NAO
NATIONAL AUDIT OFFICE

Report by the
Comptroller and Auditor General

Ministry of Defence

Accepting equipment off-contract and into service

HC 204 Session 1999-2000
11 February 2000

Report by the
Comptroller and Auditor General

Ministry of Defence

Accepting equipment off-contract and into service

Ordered by the
House of Commons
to be printed 8 February 2000

LONDON: The Stationery Office
£0.00

This report has been prepared under Section 6 of the National Audit Act 1983 for presentation to the House of Commons in accordance with Section 9 of the Act.

John Bourn
Comptroller and Auditor General

National Audit Office
28 January 2000

The Comptroller and Auditor General is the head of the National Audit Office employing some 750 staff. He, and the National Audit Office, are totally independent of Government. He certifies the accounts of all Government departments and a wide range of other public sector bodies; and he has statutory authority to report to Parliament on the economy, efficiency and effectiveness with which departments and other bodies have used their resources.

For further information about the National Audit Office please contact:

National Audit Office
Press Office
157-197 Buckingham Palace Road
Victoria
London
SW1W 9SP

Tel: 0171-798 7400

email:nao@gtnet.gov.uk

Web site address: www.nao.gov.uk

Contents

Executive summary **1**

Part 1: Introduction **6**

Background 6
How the acceptance process works 6
The Department are revising the acceptance process 6
Introducing the new processes will take time 6
There must be consistency in demonstrating that User needs and contractual obligations have been met 7
There are two main milestones in the acceptance process 9
Previous Parliamentary interest 10
Scope and methods 11

Part 2: The outcome of the acceptance process **13**

Introduction 13
Variances from the Staff Requirement 13
Forty per cent of equipments accepted off-contract fully meet operational requirements 13
How the Department deals with variances against the Staff Requirement 15
Agreeing Concessions 15
The Department made concessions where they did not consider that shortfalls affected operational capability 15
User pressure can lead to concessions 16
Taking equipments into service before acceptance is complete can weaken the Department's negotiating position 17
Agreeing provisos 17
Provisos are a commonly used method for dealing with shortfalls, particularly in the Land Systems area 17
The flexible use of provisos can bring operational benefits 19
Provisos can become concessions 19
Deleting parts of the Staff Requirement 19
Deletion of requirements may have adverse operational implications 19
Accepting the shortfalls 20
Industrial pressures can lead to performance shortfalls 21
Agreeing designs can leave the Department responsible for shortfalls 22
Summary 23

[****] denotes information classified for either security or commercial reasons

Part 3: Planning and managing the acceptance process **24**

Introduction 24
Differences of approach between the services 24
Each of the services has adopted slightly different approaches to acceptance 24
Planning for acceptance 25
Putting the right strategies in place 26
Most projects had acceptance strategies in place 26
Drawing up acceptance strategies is difficult 26
Acceptance strategies were not always adequate 27
Identifying and minimising risks 27
In half the categories examined more difficulties emerged than were identified as risks at the outset 28
Human factors must be taken into account early in the design and acceptance process 29
Underestimating technical risk at the outset can lead to problems further downstream causing delays and cost overruns 29
The Department's track record in managing reliability risks is mixed 29
Choosing and applying the right testing and evaluation techniques 30
All projects used some form of controlled or real-world testing 30
Simulation can reduce costs but must be validated 31
Acceptance based on demonstrations in conditions unrepresentative of their future operating environment can mask shortcomings in real-world performance 31
Progressive acceptance of Sea Systems has not always identified problems 31
Trials using specialist test staff may not represent the activities of Service Users 32
Acceptance of strategies where large numbers of equipments are being procured must reflect potential variations in standard production 32
Agreeing the outcome of the acceptance process 34
Analysis of acceptance options is predominantly qualitative 34
Those involved in the acceptance process usually reached a consensus on decisions 35
Acceptance decisions can have unexpected operational implications 37
Summary 37

Part 4: How the Department contract for acceptance **38**

Introduction 38
Whether contract acceptance criteria reflect the Staff Requirement 38
- Acceptance criteria in one third of contracts did not fully reflect the Staff Requirement 38
- Poor contractual specifications can lead to performance shortfalls and extra costs 38
- Including ambiguous acceptance criteria in contracts can have detrimental implications 40
- Buying overseas can lessen contractual protection against shortfalls 41

Securing appropriate recompense for shortcomings highlighted by acceptance 42
- Concessions do not always result in financial or other benefits in return 42
- Warranties can provide quick and comprehensive remedies 43
- Warranties were most commonly used for ships and submarines 44
- There have been disagreements over warranty provisions 44
- Deploying equipments operationally can make warranties difficult to enforce 45
- Liquidated Damages clauses were included in contracts on two-thirds of equipments surveyed 45
- The Department rarely pursue general damages 46

Summary 47

Annexes

A: Study methodology 48
B: Equipments surveyed by the National Audit Office 51
C: The Case Studies 52

Executive summary

Introduction

1 Acceptance is the process by which the Ministry of Defence (the Department) confirm that Users' needs for military capability have been met by the systems supplied. The Department have accepted into service some 65 major equipments each of the value of £10 million or above in the past five years. Traditionally acceptance has had two main parts - acceptance off-contract and acceptance into service – reflecting differences in the responsibilities of those involved in procuring and operating the equipment. As part of the Smart Procurement Initiative, the Department are revising their acceptance procedures with the aim of introducing a single outline process for all major programmes.

2 This report examines the Department's track record and current procedures for accepting equipment off-contract and into service. Our main findings and recommendations are summarised below and are intended both to re-inforce and to inform the on-going development of the Department's "Smart Acceptance" procedures.

Getting the right equipment

3 Acceptance provides the link between the means - procurement - and the ends - operational capability - that go towards the creation of a modern and effective military capability. A survey of equipments accepted over a 5-year period revealed that, when the decision was made to accept the equipment off-contract, 40 per cent of equipments fully met the operational requirements. In half of the equipments where this was not the case, the Department made concessions which removed from the contractor the obligation to make good the shortfall either because they did not consider that shortfalls affected operational capability or because of pressure from the User. On the other hand, the other half of these equipments were subject to the contractor accepting responsibility for rectifying the shortcoming at its own expense. However, this did not always happen, and exceptionally the Department deleted parts of the Staff Requirement in order to get equipments into service. Finally, we found that in some cases equipments were accepted whilst not meeting the Staff Requirement because of poor contractual definitions, industrial or other factors, with the Department remedying the shortfalls at their own expense.

4 We recommend that the Department:

- Take forward their intention to work closely with industry within Integrated Project Teams to understand what is technically achievable, to identify risks to project success and to reflect these in the new Integrated Test, Evaluation and Acceptance Plans. Such actions should help to prevent nugatory effort and reduce the incidence of concessions.

- Build on their closer relationship with industry, working as stakeholders in Integrated Project Teams. They should also develop Smart Procurement techniques, including Smart Acceptance, which offer potential for better management of the acceptance process. Finally, the Department should examine the scope to make more use of provisos to secure early operational benefits where there are performance difficulties. Such arrangements should not be seen as an excuse for not forcing industry to deliver the full capability that they have been contracted for within agreed timescales.

The acceptance process

5 The acceptance process is central to the successful delivery of an equipment or operational capability to the Front Line user and spans virtually the entire length of an equipment procurement project's life. We found that acceptance processes varied between air, sea and land environments, reflecting the different scale and nature of procurements involved and that there was only general guidance available on how to construct cost-effective acceptance strategies. However, the vast majority of projects surveyed had strategies in place for identifying, gathering and analysing the evidence required to demonstrate equipment performance. These acceptance strategies and project risk assessments tended to emphasise the importance of integration risks, while underplaying potential problems with reliability, environmental testing, the quality of individual components and human factors. And the strategies had mixed success with over half of the projects surveyed having difficulties in demonstrating aspects of performance during acceptance off-contract. Ninety per cent of projects also undertook additional trials to demonstrate performance before accepting equipments into service. In 40 per cent of these further trials, problems emerged in meeting the Staff Requirement. In general, the Department's considerable experience in testing and trialling meant that most performance defects were identified but in some cases the techniques used did not provide sufficient or accurate results before acceptance decisions were made. Such decisions were

largely qualitative and, whilst stakeholders usually reached a consensus view, there were some differences of opinion and some of the decisions had unexpected operational implications.

6 We recommend that the Department:

- Improve the clarity and quality of guidance on acceptance planning.
- Learn lessons from past experience of technical and project management difficulties and from the performance of individual contractors in managing the acceptance process and dealing with shortcomings. The results should be used to inform the design of future acceptance strategies to ensure that they are tailored to the circumstances of individual programmes.
- Build on the introduction of Integrated Project Teams to ensure that all key players, including in the future the Defence Evaluation and Research Agency, and industry, are brought in to the acceptance process at an early stage to ensure a more systematic approach to the design of acceptance strategies.
- Introduce more quantification into their decision-making on the outcome of acceptance to bring such analysis into line with that underpinning both the formulation of Staff Requirements and the evaluation of contractors' bids.
- Review and evaluate the effectiveness of the Smart Acceptance procedures when a body of experience exists.

Contractual problems in the acceptance process

7 The acceptance process will run smoothly only if the procurement contract fully reflects the objectives of the Staff Requirement and the specific characteristics of the equipment being procured. In one-third of cases examined, contract acceptance criteria did not fully reflect the Staff Requirement. In some of these cases, the Department had some success seeking financial redress, but in other cases they had to pay for remedial work themselves or sacrifice the element of equipment performance in question. There were additional difficulties in

matching contractually binding acceptance terms to the Staff Requirement where equipments were purchased from overseas and particularly when the United States Foreign Military Sales system was used.

8 Contracts should provide some means of redress for the Department if the contractor fails to achieve the objectives specified. We found that the granting of concessions to contractors was not always accompanied by any financial recompense; warranties were negotiated in just over one-quarter of projects surveyed and were invoked in all cases – albeit with mixed success – and two-thirds of projects surveyed included liquidated damages clauses in their contracts. On eight projects examined, difficulties with the acceptance process were a cause of delay and contributed to the Department's decision to claim liquidated damages. In line with their usual practices, the Department did not pursue general damages on any of the projects we surveyed.

9 We recommend that:

- Given the Department's mixed track record in agreeing unambiguous contract acceptance criteria and linking these to the Staff Requirement, they will need to take great care to ensure that the new Smart Acceptance procedures are rigorously applied on all major programmes, particularly where they represent a change to more traditional approaches.

- All significant procurement contracts should include clearly defined provisions to enable the Department to obtain appropriate financial redress in cases of performance or schedule shortfall. In line with the aspirations underpinning Smart Acceptance, but in contrast to their track record, the Department should make the fullest use of such powers.

- The Department consolidate their experiences to generate quantified analyses of the financial and operational merits of provisions such as warranties, liquidated damages and reliance on general damages to make sure that the contractual arrangements put in place are the most cost effective in specific circumstances.

Concluding comments

10 The Department have always had in place defined processes to judge whether the equipments which they procure have met both the terms of the contract and operational needs. This is a complex task and in most cases the Department have achieved what they assess to be satisfactory outcomes. Our

analysis has shown that in a significant minority of cases weaknesses in specifying requirements, contracting, testing or pursuing contractual remedies cost the Department one or all of time, money and capability. In theory, the Department's new Smart Acceptance process will address many of the shortcomings which we have identified but this will only be the case if it is applied with more rigour than has been apparent under the current system and if lessons are learned in the light of their emerging experience. Our report re-inforces the need for the new approach and makes recommendations to further improve the efficiency of the acceptance process and effectiveness of outcomes. In the course of our work, we have identified £60 million of costs associated with equipments accepted which did not fully meet requirements. The Department must ensure that they can demonstrate the effectiveness of their new approach in minimising such costs and in achieving effective acceptance outcomes.

Part 1: Introduction

Background

1.1 The Ministry of Defence (the Department) accept into Service an average of 13 major new or significantly upgraded equipments every year which have cost £10 million or more to procure or modify. The objective of the acceptance process is to ensure that Users' needs for military capability have been met by the systems procured. Getting the acceptance process right is essential. Any failure to do so may give rise to expensive modifications and storage costs, and may result in a loss of operational capability. Difficulties with the acceptance process can also require the Department to run on ageing equipments while problems with their replacements are resolved.

How the acceptance process works

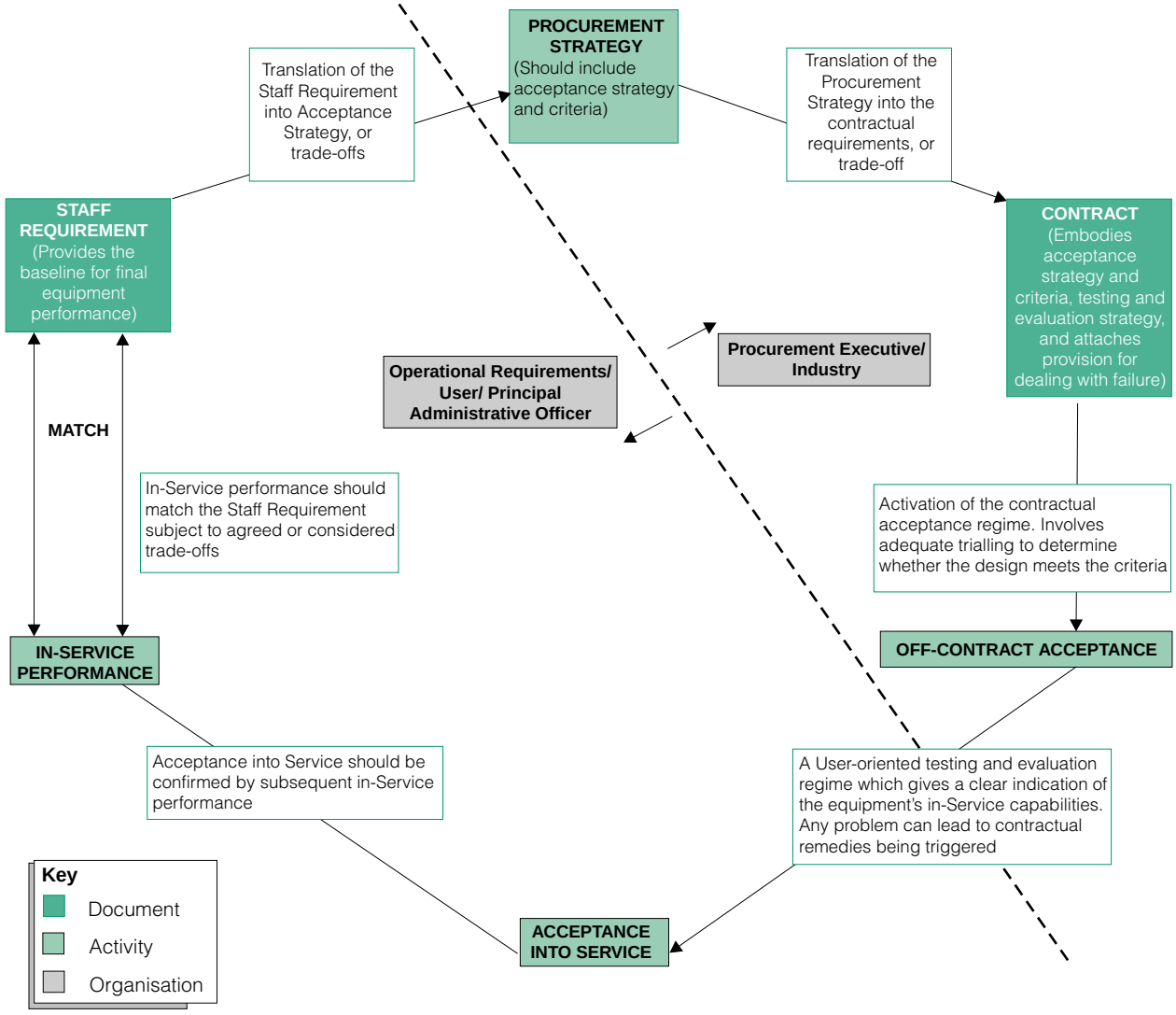
The Department are revising the acceptance process

1.2 Traditionally, the acceptance process has differed between the land, sea and air environments. It has also differed according to the sophistication of the equipment involved and whether the equipment has been procured off-the-shelf or following full development. As part of their Smart Procurement initiative, the Department are revising their acceptance procedures with the aim of introducing a single outline process for all major programmes. Figure 1 shows how acceptance fits into the pre-Smart Procurement acquisition process and Figure 2 shows the Department's proposed new "Smart Acceptance" procedures.

Introducing the new processes will take time

1.3 Figures 1 and 2 show that acceptance is an integral part of the procurement process. Given that equipment acquisition cycles are often long and that it will be difficult to alter the fundamentals put in place on many on-going programmes, Smart Acceptance will not replace the existing processes overnight. The following paragraphs describe the existing acceptance process and how the process – but not many of the underlying principles - will change as Smart Acceptance is introduced.

Figure 1 How the acceptance process fits into the procurement lifecycle



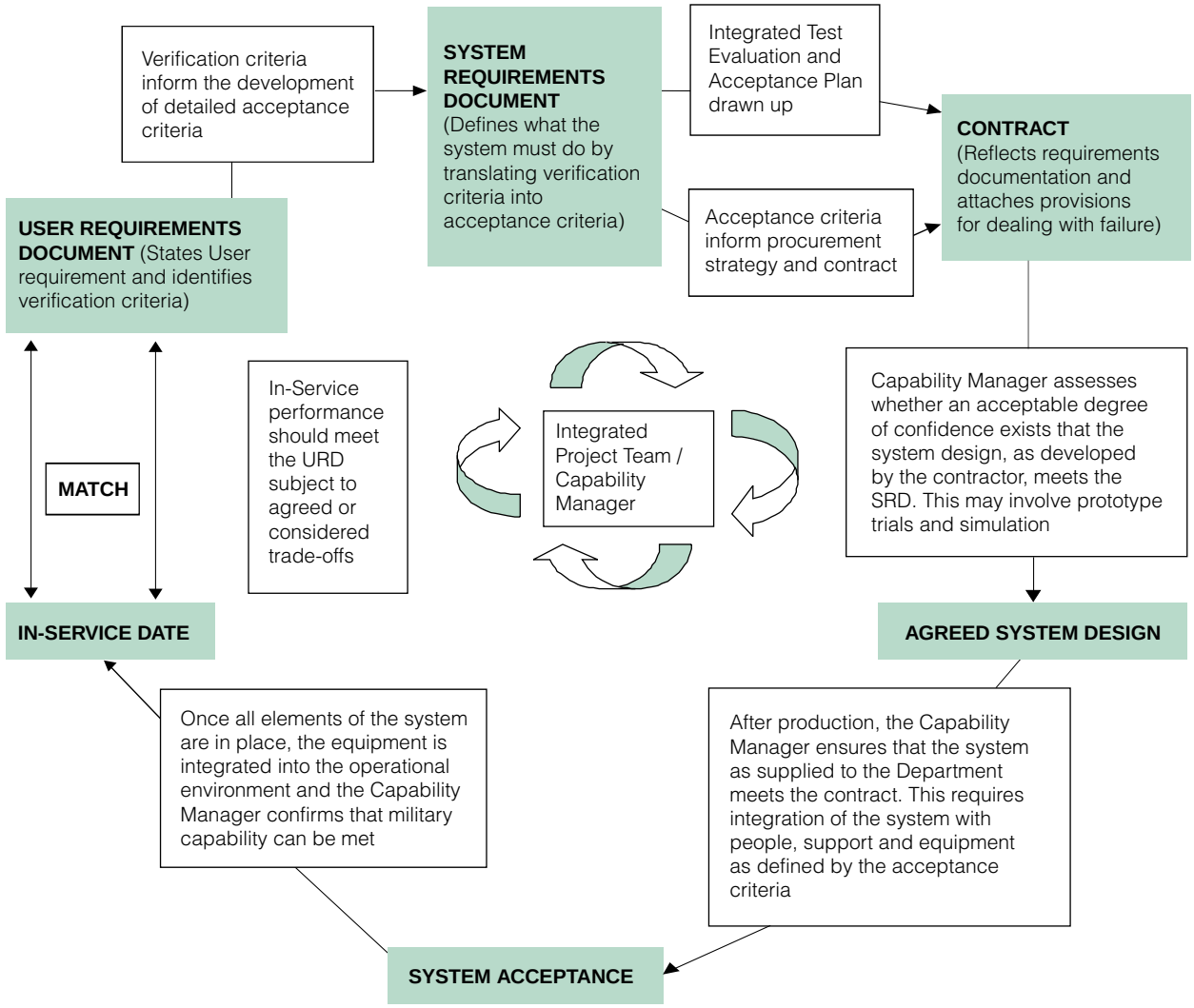
Comment: Acceptance is an integral part of the procurement cycle.

Source: National Audit Office

There must be consistency in demonstrating that User needs and contractual obligations have been met

1.4 The starting point of the acceptance process has traditionally been the Staff Requirement which is drawn up by military planners after consultation with other interested parties, such as the Defence Procurement Agency (formerly the Procurement Executive), Users and industry. The Staff Requirement should state clearly and unambiguously the operational purpose for which the equipment is required and should form the basis from which to develop a sound strategy for

Figure 2 **The Smart Acceptance process**



Comment: The Department are revising their acceptance procedures.

Source: National Audit Office

acceptance of the equipment procured and against which its in-Service performance can be measured. The Staff Requirement provides the basis against which acceptance criteria, together with any Agreed Characteristics which amplify these criteria, are drawn up. For the acceptance process to work well, these acceptance criteria and characteristics must then be reflected accurately in a contract: an equipment that complies with the contract should also satisfy the Staff Requirement.

1.5 Under Smart Acceptance, the Department intend that an acceptance strategy and an Integrated Test, Evaluation and Acceptance Plan should be drawn up at an early stage in the acquisition process. These plans are to reflect:

- **Verification criteria** based on a User Requirements Document drawn up by a Capability Manager and stating the outputs or results which Users require from the system. The criteria will describe how the achievement of these User requirements will be verified.

- **Acceptance criteria** based on a System Requirements Document drawn up by the Integrated Project Team Leader in conjunction with the Capability Manager and describing what the system must do to meet the User needs stated in the User Requirements Document. These criteria will state how achievement of each system requirement will be demonstrated and the standard to be achieved. In a similar manner to the use of acceptance criteria and Agreed Characteristics under the present system these criteria are intended to form the basis for contracting with suppliers.

There are two main milestones in the acceptance process

1.6 Traditionally, there have been two main milestones in the acceptance process. The first is **acceptance off-contract**, at which point sufficient testing and trialling should have confirmed compliance with the contractual specification and criteria. The second is **acceptance into service** when it is assessed that the equipment meets the specific expectations and requirements of equipment operators. Acceptance into Service does not mean that the full military capability has been realised since factors such as integration with other systems, trained personnel, logistics support, tactics and procedures may not have been fully defined.

1.7 These two milestones reflect organisational divisions within the Department. Responsibility for the procurement of equipment rests with the Procurement Executive – now the Defence Procurement Agency – who have sought to define sufficient tests and trials to enable them to assess that the equipment delivered by industry meets the contractual requirement and, if not, to provide a suitable mechanism to seek appropriate redress. The interests of the services have lain in assessing whether the equipment procured meets their operational needs – as set out in the Staff Requirement – and they have therefore undertaken a more detailed examination of the equipment's capability, defining the performance envelope, and confirming compliance with safety and maintenance standards.

1.8 Under Smart Acceptance, the process will focus more clearly on meeting military needs with the decision to accept an equipment resting with the Capability Manager. Acceptance will be in two stages. Achievement of the **In-Service Date** will only be declared when the military capability to be provided – not just the equipment - is assessed as available for operational use. Prior to this, **System Acceptance** will assess whether the system acquired by the Integrated Project Team satisfies the System Requirements Document. The two stage approach reflects the fact that the Integrated Project Team Leader, whilst responsible for ensuring the successful integration and development of his system into an operational capability, may not have authority over all elements contributing to operational availability.

1.9 In terms of the relationship with industry, the Integrated Project Team Leader will be responsible for contracting with industry and the management of the acceptance process, including the gathering and presentation of evidence to demonstrate that acceptance criteria have been satisfied. At the point in time at which the Capability Manager decides to award Full System Acceptance, the intention is that the Integrated Project Team Leader should be in a position to confirm that industry has fulfilled the contractual commitments placed upon it. In reaching this judgement, the Integrated Project Team Leader should be able to rely on the same evidence used to demonstrate Full System Acceptance. However, circumstances may arise where the system satisfies fully the Capability Manager but the supplier has not met its contractual commitments in full, for example if the Capability Manager assesses a performance shortfall as acceptable. Under the existing arrangements, agreeing how to deal with such situations would have been part of acceptance off-contract but the intention under Smart Acceptance will be that the Integrated Project Team Leader should seek appropriate redress against the contract separately.

Previous Parliamentary interest

1.10 In general, previous Parliamentary and National Audit Office work has focused upon issues related to the cost and schedule risks of major procurement projects rather than with specific issues of acceptance. The Committee of Public Accounts have, in particular, commented for many years on the effect of technical problems on procurement projects and of weak contracting, most recently in their Major Projects Report 1997 (HC 101, 1998-99).

Scope and methods

1.11 This Report focuses on three aspects of the Department's approach to the acceptance of equipments off-contract and into service:

- the outcome of the acceptance process (Part 2);
- how the Department plan for and manage the acceptance process (Part 3); and
- how the Department contract for acceptance (Part 4).

1.12 For the purposes of our study, we limited our examination to the acceptance of projects with a value of at least £10 million. Projects of this nature represent the bulk of the annual equipment procurement expenditure of some £6 billion. The two main methodologies which we used are shown in Figure 3 and were designed to provide insights into the acceptance processes operated by the Department. We also explored the prospects for benchmarking the Department's practices against overseas comparators. Our provisional work suggested that, on the limited information which other countries were prepared to release to us given the operational sensitivities of the judgements involved, the outcomes from the Department's acceptance processes were not obviously better or worse than those for other countries. However, differences in the acquisition processes followed by other countries, the way in which acceptance fitted within these processes and the roles taken by procurement agencies, the services and industry meant that detailed analysis of the processes followed would have been of very limited utility.

1.13 We would like to thank all those within the Department and elsewhere who provided inputs to the Report.

Study Methodologies used by the National Audit Office

Figure 3

- **Detailed Survey**. A random sample of 43 of the 78 projects valued at over £10 million, and accepted between 1993 and 1998, was surveyed by sending a questionnaire to the appropriate Project Office/Principal Administrative Officer. The questionnaire covered acceptance strategies, risk assessments, contractual information, testing and evaluation, and in-Service performance. Five of the most interesting responses were followed-up by interview. A list of the projects surveyed is given at Annex B.

- **Six Case Studies**. Two equipments from each service environment were subjected to more in-depth analysis of the acceptance process including file reviews and seeking opinions from the Procurement Executive, Operational Requirements staff, contractors, equipment users, and the Principal Administrative Officer. This exercise provided a historical perspective by enabling distinctions to be drawn between the Department's differing approaches to acceptance over the past decade by including both equipments currently being accepted and those which entered service some time ago.

Note: Further details of the methodologies are provided at Annex A

Comment: The methodologies used helped to provide a clear picture of the strengths and weaknesses of the acceptance process.

Source: National Audit Office

Part 2: The outcome of the acceptance process

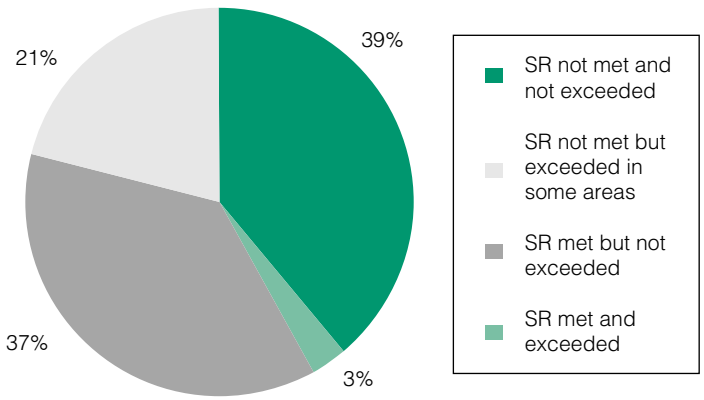
Introduction

2.1 Acceptance provides the link between the means - procurement - and the ends - operational capability - that go towards the creation of a modern and effective military capability. This Part of the report examines:

- The extent to which equipments accepted into Service met the terms of their original operational requirements (paragraph 2.2); and
- How the Department have dealt with variances against Staff Requirements in deciding whether to accept equipments (paragraphs 2.3-2.19).

Figure 4

Performance against the Staff Requirement at the time of the decision to accept off-contract



Source: National Audit Office

Comment: The Staff Requirement was met or exceeded on 40 per cent of equipments surveyed.

Variances from the Staff Requirement

Forty per cent of equipments accepted off-contract fully meet operational requirements

2.2 Figure 4 shows that, at the time the decision was taken to accept equipment off-contract, the Staff Requirement was met in full in 40 per cent of cases. Figure 5 illustrates typical reasons for variances from the Staff Requirement on the equipments that we surveyed.

Figure 5

Examples of variances from the Staff Requirement when equipments are accepted off-contract

Project	Shortfall	Excess
High Velocity Missile	■ Missile lethality at short ranges not met. Reliability 79.5 per cent against a required 90 per cent. ■ Minimum range of 300 metres not met. ■ Electro-Magnetic Compatibility – not compliant over a number of specific emission frequencies	■ Lethality of the missile for the self-propelled version is greater than the requirement at longer ranges.
Bridging for the 90s		■ Mission reliability was 97.5 per cent rather than 95 per cent for both the Close Support Bridge and General Support Bridge. ■ Close Support Bridge is capable of being trafficked at 1:5 longitudinal slopes rather than 1:10. ■ Close Support Bridge is capable of being launched into flowing water with a current below or equal to 1.5 m/s and water level to within 10 cm. of trackway.
Trident submarines	■ A fully Reelable Towed Array and Handling System was not achieved. ■ Unable to propel continuously at low shaft speeds. ■ Autopilot has unsatisfactory depth keeping in high sea states and at low speeds.	
Tornado Bol Chaff and Flare	■ Reliability requirements not met.	
Single Role Minehunters (HMS Bridport and HMS Inverness)	■ Speed temporarily restricted to about 1 knot below the requirement because of concerns over the reliability of the gearing. ■ Recovery of the Remote Controlled Mine Disposal Submarine has proved problematic in certain sea states.	
Canberra Sensor System Update		■ Better than expected resolution performance of sensor systems.
Tornado Reconnaissance Exploitation Facility		■ Time to produce "recce" report from receipt of tapes from aircraft is less than the requirement.
Nightbird Night Vision Goggles		■ Reliability (in terms of mean time between failures) is better than the requirement.
SALIENT surveillance system		■ Range performance exceeded.

Comment: There are a wide variety of reasons for variances from the Staff Requirement

Source: National Audit Office

How the Department deals with variances against the Staff Requirement

2.3 The Department have various options open to them when a contractor offers equipment which does not meet the Staff Requirement. These include:

- agreeing concessions whereby the need to satisfy all aspects of the requirement is dropped. (Paragraphs 2.5-2.9);
- accepting the equipment into service with provisos whereby in some cases the contractor is obliged to remedy the performance deficiencies at his own expense. (Paragraphs 2.10-2.14);
- deleting aspects of the Staff Requirement. (Paragraphs 2.15-2.16); or
- accepting the equipment and remedying the shortfalls at their own expense. (Paragraphs 2.17-2.19).

The following paragraphs examine the application of each of these options.

2.4 Smart Acceptance makes provision for the continued use of the first two of these options by giving the Department the option of accepting limited system acceptance when there is sufficient evidence to assess that the equipment is suitable for widespread service use but all acceptance criteria have not been achieved. Deficiencies will be raised as provisos identifying actions needed to reach satisfactory level or to confirm that level of performance already demonstrated, whilst not meeting fully the System Requirements Document, is acceptable without further work (previously known as concessions).

Agreeing concessions

The Department made concessions where they did not consider that shortfalls affected operational capability

2.5 Our survey showed that in half of the cases where the Staff Requirement was not fully met, the Department made concessions that removed from the contractor the obligation to make good the shortfall. In one case, the High Velocity Missile, the Department traded off a shortfall in one area of the requirement against a better than specified performance elsewhere in the requirement. In all of the other cases, the nature of the shortfalls made it inappropriate for them to be

traded off, and the Department agreed the concession because they decided that the shortfall against the requirement would have no effect on overall military capability given the way in which the military environment had evolved since the Staff Requirement had been written.

2.6 The AS90 self-propelled gun provides a typical example of a project where the Department agreed concessions. The gun was subject to a User trial prior to acceptance off-contract, to ensure that the gun's performance matched the Staff Requirement. The one major shortfall in meeting the requirement concerned the durability of the 39-calibre barrel. The Staff Requirement (which was accurately reflected in the contract) stipulated a barrel life of 2,500 Equivalent Full Charge firings using full calibre rounds. This figure had been derived as a direct read-across from preceding systems, and the Department assumed that, by using existing barrel technology, the required AS90 barrel life could be achieved. However, the advent of more energetic propellants in the interim had acted to increase barrel wear. When the gun was tested under severe conditions during the user trial, only half the number of Equivalent Full Charge firings required were achieved. However, the gun was still accepted since the User assessed barrel durability as acceptable in the prevailing operational environment.

AS90's on exercise

2.7 In the AS90 example, rather than provide each gun with a second barrel to allow a capability of meeting 2,500 Equivalent Full Charges, the imminence of an Extended Range Ordnance programme across most of the fleet, whereby 52-calibre barrels are being procured to replace the existing 39-calibre barrels, allowed a trade-off to take place. The 39-calibre barrels will be made redundant as a result of the Extended Range Ordnance programme and they will be re-allocated as replacement barrels for those guns which are not being upgraded. As a result of this experience, the Department have learnt a lot about barrel characteristics which should help to ensure that future designs will quantify requirements more accurately.

User pressure can lead to concessions

2.8 Another reason for the Department agreeing concessions was pressure from the User to accept the equipment when the system being replaced is so old as to have a very low level of capability or there is an Urgent Operational Requirement for the equipment. For example, TIALD, an airborne laser designation equipment,

was accepted with a long list of concessions against the specifications enshrined in the contract because the Royal Air Force had an urgent operational need for the equipment. In this case, acceptance was given with the caveat that the shortfalls would be rectified by the contractor at no extra cost to the Department. To date, the majority of the shortfalls have been addressed, with the remainder currently subject to negotiation with the contractor.

Taking equipments into service before acceptance is complete can weaken the Department's negotiating position

2.9 In extreme cases, equipments can be taken into service before being accepted leading to a severe weakening of the Department's negotiating position. For example, the Tri-Star simulator was accepted off-contract 10 months late. However, the Royal Air Force had already begun to use the equipment to meet an urgent training requirement before this time despite some functions not being operational. The contractor, Thomson Training and Simulation Ltd., was able to argue that the Department were not able to claim liquidated damages since they had obtained benefit from the simulator and the shortfalls in performance were irrelevant.

Agreeing provisos

Provisos are a commonly used method for dealing with shortfalls, particularly in the Land Systems area

2.10 One way of dealing with shortfalls against the Staff Requirement is to accept the equipment into service with provisos. These refer to issues outstanding at acceptance into service, and include matters that fall outside the contract, for which the contractor is not liable, as well as matters still unresolved from the time of acceptance off-contract, for which the contractor may be liable. In half of the cases covered by our survey, where the Staff Requirement had not been fully met, the contractor was liable for ensuring that this was rectified.

2.11 Acceptance with provisos was most common in the Land Systems area. A typical example is the Bridging for the 90s project where the Department accepted the Close Support Bridge and General Support Bridge for service use in August 1994 with one major and a number of minor provisos. The major proviso concerned a safety stop mechanism to prevent the inadvertent launch of a partially constructed General Support Bridge that had important safety implications for the

User. No deliveries or stage payments were made until the solution to the problem had been satisfactorily demonstrated in this instance, before equipment entered service.

2.12 Another example of the use of provisos in the land systems area is the High Velocity Missile. In this case, the Department used provisos to avoid delay to the introduction of the equipment into service. The result has been that there is a stock of 6,404 missiles which do not meet the original requirement but which the Department consider adequate in the short term for training purposes and which will, over time, be replaced by missiles which exceed the modified requirement. Box 1 provides further details of the High Velocity Missile case.

Box 1: High Velocity Missile

1. The High Velocity Missile is a Very Short Range Air Defence System which is required to protect land forces where there is an air threat. It is the successor to the Javelin S15 missile system. The contract for development and production of Tranche 1 of the system was placed with Shorts Missile Systems in November 1986. The Tranche 1 contract included 135 Self Propelled missile vehicles, 147 Shoulder Launched/Light Weight Multiple Launch systems and 4,104 missiles.

2. The lethality of the Missile, as assessed in development, fell short of the Staff Requirement and contract acceptance criteria at short ranges whilst exceeding them at longer ranges. Technically, it was impossible to achieve the required short-range performance at that time. Consequently, in December 1992, the Department decided to trade-off long-range excess performance against the short-range deficit and a modified lethality curve was agreed with Shorts Missile Systems.

3. In 1995, it became apparent that the Tranche 1 missiles did not meet the revised lethality criteria and that their performance was unlikely to improve in the short term. On the basis of the then demonstrated level of lethality generally exceeding that of the existing Javelin system, the User decided to accept the missile into service. However, they attached the proviso that the outstanding lethality problem should be resolved.

4. To meet User needs and to gain the cost benefits offered from continuity of production of the missile, in 1995 the Department placed two orders for a further 2,300 missiles (the Tranche 1A and 1B contracts). The orders were placed on the condition that Shorts Missile Systems undertook a Missile Recovery Programme to rectify the lethality deficiency at their own expense and the unit price was agreed on the basis that the Department would, over time, order a specified number of missiles. If the Department ordered a lower number of missiles than proposed the contract made provision for the unit price to rise. Both the Tranche 1A and 1B contract acceptance criteria reflected the performance of the then current missile build standard rather than the performance set out in the modified lethality curve and the missiles have been accepted into service on this basis.

5. By January 1997, the Missile Recovery Programme had fallen behind schedule. However, to ensure continuity of production and hence the unit price agreed in 1995 for the entire order, the Department ordered a further 1,000 missiles (Tranche 1C) from Shorts Missile Systems. Unlike the Tranche 1A and 1B orders, the Tranche 1C missiles were ordered to meet the full Tranche 1 lethality requirement. In addition, should the company fail to meet its obligations, the contract provided for the Department to avoid any price increases even if the full quantity of missiles on which the price was based were not ordered.

6. Lethality of the missiles now significantly exceeds the modified lethality curve and the Department are currently negotiating contracts for further HVM systems.

The flexible use of provisos can bring operational benefits

2.13 The use of provisos can help the Department to secure early operational benefits from the equipment being accepted, a scenario well illustrated by recent experience with the new Landing Platform Helicopter ship, HMS OCEAN. In this case, as a result of delays during the construction programme, and technical problems, the acceptance programme fell behind schedule. The ship was accepted off-contract from VSEL in June 1998, some nine months late, on the understanding that an agreed package of outstanding work would be completed at the company's expense during the Summer 1998 programmed maintenance period. At this stage, the Department concluded that the ship had reached a sufficiently mature stage to be operated safely by the Royal Navy during the remainder of the trials process. The vindication of this strategy is that HMS OCEAN successfully completed the outstanding acceptance trials, and also provided emergency relief to Honduras and Nicaragua in November 1998, yet was still handed over to Fleet in March 1999 on a date agreed in August 1997 when the complete programme was reviewed.

Provisos can become concessions

2.14 Provisos noted at the time of acceptance can sometimes become concessions. This process is illustrated by the Rapier air defence system, which was accepted into service with 88 provisos covering a wide range of problems, not all of which were shortfalls against the contract. Fifty-one of those 88 provisos have now been cleared. In some cases, the contractor Matra BAe Dynamics have corrected shortfalls at no cost to the Department, in other areas they have disputed liability. In one area of dispute the Department have accepted liability after taking legal advice and funded a modification costing some £1.5 million. Other provisos relate to minor shortfalls at the boundaries of system performance. These do not adversely affect the overall system capability but would require considerable extra design and development work at significant cost to fully meet the individual requirements, so they are unlikely to be addressed until the time of the system's mid-life update.

Deleting parts of the Staff Requirement

Deletion of requirements may have adverse operational implications

2.15 Sometimes the Department delete parts of the Staff Requirement in order to get equipments into service. Such actions may have adverse operational implications. For example, in September 1995, the self-propelled version of the

High Velocity Missile system was accepted for service and an Initial Operating Capability for the system was declared in October 1995. Formal achievement of the in-Service date was dependent on service acceptance of the two "reversionary" modes - Shoulder Launched and Lightweight Multiple Launcher - designed to increase the overall effectiveness and flexibility of High Velocity Missile users. Problems with the aiming unit common to both of these modes caused continual slippage to the trials programme and hence the in-Service date. For budgetary reasons, the Department decided to delete the requirement for the reversionary modes from their initial (Tranche 1) buy and to delay deploying the capability until the equipment procured as part of Tranche 3 (currently being negotiated) is available, hence allowing time for the problems to be solved. In the meantime, the Department are minimising the loss in capability by running-on the existing Javelin system.

2.16 The Fully Reelable Sonar Towed Array for the Trident submarine detailed in Box 2 provides another example of the operational factors which may lead the Department to delete part of the Staff Requirement.

Box 2: The Trident Submarine Fully Reelable Sonar Towed Array

1. The Staff Requirement for Trident submarines included a Fully Reelable Sonar Towed Array and Handling System. Despite the evidence of simulations, testing in a sea environment revealed a number of problems with the initial deployment and handling of the Towed Array, and with its robustness. Until these problems are resolved, a reelable cable or hybrid clip-on system is being used in which only the cable is reeled and the array attached by a tug before the submarine's departure for patrol. The array is removed in similar manner when the submarine returns from patrol. The use of a tug in this way has both cost and safety implications. There is a risk to the health and safety of the Towed Array Handling Party, which performs the array attachment and recovery operations from the tug, sometimes in poor weather conditions.

2. [****]

Accepting the shortfalls

2.17 The worst possible scenario is where the Department accept the equipment from the contractor but are forced to remedy shortfalls at their own expense - a circumstance which may arise if the Staff Requirement is not adequately reflected in the contract. Our survey showed that in one-third of projects, the contract acceptance criteria did not reflect the technical objectives of the Staff Requirement in all material respects. The reasons for such shortcomings are examined in more detail in Part 4 of this Report.

Industrial pressures can lead to performance shortfalls

2.18 Other reasons for the Department accepting performance shortcomings may be where they are forced to make early decisions by factors outside their ability to influence or where designs approved by the Department prove to be flawed. The case of RFA Fort Victoria, detailed in Box 3, provides an example of the influence which external events may have on forcing the Department to accept equipment when there are known shortfalls.

Box 3: RFA Fort Victoria

1. The Royal Fleet Auxiliary Fort Victoria is the First-of-Class Auxiliary Oiler Replenishment vessel. Its role is to provide the Royal Navy with supplies of fuel, ammunition, food and solid stores. The vessel was designed and built by Harland and Wolff under a contract placed in April 1986.

2. Fort Victoria was originally due to be accepted off-contract in April 1990 but, in the event, acceptance was almost three years late. During this time, numerous disputes arose between the Department and Harland and Wolff about the acceptance process:

- The contractor was not properly aware of the Department's acceptance criteria, and expected the inspecting authority to act as their Quality Assurance agent.
- Weapons Acceptance Staff conducted their inspection against the latest design standards, even though Harland and Wolff was not contractually obliged to keep the equipment up to such a state.
- The role of Naval Engineering Standards was obscure within the terms of the contract, and there was room for dispute as to whether the standards were mandatory, or purely for purposes of guidance.

3. Before contractor sea trials had taken place, Harland and Wolff decided to complete the outfitting of the vessel after the trials by using the labour and facilities of Cammell Laird. This was partly because of the serious problems Harland and Wolff had in managing the programme to time and also resulted from their desire to concentrate on the construction of other vessels following the takeover of the company by Fred Olsen. Acceptance off-contract was achieved in March 1993 at Cammell Laird, but from Harland and Wolff.

4. When acceptance off-contract took place, Harland and Wolff informed the Department that a larger number of defects than normal would occur. Some 13,000 defects were discovered, although half were considered to be insignificant. As the Department wanted to accept the vessel as soon as possible given that Cammell Laird was on the verge of closure, and that the end of the financial year was imminent, they agreed to write off the less significant defects. However, the Department protected their position by retaining £5 million from the final milestone payment to cover the costs of rectifying the remaining defects. Unfortunately, this sum was paid to Harland and Wolff by mistake, and it took the Department several months to recover it.

continued ...

Box 3: RFA Fort Victoria *continued*

5. Acceptance off-contract was followed by the transfer of the ship to Portsmouth where a project team formed by the Procurement Executive oversaw the 12-month Guarantee Defect Period. This team liaised with the Department's Fleet Maintenance and Repair Organisation which had enough spare capacity to undertake rectifications. Given the large number of defects involved, they concentrated on the ones which were considered to be the most urgent in making the ship operational. Among the worst problems were ill-fitted propeller shaft seals which caused oil to leak. Furthermore, some of the pipelines had been cleaned and filled with water after the contractor sea trials. These were not drained with the consequence that they rusted. The cost of the defect rectification package, carried out during the guarantee period, was calculated at £400,000. This sum formed an internal transfer within the Department using the money retained from the contract.

6. As the guarantee period was spent sorting the defects out, the vessel was not actually operational until May 1994 and problems which actually occurred whilst operating the ship were therefore not covered by the defect guarantee. In total, the Department estimate that it will have cost them some £1.4 million to rectify defects identified which would otherwise have been covered by the guarantee.

Agreeing designs can leave the Department responsible for shortfalls

2.19 For ship and submarine projects it is the Department's standard practice to approve the design of the ship whilst it is being built. Sometimes, the design which the Department have approved has proved inadequate for the task, a fact which will not be clear at the time of acceptance if the operating parameters of the ship are not fully explored. This was the case with the first batch of five Single Role Minehunters which were accepted before operations in high sea states had been fully demonstrated. Subsequently, the recovery of the Remote Control Mine Disposal System or "yellow submarine" was shown to be problematic in the high sea states specified in the Staff Requirement and recovery over the stern assessed as unsatisfactory owing to turbulence caused by the ship's motion. The Department have put in place "work around" procedures for recovery in current operations and, as a result of various studies which they have funded, have decided to redesign the crane and to introduce revised procedures and a number of other modifications to enable the crew to reach further out when hooking on. This improved arrangement has been introduced into the design of the second batch of seven vessels which are currently under construction and the Department have purchased replacement cranes for the first five vessels which will be installed at the earliest refitting opportunity for each vessel. The Department will be required to pay for the improvements on these five vessels because the contractor fulfilled his contractual obligation and built the vessels according to the drawings and standards approved by the Department at the time of contract placement.

Summary

2.20 Our survey showed that, at the time decisions were made to accept equipments off-contract, some 40 per cent of equipments met the approved Staff Requirement for that equipment in full. In most cases where Staff Requirements were not met, the Department made concessions on performance requirements because they considered the shortfalls had no operational significance. Sometimes, they accepted equipments subject to provisos that defined shortfalls were to be fixed - although we found that this did not always happen. In some cases where equipments were accepted which did not meet the Staff Requirement, the Department were forced by poor contractual definitions, or by industrial or other factors, to accept such equipment and then remedy shortfalls at their own expense. The next Part of this Report explores the acceptance processes followed and the extent to which they contribute to this situation.

Part 3: Planning and managing the acceptance process

Introduction

3.1 The acceptance process is central to the successful delivery of an equipment or operational capability to the Front Line user and spans virtually the entire length of an equipment procurement project's life, even though most acceptance effort may be concentrated in the later testing and trialling phases. This Part of our Report reviews the quality of acceptance planning, the success of the trialling and evaluation techniques selected, and how the outcome of the acceptance process is agreed.

Differences of approach between the services

Each of the services has adopted slightly different approaches to acceptance

3.2 Each of the sea, air and land environments has developed slightly different acceptance approaches, which reflect the different circumstances of particular equipment types, the numbers of equipments being accepted, and different traditions of equipment management. Thus:

- **Sea systems** are usually subject to progressive acceptance whereby they are involved in an almost continuous series of trials that begin during the earliest stages of build and are only completed shortly before the ship is formally accepted for full operational service. Given the diversity of the weapons and sensor systems, it may be some time before Fleet Acceptance of a ship or submarine is achieved. Moreover, for the first ships of a class a more comprehensive series of trials, of both weapons and platform systems, will be conducted, typically at climatic extremes in the Arctic or in the Tropics to prove the effectiveness of various systems in such conditions.

- **Land systems** acceptance tends to be characterised by the need to demonstrate the performance of large numbers of equipments with acceptance off-contract and into service often happening virtually

instantaneously. Ideally provision will be made for testing not just of initial deliveries but also of later batches of the equipment to ensure continued compliance with the Staff Requirement.

- **Air systems** undergo a type of acceptance procedure which culminates in the issue of a Release to Service certificate prior to Service Use. This is equivalent to a civil Certificate of Airworthiness, and is issued in addition to any trialling carried out beforehand by the contractor, which tends to be limited to ensuring that the aircraft complies with the contract specification. The Release to Service certificate includes a Military Aircraft Release that indicates that the equipment and its weapon systems have performed to an adequate standard and are safe for use. It also states any limitations and restrictions to be observed in use, defines the build standard, and includes any essential modifications that must be in place before the equipment can undertake a particular task. Once Military Aircraft Release is achieved, in-Service trials will be conducted by the User to establish performance over a specified range of environmental parameters within the required operational envelope. Subsequent deliveries will be subject to less rigorous testing to ensure that they comply with the accepted design.

Planning for acceptance

3.3 The Department must plan for the acceptance process if that process is to be cost-effective. The Department's new Smart Acceptance procedures are intended to provide a basis for such planning but their existing guidance provides only a general steer on the adoption of a cost-effective approach. The following paragraphs draw on the outcome of a number of individual projects to examine the quality of the Department's planning for acceptance against three main criteria:

- Whether the right acceptance strategies were put in place (paragraphs 3.4-3.7);
- Whether risks were identified and minimised (paragraphs 3.8-3.15); and
- Whether suitable test and evaluation techniques were selected (paragraphs 3.16-3.29).

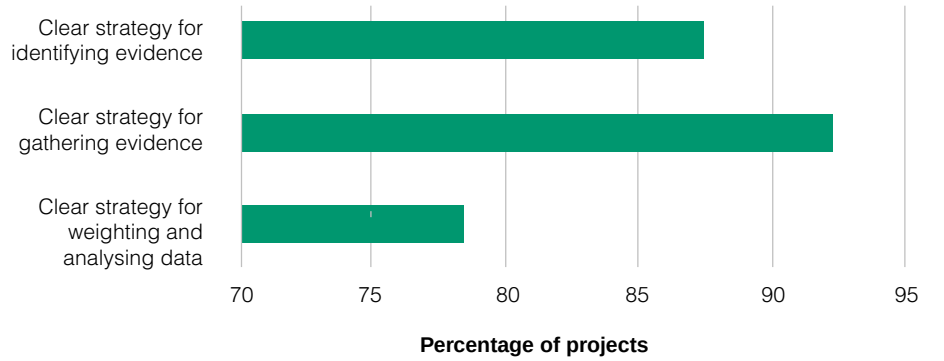
Putting the right strategies in place

Most projects had acceptance strategies in place

3.4 Figure 6 shows that the vast majority of projects had strategies in place for identifying, gathering, weighting and analysing the evidence required to demonstrate equipment performance. Notable exceptions were the first two Trident submarines where there was no overall strategy for testing as the platforms and particular systems such as the reactor, strategic weapons, and tactical weapons were run as distinct projects. The situation was exacerbated by the fact that equipment performance and reliability requirements were poorly expressed in the Staff Requirement thus militating against the gathering and proving of useful data.

Figure 6

The extent to which projects had acceptance strategies in place



Source: National Audit Office

Comment: The vast majority of projects had clear acceptance strategies in place.

Drawing up acceptance strategies is difficult

3.5 Devising a cost effective acceptance strategy is difficult. Over half of the projects surveyed reported difficulties in demonstrating aspects of equipment performance at the time of accepting equipment off-contract. And for 85 per cent of projects surveyed, additional trials were required to demonstrate performance before accepting equipments into service. In 40 per cent of these further trials, problems emerged when comparing performance with the Staff Requirement.

3.6 The main causes of difficulty were in demonstrating the reliability of equipments and their performance in specified environmental conditions. In particular, demonstrating performance in specified environmental conditions caused difficulties on one third of the projects we surveyed both in accepting equipments off-contract and into service. The C-130J Hercules aircraft produced

by Lockheed Martin provides a good illustration of the challenges faced. In 1997, the test and evaluation programme at Lockheed Martin, which was already behind schedule, was further delayed because of the stringency of the United States Federal Aviation Authority's testing requirements for the aircraft's de-icing system and the difficulties Lockheed Martin experienced in finding the appropriate testing environment to comply with these regulations. When the C-130J was originally devised, no specific customer existed. Lockheed Martin therefore had no particular flight certification regime to test to and decided to use American civil requirements and gain Federal Aviation Authority clearance. The Department subsequently decided to procure the C-130J and built its testing requirement on the back of an existing regime rather than start afresh. This strategy has allowed the Department to limit their own testing to that necessary to explore the performance of the aircraft's systems and its performance in delivering supplies and equipment which are required to achieve Military Aircraft Release.

Acceptance strategies were not always adequate

3.7 As our analysis of the success of the trialling and evaluation techniques used by the Department at paragraphs 3.16 to 3.25 demonstrates, the strategies in place did not always fully address all of the relevant acceptance issues, suggesting that there is scope to improve the quality of acceptance planning. But in some cases, even where suitable evaluation techniques were identified, acceptance was still problematic owing to circumstances which the acceptance process could not reasonably address. For example, on the Tornado Reconnaissance Exploitation Facility communications system, testing was problematic since the system has a capability not yet realised in other service areas. In another case, the Harrier Missile Approach Warning, installed performance was impossible to duplicate accurately in a safe manner owing to the hazardous nature of the circumstances in which the equipment is required to function.

Identifying and minimising risks

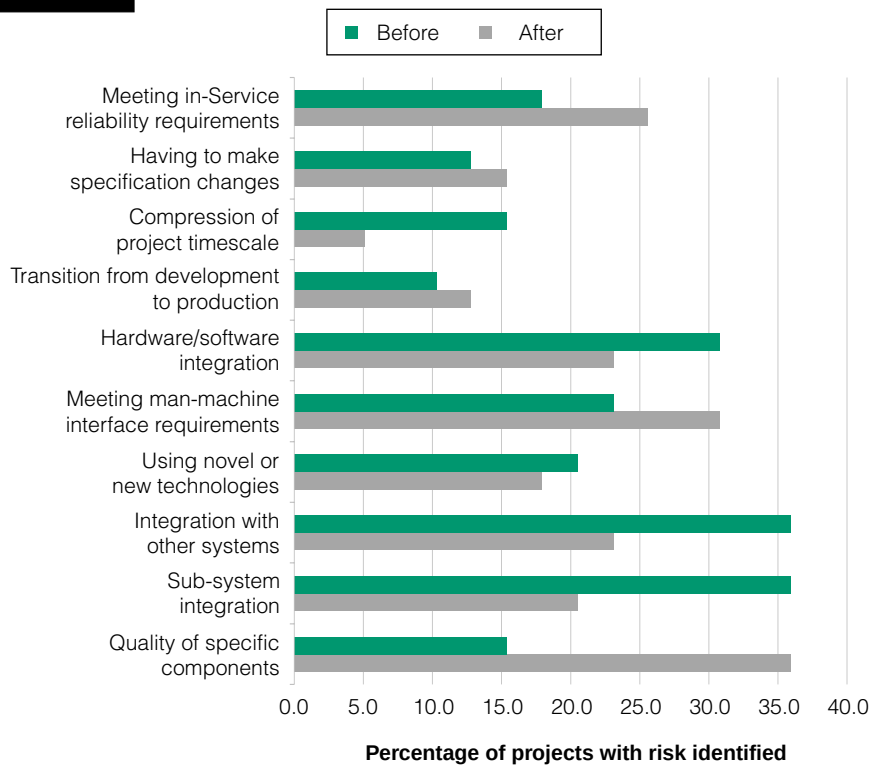
3.8 Another dimension of acceptance planning is the extent to which major risks are identified and managed. While all important elements of performance need to be tested, an efficient acceptance process should pay special attention to monitoring the high risk elements of the project. The significance of under estimating a type of risk is that any resulting problem is more likely to emerge late in the day, and so cause delay, or perhaps, extra costs. The following paragraphs outline the extent both to which risks were identified at the outset and matured into problems during the project.

In half the categories examined more difficulties emerged than were identified as risks at the outset

3.9 Figure 7 shows that in half of the categories of risk identified by our survey fewer risks matured than were identified at the outset. This suggests that in these cases, the Department had successfully managed out some of the risks identified but that, on the other five categories, their risk identification and management track record was less satisfactory. The most common problem to emerge was the quality of specific components which arose on more than twice the number of projects – one-third of the total number we surveyed – than anticipated at the outset. These tended to be identified during testing and remedied. The following paragraphs explore in more detail some of the more significant reasons for the difficulties that did emerge.

Areas of risk

Figure 7



Source: National Audit Office

Comment: In half of the categories of risk more difficulties emerged than were identified at the outset

Human factors must be taken into account early in the design and acceptance process

3.10 The acceptance of Trident nuclear submarines illustrates the way in which human factors can influence the acceptance process and can lead to specification changes. In this example, the requirement for adequate space for recreational activities and access for maintenance emerged late in the build and could only be met by amendments to the contract which resulted in an expensive compromise. The Department have learnt from their experience on this project that Specialist Human Factors Engineering principles need to be employed from the outset so that more attention can be paid to compartment layout, seating, lighting, information flow, ease of access and maintenance, personal safety and other habitability issues.

Underestimating technical risk at the outset can lead to problems further downstream causing delays and cost overruns

3.11 [****]

3.12 [****]

The Department's track record in managing reliability risks is mixed

3.13 Another area of risk which has caused the Department more difficulties than they had anticipated was achieving specified levels of equipment reliability. On some of the projects which we examined, the Department had put in place successful strategies to manage such risks. For example, on a project to provide a means of dispensing chaff and flare countermeasures on Tornado aircraft, the system was accepted off-contract without fully meeting the specified reliability requirements and with full acceptance dependent on successful completion of an In-Service Reliability Demonstration. The demonstration resulted in four modifications at no extra cost to the Department.

3.14 In another case, following problems with reliability during development of the Spearfish torpedo, the Department included provision in the production contract for in-water testing of all torpedoes. If the results are unsatisfactory, production of torpedoes will be stopped until causes are identified and remedies incorporated. The contract includes batch and cumulative reliability clauses that allow the Department to retain payments until reliability requirements are met.

Spearfish Heavyweight Torpedo

3.15 In contrast to these examples, on the Challenger II tank the Department's acceptance strategy proved inadequate, even though reliability considerations featured explicitly in the contract which made provision for an In-Service Reliability Demonstration. However, in this case, the contract also provided for a Production Acceptance Test, to be carried out by the contractor, Vickers Defence Systems, which was designed to confirm that vehicles had achieved the specified performance criteria. The tank passed this test but failed a subsequent Production Reliability Trial conducted by the Department which showed that the tanks' reliability was significantly lower than the contracted requirement. Given that the tanks had passed the mandated acceptance test, the Department's considered opinion was that they could not subsequently reject the tanks on reliability grounds.

Choosing and applying the right testing and evaluation techniques

All projects used some form of controlled or real-world testing

3.16 Acceptance plans should specify an appropriate range of tests and trials, and schedule them to best effect. The circumstances and requirements of individual equipments will govern the options available and final selection of tests and trials. There are two main types of tests available for most equipments – controlled or real testing, and simulation. Whilst we found that every equipment surveyed used some form of real testing, 30 per cent of projects also used simulation. Figure 8 summarises the advantages and disadvantages of each type of test. The following paragraphs explore how the techniques have been applied in practice.

Figure 8

The Alternative Means of Testing and Trialling used by the Department

Type of test/trial	Advantages	Disadvantages
Simulation	■ Flexibility ■ Speed	■ High set up costs ■ Difficulty in validating results
Controlled or real testing	■ Greater certainty about performance in specific conditions ■ Yields a better general picture of performance	■ Less certainty about the causes of certain types of shortfall ■ Difficulty undertaking tests across the full range of environmental conditions

Source: National Audit Office

Comment: The Department use two types of test to accept equipment.

Simulation can reduce costs but must be validated

3.17 [****]

Acceptance based on demonstrations in conditions unrepresentative of their future operating environment can mask shortcomings in real-world performance

3.18 Problems have also arisen in the testing of equipment in conditions unrepresentative of their future operating environment. The Sonar 2054 suite installed on Trident submarines was the first fully integrated sonar suite to be developed for the Royal Navy. Problems arose because there was no representative platform available on which to conduct full scale testing at sea prior to the design being frozen. The Department tried to reduce the risks posed by conducting sea trials of some component parts of the system and providing a land based testing facility but recognise that reliance on these fallbacks - in conjunction with a factory based acceptance demonstration - contributed to performance and reliability problems subsequently experienced with Sonar 2054. These problems led to a delay to Fleet Weapons Acceptance currently estimated at nearly five years.

Progressive acceptance of Sea Systems has not always identified problems

3.19 Sea Systems equipments often employ "progressive" acceptance because of the impossibility of validating every aspect of a ship's build and performance after the vessel has been built – for example, where spaces may be sealed for life. For the First of Class Trident submarine, HMS Vanguard, Departmental staff sited at VSEL's shipyard undertook progressive acceptance that involved inspection of systems, equipment and compartments during installation and build. In addition, those staff witnessed tests carried out on systems and equipment by the shipbuilder, and validated the achievement of milestones in a milestone payments plan. The merits of this approach are the possibility of early action to remedy any defects, the reinforcement of milestone incentives and the lessening of the testing burden at final acceptance stages.

3.20 However, such progressive testing has not always been successful in preventing acceptance problems. For example, whilst still at VSEL, a basin trial for the new Landing Platform Helicopter ship, HMS Ocean, disturbed debris in the bottom of the dock and a discarded electrical cable became entangled in the port propeller shaft causing damage to the aft bracket bearing. During rectification work on the port shaft bearing, the stern bush bearing material was found to have been designed 50 per cent undersized for the loads involved - despite having been

inspected and accepted by sub-contractor and insurance surveyors. Both propeller shafts have had to be withdrawn so that larger sized bearings could be inserted. The technical investigations have been completed and professional claims adjusters are assessing the Department's liability for a proportion of the costs under the contract indemnity.

Trials using specialist test staff may not represent the activities of Service Users

3.21 In acceptance trialling, specialist trials staff, such as test pilots for aircraft, whose levels of expertise are higher than those who would normally operate the equipment, will often test equipments. This practice yields benefits from the expertise of such staff, but also carries two main risks. First, trials staff tend to be selected from the more experienced and able equipment operators who may not always react to situations in quite the same way as a normal operator does. Secondly, their higher levels of skill may permit them to operate the equipment in a manner that would not be typical of the normal service operator.

3.22 The Department experienced several problems relating to the second of these points with the acceptance of six Sea King Mk. 3a Search and Rescue helicopters. The aircraft's autopilot was thoroughly tested during Military Aircraft Release trials, and no problems were found. However, once the Mk. 3a entered service, problems arose. Test pilots, who had performed the bulk of the acceptance trialling, had tended to position the adjustable pilot's seat to middling settings. However, Service Users tended to fly with the seat fully forward and up to allow a better view out of the cockpit which increased the likelihood of fouling the helicopter's flight controls, with the possibility of accidentally disengaging the autopilot. Despite some User involvement during acceptance trials, their contribution was not sufficient to prevent the later in-Service problems which have now been resolved by the manufacturer GKN Westland re-positioning the cyclic stick to reduce the likelihood of fouling at no extra cost to the Department. It is now the Defence Evaluation and Research Agency's policy to involve the User as fully as possible in acceptance testing.

Acceptance of strategies where large numbers of equipments are being procured must reflect potential variations in standard production

3.23 Contracting for land systems acceptance is often characterised by the need to demonstrate performance and accept large numbers of equipments. The AS90 self-propelled gun provides a good example of a successful contractual acceptance strategy. The Department used the Defence Evaluation and Research Agency to

conduct range and accuracy tests, and also tests of the strength and design of the barrel. These tests were carried out in controlled conditions. Broader tests of the vehicle and firing under "real" conditions were also conducted during User Trials on Salisbury Plain. These included tests of mobility, navigation, communication, stowage, towing, safety, night driving and live firing. Over 80 rounds were fired by detachments wearing protective clothing against nuclear, biological and chemical threats. These trials, largely successfully completed, gave a good picture of the equipment's likely real world performance, and formed the basis for the equipment's acceptance off-contract.

3.24 In addition to these tests, there was also a subsequent In-Service Reliability Demonstration that comprised 11,200 rounds fired from an eight gun battery of AS90s, and 6,000 km of running on road and across country. These tests were equivalent to 80 Battlefield Days, as specified in the contract. The Demonstration was also completed satisfactorily, with a few minor problems revealed which have since been rectified.

3.25 However, acceptance has not always progressed as smoothly where evaluation and testing regimes were not as comprehensive or as clearly stated in the contract as in the AS90 example. The RB44 Heavy Duty Utility Truck case described in Box 4 illustrates this.

Box 4: The RB44 Heavy Duty Utility Truck

1. In June 1988, the Department placed a contract worth some £25 million with Reynolds Boughton for 846 Heavy Duty Utility Trucks – known as the RB44 - to meet a requirement to replace the ageing 1 tonne Land Rover fleet. The RB44 was selected following evaluation trials of one vehicle type from each of three contractors. Although the RB44 used in those trials met the stated requirement and complied with road traffic legislation, the user mandated changes to the production vehicles' design to refine its braking efficiency.

2. The Reynolds Boughton contract provided for the first ten vehicles produced to be validated against the Statement of Requirement in a series of trials following which the Department would consider whether to exercise an option to buy the remaining vehicles. These main production vehicles were to be manufactured to the agreed build standard as set and proved through the series of trials. Reynolds Boughton's quality assurance procedures and their production testing were to ensure this, as stipulated in the contract. The validation trials began in September 1989 and raised concerns about the braking efficiency.

continued ...

Box 4: The RB44 Heavy Duty Utility Truck *continued*

3. Incorporating the mandated changes, a manual transmission to improve off-road handling and further modifications to enhance the braking system, cost the Department some £940,000. Following the successful completion of the validation trials, the design of the vehicle was formally accepted in May 1990 and the production option exercised. However, in April 1991, following delivery of the production vehicles to Units, braking faults began to appear. The Department therefore carried out brake tests on 18 RB44s to determine the cause. Half of these vehicles were assessed as having unsatisfactory performance. Reynolds Boughton argued that the problems were caused by the brakes "bedding-in". Given the low utilisation of the fleet, that "bedding-in" is a recognised phenomenon, and the successful demonstration of the vehicle prior to acceptance, this argument was accepted. But the Department continued to monitor the position. After Units continued to express concern with the braking performance, the Department conducted additional investigations, after which deliveries of RB44 were suspended in September 1992. Deliveries only recommenced when Reynolds Boughton demonstrated a modification which appeared to resolve the problem and which was incorporated on all of the RB44s already delivered at no cost to the Department.

4. By August 1993, the braking problems had recurred with the Royal Electrical and Mechanical Engineers reporting that 37 out of 57 in-Service vehicles investigated had a tendency to deviate to the left when braking at 35 mph. Vehicles being used on United Nations peacekeeping duties in Bosnia were reported to be experiencing similar problems and were withdrawn from service. Finally, in December 1993, the Quartermaster General declared all RB44's "vehicle-off-the-road". Investigations by the Department discovered that maintenance on the vehicles in storage had been suspended and that some Units were applying incorrect maintenance procedures.

5. Responsibility for rectifying the performance shortcomings was the subject of negotiation between the Department and Reynolds Boughton. The company argued that the Department should pay for any modifications required because the vehicle had successfully completed its trials and been accepted into service. The Department continued to argue that liability rested with Reynolds Boughton given that the inherent problem lay in the original design.

6. In the event, both parties contributed to the necessary work. Reynolds Boughton estimate that they spent about £250,000 between January 1994 and September 1995, whilst the Department estimate that in total they have spent some £1.5 million to resolve the braking problems and to make the vehicle fit for service use. These changes included modifications to the build standard to reduce both suspension-related steering characteristics and sensitivity to any shortcomings in the maintenance regime. (These figures ignore the £1.7 million additional storage costs incurred and the operational implications of having to run on the existing 1 tonne vehicles.)

Agreeing the outcome of the acceptance process

Analysis of acceptance options is predominantly qualitative

3.26 In 40 per cent of the cases surveyed, equipment performance matched or exceeded requirements and the decision to accept was therefore straightforward. In the remaining cases where some form of remedy or concession was needed, analysis of options - in terms of operational, cost and time implications - was largely qualitative, and consensus was reached through discussion and argument

between the main stakeholders. This contrasts with the sort of extensive and expensive modelling and analysis which underlies both the formulation of Staff Requirements and the evaluation of contractors' bids.

Those involved in the acceptance process usually reached a consensus on decisions

3.27 Our survey showed that in 90 per cent of cases, there was consensus on the way forward. Where differences of view were evident, they ranged in nature from situations where the Department had to make judgements on the merits of conflicting advice from non-executive organisations involved in the acceptance process (illustrated by the Chinook Case Study in Box 5) to those related to internal definitions, such as on the Boxer programme.

3.28 Project Boxer is a high capacity trunk telecommunications system. At the conclusion of the acceptance process in early 1998, there was a dispute between the Procurement Executive and the User over the exact definition of the in-Service date. The User would not acknowledge that the in-Service date had been achieved until it perceived the whole system to be in place and operationally functioning. However, the Procurement Executive argued that as some 97 per cent of the system was complete and working at this time, this was sufficient for the system to be declared operational. In the end, the system was finally accepted into Service in November 1998 when the Procurement Executive was able to assure the User that the outstanding issues could be resolved.

A typical Boxer site

Box 5: Chinook MK 2 Mid-Life Update

1. In 1990, the Department placed a £143 million contract with Boeing Helicopters to upgrade 32 Chinook Mk1 helicopters to the Mk2 standard. The conversion involved the replacement of the transmission, hydraulic and electrical systems, various structural modifications and fitting converted modified Textron-Lycoming T-55 engines and a Full Authority Digital Electronic Control system (FADEC). The FADEC maintains the correct balance between the fuel flow, and therefore power output, of the Chinook's two engines which reduces pilot workload and makes the aircraft "easier" to fly. It is made up of a computer system which utilises inputs from various sensors to measure the amount of fuel that the helicopter's engines need, and a mechanical system which delivers the correct amount of fuel.

2. Because of the extent of the upgrade, the Mk2 was designated a new type within the United Kingdom fleet and the aircraft therefore had to receive United Kingdom military airworthiness certification – then called Controller Aircraft Release - before being returned to operational service. This involved the aircraft being put through a series of ground and flying trials costing some £1 million by the Defence Evaluation and Research Agency based at Boscombe Down.

3. As part of these trials, Boscombe Down wished to verify the software in the FADEC system using their preferred method known as Static Code Analysis. This element of the trials programme accounted for roughly ten per cent of the overall costs and a contract was placed on EDS-SCICON, an expert software engineering and testing company, for this purpose. In verifying the software, EDS-SCICON divided the anomalies which they found into four categories, with category 1 being the most significant. In their view, well developed software should contain none or very few category 1 and only a small number of category 2 anomalies. However, by the time EDS-SCICON had tested 18 per cent of the lines of code in the FADEC software they had already identified 21 category 1 and 154 category 2 anomalies in the software structure and documentation. Having discovered such a high incidence of anomalies at such an early stage, EDS-SCICON stopped testing because the way the software had been written made it unsuitable to full verification using the Static Code Analysis technique. The Department chose to terminate the EDS-SCICON contract at this point because the requirement for Static Code Analysis was an internal Boscombe Down policy, not supported by Defence Standards. The anomalies identified by EDS-SCICON were all reviewed by the equipment's Design Authority, who confirmed that whilst undesirable, none of them represented an airworthiness concern.

4. On the basis of EDS-SCICON's work, in October 1993, Boscombe Down advised the Department that they could not recommend Controller Aircraft Release for the Chinook Mk2 because of the "unquantifiable risk associated with the unverifiable nature of the FADEC software," and concluded that rewriting the software was essential.

5. In making their recommendation, Boscombe Down recognised that operational use of the Mk2 might be necessary before re-written software became available and provided a set of recommendations which were intended to allow flying if necessary but which would mitigate any consequent risk associated with their concern over potentially unpredictable FADEC software behaviour. In recognition of Boscombe Down's continued, but unsubstantiated concerns, the Department accepted their advice and restricted the loads carried by the Mk2 to ensure that the helicopter's all-up mass did not exceed 18,000 kilograms – the level at which the helicopter can fly normally with only one engine functioning – and a reduction of 26.5 per cent in load carrying capacity compared with the Staff Requirement. This precautionary limitation had a minimal impact as 90 per cent of all operations are carried out within the 18,000 kilograms limit. In March 1994 the restriction was relaxed to apply only to internal loads since underslung loads to an all-up mass of 22,700 kilograms (as specified in the Staff Requirement) could be jettisoned in an emergency.

6. As a result of the concerns raised about the software, the FADEC manufacturer has addressed some of the anomalies within the software, and produced an improved version which was then subjected to a Sneak and Traceability analysis to gain further confidence in its integrity. In September 1998 the Department, with the Royal Air Force's consent, issued full Controller Aircraft Release for the Chinook Mk2, removed the internal carriage all-up mass restriction for internal loads and allowed the Mk2 fleet to operate to the maximum payloads specified by Boeing which are 21 per cent higher than those specified in the Staff Requirement. In making the decision to issue full Controller Aircraft Release, the Department, as is their right as executive airworthiness authority for the aircraft, weighed the advice of Boscombe Down against other factors, including the equipment's Design Authorities and the consequences of failure, and concluded that the aircraft could be cleared for safe flight within the parameters identified. Notwithstanding the internal differences of opinion over FADEC, there were no significant impacts on acceptance into service and the Chinook Mid-Life Update was delivered on time, below budget and provided a significant increase in payload capability compared to the Staff Requirement

Acceptance decisions can have unexpected operational implications

3.29 In other cases where qualitative judgements have been made to accept equipments into Service despite shortcomings against the Staff Requirement, the operational implications have been greater than expected. For example, on the Sea King Mk. 3a, the aircraft's radio service can sometimes be swamped by excessive interference. The Defence Evaluation and Research Agency highlighted the problem during Military Aircraft Release trials, but despite the irritating effects of interference, the aircraft was passed fit for use with the recommendation that this problem should be rectified. In-Service experience has shown that when the aircraft is flown close to high power civilian radio transmissions, the receiver picks up a multitude of local domestic radio transmissions. This was the major flight safety constraint on the aircraft, and a trial concerning the introduction of filters to eradicate external radio traffic has been completed and modification action is in hand.

Summary

3.30 The acceptance process varied between air, sea and land environments, reflecting the different scale and nature of procurements involved. There was little guidance available on how to construct cost-effective testing and trialling plans. Whilst virtually all of the projects examined had put in place acceptance strategies, over half reported difficulty in demonstrating aspects of equipment performance. Acceptance strategies and project risk assessments tended to emphasise the importance of integration risks, while underplaying potential problems with reliability and the quality of individual components. While the Department's considerable experience in testing and trialling meant that most performance defects were identified before acceptance decisions were made, in 40 per cent of those cases where further trials took place, problems arose late in the day. Decisions on the outcome of the acceptance process were largely qualitative and, whilst stakeholders usually reached consensus, there were some differences of view evidenced and in some cases the decisions reached had unexpected operational implications. The next Part explores the significance of contracting for acceptance, and the extent to which acceptance processes and taut contracting are mutually supportive.

Part 4: How the Department contract for acceptance

Introduction

4.1 The acceptance process can run smoothly only if the contract with the equipment provider fully reflects the objectives of the Staff Requirement and the specific characteristics of the equipment being procured and provides some means of redress for the Department if the contractor fails to achieve the objectives specified in the contract. This Part of our Report examines:

- The extent to which contract acceptance criteria reflect the Staff Requirement (paragraphs 4.2-4.8); and
- Whether the Department secure appropriate recompense for shortcomings highlighted by acceptance (paragraphs 4.9-4.21).

Whether contract acceptance criteria reflect the Staff Requirement

Acceptance criteria in one third of contracts did not fully reflect the Staff Requirement

4.2 Figure 9 shows that, in one-third of cases examined the contract acceptance criteria did not fully reflect the Staff Requirement. This represents a weakness which prevents the Department from ensuring that the equipment contracted for meets their performance requirements and may result in them being forced to bear the cost of rectifying the shortcomings. The consequences of failing to match the contract to the requirement vary as the following paragraphs illustrate.

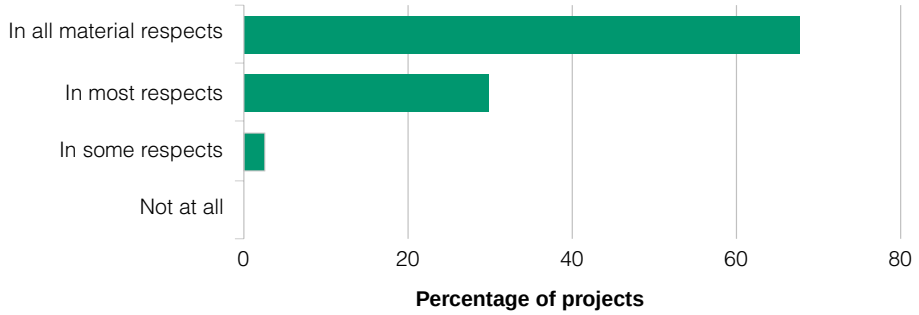
Poor contractual specifications can lead to performance shortfalls and extra costs

4.3 The Radar Type 996, which entered Service in 1991, is the prime sensor for ship defence against aircraft and anti-surface ship missiles, providing target indication to both the Seawolf and Sea Dart missile systems. It is widely fitted to Royal Navy ships including aircraft carriers, the Landing Platform for Helicopter ship, Type 23 frigates and Type 42 destroyers. It is expected to remain in service

How contract acceptance criteria reflect the Staff Requirement

Figure 9

How fully did the contract acceptance criteria reflect the Staff Requirement?



Source: National Audit Office

Comment: In one third of cases, the contract acceptance criteria did not fully reflect the Staff Requirement.

until at least 2032. The radar was procured from Siemens Plessey Systems (now British Aerospace Defence Systems Ltd) as an "off the shelf" solution against a Cardinal Points Specification in 1983. Even though Siemens Plessey Systems achieved the performance specified in the Cardinal Points Specification the system did not fully meet the Staff Requirement owing to shortcomings in object tracking performance and low operational availability.

4.4 Since 1992 various tracking improvements and modifications have been made to the existing track extractor and to improve availability which have provided some improvement in performance. However, the performance required to meet the Staff Requirement in full can only be delivered through procurement of a new track extractor and, in April 1999, the Department therefore placed a contract with British Aerospace Defence Systems Limited to achieve this end. At the same time, the Department also placed a separate contract with British Aerospace for an Availability Improvement Programme to address the outstanding availability difficulties. Taking into account actions since 1992 and the value of the two contracts placed in April 1999, the overall cost of remedying shortfalls against the Staff Requirement is expected to be £45.1 million.

4.5 A similar problem occurred when the Department contracted for a Central Computer Facility for the Royal Artillery Range Hebrides. The facility allows range staff to monitor and control the conduct of live firings for various weapons and targets. In this case, the Staff Requirement did not define any acceptance guidelines and the contract allowed the contractor, GEC Marconi Radar and Defence Systems, to conduct minimal testing which resulted in failures during User acceptance testing. The User acceptance tests had to follow "initial"

acceptance off-contract because the equipment was owned by the contractor until then. Extensive rework was undertaken at no cost to the Department but parts of the requirement, for example the need to track SKYFLASH missiles, were deleted.

Including ambiguous acceptance criteria in contracts can have detrimental implications

4.6 In order to avoid disputes with contractors it is important that contract acceptance criteria are expressed in a clear, unambiguous way. For example, the complex contract acceptance criteria for Bridging for the 90s resulted in several contradictory requirements being highlighted during development allowing the contractor to fulfil the one of his choice. The problem stemmed from the fact that Bridging for the 90s is a complex system doing a wide range of jobs. The requirement detailed certain performance criteria, but also referred to other documents such as standard military Bridging specifications.

Bridging for the 90s

In some instances there were contradictions in detail between the documents called up. When this occurred, the conflicting statements were reviewed and in some circumstances the contractor was allowed to offer a solution which did not satisfy both provided this met the requirement to the user's satisfaction. An example was the requirement for one Main Battle Tank at a time to cross a 32 metres General Support Bridge. This contrasted with another document called up ("Trilateral Design and Test Code for Military Bridging") which mandated an ability to cross tanks at a spacing of 30.5 metres which in theory meant that two could be on a bridge at any one time. After consideration, the Department relaxed

the 30.5 metres tank spacing requirement as it had no material impact on performance. The Department have learned lessons from this difficulty on subsequent bridge programmes.

Buying overseas can lessen contractual protection against shortfalls

4.7 It has also proved difficult to match contractually binding acceptance terms to the Staff Requirement when equipments have been purchased from overseas. In particular, when using the United States Foreign Military Sales system, the Department's order is usually added to existing orders for the equipment with the United States Government acting as purchaser. In the case of the Advanced Medium Range Air-to-Air Missile (AMRAAM), the Department used the technical acceptance criteria employed by the United States Government for its own missiles. Box 6 highlights the difficulties which such restrictions can cause.

Box 6: The Advanced Medium Range Air To Air Missile (AMRAAM)

1. Foreign Military Sales was the only means by which the United States Department of Defense would allow the Department to purchase AMRAAM. Under this arrangement, the Department did not have a direct contract with the prime contractor, Raytheon, and relied on United States Department of Defense acceptance procedures, and on its own firings, which were necessarily few in number, for evaluations of the suitability and safety of AMRAAM on UK platforms.

2. [****]

3. [****]

4. The over-arching issue for the Department now is one of confidence in the missile's operational deployment on United Kingdom aircraft types. Given the different environmental conditions to which the United Kingdom missiles may be exposed compared to the United States missiles, sufficient evidence must be available to guarantee that missiles remain safe and serviceable.

5. In the case of chaff and fuzing, the Royal Navy have initiated a programme of in-Service firings to understand the weapon performance sufficiently for tactical development purposes. The United States Government is currently denying direct access to such information.

6. We noted the restrictions on the availability of technical data on AMRAAM in the Major Projects Report 1994. At that time we recommended that pressure be maintained on the United States authorities to provide the technical information required to assess AMRAAM's capability. In 1998, the United States Department of Defense lifted this prohibition and authorised commercial sales of AMRAAM to the Department through a direct contract with Raytheon. This may help to prevent the problems outlined above from occurring again in the future.

4.8 The Department experienced similar problems with the availability of technical data from the United States against which to conduct acceptance when they procured a sensor system update for the Canberra aircraft which was outside the Foreign Military Sales system. The procurement was partially satisfied by a co-operative programme called RADEOS (RApid Deployable Electro Optical

System) whereby the United States Department of Defense supplied certain elements of the sensor system update to the United Kingdom on long-term loan. The Department then supplied these items to the prime contractor, FR Aviation Ltd., as Government Furnished Equipment. However, technical information on the systems was not forthcoming from the United States Department of Defense and this has caused difficulties for the Department in deciding whether to accept the upgrade when problems arose with the functional performance and reliability of some of the equipment.

Securing appropriate recompense for shortcomings highlighted by acceptance

4.9 Our survey showed that in half of the cases where the Staff Requirement was not fully met, the Department made concessions against the specified requirement. Our analysis has also shown that problems with the acceptance process have, on occasion, led to delays in equipments entering service and that there have been difficulties demonstrating reliability and the satisfactory performance of equipments. The following paragraphs show the varying extent to which the Department secured suitable financial recompense through the use of contractual provisions where these and other such difficulties have occurred.

Concessions do not always result in financial or other benefits in return

4.10 Our survey showed that the granting of concessions to contractors was not always accompanied by any financial recompense. While many concessions are granted to record minor deviations from the specification and have minimal financial value, it is nevertheless surprising that such benefits have not, in the past, been pursued in more cases as the contractor will normally price the work at the outset against the contractual requirement.

4.11 The Department's track record in securing financial recompense for concessions granted on the Trident submarine programme provides a good example of the difficulties that may occur in agreeing concessions on ships and submarine projects. In the case of the first submarine, HMS Vanguard, although the Department granted concessions to VSEL there was a dispute over whether financial benefits were due to the Department. In the end, the Department received a reduction of £500,000 in the contract price. The same problem occurred with the second vessel, HMS Victorious, where the majority of concessions were again granted without financial compensation. In the end, a reduction of £250,000 was agreed in the final price in exchange for over 1,000 major concessions which had

been made piecemeal to progress the programme. In this case, the Department had not kept a record of any related monetary values, thus weakening their negotiating position. Learning from this experience, the Department have maintained such a record for use during the final pricing of HMS Vengeance.

4.12 On more recent projects – and in line with their new Smart Acceptance procedures - the Department have told us that they expect a commensurate reduction in the contract price before a concession is granted and have highlighted the following cases which are outwith our survey sample, but where concessions led to a price reduction. These examples are listed in Figure 10.

Examples of Concessions leading to a Price Reduction

Figure 10

Project	Concession	Price reduction
SKYNET 4, Stage 2	Omission of Electromagnetic Capability testing and computer security evaluation	£57,500
Local Data Communications Network, Phase 1	Requirement to tag cabling every 5m waived	£14,000
Blue Vixen Radar	Relaxation of burn in time	£39,000

Source: Ministry of Defence

Comment: Concessions can lead to the Department being recompensed.

Warranties can provide quick and comprehensive remedies

4.13 The Department can protect itself from the financial and operational consequences of defects which arise after acceptance off-contract by including warranty provisions in the contract. Our survey found that warranties had been negotiated in just over one-quarter of cases and had been invoked in all cases where they existed but normally to remedy only minor defects. They had proved particularly valuable where fleet-wide remedies had been obtained on the basis of only a proportion of those vehicles experiencing problems. For example, in the case of the AS90 self-propelled gun, a four-year in-Service reliability warranty was inserted in the contract and has been invoked to remedy shortfalls in reliability against the contract specification.

Warranties were most commonly used for ships and submarines

4.14 Warranties were most commonly used for ships and submarines – all such vessels in the survey had warranties which ran for one or two years from the date of acceptance during which time contractors had to remedy defects at their own expense. The warranties worked well when dealing with modest numbers of defects which could be remedied quickly. They worked less well when, as in the case of RFA Fort Victoria (described in Box 3), the huge number of defects initially identified swamped the warranty period, leaving defects identified later to be remedied at the Department's expense.

There have been disagreements over warranty provisions

4.15 In some cases there were problems over the interpretation of warranties. For example, the contract for the HMS Sutherland, Grafton and Somerset Type 23 frigates included a warranty covering defects on each vessel for two years following acceptance of each vessel. The warranty required the contractor to correct any faulty design, material or workmanship, although consequential loss or damage was excluded. Unless a defect was clearly not an item covered by the Guarantee, the Department would automatically raise it as a potential Guarantee Defect. The company, however, was not always satisfied that this was necessarily so within the terms and conditions of the contract. The item concerned would be discussed between the parties so that they could come to an agreement as to liability.

HMS Norfolk, Type 23 Frigate

4.16 Yarrow Shipbuilders Limited have rejected liability for docking costs incurred when a defect for which they accepted liability was repaired, arguing that such docking costs were "consequential". The Department's view is that it is self-evident that a repair to the underside of the vessel would require a docking and that a reasonable shipbuilder would allow for this. The Department have funded the docking costs to date but are considering a retention from the final stage payment equal to the docking costs.

Deploying equipments operationally can make warranties difficult to enforce

4.17 Negotiations with Yarrow Shipbuilders Limited have been further complicated by the fact that HMS Sutherland, Grafton and Somerset were deployed before their two year warranty period was completed, making application of the warranty provisions more difficult for two reasons. First, essential repairs carried out by ship's staff could invalidate the warranty. Second, Yarrow Shipbuilders Limited's liability for paint defects was difficult to argue because of normal "wear and tear", paintwork damage caused by crew work on approved alterations and, in the case of HMS Grafton, collision damage repair. In this latter case, the Department successfully negotiated a rebate from Yarrow Shipbuilders Limited for HMS Grafton because she was due to deploy over the final period of the paintwork guarantee thus preventing a final inspection.

Liquidated Damages clauses were included in contracts on two-thirds of equipments surveyed

4.18 Two-thirds of projects surveyed included liquidated damages clauses in their contracts. Such clauses provide for a fixed sum, agreed when the contract is placed, to be paid as compensation in case of a particular breach of contract, to mitigate the financial effects of such a breach of contract - usually late delivery.

4.19 Difficulties with the acceptance process which lie outwith the Department's control can cause delays in the delivery of equipment and therefore contribute to their decision to invoke liquidated damages clauses where these are in place. This was the case with the Hercules C-130J aircraft (see paragraph 3.6 above) and with six of the projects surveyed. This scenario also arose on one of the case studies, the Landing Platform Helicopter ship, HMS Ocean, which was accepted into operational service in March 1999, some 12 months later than originally planned. The Department were paid the maximum liquidated damages permissible under the contract: two per cent of the contract price. The liquidated damages were claimed because the ship was delivered late. The Department considers that a

significant factor in the delay was the inability of the Prime Contractor, VSEL, and their principal sub-contractor, Kvaerner-Govan Ltd., to present systems and compartments for acceptance to an acceptable standard against the agreed programme. VSEL have argued that the Department contributed to the delay and commercial discussions between the Department and VSEL are continuing.

HMS Ocean, Landing platform for helicopters

The Department rarely pursue general damages

4.20 There are a range of common law rights which may be available to the Department in, for example, cases of negligence. However, in relation to shortcomings highlighted by the acceptance process the most likely common law right to which the Department could turn is the Sale of Goods Act 1979. This Act implies certain conditions into contracts which enable the buyer to terminate the contract and sue for damages if the goods are not of satisfactory quality and/or are not fit for purpose. The Act therefore provides another potential avenue for the Department to seek redress against a contractor for defective goods provided this is not precluded by the terms of an express warranty included in the contract.

4.21 Our survey showed that the Sale of Goods Act had not been used on any of the equipments accepted over the last five years. The Department explained to us that they do not often specifically cite the Sale of Goods Act even when alleging goods are not fit for purpose since the level of specification included in contracts for much of their equipment is sufficiently detailed to incorporate those rights that would otherwise be implied by the Act.

Summary

4.22 In one-third of cases surveyed, the contract acceptance criteria did not fully reflect the Staff Requirement. The consequences of this varied. In some instances, the lack of a proper contractual specification led to performance shortfalls and extra costs. In one case, that of AMRAAM the Department did not specify any acceptance criteria because the equipment had been procured via the United States Foreign Military Sales system.

4.23 Where the Staff Requirement was not fully met, the granting of concessions to contractors did not always result in financial or other recompense. Under Smart Acceptance, the Department intend to claim a commensurate reduction in the contract prior to granting a concession. On eight projects reviewed, the Department used liquidated damages clauses to compensate them for delays caused by acceptance. Warranties covering in-Service performance were invoked where relevant, although here, too, there were difficulties in achieving full benefit from them. In cases where there were shortfalls but the contract contained no Liquidated Damages clauses or warranties, the Department did not pursue general damages.

Annex A: Study methodology

Introduction

The National Audit Office undertook two main exercises in obtaining evidence for this Report. The exercises were designed both to capture existing information and to generate new information. This Annex describes the methods employed and the use made of the results.

Exercise 1: Case Study analysis

Sample size and selection

A judgemental sample of six equipments (detailed in Annex C) was selected for detailed examination. The sample included:

- two equipments from each military "environment" (Sea/Land/Air);
- equipments that have been through both strong and weak acceptance procedures as perceived by the Department; and
- equipments covering a range of values from £39 million to £1,795 million.

One of the equipments chosen was to represent the latest approach to acceptance, even though this ship was still undergoing trials.

Examination of the acceptance processes followed

Our examination of the six case studies focussed principally on:

- how initial and subsequent Staff Requirements are translated into contract terms;
- how acceptance criteria are translated into a testing and evaluation programme;
- how the results of trials are used to confirm equipment performance; and

- whether the Department had negotiated taut contracts which made best use of incentivisation clauses and legal provisions for non-performance.

Evidence was derived from file examination and interviews with Project Managers, Operational Requirements staff, contracts staff, equipment operators, equipment managers, testing and evaluation teams and central acceptance staffs. Where appropriate we have also held discussions with the main contractor(s).

The case studies have been used to illustrate the key elements of the acceptance process: the establishment of the acceptance framework, the process of gathering performance evidence and the negotiation of performance trade-offs. The results of the case study examination were used to show how different acceptance procedures have been followed in the different environments and the strengths and weaknesses of each approach.

Exercise 2: Survey of accepted equipments

Sample size and selection

The population from which we drew the sample was defined as all equipments having a value of £10 million or more accepted between 1993 and 1998. The population comprised some 78 equipments. A stratified random sample of 43 equipments was selected from the population with the aim of obtaining equal representation across the three environments. Further details of the projects sampled are at Annex B. The sample therefore represented some 55 per cent of equipments accepted since 1993.

Method of collecting data and response rate

A self-completion postal questionnaire was sent to 43 project/equipment managers. 40 usable responses were received representing a final response rate of 93 per cent. On the other three projects - Harrier Chaff, ECM Resistant Comms and CACS1 – fully reliable data was not available.

Completed questionnaires for five projects were followed up by visits in order to obtain further information.

Coverage of the questionnaire

The questionnaire was constructed in six sections with the following main headings:

- General information
- Information about risks to the programme
- Summary contractual information
- Information about the acceptance strategy
- Information on acceptance outcomes
- Post-acceptance information

Most questions on the questionnaire were of the "closed" form to allow quick and easy tabulation, analysis and comparison. Some of the questions sought straightforward factual information from the respondent whilst others required a measure of judgement. A questionnaire helpline, staffed by NAO study team members, was available to provide assistance at all times.

Presentation of results

Survey results have been used in the report in two main ways. First, responses have been aggregated for a number of the questions to illustrate the overall acceptance picture. Because the sample represents a large percentage of the population and coverage has been chosen to be representative, we have not attempted to extrapolate the sample results to the population. Secondly, we have used information from some of the survey projects to illustrate or reinforce points where appropriate.

Annex B: Equipments surveyed by the National Audit Office

Project Name	Description	Cost (£m)
Land Systems		
SALIENT	Surveillance system	10.4
51mm HE Ammunition	Provides integral platoon level mortar firepower	66.9
Precision Gunnery Training Eqpt	Trains Challenger tank crews in basic skills	35.6
MLRS reduced range practice rocket	Used for tactical training on UK ranges	12.1
RARH central computer facility	Monitors live firings in Hebrides ranges	**16**
KIPLING	Data entry device	**12**
Bridging for the 90s	Mobile and rapid deployment bridging system	204.8
Field Electrical Power Distribution System	Sends electric power to HQs and support units	13.8
Reduced range RARDEN cannon	Gunnery training device	17.7
Direct Fire Weapon Effect Simulator	Simulates the effects of direct fire weapons	39.7
Self-propelled High Velocity Missile	Very short-range air defence system	265.5
Rapier Field Standard C	Short-range air defence missile system	1861.9
Challenger II	Main Battle Tank	**1310.9**
SPIRE Thermal Imaging Sight	All-round armoured reconnaissance capability	11.5
Live Fire Monitoring Equipment	Monitors tank crews during live firing exercises	14.5
Air Systems		
Type 101 Radar for the UK	Air defence tactical radar system	25.7
Tri-Star Simulator	Trains Tri-Star flight crew	12
Canberra Sensor System Update	Upgraded reconnaissance sensor	43.5
Tornado Reconnaissance Exploitation Facility	Analyses reconnaissance image data	22.1
Conversion of 5 VC10 to VC10K Mk4	Upgrade of tankers to tanker/transporters	163.8
Sea King HAR Mk3a	Provides military and civilian search and rescue	75
Harrier Missile Approach Warning	Counters infra-red homing air defence weapons	50.3
Tornado F3 Chaff and Flare	Ejects chaff and flares on Tornado F3	25
Sea Harrier F/A2-IN/GPS	Allows Navy capability to reduce error at sea	32.9
Nightbird Night Vision Goggles	Allows fast jets to fly at low levels in low light	19.5
TIALD	Airborne laser designation for Harriers/Tornadoes	92
Paveway III	Low-level laser guided bomb for hard targets	329.1
Advanced IR decoy flares for tactical aircraft	Protects against infra-red heat-seeking missiles	13.1
Sea Systems		
RFA Fort Victoria	Auxiliary Oil Replenishment supply vessel	240.5
HMS Sutherland	Type 23 light anti-submarine frigate	86.6
HMS Inverness	Single Role Minehunter	30.4
HMS Bridport	Single Role Minehunter	29.3
HMS Vanguard	Submarine equipmented with Trident nuclear missiles	1604.9
HMS Vigilant	Submarine equipmented with Trident nuclear missiles	837.2
Navigational Radar Type 1007	Provides navigational and surface surveillance	**10.5**
AMRAAM	Naval air defence missile	109.3
Narrow Band Digital Voice System	A long-range high frequency encrypted voice/data device	**10.4**
Outfit DCB Upgrade	Processor for submarine computer systems	11.4
Sonar Type Variant 2020 AB	Upgraded active/passive submarine bow sonar	**12.5**
GPS for RN helicopters	Gives effective navigational command and control	**30.2**

Note: **16** indicates outturn prices rather than 1998/99 prices

Source: National Audit Office

Annex C: The Case Studies

AS90 Self-Propelled Gun

Project Value	£309.7M (Outturn prices).
Numbers Procured	179 self-propelled guns.
Operational Role	A 155mm self-propelled howitzer which replaced older artillery systems including the Abbot 105mm. AS90 provides a 24-hour all weather capability to apply heavy and sustained fire.
Acceptance off-contract	May 1992.
In-Service Date	September 1993.

RB44 Truck Utility Heavy Duty

Project Value	£39.4M (1998/99 prices).
Numbers Procured	846 trucks.
Operational Role	A two tonne truck which replaced the 1 tonne Land Rover. It acts as a towing vehicle for light guns and can also carry Rapier missiles.
Acceptance off-contract	June 1990.
In-Service Date	September 1992.

Spearfish

Project Value	£1,795M (1998/99 prices).
Numbers Procured	[****]
Operational Role	Tigerfish Heavyweight torpedo replacement carried by submarines. Capable of countering fast and slow submarine and surface targets.
Acceptance off-contract	Provisional acceptance was given in 1995 and allowed the release of further funding for Post-Design Services.
In-Service Date	March 1994.

HMS Ocean

Project Value	£201.6M (1998/99 prices).
Numbers Procured	One vessel.
Operational Role	Landing Platform for Helicopters (LPH) which will aid the Royal Navy's amphibious assault capability by carrying helicopters and up to 800 troops.
Acceptance off-contract	June 1998.
In-Service Date	March 1999.

Project Boxer

Project Value	£342.3M (1998/99 prices).
Numbers Procured	One system.
Operational Role	To provide Electromagnetic Pulse-Protected (EMPP) 2 Megabit bearers for use by the Defence Fixed Telecommunications System: a) in meeting the military requirements for EMPP point-to-point services; and b) as a key part of the rich connectivity required for the UNITER switched network.
Acceptance off-contract	Boxer was accepted off-contract as a series of working "testable sections" from 1989 onwards and was in use during the Gulf War of 1991.
In-Service Date	November 1998.

Chinook Mk II

Project Value	£199.9M (1998/99 prices).
Numbers Procured	32 modified aircraft.
Operational Role	Medium support helicopter which upgraded the Chinook Mk I at its mid-life update.
Acceptance off-contract	May 1993
In-Service Date	1994