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Sustaining Design and Production Resources

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Prepared for the
United Kingdom's Ministry of Defence

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Summary

Since the end of the Cold War, the United Kingdom's defence budgets and military force structures have gotten much smaller. As a result, the defence industrial base has contracted as well. This industrial base must now be carefully managed to ensure that the capabilities required to support the nation's forces do not deteriorate to the point at which they cannot support defence requirements. An important factor in ensuring the sustainability of the industrial base is the scheduling of major weapon system acquisition programmes. Gaps in design and production can lead to the departure of experienced personnel to other industries and to the erosion of defence system production skills. This is particularly true of the nuclear submarine production base, for which special skills are required.

Given these concerns, the Attack Submarines Integrated Project Team within the Ministry of Defence (MOD) asked the RAND Corporation to examine the following questions pertaining to submarine design and production:

- What level of resources is needed to sustain a submarine design capability? When might, or should, the next design effort be undertaken? What actions should be taken to maintain submarine design capabilities during gaps between design efforts?
- How should submarine production be scheduled for efficient use of the industrial base? What are the implications of decisions regarding fleet size and production rate? How viable is the non-nuclear vendor base supporting submarine production?

Clearly, these questions can only be meaningfully addressed if a long view is taken. Definitive answers are thus not yet possible because aspects of the long-term future submarine fleet structure are unsettled. What we seek to accomplish here is to make some assumptions regarding that structure and work out the implications of acquisition options for the industrial base. In doing so, we develop an analytic framework that the MOD can apply again once more specifics are available.

The Fleet: Current and Planned

The UK submarine fleet now consists of 11 nuclear-powered attack submarines (SSNs) of the Swiftsure and Trafalgar classes and four nuclear-powered fleet ballistic missile submarines (SSBNs) of the Vanguard class. The Swiftsure boats are being retired over the next six years, and retirement of the Trafalgar class will begin shortly thereafter. Meanwhile, construction of the new Astute class of SSNs is under way. The first three boats of that class are under contract, and it has been announced that up to five more may be built. The first of class is now scheduled for delivery in 2009, with the next two boats following at 18-month intervals.

Sustaining the Design Base

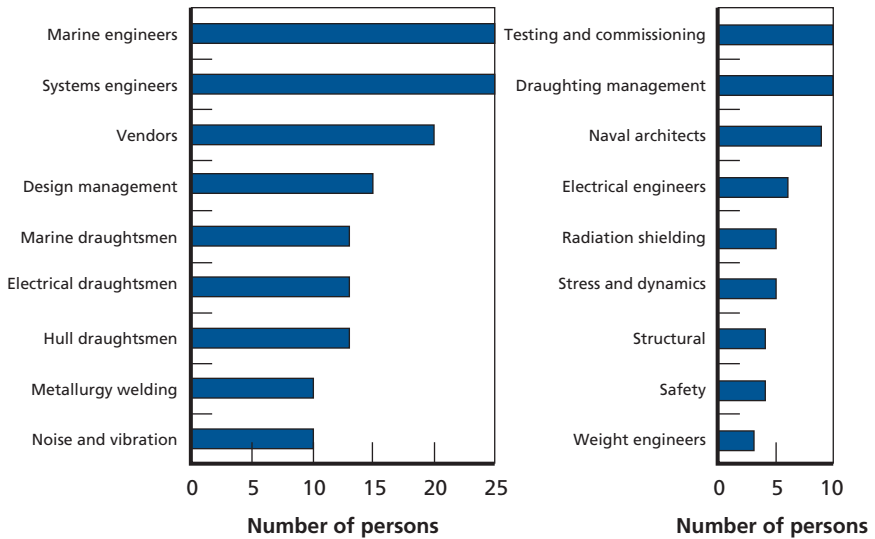
The submarine design base is rapidly eroding. Demand for the design and engineering resources of BAE Systems Submarine Division at Barrow-in-Furness, which is designing and building the Astute class, is declining as the design of the first of class nears completion. Some professionals will be retained through the remainder of Astute-class production to provide design support to construction, but the number required will be fewer than that needed to sustain a viable nuclear submarine design base.

To sustain the United Kingdom's nuclear submarine design expertise, some minimum core of professionals must continuously

work in that area. The number required varies with the domain of expertise: A few people may be enough to sustain submarine-specific expertise in some specialties, whereas some two-dozen persons may be needed to do so in disciplines such as marine engineering and systems engineering (see Figure S.1). The total number required across all domains is approximately 200. Even if the current distribution of skills among the BAE Systems submarine design force reflected that required to sustain the design base, the workforce could drop below this critical level in the near future without a new design programme.

Although there are other various options (which we will discuss below) for sustaining the 200-person submarine design core, the ideal way would be to soon commence the design effort for a new class of submarines. At this point, it is unclear when or even whether the United Kingdom will build another class of nuclear submarine. No decisions have been made regarding any programmes beyond the

Figure S.1
Number of People with Various Skills to Support a Nuclear Submarine Design Core



Astute class. However, the current Vanguard SSBN class could begin retiring as early as 2018. If the United Kingdom wishes to retain a submarine-based strategic nuclear deterrent, design of a follow-on SSBN class would have to start approximately 15 years prior to the desired in-service date for the replacement submarines. With retirements of the Vanguard class starting around 2018, the design for a follow-on class would have to begin immediately. The Astute-class boats will also need eventually to retire, and if the replacement for that class, now termed the Maritime Future Underwater Capability (MUFC), is to be a nuclear submarine, design would have to begin some 10 years in advance of delivery of the first of class.

For the purposes of developing and exercising a framework to permit the analysis of long-term programme planning and its implications for the industrial base, we make two assumptions: that the next submarine programme will be for a follow-on SSBN class and that the MUFC will be a class of nuclear attack submarines with the first of class delivered approximately 25 years after the first Astute-class boat becomes operational.¹ We assume design and production efforts for the MUFC will be similar to those for the Astute class, and we scale up the SSBN effort from that for the Astute class. (Should the next class be an SSN rather than an SSBN, some of the quantitative specifics presented here would differ somewhat, but our qualitative conclusions would not—and, of course, the analytic framework would remain valid.)

The first boat of the Vanguard class is now completing its mid-life refuelling. Originally, the Vanguard-class submarines were to have a life of 25 years, and that plan has not yet officially been changed, but the new reactor cores should permit operation until age 40. Were the Vanguard class to be retired at age 25, the design effort for the next of class would have to start immediately. That would reverse the near-term erosion of the design workforce. However, it would leave a gap of some six years between the major design efforts for the follow-on SSBN and the MUFC during which these pro-

¹ We also examine the implications if there is to be no follow-on SSBN class of submarines and if the MUFC programme can be moved forward.

gramme demands would be insufficient to support a core of expertise (see Figure S.2; Astute is omitted). Were the Vanguard class to be retired at age 40, that would close the gap between the SSBN design effort and that for the MUFC, but it would open an even larger gap in the near term. From a design base standpoint, the most desirable retirement age for the Vanguard class would be 30 to 35 years. That would largely close both the near-term gap between the Astute and SSBN classes and the far-future gap following the SSBN design effort (see Figure S.3; Astute is omitted).

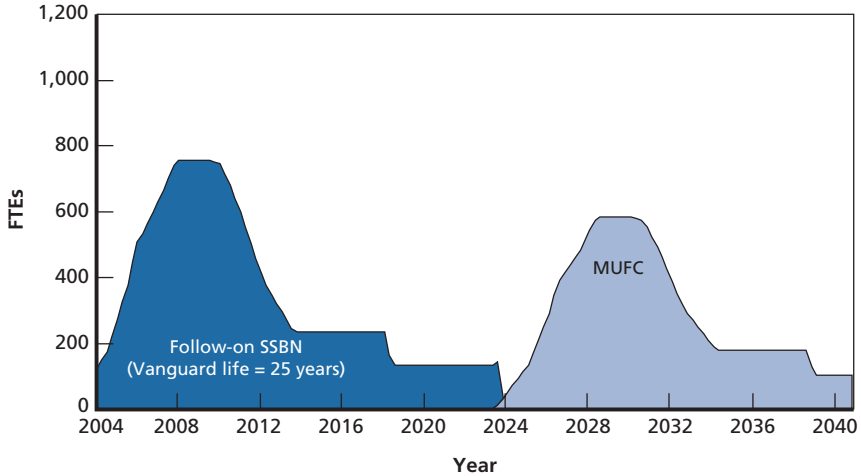
Even if the Vanguard class is retired at 30 to 35 years of age, there may still be a period of time when the design core is inadequate in at least some of the specialties required to sustain expertise. And a retirement date that is not optimal for sustaining the design base may have to be chosen for some other reason. How might the design core be sustained through periods of slack demand? There are several possibilities:

- spiral development of the Astute class, that is, evolution of the Astute design as more boats are built to take advantage of new technologies and respond to changes in the threat the class is to meet
- continuous work on conceptual designs for new submarine classes, whether or not those classes are ever built
- design of unmanned undersea vehicles.

These options are not mutually exclusive; they could be exercised simultaneously. However, taken together, they could not by themselves adequately sustain a submarine design core. The work might not be quite enough, nor would it be entirely of the required character.

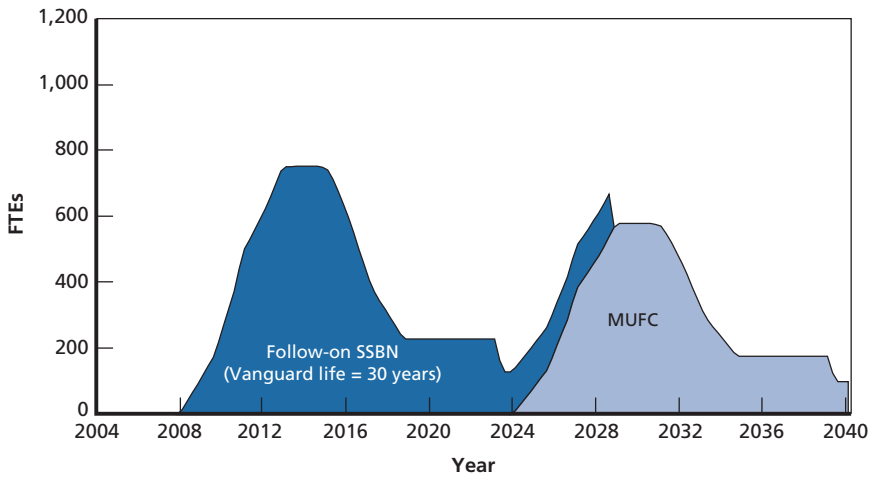
Collaboration with the United States or another submarine-producing country should also be considered. The United States confronts some of the same challenges in sustaining nuclear submarine design resources as does the United Kingdom. Design work on each country's submarine programmes could help sustain the other's

Figure S.2
Future Submarine Design Demands, Assuming Earliest Possible Start for Design of New SSBN



NOTE: Remaining Astute-related design work omitted to protect business-sensitive data.
RAND MG326/1-5.2

Figure S.3
Future Submarine Design Demands, Assuming Start for Design of New SSBN to Replace Vanguard Class at Age 30



NOTE: Remaining Astute-related design work omitted to protect business-sensitive data.
RAND MG326/1-5.3

design core. If the United Kingdom could count on US assistance with submarine design, elements of the design core could be eliminated and the costs of sustaining it reduced (with some concomitant loss of independent design capability). Collaboration could also increase the interoperability of the countries' submarine forces. For collaboration to aid in sustaining the design core, however, the two countries cannot be at parallel positions in their submarine design programmes. At present, they are. The United States does not have a submarine design programme getting under way in the near future.

The MOD should also consider promoting collaboration between the UK organisations designing new submarine programmes and those supporting in-service submarines. There is not enough demand across nuclear submarine design, production, and support to continuously sustain large numbers of design professionals at each organisation. Support organisation designers and engineers could be part of any new submarine design programme, bringing their general knowledge of submarine design plus their specific knowledge of the support of in-service submarines. Likewise, designers and engineers from the Barrow shipyard could aid in the in-service support of the Astute class.

Sustaining and Maximising the Efficiency of the Production Base

As mentioned above, the United Kingdom's submarine production base will be sustained for the next several years by the current Astute contract. That leaves two questions: What happens after that, and could the Astute boats be built more slowly than the prevailing 18-month production 'drumbeat'?²

The answer to both questions again depends on when construction of the next submarine class begins. If the next class is to be a follow-on SSBN class, that would in turn depend on when the Van-

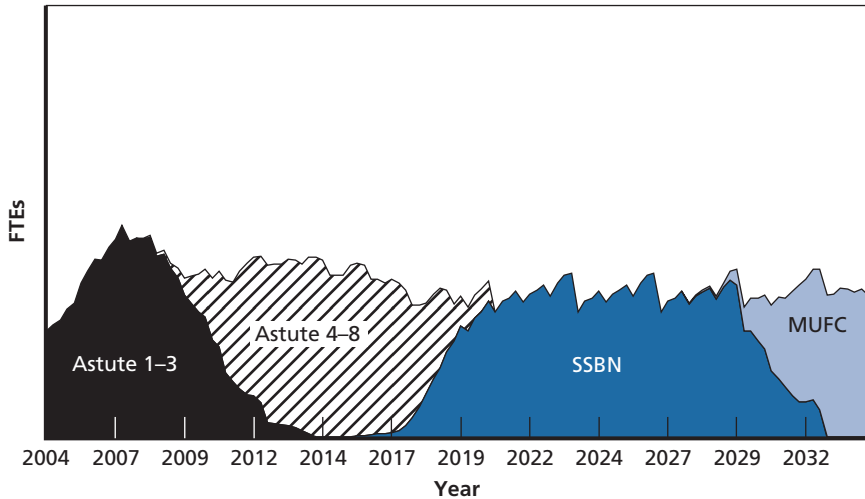
² We use the term *drumbeat* throughout this report to represent a consistent production rate. An 18-month drumbeat suggests the construction of a new submarine begins every 18 months.

guard class retires. The conclusions here reflect those of the design base analysis. Production consistent with a 25-year retirement date leaves too great a gap after SSBN construction concludes and before MUFC construction starts. It also overlaps Astute production too much, giving rise to a peak in the demand for submarine construction resources that the Barrow shipyard would have trouble satisfying. A 40-year retirement date implies simultaneous production of the next SSBN and MUFC classes following a long production gap after Astute construction ends. A 30- to 35-year retirement age for the Vanguard class provides the opportunity for continuous submarine production into the distant future.

In the event of a 30-year SSBN replacement schedule, the end of follow-on SSBN construction could be timed for a smooth overlap with the start of MUFC construction. The nature of the overlap at the start of SSBN construction depends on how fast the SSBNs and Astute-class boats are built. Slowing down Astute production and building the SSBNs relatively quickly would result in a reduced demand for production resources between 2010 and 2020, followed by a ramp-up to meet the SSBN demand. An almost even demand profile could be achieved with a relatively fast Astute drumbeat of 18 months, followed by a slow SSBN drumbeat of 36 months (see Figure S.4). The transition from Astute production to SSBN production would then occur between 2015 and 2020. It is noteworthy that the overlaps allowed by long-term production planning smooth not only the total production demand but also the demand for broad skill categories such as hull construction and outfitting.

Starting new submarine programmes after gaps in submarine production at Barrow will incur substantial costs and risks. If there is no follow-on to the Vanguard class, production of the remaining Astute-class boats may have to be stretched (i.e., built at a slower drumbeat) and the start of the MUFC programme accelerated. Even with these actions, maintaining a force size of eight SSNs could be prohibitively expensive. Unit production costs could be reduced if more SSNs are built either by increasing the fleet size or by retiring active submarines early. However, both of these strategies could lead to higher total nuclear submarine production and through-life costs.

Figure S.4
Workforce Demands at Barrow (18-month SSN/36-month SSBN Drumbeats)



RAND MG326/1-5.4

Smoothing out the demand on submarine production resources would allow the industrial base to operate at peak efficiency and could reduce production costs by 5 to 10 percent per boat. However, demand-smoothing is not likely to be the only factor considered in scheduling production. It may be necessary for other reasons to build the last five Astute boats more slowly or even to delay the start of their construction. If so, the resulting valleys in production demand at Barrow could be filled with work on other ship programmes. In the coming years, the United Kingdom will be building the Type 45 surface combatants, the Future Aircraft Carrier (CVF), and the Maritime Reach and Sustainability (MARS) ships. These simultaneous programmes will tax the nation's shipbuilding capacity, and some contribution from the Barrow yard to the effort may be helpful.

It should be kept in mind that an 18-month production drumbeat is quick only in relative terms. It is still slow enough that we sought to determine whether any of the nonnuclear vendors to the

Barrow yard³ might be having difficulty surviving and whether their loss could give rise to critical supply gaps. We found that, although some firms had indeed dropped out of the vendor pool, replacements had been found or alternatives were available. Furthermore, no companies still in the vendor base were both irreplaceable and in danger of failing. However, stretching production drumbeats beyond 24 months will require actions on the MOD's part to sustain portions of the vendor base.

Recommendations

From the preceding analysis, we infer a number of actions that the MOD could take to ensure that the United Kingdom's nuclear submarine industrial base is sustained and operates efficiently:

- Decide as soon as possible whether there will be a next-generation SSBN class and when it will be designed and built. This decision is needed to inform any further actions to sustain the design base and schedule remaining Astute production to maximise efficiency. If the Vanguard class is not to be replaced, then planning should begin for an early follow-on SSN class if the submarine design base is to be sustained.
- Plan on annual investments to sustain a core of submarine-specific design resources. A core of 200 designers, engineers, and draughtsmen would require annual funding of perhaps £15 million. That would permit the core to participate in meaningful work such as spiral development of Astute and continuous conceptual development when there is no new submarine design effort.
- Take steps towards collaboration. Although there is not a near-term US submarine programme to support the UK design core during a lapse in demand, collaboration might be beneficial in

³ Nuclear vendors are being considered in a separate analysis conducted for the MOD by another organisation.

the future. It would thus be prudent to begin talks towards a small collaborative effort, with respect to either spiral development of the Astute and US Virginia classes or the design of follow-on SSBN classes in both countries. Meanwhile, the MOD should encourage collaboration between BAE Systems' Barrow-in-Furness shipyard and the contractors employing engineers and draughtsmen for in-service support.

- Decide on the timing of construction for the next Astute-class contract. To sustain and make most efficient use of the submarine production base, an 18-month (or, at most, 24-month) drumbeat should be employed, with no additional break between the third and fourth boats of the class (i.e., the last boat under the current contract and the first under the next). If slower production or a delay is required for some reason, the MOD should allocate some of the work from such programmes as the CVF or MARS to the Barrow yard to level the load there.
- Take action to support nonnuclear vendors. Although there are typically ongoing challenges in maintaining the vendor base that supports shipbuilding programmes (because some suppliers decide to leave the industry or to forego naval contracts), no vendor problems are currently foreseen that cannot be solved. However, the MOD might preempt future problems by placing orders for multiple ship sets of equipment, encouraging other shipbuilding programmes to use the submarine programme vendors when possible, and collaborating with the United States to identify common vendors.