National Audit Office

MINISTRY OF DEFENCE

Chinook Mk3 Helicopters

REPORT BY THE COMPTROLLER AND AUDITOR GENERAL | HC 512 Session 2007-2008 | 4 June 2008

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SUMMARY

1 The Ministry of Defence (the Department) operates a fleet of 40 Chinook Mk2/2a helicopters, primarily in support of Army and special operations. In 1995 the Department ordered 14 Chinook Mk2a helicopters from Boeing of which six were retained as Mk2a and have flown satisfactorily since they were delivered. The other eight, however, were modified as Mk3 to meet a longstanding requirement for dedicated helicopters for special operations. Those eight Chinook Mk3 helicopters cost some £259 million and the Department took delivery of them from Boeing in December 2001. Although Boeing met its contractual obligations, the avionics software fell short of United Kingdom military airworthiness standards and the helicopters have not flown on operations.

2 In 2004, the Committee of Public Accounts described the original procurement of the Chinook Mk3 Helicopter as "one of the worst examples of equipment procurement" that it had seen. This report follows on from the Committee's concerns and examines whether the Department has taken appropriate steps to make the eight Chinook Mk3s operational. Our methodology is set out at Appendix 1.

The decision making process

3 There was no immediate solution on how the Chinook Mk3 helicopters could be made operational. In September 2004 the Department identified a "Fix to Field" project as the best value for money solution. This project involved replacing or modifying the cockpit display and other systems, which would deliver more capable helicopters for special operations. It would also reduce shortfalls in helicopter lift by freeing up Mk2/2a helicopters that had been modified to deliver the special operations capability in the interim.

4 The Department began a preparation phase for the Fix to Field solution in September 2004, and the project was estimated to deliver in-service helicopters in 2008. In the end it took 30 months for the Department and Boeing to agree an affordable programme of work. Although the preparation phase was protracted, it did result in a robust business case with which to take the project forward. The final estimate for the in-service date was 2011-12 with a predicted cost of £215 million.

Change of strategy – the general shortage of helicopters

5 The delay in making these Chinooks airworthy contributed to the overall shortfall in helicopter lift and meant that the Department had a smaller Chinook fleet from which to provide capability in Afghanistan. Assuming an appropriate level of pilots and logistic support, additional Chinook flying hours could have been used to carry out operations with greater flexibility including more non-essential military tasks in support of the international mission in Afghanistan.

6 In July 2006 the Department announced that the number of troops stationed in Afghanistan would be increased from 3,500 to 4,000 and in January 2007 the number was increased to 7,700. As a matter of urgency, the Department began to search for ways to increase significantly the levels of helicopter capability available to commanders in operational theatres, especially in Afghanistan. The Chinook is the most capable support helicopter in the adverse hot and high conditions of Afghanistan. In March 2007 the Department therefore decided to make the eight Mk3 Chinooks available for operations as soon as possible. The Fix to Field project was cancelled in favour of converting (or "reverting") the Mk3 to the Mk2/2a standard. The Department estimated that the Reversion project would make them available for operations two years earlier than the Fix to Field project. In March 2007 the Department also purchased six Merlin helicopters for use in Iraq.

7 The need for more helicopters in Afghanistan and elsewhere was recognised and the decision to cancel the Fix to Field project and revert the Chinook Mk3 was undertaken quickly. The timescale imperative meant that the Department undertook limited analysis of the operational benefits and drawbacks, and the costs and risks of this decision. However, detailed Business Cases were subsequently prepared and approved in accordance with the Department's regular approvals processes before the main contract was signed in December 2007.

8 The Department and Boeing are confident that the Reversion project can deliver the additional operational capability by 2009-10. They have, for example, adopted fast track procurement arrangements and, building on the earlier investment in the Fix to Field project, developed a safety management plan, agreed by Boeing, which is expected to deliver an airworthy helicopter. In March 2007, the cost of Reversion was estimated at £53 million. The Department acknowledged at that time that the estimate was immature and had been produced quickly. By the time the Department had developed a mature estimate in November 2007, the cost estimate had risen to £90.1 million (an increase of 70 per cent). This excludes £22.5 million of specific equipment required for Afghanistan funded by the Treasury from the Contingency Reserve.

9 Since 2002, the Department has met the needs for demanding very low light special operations by using Chinook Mk2/2a helicopters modified with a Night Enhancement Package. The ergonomics of the modified cockpit are imperfect and, while the Department is content that the modified Chinook Mk2/2a helicopters are safe to fly, it accepts that there are safety and operating risks associated with the Night Enhancement Package. The Department has partially mitigated these risks. As part of the latest equipment planning round the Department has earmarked funding to introduce an enhanced partial digital cockpit across the entire Chinook fleet to address these concerns, maintain commonality and increase operational flexibility. The Department expects the enhanced Chinooks for special operations to start to enter service early in the next decade, sooner than under the Fix to Field project. The full special operations capability, using the Chinook Mk3 helicopters "fat" fuel tanks, will be met but later than planned under the Fix to Field project. The costs of the project are commercially sensitive as negotiations are on going.

Conclusions

10 Our conclusions on the progress of the project are:

- The Department's progress up to the point of committing to reversion in March 2007 on the Chinooks and how they could be made operational was protracted. As a result the shortage of helicopters to support operations has been exacerbated.
- Had the Department progressed the Fix to Field project more quickly the Reversion project would have been unnecessary.
- The Department's decision to revert the Chinook Mk3 helicopters will make them available, to meet the overriding priority for additional helicopter lift, two years earlier than would have been the case under the Fix to Field project and will result in a largely common cockpit across the fleet with consequent improvements in operational flexibility. The Department expects this will also result in a lower level of support costs.
- Although the Department has met the needs for special operations by adapting Chinook Mk2/2a helicopters the solution has been sub-optional.
- Early in the next decade, to solve the risks associated with the cockpit ergonomics of the Night Enhancement Package, the Department plans to introduce an enhanced partially digital cockpit across the Chinook fleet, which will enable the prosecution of special operations with greater flexibility and less operational risk.
- The timescale imperative meant that the March 2007 decision to revert the Chinook Mk3 helicopters, whilst informed by a high level consideration of options, was not based on the level of detailed analysis that we would usually expect to see for an investment of this magnitude. The project has subsequently passed through the Department's regular approvals process.
- The total costs associated with the Chinook Mk3 helicopters from their initial procurement through to completion of the Reversion project will be some £422 million **(Figure 1)** some £85 million less than the Fix to Field project. This figure does not however include further expenditure required to sustain the Night Enhancement Package which is currently being negotiated with industry and is therefore commercially sensitive.

1 Estimated costs of procuring the eight Chinooks, making them operational and sustaining the special operations capability

	Fix to Field Costs (£ million)[1]	Reversion Costs (£ million)
Total expenditure on Mk3s	474.56	389.41
Total expenditure on Night Enhancement Package for Mk2/2a	32.3	32.3 + X[2]
Total expenditure	506.86	
Expected In-service Dates	2011-12	2009-10

Source: National Audit Office analysis of Ministry of Defence data

NOTES

1 Estimated costs and In-service date of Fix to Field post capability and cost reduction exercise and re-bid in 2006-07.

2 Sustainment costs for the Night Enhancement Package are commercially confidential until a contract is let.

PART ONE

Problems with the original procurement

1.1 The Chinook helicopter is a highly capable and versatile support helicopter that can operate in environments ranging from cold weather "arctic" conditions to desert warfare operations. Chinook helicopters are manufactured by The Boeing Company ("Boeing") in the United States and are used in the United Kingdom primarily in support of Army and special operations. The Ministry of Defence (the Department) operates the second largest fleet of Chinook helicopters after the United States Army with a total of 40 helicopters (see Appendix 2 for details about the United States Army's fleet). Currently the Chinook is the Department's most capable support helicopter, able to operate all year round in the adverse high altitude and hot conditions in Afghanistan whilst carrying an operationally useful load. **Figure 2** provides more information about the United Kingdom's Chinook fleet.

Airworthiness issues

1.2 In 1995 the Department ordered 14 Chinook Mk2a helicopters from Boeing of which six were retained as Mk2a and have flown satisfactorily since they were delivered. The other eight, however, were upgraded to a Mk3 standard. The Mk3 helicopters were fitted with specialist equipment and larger ("fat") fuel tanks to extend their range **(Figure 3 overleaf)**. The fat tanks avoid the need to carry fuel inside the helicopter thereby allowing more personnel and equipment to be carried on long range missions. The Chinook Mk3 helicopters featured unique cockpit avionics which, reflecting affordability constraints, were a hybrid of analogue and digital systems.

1.3 The Chinook Mk3 helicopters have not flown on operations because the Department refused to grant the helicopters an airworthiness certificate. Although Boeing met its contractual obligations the avionics software could not be shown to meet United Kingdom standards.

2 Key facts about the United Kingdom's Chinook helicopter fleet

- Each Chinook helicopter can carry up to 55 troops, ten tonnes of cargo or two Land Rovers in the cabin, whilst a variety of additional loads can be carried externally.
- They have seen service in the Falklands, Northern Ireland, Kuwait, Bosnia, Sierra Leone, Iraq and Afghanistan.
- The Chinook Mk2 and Mk2a helicopters currently have out-of-service dates of 2015 and 2025 respectively although the Department expects to extend these to 2040.
- Chinooks are operated by the Joint Helicopter Command which brings together the battlefield helicopters of the Royal Navy, Army and Royal Air Force. As well as the Chinook, the Joint Helicopter Command operates a further seven helicopter types, in total over 250 helicopters.
- The United Kingdom's fleet of Chinooks are flown by three Royal Air Force operational squadrons (No 7, No 18 and No 27) which are based at RAF Odiham in Hampshire.
- A further eight Chinook Mk3 helicopters were held in storage at the Department's Boscombe Down facility but are now being worked upon as part of the Reversion project.

Source: National Audit Office

The helicopters can fly but are restricted to flying on cloudless days above 500 feet where the pilot can navigate via landmarks. In 2004, the Committee of Public Accounts report[1] described the procurement of the Chinook MK3 Helicopter as "one of the worst examples of equipment procurement" that it had seen. The Committee's conclusions and recommendations are listed in Appendix 3. The helicopters cost some £259 million and had a projected in-service date of January 2002. The Department took delivery of the helicopters from Boeing in December 2001.

1 Committee of Public Accounts, Ministry of Defence: Battlefield Helicopters, Eighth Report 2004-05 (HC 386).

3 The Chinook Mk2/2a and Mk3 helicopters

Chinook Mk2/2a

Chinook Mk3

Source: Ministry of Defence and Qinetiq Group PLC

1.4 Since their delivery to the United Kingdom in 2001, the Chinook Mk3 helicopters have been kept in climate controlled, de-humidified aircraft shelters at the Department's facility at Boscombe Down. The helicopters are inspected once a week and moved out of the shelters every two years for more detailed inspections to be performed. These activities have so far cost the Department an estimated £560,000.

1.5 By the time the airworthiness issues with the Chinook Mk3 helicopters became apparent, emerging legislation and operational requirements meant that the helicopters would need to be modified before they could be deployed on operations. In early 2003 the use of flight recorders (Black Boxes) and Health and Usage Monitoring Systems on all aircraft flying in the United Kingdom was mandated. As well as being important to understand air accidents, these monitoring systems are also used to enable analysis of flying hours, aircraft fatigue and maintenance schedules. The need for improved defensive systems and night vision capability further challenged the Department which was already limited by the funding available to address the airworthiness and modification issues.

1.6 In order to meet the Department's airworthiness standards, (Appendix 4), analysis and testing of the software source code for the Mk3 cockpit was required to reduce the possibility of unforeseen system and safety problems during flight. The Department had failed to specify access to the source code in the original procurement and therefore had no leverage with which to negotiate with Boeing for release of the source code. Boeing and its sub-contractors, for their part, in seeking to protect their intellectual property rights, resisted the Department's requests for access to the source code. Even if it had been able to access the source code, the Department estimated that it might take up to two years to analyse the source code with no guarantee that the code would be written in a way which might make it comprehensible for analysis purposes.

1.7 When faced with similar difficulties accessing source code to prove airworthiness on other United States aircraft with digital cockpits, such as the C17 aircraft, the Department has accepted data and assumptions provided by United States' authorities and flies these aircraft within the United States Air Force operating limits. In other cases the Department has sought to overcome airworthiness data issues by looking at similar systems on other aircraft. At the time United States' Chinooks were not fitted with digital cockpits and the Department investigated whether there was sufficient commonality with the digital cockpit that Boeing had fitted to Chinook helicopters used by the Royal Netherlands Air Force to enable the preparation of an appropriate safety case. This turned out not to be the case.

1.8 A 2004 report prepared by experts in the Department supported these judgements and concluded that the unique nature of the Mk3 cockpit and the lack of evidence provided by Boeing meant that it would have been difficult to recommend anything other than stringent restrictions on the operation of the aircraft. The Director of United States Army Aviation concurred with this view and said that given the standards operated by the United Kingdom authorities, the Department took the right course of action in not granting an airworthiness certificate to the Mk3 helicopters.

1.9 In 2002 the Department equipped eight of the Chinook Mk2/2a fleet to meet requirements for special operations. The delay in making the Chinook Mk3 helicopters airworthy contributed to the overall shortfall in helicopter lift and meant that the Department had a smaller Chinook fleet to provide capability in Afghanistan. Assuming an appropriate level of pilots and logistic support, additional Chinook flying hours could have been used to carry out operations with greater flexibility including more non-essential military tasks in support of the international mission in Afghanistan.

PART TWO

Development of solutions

2.1 This Part examines how the Department developed a "Fix to Field" solution to enable the helicopters to fly on operations; and the Department's eventual change in approach which involved cancelling the Fix to Field project and reverting the Mk3 helicopters to the Mk2/2a standard.

Analysis of options

2.2 In 2002 the Department began work on various options for how it might proceed with the Chinooks. The analysis considered whether the requirement for eight Chinooks for special operations was still necessary and generated a range of fully appraised options which included assessing the impact of each on both support helicopters and the special operations capability. In parallel the Department explored the scope to sell the helicopters but was unable to find a suitable buyer.

2.3 By February 2004, the Department had analysed twelve options, of which eight were rejected because they either did not meet requirements for special operations, had late in-service dates, or because of poor cost-effectiveness. In June 2004, the Department decided to undertake further analysis of four options which are summarised in **Figure 4**.

2.4 In September 2004 the Department decided to explore further a "Fix to Field" solution which involved the replacement or modification of the cockpit display systems, the communications systems and fuel quantity gauging, together with the integration of special operations equipment and a comprehensive Defensive Aids Suite. Although this option was the most expensive (at £149 million) the Department assessed that it offered the best value for money solution: it would reduce shortfalls in both standard helicopter lift (by freeing up the eight Mk2/2a helicopters currently used for special operations) and would meet the requirement for dedicated special operation helicopters.

2.5 To provide additional assurance, the Department commissioned ERA Technology, QinetiQ and the Defence Scientific Advisory Council to examine the feasibility of the Fix to Field option. Each confirmed that the solution was technically feasible, had a sound approach to airworthiness and would enable the Chinook Mk3 to be declared an operationally effective helicopter to be used on special operations.

Development of the Fix to Field project

2.6 In September 2004, the Department began a preparation phase, initially expected to last eight months, to fully develop the technical solution, the underpinning initial safety case and an in-service support plan to establish a firm price. The Department's expectation was that the first helicopters would be available in 2008 and the total cost of the project, including the price of the Boeing contract, would be £163 million. In the end it took 30 months for the Department to agree an affordable programme of work with Boeing. There were two main reasons for the delay:

- It took longer than expected to agree on a programme of work with Boeing. A detailed work project in which all parties could have confidence was not agreed by the Department and Boeing's senior management until April 2005. This meant the preparation phase was extended to July 2006.
- In March 2006 Boeing submitted a proposal which was £105 million more than the Department had budgeted for and considered affordable. In subsequent negotiations the Department, working closely with Boeing, sought to reduce the price, in part by trading non-essential elements of capability whilst maintaining the minimum capability required to meet the needs of special operations. This process took until November 2006.

4 In June 2004 the Department decided to examine four options in detail

Option	Detail	Cost or Saving £ million	Result of the Department's analysis
Do nothing	Run the existing modified MK2/2a helicopters to the end of their operational life; assume that no additional funding is available to sustain the specific equipment. Use the MK3 as spares for the MK2/2a fleet. Assume that no solution is available through the Support and Amphibious Battlefield Rotorcraft Project[1].	–21	Reduces effectiveness, by nearly 20 per cent.
Do minimum	Continue to use the modified MK2/2a helicopters, assume that funding is made available to sustain the specific equipment to its out of service date. Use the Mk3 as spares for the Mk2/2a fleet.	62	Only maintains the current capability for a short period of time and reduces the effectiveness by 10 per cent when the Support and Amphibious Battlefield Rotorcraft helicopter reaches its in-service date.
Fix to Field	Minimum modifications required to upgrade the Mk3 helicopter to ensure that it is at least as capable as the modified Mk2/2a helicopters.	149	Increases effectiveness by 26 per cent and allows the return of the 8 Mk2/2a helicopters to the Support Helicopter fleet.
Sell Mk3 and rely on Support and Amphibious Battlefield Rotorcraft	Maintain the modified MK2/2a helicopters until the entry in to service of the future Support and Amphibious Battlefield Rotorcraft helicopter, modified for use on special operations. Sell the Chinook Mk3 helicopters.	62	Although it appears to be cheaper than Fix to Field it does not include the procurement of the helicopters which would provide the future capability.

Source: National Audit Office analysis of Ministry of Defence data

NOTE

1 In 2005 the Support and Amphibious Battlefield Rotorcraft Programme was absorbed within the Department's Future Rotorcraft Capability Programme which aims to provide a coherent future programme for all types of helicopter.

2.7 The delays to the preparation phase meant that the in-service date of the Chinook Mk3 helicopters slipped to 2011-12 and the total costs, including the price of the Boeing contract, rose to £215 million. These costs include the estimated cost of the preparation phase which had increased from £13.25 million to £23.5 million.

2.8 Although the preparation phase for the Fix to Field project was protracted, the resultant project was well planned, technically mature, and affordable and was still assessed by the Department as offering the most cost effective solution to meet the special operations requirement. In particular:

- Steps were taken to minimise the technical risks to the project. For example, Boeing selected Thales Limited to provide its "Top-Deck" digital cockpit which is from the same family as the cockpit fitted to the Department's own A400M transport aircraft and the Nimrod MRA4.
- The Department worked closely with Boeing and QinetiQ (the independent safety assessor working for the Department) to ensure that earlier airworthiness problems would not be repeated. Boeing personnel were trained in United Kingdom safety regulations and worked with the Department to develop a safety management plan. Arrangements were made so that QinetiQ could provide direct advice to Boeing on generic safety issues to assist them in the development of the airworthiness case. In November 2006, QinetiQ reported that the Fix to Field project would meet safety requirements and that airworthiness certification would almost certainly be given at the end of the project.
- A Gateway review by the Office of Government Commerce conducted in December 2006 and a review ("Red Team") led by the United States Army Director of Army Aviation concluded that the Fix to Field project was a high quality project which would succeed in delivering the required capability.

Change of strategy

2.9 From mid 2006 the Department began to urgently search for ways to quickly and significantly increase the levels of helicopter capability available to commanders in operational theatres. The imperative was made acute by the increased tempo of war fighting and reconstruction operations in Afghanistan and by the wider geographical distribution of United Kingdom forces. The threat from road-side bombs also increased and alternatives were sought to moving troops and materiel by road. In July 2006 the Department announced that the number of troops stationed in Afghanistan would be increased from 3,500 to 4,000. In January 2007 the number was further increased to 7,700.

2.10 In early 2007, in response to the increased troop levels, the Department examined a range of options **(Figure 5)** to increase the helicopter capacity available to support United Kingdom forces in Afghanistan. As a result in March 2007 the Department decided it was imperative to make the eight Mk3 Chinook helicopters available for operations in Afghanistan as soon as possible. The Joint Helicopter Command judged that it had sufficient aircrew to cover the increase, although it could mean the guidelines setting out the amount of time Armed Forces personnel are required to be away from home on operational duty ("the harmony guidelines") would be further stretched.

2.11 The Fix to Field project was therefore cancelled in favour of a project – known as the "Chinook Mk3 Reversion" – to convert the helicopters to a similar standard as the Mk2/2a Chinook helicopters. Converting the helicopters involves removing the existing Mk3 hybrid digital/analogue cockpit and replacing it with the analogue cockpit fitted to the Mk2/2a, fitting a health and usage monitoring system, United Kingdom specific communications equipment and defensive systems.

2.12 The Department estimated that the Reversion project would deliver an extra eight Chinook helicopters from 2009-10 (some two years earlier than Fix to Field) and with lower technical risk. The Director of United States Army Aviation agreed with the Department's assessment that, given the United Kingdom airworthiness requirements, reversion to the Mk2/2a cockpit standard would be the quickest way to bring the Mk3 into service.

5 Key options to increase helicopter capacity in Afghanistan

- **By obtaining Chinooks from other countries.** The global shortage of Chinooks meant that, despite strenuous efforts by the Department, none were available either to buy or loan. For example, the United States Army told us it was approximately 100 Chinooks short of their overall requirement of 489 helicopters.
- **By modifying existing helicopters** to enable their use in the hot and high conditions of Afghanistan. For example, new rotor blades have been fitted to Sea King helicopters at a cost of £5.25 million.
- **By acquiring other types of support helicopter.** In March 2007 the Department purchased six Merlin helicopters which had been ordered by the Royal Danish Air Force for £198 million (of which £48 million was spent on spare parts and new rotor blades to provide enhanced performance). The Merlin helicopters are undergoing a conversion project to meet United Kingdom requirements and are being equipped with a modern defensive aids suite. The initial operating capability was achieved on time in March 2008, the full operating capability is on track for July 2008. Merlin helicopters have replaced the Sea King helicopters in Iraq, which have been redeployed to Afghanistan.
- **By altering maintenance arrangements** to enable more flying hours to be achieved. The Department, working closely with Boeing and the Defence Aviation Repair Agency has increased the number of flying hours achieved by the Chinook fleet from 12,000 hours in 2005-06 to 13,000 in 2006-07.

Source: National Audit Office analysis of Ministry of Defence data

2.13 The decision to cancel the Fix to Field project and revert the Chinook Mk3 helicopters was undertaken quickly. The timescales meant that the Department only undertook limited analysis of the operational benefits and drawbacks, and the costs and risks of this decision. In particular, we note that:

- There was recognition within the Department and more widely that additional helicopter assets were needed in Afghanistan. The capability of Chinook in the demanding operational conditions of Afghanistan was a key factor in consideration of the options to provide more helicopter assets.
- The timescale imperative meant that the March 2007 decision to revert the Chinook Mk3 helicopters was not based on the level of detailed analysis that we would usually expect to see for an investment of this magnitude. However, detailed Business Cases were subsequently prepared and approved by the Department's Investment Approvals Board in accordance with the normal approvals processes before the main contract was signed in December 2007.
- Boeing was not consulted before the initial decision was made about the potential cost of the project or whether there were any alternatives to Reversion which could make the Chinook Mk3 helicopters available for operations earlier.
- In July 2007, the Department's Investment Approval Board, the senior committee of the Ministry of Defence with responsibility for investment decisions, approved a business case for the reversion of the Chinooks as the only viable option to deliver additional Chinook helicopter capability within the appropriate timescale. In early August the Chairman of the IAB noted the Board's disappointment that the paper submitted had not included a more robust explanation of the operational imperative for providing additional Chinook aircraft in the battlefield support role within two to three years.
- At the time the decision was taken, the Department acknowledged that risks associated with the long term delivery of special operations capability remained to be addressed and has since earmarked funding to introduce an enhanced partial digital cockpit across the entire Chinook fleet to address these concerns.

PART THREE

Management of the Reversion project

3.1 The Reversion project aims to deliver the eight Chinook Mk3 helicopters to a standard such that they can be deployable to Afghanistan in 2009-10. This Part examines how the Department aims to deliver the Reversion project to time; the consequences of the Reversion project for longer term helicopter capability; and the overall costs of making the Mk3 helicopters operational.

Timetable

3.2 The Department and Boeing are confident that the Reversion project can deliver the additional operational capability quickly with one helicopter delivered to operational commanders by the end of 2009 and the remainder by May 2010. Their confidence is based upon the adoption of a fast track timetable, a comprehensive approach to ensuring airworthiness and commercial incentives (**Figure 6** provides details). The Department is confident that the project is currently on track to deliver to time and cost.

Cost of Reversion

3.3 In March 2007, the cost of Reversion was estimated at £53 million. The Department acknowledged at the time that the estimate was immature and had been produced quickly. It had not been agreed with industry and elements such as risk and theatre-entry equipment had not been included. By the time the Department had developed a mature estimate in November 2007, the cost estimate had risen to £90.1 million, or £112.6 million including modifications made specifically for operations in Afghanistan. In December 2007, the Department agreed with the Treasury that it would be able to re-claim the cost of modifications from the contingency reserve for expenditure on military operations in Iraq and Afghanistan.

Long term consequences

Capability

3.4 In order to fly operations in very low light the modified Chinook Mk2/2a (paragraph 1.9) were fitted with specialist equipment, called the Night Enhancement Package, which included items such as navigation units, thermal imagers, moving map displays and night vision goggles. The Package was installed in 2002 as a short term modification to meet operational requirements in Afghanistan and used bolt-on equipment that was not fully integrated into the cockpit in order to accelerate its entry into service. The cockpit ergonomics are imperfect because some components of the Package are placed in positions in the cockpit that lead to increased workload on the aircrew when flying **(see Figure 7)**. Senior staff in the Joint Helicopter Command also told us that the safety issues surrounding the Night Enhancement Package were among its top concerns.

3.5 The modified Chinook Mk2/2a helicopters were released to service as safe to fly, by the Assistant Chief of the Air Staff, on the basis that the safety and operating risks associated with the ergonomic aspects of the Night Enhancement Package were outweighed by the increased operational risk if the Chinook Mk2/2a helicopters were to operate without the Night Enhancement Package and could be mitigated by training procedures and time bounding the risks.

3.6 In originally issuing the clearance for the modified Chinook Mk2/2a in 2003, the Assistant Chief of the Air Staff received assurances that the Department would develop a funded project in order to mitigate the air safety risks associated with the Night Enhancement Package.

6 Why the Department and Boeing are confident that the Reversion project can deliver operational capability quickly

- The adoption of a parallel approach to design, installation and testing. For example, trial installation work has begun now that sufficient mature design information is available. The Department estimates that this will deliver the helicopters six months earlier than adopting a more traditional sequential process.
- Boeing has a strong track record in the design and delivery of Chinook helicopters. It is the Design Authority for the Chinook and provides through life support for the United Kingdom's Mk2/2a fleet.
- To maintain their engineering resources and enable them to quickly start up the new project, Boeing has preserved its team of personnel during the gap between cancellation of Fix to Field and the start of the Reversion project to enable it to build on the Fix to Field preparation phase work. Boeing told us that they were fully committed to the Reversion project.
- Boeing has categorised the Mk3 Reversion project as a prestigious "Focus" project, usually only assigned to high monetary projects worth over $500 million (£250 million).
- Boeing has engaged QinetiQ to conduct the trial installation on the first two helicopters and installation of the remaining six. QinetiQ has been integrally involved with the Mk3 helicopters and has a good understanding of the aircraft and associated safety and airworthiness issues.
- To help develop good working practices and to build strong collaborative relationships, key representatives from the Department, Boeing and QinetiQ have undertaken joint training, notably on Boeing's programme management course.
- The Department agreed a £62 million contract with Boeing to deliver the Chinooks. The contract included a time-based incentive fee agreement to encourage early delivery. The contract rewards Boeing for early delivery of three milestones, the final design review, delivery of the first aircraft and delivery of the seventh aircraft.
- Learning from its original procurement difficulties, the Department has made it a contractual requirement that Boeing satisfy the requirements of the Department's safety management plan which includes the acceptance of safety critical software. Risk reduction activities will also be undertaken earlier in the procurement cycle, including design analysis, to identify and resolve any design safety issues.
- Airworthiness risks are lower because the helicopters are being reverted to a similar standard to the existing Mk2/2a fleet for which safety information is available and the Department has appointed a dedicated safety manager.

Source: National Audit Office analysis of Ministry of Defence data

7 The Chinook Mk2/Mk2a Night Enhancement Package

Left hand pilot cockpit

Co-Pilots Night Enhancement Package Display (Obscures the forward view)

Right hand pilot cockpit

Pilots Night Enhancement Package Display

Source: Ministry of Defence

3.7 The cancellation of the Fix to Field project meant that another way had to be found to address these risks and as a result the Assistant Chief of the Air Staff stated, in March 2007, that without further funding, the clearance to continue using the Night Enhancement Package could not be assured. The Department acknowledged that the risks associated with the Night Enhancement Package still needed to be addressed and subsequently earmarked funding and started a project which it is confident will address these risks earlier than the Fix to Field project.

3.8 This project will introduce an enhanced partial digital cockpit across the entire Chinook fleet to maintain commonality and operational flexibility. The full special operations capability, using the Chinook Mk3 helicopters "fat" fuel tanks, will be met but later than planned under the Fix to Field project. The costs of the project are commercially sensitive as negotiations are on going.

Training

3.9 The Chinook Mk3 Reversion project will introduce a largely common cockpit configuration across the Chinook fleet, which would not have been achieved under the Fix to Field project. This will reduce the burden on pilot and crew training, although specific training on the use of the Night Enhancement Package will continue to be required. The Department is managing a number of issues to ensure the reverted Chinook Mk3 helicopters are successfully integrated in to the Chinook fleet including:

- Increasing the number of aircrew by 40 and engineers by 60 personnel, and running concurrent courses for both air and ground instruction, where previously they had been consecutive. In doing so there has been no requirement for additional training staff to deliver the increased output, but it does mean there will be greater demands placed on them.
- The Department is confident that it should be possible to qualify crews to operate Mk2/2a and Mk3 helicopters under a single "all Marks" qualification since the aim of the Mk3 Reversion project is to mirror as closely as possible the cockpit and controls of the Mk2/2a, thus producing a common cockpit across all Chinook helicopter variants and allowing any appropriately trained pilot to fly any Chinook helicopter.
- Common training for both the Chinook Mk3 and Chinook Mk2/2a helicopters which takes into account the different flight handling characteristics due to the larger fuel tanks which are inherent to the design of Chinook Mk3.
- Current training flight simulators do not match the requirements for flying the current Chinook helicopters. To mitigate this risk, the Department will modify the existing Chinook flight simulators before the end of 2009.

Delivery costs

3.10 **Figure 8** shows that the costs associated with the Chinook Mk3 helicopters from their initial procurement through to completion of the Reversion project will be some £422 million. The costs take into account the original purchase price of the Chinooks, the procurement costs for the Night Enhancement Package and the costs of storing and maintaining the Mk3 helicopters at Boscombe Down.

3.11 For comparison purposes Figure 8 also includes the costs of the Fix to Field project. It shows that the total cost of the Fix to Field project would have been £507 million, some £85 million more than the Reversion project. However, the reversion costs do not include further expenditure required to sustain the Night Equipment Package which is currently being negotiated with industry and are therefore commercially sensitive.

8 Estimated costs of procuring the eight Chinook Mk3 helicopters and making them operational and sustaining the special operations capability

Main expenditure items	Fix to Field Costs (£ million)[1]	Reversion Costs (£ million)
Original procurement	259	259
Reversion project, including Afghan theatre specific equipment	–	112.6
Expenditure on Fix to Field before cancellation[2]	–	17.25
Fix to Field	215	–
Storage, inspection and maintenance of eight helicopters at Boscombe Down	0.56	0.56
Total expenditure on Mk3s	474.56	389.41
Night Enhancement Package installed in eight helicopters in 2001	32.3	32.3
Sustainment and Integration of the Night Enhancement Package for eight helicopters	–	X[3]
Total expenditure	506.86	
Expected In-service Dates	2011-12	2009-10

Source: National Audit Office analysis of Ministry of Defence data

NOTES

1 Estimated costs and In-service date of Fix to Field post capability and cost reduction exercise and re-bid in 2006-07.

2 The Department told us that some of the activities arising from the preparation phase could be used on the Reversion and other projects although the extent of this has not been quantified.

3 Costs are commercially confidential until a contract is let.

3.12 Although the Fix to Field project would have ultimately met the requirement for special operations missions it would not have met the timescale imperative to provide more Chinook capacity to operations in Afghanistan. The Reversion project will provide an increase in Chinook helicopters two years earlier.

3.13 Cancellation of the Fix to Field project also meant some financial losses for industry. Thales Limited, for example, invested in the development of the Fix to Field solution in order to shorten the delivery timescales and incurred a small financial loss when the project did not proceed. Boeing lost any profit it may have made through the preparation phase of the contract.

APPENDIX ONE

Study methodology

1 This Appendix sets out the scope of our examination of the Chinook Mk3 and the methodologies we used in the course of our study.

We examined the following areas:

- Whether concerns arising from earlier reports by the National Audit Office[2] and the Committee of Public Accounts[3] have been addressed.
- The steps the Department has taken to make the eight Chinook Mk3 helicopters fully operational since 2001, including the Fix to Field project and the Reversion project.
- Whether decisions to make the helicopters operational have been taken expeditiously and based on sound advice.
- How the Department has managed shortfalls in special operations capability due to the lack of availability of the Chinook MK3s.
- The arrangements the Department has in place to ensure that the helicopters, when delivered under the Reversion project, will be airworthy for operations, and that other risks have been minimised.
- The costs of making the Chinooks operational and how these have been controlled.

We undertook a series of interviews:

2 We carried out a series of interviews with Departmental staff from:

- The Department's Defence Equipment and Support organisation responsible for the management of the Chinook Mk3 and its associated fielding projects.
- The Directorate of Equipment Capability (Air and Littoral Manoeuvre) in order to fully understand the original planning, requirements and procurement of the Chinook Mk3 along with the development of the subsequent fielding projects.
- Joint Helicopter Command personnel at Headquarters Land Command in Wilton to gain an understanding of how the aircraft are used and how the introduction of the Mk3 may affect the availability and operational performance of the Chinook fleets.
- Chinook aircrew from 7, 18 and 27 Squadron RAF along with ground crew and station personnel at RAF Odiham. We gained awareness of the day to day challenges associated with the Chinook aircraft along with the challenges faced by the station personnel in direct support of the Chinook fleet.

We examined Departmental documents:

3 We examined Departmental documents including:

- Post-project appraisals of the original Chinook Mk3 procurement.
- Papers prepared for, and approvals made by, the Department's Investment Approvals Board.
- Technical and economic appraisals of the Fix to Field and Reversion projects.
- Airworthiness standards.
- Other relevant information such as guidance and manuals.

2 National Audit Office: *Ministry of Defence: Battlefield Helicopters*, HC 486 Session 2003-2004: 7 April 2004.
3 Committee of Public Accounts: *Ministry of Defence: Battlefield Helicopters*, Eighth Report 2004-05 (HC 386).

We discussed the Chinook Mk3 projects with industrial providers and experts and observed the Chinooks at Boscombe Down

4 We interviewed representatives from industrial providers:

- Boeing was the main contractor for the original procurement and the Fix to Field project and is the main contractor for the Reversion project. We interviewed representatives of the company responsible for Chinooks at their Philadelphia factory in the United States.
- QinetiQ are contracted by the Department to provide independent advice on airworthiness and safety. We interviewed representatives at Boscombe Down.
- Thales was to provide the helicopter cockpit for the Fix to Field project. We interviewed representatives in London.

5 We observed the Chinook Mk3 helicopters in their storage facilities at Boscombe Down and interviewed those responsible for their maintenance and inspection.

We interviewed the United States Director of Army Aviation

- We met with the United States Director of Army Aviation in the United States in order to provide greater insight to the use of Chinook helicopters by the United States Army and Special Forces.

Summary of the stakeholders within the Department and other organisations which we visited

Defence Equipment and Support

Director General Helicopters

Director Future Rotor Craft Capability

Chinook Integrated Project Team

Chinook Future Heavy Lift Project Team

Ministry of Defence

Directorate Equipment Capability (Air and Littoral Manoeuvre)

Director General Scrutiny and Analysis

Defence Science Technology Laboratory

Directorate Special Forces

Royal Air Force

Headquarters Joint Helicopter Command

RAF Odiham

Industry

The Boeing Company

QinetiQ

Thales Limited

United States Army

Director of Army Aviation

APPENDIX TWO

The United States Army Chinook helicopters

1 The United States army currently operates four different versions of the Chinook Helicopter.

2 The Chinook D model which is similar to the United Kingdom Chinook Mk2/2a and the Chinook E model a Special Forces variant of the D model, similar to the United Kingdom Chinook Mk3 but with a fully analogue cockpit. An upgrade project is currently converting the D helicopters from analogue to digital cockpits and upgrading the already digital E model helicopters to the F and G model Chinooks, which will become the basis for the US Army's fleet of standard and Special Forces helicopters.

9 The United States Army's current and planned fleet of Chinook helicopters

	Analogue Cockpit	Digital Cockpit	Total
Regular Army	371 x CH 47D	35 x CH 47F	406
160th Special Operations Aircraft Regiment	15 x MH 47E	40 x MH 47G	55

Source: United States Army

3 The United States Army will buy Chinooks form the Boeing until approximately 2019, on the current delivery schedule, to meet their overall requirement of 489 aircraft. The acquisition project involves a combination of remanufacturing a total of 393 CH-47D and CH-47E model Chinooks into CH47F and G models with an additional new buy of 120 CH-47F.

4 The United States operational requirement for Chinooks in the Afghanistan theatre

- Each of the four Combat Aviation Brigades brings its CH-47 company of 12 aircraft, however;
- Operation Enduring Freedom requires an additional 12–15 Chinook aircraft above that provided by the Combat Aviation Brigades; this augmentation is generally supported by a National Guard unit.

APPENDIX THREE

Battlefield Helicopters: Committee of Public Accounts Conclusions and Recommendations concerning Chinook Mk3 and Treasury Minute response

Committee of Public Accounts conclusion and recommendation	**Treasury Minute response**
The Department has bought eight Chinook Mk3 helicopters which have not entered service and which it cannot use.	The Department agrees that there were significant problems with the acquisition of the Chinook Mk3 helicopter. Major changes, under the Smart Acquisition initiative, have been incorporated into the Department's working practices to ensure that these problems would not occur now. Areas that have been addressed include a more rigorous prioritisation of the requirement, clear guidelines on responsibilities, improved Military Aircraft Release procedures and a rigorous project review and assurance process. In the Requirements Management process 'essential elements' are identified as Key User Requirements. In particular, the development of prioritised, hierarchical requirements documents and a thorough process to track these requirements through contracts into a delivered capability is a key success of Smart Acquisition. In parallel, it has also been recognised that the trading of performance, cost and time is necessary to balance the desire to provide everything that a Customer wants against affordability in order to ensure best value for money. Current processes also require that significant risk reduction activity takes place prior to the main investment decision. Performance, Time and Cost risks are considered and no commitment is made to a project until an acceptable level of maturity and risk is attained. Key stakeholders in these processes include the Integrated Project Team, Customer and Industry.
The Department was unable to say who was responsible for the flawed procurement of the Chinook Mk3.	The Department agrees with the Committee's conclusion on appointing a single point of accountability for projects. All equipment projects have a nominated individual responsible for overseeing all aspects of the project to ensure that risks are managed and that the full benefits of the project are achieved. This individual is answerable for the introduction of capability into service and the coherent and integrated delivery of equipment; training and personnel; logistics; infrastructure; concepts; doctrine and other components of military capability. For each equipment and business change project which involves substantial change, significant complexity and/or demanding integration across boundaries, the Department has appointed a Senior Responsible Owner with responsibilities and reporting arrangements set out in formal terms of reference. For all other equipment acquisition projects, the appropriate Director of Equipment Capability has been designated as the single point of accountability for ensuring the delivery of all components of military capability inherent in an equipment investment decision. The Chinook Mk3 procurement however, predates the adoption in the Department of both Senior Responsible Owner and single point of accountability constructs. A key part of the Senior Responsible Owner and single point of accountability role is to resolve conflicting priorities and demands in order to achieve the required benefits against key strategic priorities and within time, cost and performance parameters. With the increasing complexity and integration of equipment projects, the role of the Senior Responsible Owner and single point of accountability will be vital in ensuring effective delivery of new military capability to the front line.

Committee of Public Accounts conclusion and recommendation	Treasury Minute response
The Department should determine whether there is any beneficial use that can be made of the Chinook Mk3.	The Department agrees that there have been significant problems with the acquisition of the Chinook Mk 3 helicopter and options for the future of the aircraft are being pursued. Current indications are that modifying the aircraft to provide the required capability and to meet the Military Aircraft Release requirement will offer the best value for money solution and address the shortfall in battlefield helicopter lift capability, as highlighted in the National Audit Office Report. The option to sell the aircraft remains open pending satisfactory completion of this technical and industrial preparatory work. The value of the Chinook Mk3 aircraft has been written down at present to a value equivalent to disposal or use as spares, but this is because of prudent accounting practice, and is not a reflection of future intent.

APPENDIX FOUR

United Kingdom Military Airworthiness – key principles

1 Airworthiness is essentially a technical attribute of materiel; it is concerned with airborne safety aspects that are dependent on the design of a particular aircraft type. The formal definition of airworthiness is:

- The ability of an aircraft, or other airborne equipment or system to operate without significant hazard to aircrew, ground crew passengers or to the general public over which such airborne systems are flown.

2 Airworthiness characteristics stem from the design of a particular aircraft and therefore determine not only the configuration of the aircraft, but also the requirements and limits of both its maintenance and operation. The granting of Airworthiness Authority to areas within the Defence Equipment and Support organisation limits their ability to change either the design or the operating or maintenance requirements which are derived from the design of the aircraft.

3 Additionally, Aircraft Operating Authorities, in the case of the Chinook, Commander Joint Helicopter Command, have the responsibility to preserve the airworthiness of individual aircraft by ensuring that their personnel operate and maintain aircraft within the requirements and limits specified in the Release to service and Aircraft Document Set. This responsibility is explicitly stated in the authority to operate aircraft delegated from the Secretary of State through the Chiefs of Staff and hence through to Aircraft Operating Authorities.

4 The authority to operate and regulate United Kingdom military aircraft is vested in Secretary of State. The Secretary of State requires all aircraft, associated equipment and software to be designed, constructed, maintained and operated in such a manner that they are airworthy.

5 The Secretary of State requires that the airworthiness arrangements for military aircraft should be at least as effective as those for civil aircraft contained in the Air Navigation Order, which sets out the regulations to which all civilian air traffic in the United Kingdom must adhere, and should comply with the Health and Safety at Work Act where relevant. This is particularly important in roles that are paralleled in civil operations, such as where passengers are carried.

6 The Department's Aviation Regulatory and Safety Board, chaired by the Assistant Chief of the Air Staff, sets out the Military Airworthiness Regulations in Joint Service Publication 553.

7 Joint Service Publication 553 describes the Safety Management System for the management of airworthiness of UK Military Aircraft. The Safety Management System defines the planning, organising, implementing and controlling of airworthiness management activities. It covers policy aspects of the management of design, procurement maintenance and operation of military aircraft that affect airworthiness, and, where appropriate delineates responsibilities. Within the project Safety Management System, the Safety Case provides the objective justification for the airworthiness of an aircraft and is thus the on-going basis of aircraft releases.

The Release to Service

8 The Release to Service is central to the management of airworthiness for any given aircraft. A Release to Service is only authorised following the presentation of a robust, independently assessed Safety Case for any new aircraft and subsequent modification. It disseminates the authorised limits, procedures and operating information to the personnel (aircrew and engineers) who operate the aircraft. The content of the Release to Service is divided into seven sections **(Figure 10 overleaf)**.

10 Management of Release to Service

Part A – Airworthiness and Document Management. This part covers the sections related to the airworthiness and authorisation functions of the Release together with sections that are for management of the aircraft or general Release documentation.

Part B – Aircraft Design and Handling Limitations. This part covers the information to aircrew, for limitations that are basic to flying the aircraft without external stores or other role equipment fitted. Thus it covers items such as: Speed, Altitude, Manoeuvres, Environment Conditions, and Take-off & Landing.

Part C – System Limitations and Constraints. This part covers the limitation aspects of operating the aircraft that are applicable to the aircraft systems, rather than flying the aircraft. Thus it covers items such as: Engine, Fuel System, Electrical System, Autopilot, Communications, and Radar.

Part D – Role Limitations and Constraints. This part covers the limitations that are sortie dependent; i.e. vary between flights, rather than related to the role of the basic aircraft. Thus it covers items such as: Authorised Stores Configurations; Stores Carriage, Release and Jettison Limits; Passenger and Freight Limits; Winch Operations; Air-Drop etc. There are many possible section headings that fit into this Part, but they tend to sub-divide according to the type of aircraft, for example, Fast Jets, Transport and Support and Helicopters.

Part E – Management of Temporary Information. Clearances included in this section are to be of a genuinely transitory nature: for example, the clearance of a Special Trial Fit for a short duration trial after which it will be removed; or included within this part through operational necessity as a temporary amendment, pending its inclusion in the appropriate part at the next formal amendment of the Release to Service. All such information must be supported by a safety case. This section may also be used to promulgate other urgent information to aircrew pending formal amendment of aircrew publications (for example, operating data in support of a new clearance).

Part F – Clearances with Limited Evidence. The purpose of Part F is to record where information has been included within the Release to Service that has not been derived from a fully substantiated safety case; such clearances are termed 'Clearances with Limited Evidence'. Such clearances are normally subject to periodic review, frequent amendment, and some may be applicable only to certain marks, operating units or even individual airframes. Following a periodic review or change to such clearance, the applicability and validity of the Clearance may change.

Part G – Audit Trail. This part covers the Audit trail function required to ensure airworthiness, and will be all the elements of the whole aircraft Safety Case. It is a record of all the Safety Case data that has been used in compiling the Release and provides justification for all elements of the Release content.

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Chinook Mk3 Helicopters

A report by the Comptroller and Auditor General

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