National Audit Office

Transforming logistics support for fast jets

LONDON: The Stationery Office
£13.50

Ordered by the
House of Commons
to be printed on 16 July 2007

SUMMARY

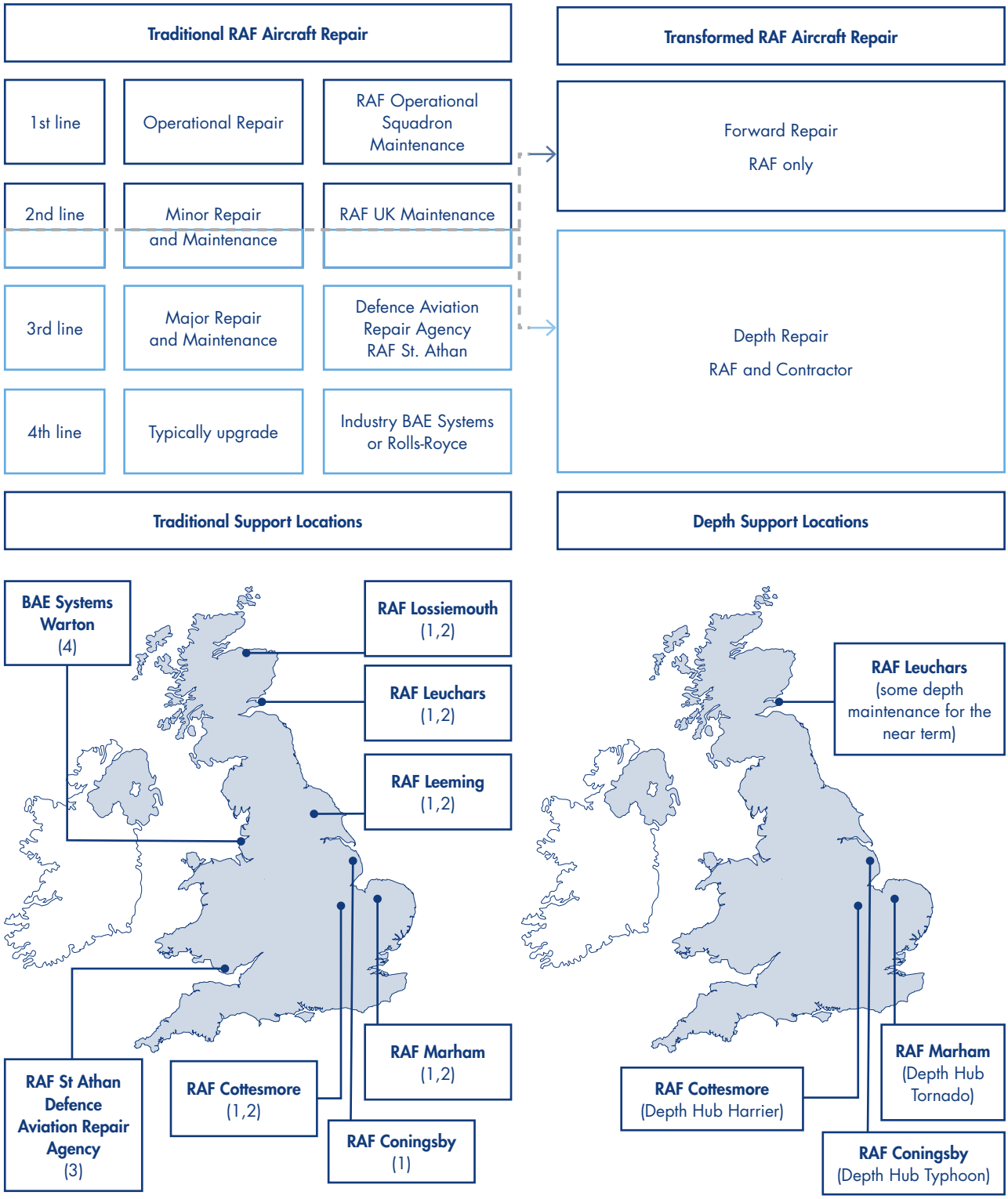
1 The Ministry of Defence (the Department) is transforming the provision of maintenance, repair and overhaul activity for Harrier and Tornado fast jet aircraft. The key driver for the change has been the Defence Logistics Organisation's[1] strategic goal of reducing operating costs by 20 per cent of the total by 2005-06 (around £1.862 billion). The changes have also been enabled by the changed threat against the United Kingdom following the end of the Cold War, which removed the requirement for a repair organisation dispersed across multiple airfield sites to provide contingent capability in the event of an attack on a Royal Air Force (RAF) main operating base. This has allowed the Department to pursue rationalisation where it makes operational and economic sense to do so.

2 In the three years since its 2003 End-to-End Review of logistics[2], the Department has significantly changed arrangements for logistics support for fast jets. The Department and industry previously carried out four levels of repair and overhaul on fast jets at multiple locations but has rationalised repair into two organisational structures: 'forward repair' is undertaken at each operational squadron; and the Department has rationalised the number of 'depth repair' locations to a single depth hub at which aircraft are maintained, repaired and overhauled. The new depth hubs are at RAF Marham for Tornado aircraft and RAF Cottesmore for Harrier aircraft **(Figure 1)**.

1 From 1 April 2007, the Defence Logistics Organisation ceased to exist as the Department established a single organisation, Defence Equipment and Support, to manage all equipment throughout its life, from acquisition to disposal.
2 Streamlining End to End Air and Land Logistics, Ministry of Defence, 1 July 2003.

1 Rationalisation of Fast Jet Repair Activity and Location

In the past the repair and overhaul of fast jets was conducted at four lines, at numerous dispersed locations. From 2004 this was changed to two organisations at a reduced number of RAF bases.



Source: National Audit Office

NOTE

Numbers in brackets denote the line of support.

3 In designing the repair processes and associated support at the depth hubs, the Department has applied lean techniques **(Figure 2)** to introduce more efficient repair processes, introducing 'pulse lines' for aircraft, engines and sub assemblies, similar to a motor car production line **(Figure 3 on pages 8 and 9)**. Upgrade work has been integrated within the depth repair process utilising pulse lines, including the major upgrade programme for Harrier from GR7 to GR9 variants, and the Department has significantly extended the number of flying hours for Tornado and Harrier aircraft between scheduled maintenance.

4 The Department has entered into new partnerships, consistent with the Defence Industrial Strategy[3], with industry Prime Contractors, BAE Systems plc and Rolls-Royce plc, which use industry managed collocated joint teams of contractors and military personnel at each depth hub. These mixed teams carry out repair and maintenance activity on the pulse lines and in the supporting repair workshops (Figure 3). The arrangements involve a move towards contracting for availability rather than traditional spares and repair contracts. Availability contracts deliver an agreed number of aircraft or engines at an agreed level of capability over the length of the deal. While there are differences in the processes and actual delivery of the maintenance of the Tornado and Harrier aircraft, the contractual approach remains broadly similar.

2 Lean techniques and pulse lines

The Department has redesigned its processes for repairing fast jets using lean techniques.

Lean techniques were developed from the Toyota Motor Manufacturer's production system in the early 1990s and have been subsequently used extensively in the manufacturing sector, and more recently in the United States Air Force. Techniques such as Value Stream Analysis and Rapid Improvement Events (Appendix 3) are used to identify and eliminate any activity or process that does not add value to the end user or customer, enabling the remaining activity to flow in the most efficient sequence possible. A typical application of these lean techniques is the pulse line production system. The Department has applied lean techniques and made use of pulse lines to transform the maintenance of its fast jet aircraft and associated sub-assemblies. In a pulse line production system, the total maintenance activity is divided into a series of equal packages, the aircraft or item is then physically moved or 'pulsed' from one pulse area within the hangar to the next. The pulse line and the use of a visual management system increase the consistency of the maintenance process. This enables the efficient management and forecasting of personnel, equipment and spares requirements within each pulse, leading to reduced maintenance times and greater visibility of remaining spares inventories.

Source: National Audit Office

5 These elements of transformation have been ongoing over recent years, with changes introduced at different times. The cost of support has decreased significantly; transformation has produced positive results in terms of reduced in-year budgets for aircraft support for Integrated Project Teams. Over the period 2001-02 to 2006-07, the Department has achieved cumulative savings on the support of Tornado and Harrier aircraft of £1.3 billion and £109 million respectively. The Department has reduced the number of Service personnel involved in depth repair by around 360. Further cost and manpower reductions are planned for both aircraft fleets. The main cost of change is associated with the super-hangar at St Athan[4] and the subsequent closure of the Defence Aviation Repair Agency's fast jet business. This is estimated to be in the region of £140 million, and is significantly outweighed by the savings achieved.

6 Performance has been broadly maintained throughout the transformation of support, with some shortfalls associated with the transition. The operational availability[5] of Harrier aircraft to frontline squadrons has been below target since 2001, pre-dating transformation. Operational availability dropped further in April 2003, with the start of the Harrier upgrade programme at BAE System's site at Warton, but improved as work was transferred to the new depth repair hub at RAF Cottesmore. In the last half of 2006 aircraft availability has been at or close to 100 per cent against a revised target, mainly because there were fewer aircraft in depth repair.

7 The Department has improved performance for the repair of Harrier aircraft. Established in 2002, the pulse line at RAF Cottesmore reduced the time taken to perform a minor maintenance by 19 per cent. Since the commencement of the Joint Upgrade and Maintenance Programme at RAF Cottesmore, which combines the minor maintenance of the aircraft with a major upgrade programme on a single pulse line, the Department has also achieved a 43 per cent decrease in the time taken to convert Harrier GR7 aircraft to GR9 standard. This allowed the Department to exceed, by two aircraft, its target of upgrading 24 aircraft by September 2006. The Department has also met a significant surge requirement for repair associated with operations in Afghanistan. These new maintenance arrangements have avoided having aircraft in depth repair and therefore an extra 11 aircraft are available to the frontline. Improved repair processes on the pulse line for the Harrier Pegasus engine have reduced turn around times by 59 per cent.

3 Ministry of Defence, *Defence Industrial Strategy: Defence White Paper*, Cm 6696, December 2005.
4 We are conducting a separate examination of the Ministry of Defence's investment in the super-hangar facilities at St Athan.
5 In the Department this is known as the Forward Available Fleet.

8 From 2000 to 2003, operational availability of the Tornado GR4[6] averaged 100 per cent of target. The start of the decline in performance pre-dates the establishment of the pulse line in December 2005 at RAF Marham, when availability averaged 93 per cent. Since September 2006 the availability trend has been rising and the target was met from the end of December.

9 The Tornado GR4 pulse line is less mature. Nevertheless, the Department has reduced minor maintenance repair time by 37 per cent compared with that previously achieved by the Defence Aviation Repair Agency. The Department expects performance to improve in a similar way to the Harrier programme, as pulse line learning increases and the specific supply chain problems are resolved. As with Harrier, the Tornado pulse line is designed to increase the number of modifications to the aircraft during repair, thus improving operational capability and mitigating the problem of having aircraft at numerous different capability standards within the fleet, but is not yet delivering an upgrade programme. The Department has improved performance for the 'off-aircraft' repair of engines and sub-assemblies. Since entering into a partnered availability contract with Rolls-Royce, the Department has achieved 100 per cent availability of the Tornado RB199 engine, and reduced rejection rates and hence the number of engines in depth repair.

10 The evolution from traditional spares and repair contracts towards contracting for availability of aircraft, engines and sub-assemblies, has required the Department to change significantly its approach to working with Prime Contractors. The Department characterises its historical relationship with industry as adversarial and it has worked hard to develop a culture of partnering. Joint working has been successfully established through combined Departmental and industry Integrated Project Teams, and the collocation of BAE Systems and Rolls-Royce personnel onto main operating bases. With this fundamental change the Department has moved away from the traditional model of paying for volume of repair and sought to motivate industry to reduce the cost of support through the use of gainshare and incentive payments.

11 There is potential for the Department to exploit transformation further, but there are risks that require careful management. There are two significant risks to the future performance of the depth repair hubs at RAF Marham and RAF Cottesmore:

- To date the Department has not been able to meet its contractual commitments for military manpower for either the Tornado or Harrier pulse lines and the skill and experience mix of the workforce does not match the plan. The Department has recognised the risk to manning the pulse lines arising from its challenging targets[7] for manpower reductions in the RAF, and is now committed to finding reductions to meet its targets from trades outside the logistics area.
- There continue to be problems with the timely supply of spares for both Harrier and Tornado pulse lines. Although the Department believes that performance is no worse than in the past, the supply chain is critical to the operation of the pulse lines and the Department is working with industry to resolve these difficulties.

12 There are promising signs that logistics transformation is becoming self-sustaining. The RAF is taking ownership of transformation, is adopting the lean techniques pioneered by depth organisations, and the Defence Logistic Organisation's Lean Teams have helped establish a culture of continuous improvement at station level. The lessons learned in transforming logistics support for Tornado and Harrier are being used in the design of support for the new Typhoon aircraft. Our recommendations highlight a number of issues that the Department needs to address in continuing to improve support to fast jets, which are likely also to be relevant to transformation in other areas of its business.

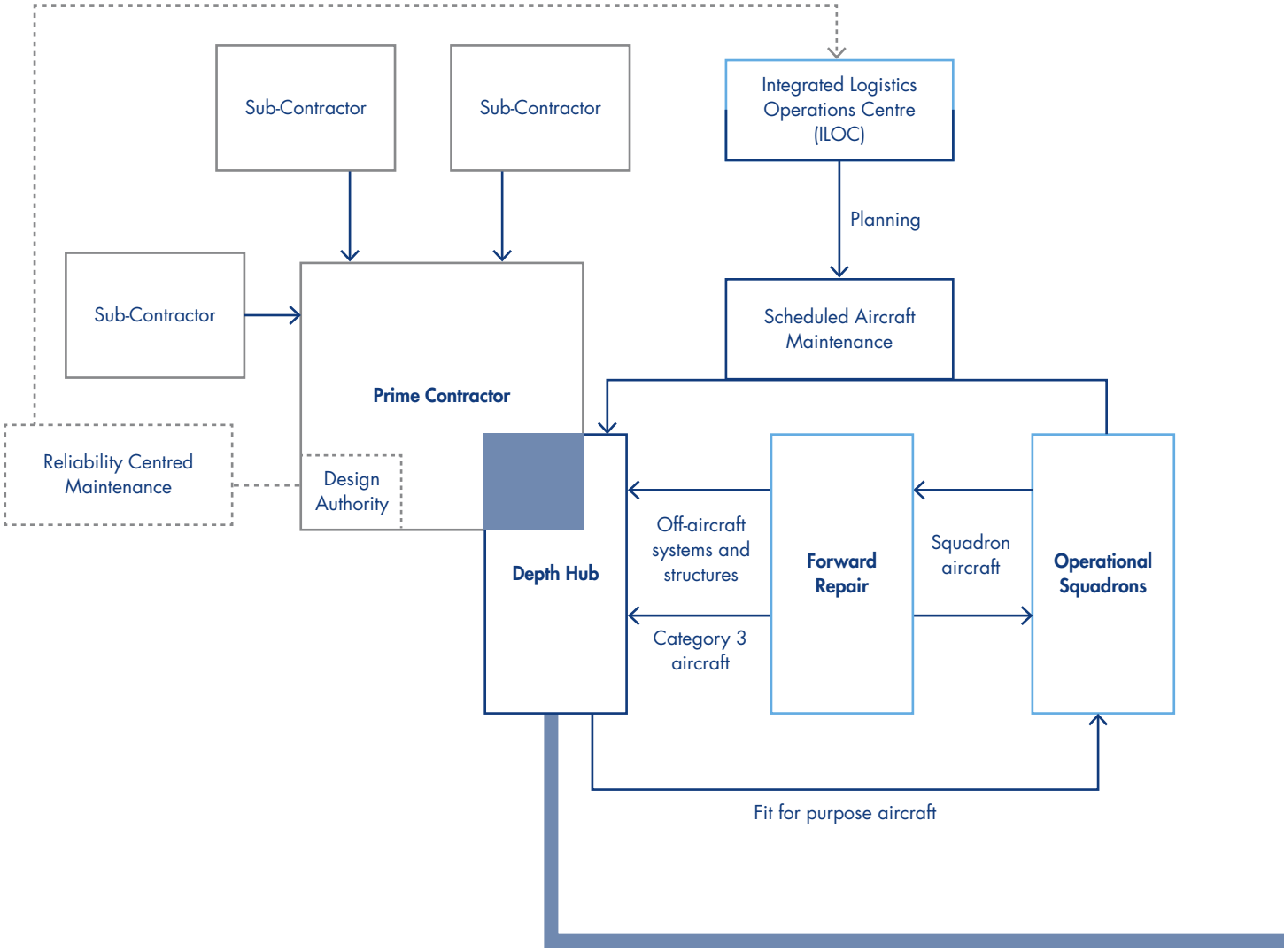
Overall Value for Money

13 The Department has made significant reductions in the cost of support to fast jets; the Tornado and Harrier Integrated Project Teams' costs have reduced from a total of £711 million in 2001-02 to £328 million in 2006-07, providing a cumulative saving of some £1.4 billion over the six-year period. At the same time, although aircraft operational availability declined during the transition to the new depth repair hubs, the subsequent meeting of availability targets on Harrier over the last five months suggests that availability can be achieved consistently on Tornado once the pulse line achieves a similar level of maturity. The Department has continued to achieve broadly the same level of performance in terms of flying hours throughout the transformation. On this basis, the Department's transformation of logistics support represents good value for money to date and although there are risks, the Department is working to manage them.

6 Tornado has two variants: the fighter designated F3 and the bomber designated GR4; this Report deals predominantly with the GR4 variant.
7 Calculated top down in response to the cross-Government Gershon Efficiency Review.

3 The organisation and activity of forward and depth repair hubs

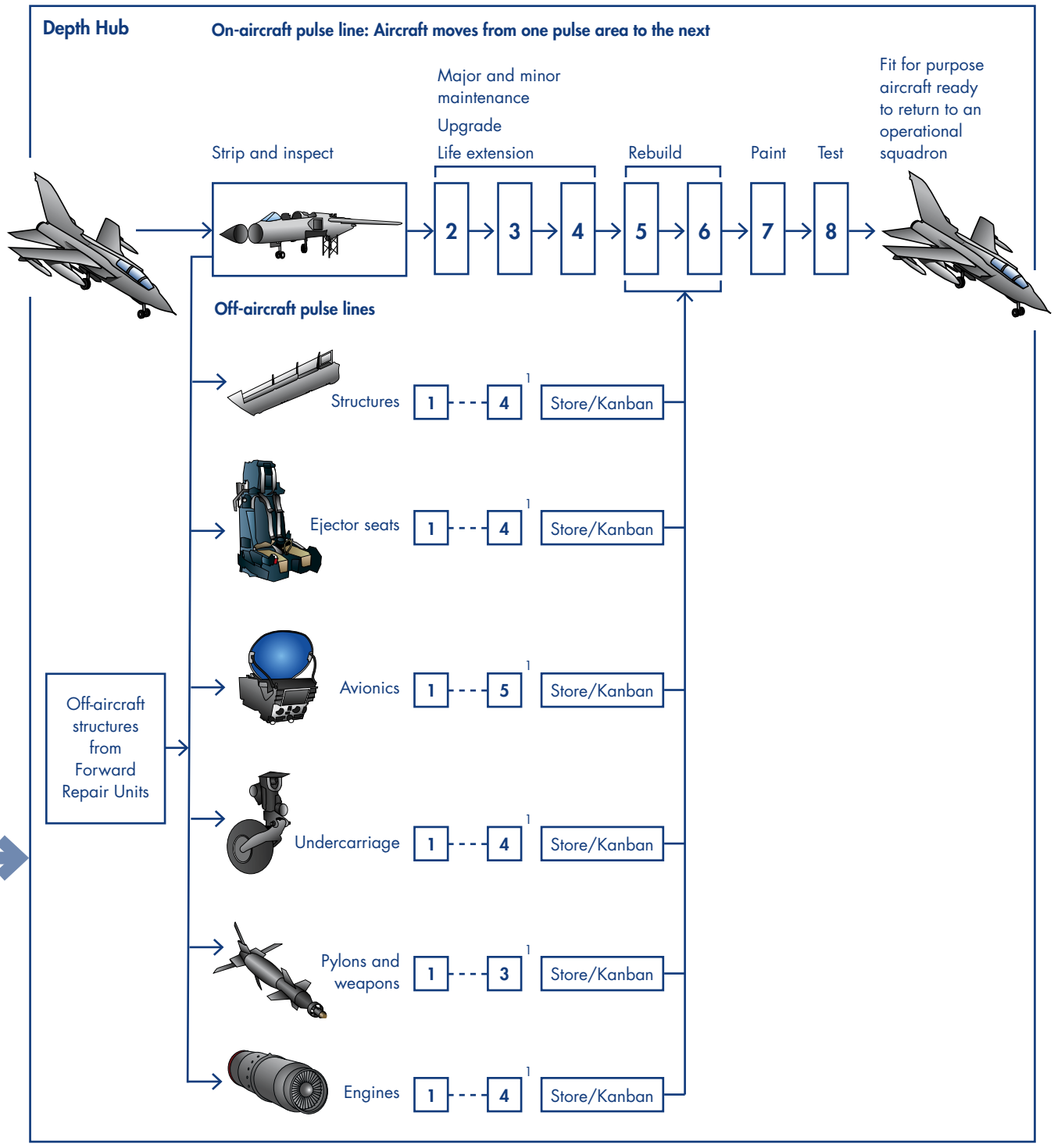
An illustration of how the new repair arrangements operate at RAF Cottesmore for Harrier aircraft and RAF Marham for Tornado aircraft.



Source: National Audit Office

NOTE

1 Length of off-aircraft pulse lines are for illustrative purposes only. The total number of pulses can vary depending on the level of maintenance and the particular piece of equipment being maintained.


Depth Hub
On-aircraft pulse line: Aircraft moves from one pulse area to the next
Strip and inspect
Major and minor maintenance
Upgrade
Life extension
Rebuild
Paint
Test
Fit for purpose aircraft ready to return to an operational squadron
2
3
4
5
6
7
8
Off-aircraft pulse lines
Structures
Ejector seats
Avionics
Undercarriage
Pylons and weapons
Engines
1
4
5
3
Store/Kanban
Off-aircraft structures from Forward Repair Units

14 The Department's financial information systems enabled us to calculate the key costs of support for fast jets borne by the Harrier and Tornado Integrated Project teams, and assess the overall savings achieved by the Department. However, the Department does not have sufficient data to be able to assess the impact on total costs of changes in the pattern of frontline operations, and further productivity increases through the extension of lean techniques. We recommend that the Department develop its management accounting capability and costing processes to develop a more comprehensive picture of the overall cost of output for each aircraft fleet, and a better understanding of the link between different cost drivers for support and the operational output achieved.

Recommendations

15 Given our conclusion that the Department's transformation of logistics support to fast jets represents good value for money to date, our recommendations aim to support and enhance the work the Department is already undertaking to manage the risks in the new support arrangements and further embedding the culture and practice of continuous improvement. Many, if not all, of our recommendations are likely to be relevant to changes in support arrangements, underway or planned, for other aircraft types and for land and maritime equipments. Our key recommendations are set out below, with more detailed recommendations in Appendix 1.

Managing the key risks to the performance of the pulse lines at the depth repair hubs

16 By implementing the following recommendations, the Department should be better placed to manage the key risks to the future performance of the depth repair hubs for Tornado and Harrier aircraft at RAF Marham and RAF Cottesmore:

17 **Recommendation 1:** The Department should improve its ability to provide the level of Service personnel contracted to work in the depth repair hubs at RAF Marham and RAF Cottesmore. The Department should also review if it has sufficient flexibility to meet operational contingencies.

18 **Recommendation 2:** The Department should improve the availability of spares by continuing to work with its industry partners to address the problems that are preventing the pulse lines from running as efficiently as planned.

Entering into future partnering arrangements

19 By implementing the following recommendations, the Department should strengthen its capability to enter into cost effective partnering arrangements with industry:

20 **Recommendation 3:** The Department should improve its guidance and consistently apply a common methodology for constructing internal value benchmarks against which to assess the value of proposed contracts. Internal benchmarks should make allowance for realistic efficiency improvements through any in-house solution.

21 **Recommendation 4:** The Department should assess whether it has sufficient commercial, cost modelling and project management skills to develop the commercially viable support solutions and negotiate contracts, given the increasing complexity and likely volume of industrial logistics support.

Prioritising further improvements to support for fast jet aircraft

22 By implementing the following recommendations, the Department should be able to prioritise better its future change activities for fast jets to derive the greatest operational benefit:

23 **Recommendation 5:** The Department should improve its understanding of the future output requirements, in terms of both operational and training flying demand, by modelling the relationship between the required output and different elements of repair and support. In doing so, the Department should improve its management information systems so that this data is routinely available, including the full costs of supporting aircraft across all of the budget holders involved.

24 **Recommendation 6:** The Department needs to conduct a high-level end-to-end assessment of key elements of change to identify which have delivered the greatest benefits to date and where there is the greatest potential for further transformation, given constrained resources.

Incentivising transformation and continuous improvement

25 By implementing the following recommendations, the Department should further incentivise the behaviours of project teams and industry to improve fast jet support and other activities across the Department:

26 **Recommendation 7:** The Department should take the opportunity afforded by the transfer of budgetary accountability to frontline commands, including RAF Strike Command, to align incentives further between the frontline customer and support organisations, so that the impact of frontline activity on support requirements is considered.

27 **Recommendation 8:** The Department's challenging targets for cost reduction have been a key driver for transformation but there is a balance to be struck between these reductions and the ability to invest in transformation. The Department should make a proportion of the savings from transformation, and particularly from gainshare achieved on contracts, available to teams to reinvest in future improvements. This could help embed the culture of continuous improvement by incentivising teams better to drive through change.

28 **Recommendation 9:** In time, the Department should use its experience of the newly introduced gainshare arrangements on fast jet support contracts to inform future decisions on the level of gainshare required to effectively incentivise industry. In doing so, the Department should assess whether industry has been sufficiently incentivised to drive through future efficiency gains and performance improvements in their own management of the service, and in the supply chain.

Maintaining the capability to apply lean methodologies

29 By implementing the following recommendations, the Department should further strengthen its capability to apply lean methodologies in logistics support and elsewhere in its business:

30 **Recommendation 10:** In order to maintain the momentum of transformation for fast jets, and facilitate successful transformation in other areas of its business, the Department should review whether it is able to deploy sufficient internal and external expertise in methodologies such as using lean techniques.

31 **Recommendation 11:** The Department should adopt a common toolset and language for lean techniques across all areas of its business. The Department should make its lessons learned material more evaluative to provide information on how the methods were applied, and quantify the results they achieved.