the vessel would accommodate the conventional, not STOVL (short take-off and vertical landing), version of the US/UK F-35 Lightning II aircraft. In 2015 this decision was reversed – and the audience were made well aware of the significance of having to commit to a design with either a curved-prow deck for take-off (STOVL), or a flat-deck with catapults (conventional). The speaker did not dwell on this contentious political interference with the operational design, which was reversed no doubt with the joint MoD/industry consortium exercising considerable influence in remedying a budgetary-led design-change that was instigated long

after a point in the design process when it should have been regarded a past consideration. The speaker's view was that a simpler lower-cost aircraft variant needs a more complex vessel: coming back to the more complex and expensive aircraft has allowed the carrier to remain a more flexible contributor to anticipated sea-fleet operation.

The flight deck has a total area of some 3.25 acres and looks deceptively 'typical,' although the typical angle-deck planform is absent. It has two 'islands' – one each for maritime (forward island) and aviation-related (aft island) operations control - on the starboard side. Large sponson-supported side areas make the deck relatively wide. The prow section is a 'ski-jump' deck to assist F-35B take-off with large payloads. There is no catapult launch capability. On their return aircraft will approach and conduct vertical landings. He shows an example of the 'grippy' metal-sprayed flight-deck finish which meets performance-related requirements - including withstanding the intense downward F35B exhaust. As an example of how simple requirements cascade in a complex design, it was commented that accidental skin-abrasion could be very severe for deck-crews and has impacted the design of protective clothes for all people on deck.

The configuration and rationale for some of the unique features of large on-board systems was described in detail: two examples to quote.

Propulsion – This uses two 33-tonne electrically-driven propellers. There is a choice of diesel or gas-turbine power sources, with diesel offering low-cost and limited power for cruising, and the two gas-turbines (each based on a modified Rolls-Royce Trent core) offering fast-response for large-power – 40MW - output when operational circumstances require. Gone are the days of the big engine room close to the keel, as in this design the engines are distributed in the hull, and positioned to maintain the vessel centre of gravity on the centreline (offsetting the flight deck islands), and simplify the routing of engine exhaust gases. Refuelling is necessary, but the infrastructure costs associated with nuclear propulsion led to it being avoided in the design.

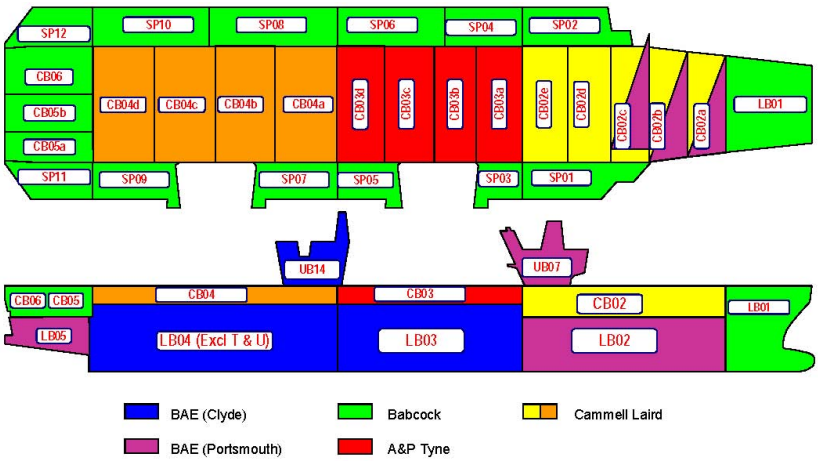
Automated magazine - A hidden element in all warships is the 'magazine'. It is where weapon sets (from gun shells to complex bombs) are stored, assembled and distributed for on-board systems or aircraft use. Traditionally it is labour, and space intensive. The new ship will have a fully-automated and unique weapons-carriage and distribution system, with responsible personal vastly fewer in number, and largely co-located within the core operations team.

Equivalent advancements as are exemplified in the two examples above abound in the ship's design. It was pointed out that saving one crew member on a watch is magnified in any ship's total crew number immediately, as typically there will be a four-watch rota. The QE-class crew complement is considered to be low, with a ship crew of 679, increasing to 1,600 or so when the air elements are embarked. This is barely one half the equivalent complement in existing generation aircraft carriers. This was a valuable insight into how industries now seek to excel at moulding technological advancements into designs, and avoiding an impact on the capability to operate effectively. It made the presentation especially illuminating.

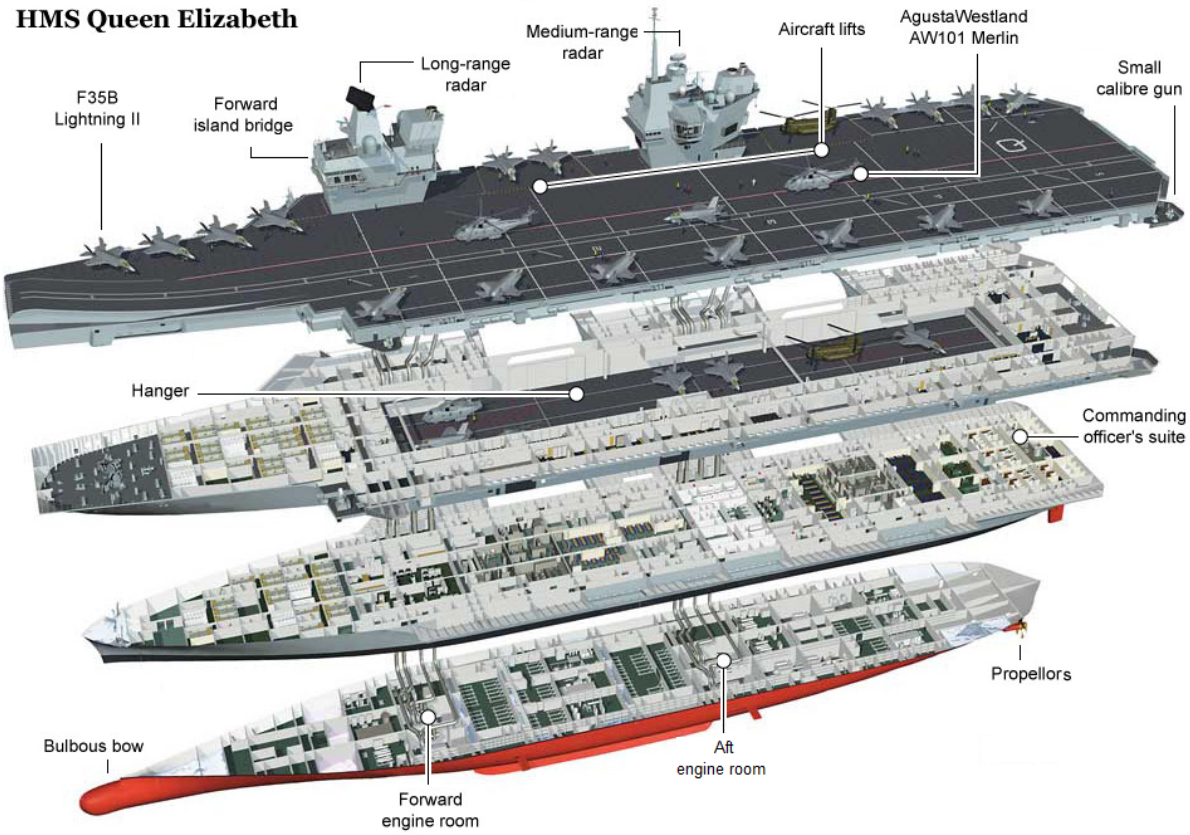
The new ships are designed to be in service for up to 50 years, and will need to be adaptable to systems changes that arise from yet unforeseen military paradigms. The insight was clear that these circumstances were evident to the team developing the system today, and the customer/client 'alliance' goes a long way to making sure that the relationships of the major operational parameters used by the design teams today seek to incorporate flexibility to make the ships adaptable to future needs.

Lecture notes by Mike Hirst

The 'Queen Elizabeth' aircraft-carrier on the occasion of its first float after assembly



The design breakdown into assembly 'blocks'



This 'layer' drawing shows some of the internal configuration on a few of the deck levels

Yet to come!

An artist's impression of an F-35B Lightning II returning from a sortie.

(Note the 'flight' island on the right, and the 'ship' island further forward on the deck).