

New Submarine Project

Department of Defence

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Canberra ACT
24 March 1998

Dear Madam President

Dear Mr Speaker

The Australian National Audit Office has undertaken a performance audit of the Department of Defence. In accordance with the Authority contained in the *Auditor-General Act 1997* I present this report and the accompanying brochure to the Parliament. The report is titled *New Submarine Project*.

Yours sincerely

P. J. Barrett
Auditor-General

The Honourable the President of the Senate
The Honourable the Speaker of the House of Representatives
Parliament House
Canberra ACT

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Audit Manager

Ray McNally

Abbreviations / Glossary

ADF	Australian Defence Force
ANAO	Australian National Audit Office
ACF	Australian Construction Facility
All	Australian Industry Involvement
AS	Australian Standard
ASC	Australian Submarine Corporation Pty Ltd
CMACS	Contract Management and Control System
CRF	Consolidated Revenue Fund
CS ² or C/SCS	Cost and Schedule Control System
Defence	Department of Defence
Defense	US Department of Defense
DDR	Design Development Reviews
DGUWS	Director General Underwater Warfare Systems
DOD-STD	US Department of Defense Standard
DoF	Department of Finance
DSTO	Defence Science and Technology Organisation
DQAO	Defence Quality Assurance Organisation
FCA	Functional Configuration Audit
FIMA	Fleet Intermediate-level Maintenance Authority
HMAS	Her Majesty's Australian Ship
ILS	Integrated Logistic Support
IP	Intellectual property
ISCMMS	Integrated Ship Control Management and Monitoring System
ISO	International Standards Organisation
ISS	In-service Support
IT&T	Inspections, Tests and Trials
IV&V	Independent Verification and Validation
JCPA	Joint Committee of Public Accounts

JORN	Jindalee Operational Radar Network
LBTS	Land-based Test Site
MIL-STD	US Military Standard
Navy	Royal Australian Navy
NDE	Non Destructive Examination
OT&E	Operational Test and Evaluation
PCA	Physical Configuration Audit
PDA	Post Delivery Availability
ProMIS	Project Management Information System
QA	Quality Assurance
QC	Quality Control
RAF	Royal Air Force
RAN	Royal Australian Navy
RSSA	Rockwell Ship Systems Australia
SDR	System Design Review
SIMS	Ships Information Management System
SIS	Ships Information System
SOE	Safe Operations Envelope
SRR	System Requirement Review
STSSF	System Test and Software Support Facility
SUBSAFE	Submarine Safety
SWIP	Supplementary Weapons Integration Program
TDHS	Tactical Data Handling System
TI-338	Report of Material State at Delivery
UK	United Kingdom
US	United States of America
V&V	Verification and Validation
WDC	Weapon Data Converter

Part One

Summary and Recommendations

Summary

1. Defence's \$5.05 billion New Submarine Project involves the design and construction of six Collins-class submarines and associated supplies and services. The major part of the Project is the \$4.38 billion prime contract with Australian Submarine Corporation Pty Ltd (ASC).¹ ASC manages over 70 subcontractors, which in turn have many subcontractors that bring the total project contractor complement to about 1500 firms. The chosen design is the Swedish Kockums AB type-471 with a combat system supplied by a consortium led by Boeing Australia Limited. The submarines were scheduled for delivery from January 1995 through to October 1999, in time to replace the Navy's ageing Oberon class submarines as they reached the end of their service lives.

2. The Collins-class submarines are designed for long-range maritime patrol and response, maritime strike and support. The *Defence Corporate Plan 1996-2000* states that introduction of the Collins-class submarines into service is a key strategy in achieving Defence's foremost objective of making the ADF capable of defeating any attack which could credibly be mounted against Australia.

3. The Project Office was created in 1982. The contract with ASC was signed in June 1987. The first submarine, HMAS *Collins*, was launched in August 1993. This was a significant achievement for ASC and its subcontractors given that the production program commenced at widely separated sites in 1987 and ran in parallel with design and system development. After completing some contractor sea trials *Collins* was delivered by ASC, and provisionally accepted and commissioned into service in July 1996. *Collins* has been undergoing contractor sea trials and operational tests and evaluations by Navy since then.

4. ASC launched the second and third submarines, *Farncomb* and *Waller*, in December 1995 and March 1997 respectively. *Farncomb* was delivered by ASC and provisionally accepted by Navy on 15 December 1997 and commissioned on 31 January 1998. *Farncomb* has been undergoing contractor sea trials and operational tests and evaluations by Navy since then.

5. Delivery of the remaining submarines, *Waller*, *Dechaineux*, *Sheean* and *Rankin*, has been delayed by about 20 months with the last due in May 2001. Even though the delay will result in greater costs, Defence still expects the

¹ These amounts are the sums of payments made, or to be made, over the life of the Project as indicated in Project Office records. They are based on December 1997 prices.

project to be completed within the approved total project cost, adjusted for price rises and foreign currency variations. (*Dechaineux was due to be launched in March 1998.*)

6. Defence's Director General Underwater Warfare Systems (DGUWS) is responsible for the submarine project's performance, including cost, schedule (timing) and quality outcomes. DGUWS heads Defence's New Submarine Project Office in Canberra. There are also regional offices at the submarine construction site near Port Adelaide and at the Combat System contractors' offices in Sydney.

Audit objective and criteria

7. The audit's objective was to assess the performance of the Department's management of the project in the light of accepted better-practice project management techniques, including managing risk effectively. An important part of the audit was to derive lessons to be learnt from a project management perspective and recommendations that could be applied to the remainder of the project and to other large Defence projects now and in the future. This was *not* an audit of the contractors' operations. Nor did the audit examine Defence's evaluation and comparison of the New Submarine Project tenders, the technical specifications in the contract, or Defence's Submarine Safety (SUBSAFE) Program.

Overall audit conclusions

8. The submarines appear to have the potential to achieve the capability specified in the contract but it is not possible to be conclusive on that question at this time. Moreover, actual achievement may not occur before 1999, at which time almost all the Project's budget will have been spent. The Project Office has now paid over 95 per cent of the construction contract funds but only two submarines have been provisionally accepted by Navy and one other launched. The remaining contract payments (and other funds available to ASC) are needed to fund ASC's submarine construction, tests and trials operations until the last submarine's warranty period expires in May 2002. Any amendments that affect ASC's scope of work will change the Project's remaining cash flow and risk balance.

9. The Project has struck problems resulting in ASC diverting its resources to rectify design, material and work defects. ASC's resources have also been diverted to conduct ad hoc in-service support of *Collins*. Project records indicate these diversions have extended the submarines' delivery schedule. Many quality problems may have been prevented but, repeatedly, when risks emerged, there was a general lack of decisive action by the Project Office to

put sufficient commercial pressure on the contractor to correct the situation and protect the Commonwealth's interests. Carrying excessive risk and leaving work to be done later in the program only adds to Project risks and costs and exacerbates project management problems particularly at a time when available Project funds have been largely expended.

10. This audit follows a 1992 audit of the Project. In the earlier audit report the ANAO expressed concern about the Project Office's lack of business acumen. The 1997 audit has revealed little improvement in this respect. Project Office practice has been to monitor events without taking firm contractual action as problems arose. There was considerable scope for the Project Office to be more pro-active in managing the Project in the Commonwealth's best interests by taking firm action with the contractor to improve overall performance.

11. The audit identified some business-related concerns in respect to the following issues:

- the change from commercial insurance to Commonwealth indemnity before completing a qualified review of the risks likely to be beyond Commonwealth control;
- diversion of \$2.4 million to help ASC to maximise the benefits of the indemnity without apparent benefits to the Commonwealth;
- omission of key submarine endurance trials from *Collins'* successors before completion of *Collins'* endurance trials and at a time when *Collins* was experiencing propulsion system problems;
- discipline applied to project progress monitoring by means of the Project's contract management and control system;
- effective follow-up on immature-design issues;
- the response to early indications of quality problems in imported sections of *Collins'* hull, and imported seam-welded pipes in all *Collins* submarines ;
- follow-up on early indications of combat system integration software development deficiencies;
- issues concerning safety-critical software; and
- progress in assisting Navy with in-service support transition.

12. The Project Office's advice to the ANAO that 'in a fixed price contract the balance between quality assurance and quality control is an issue for the contractor' is not consistent with sound project management. There were clearly significant risks inherent in the Project. The contractor is required to provide quality control systems containing operational techniques and activities which ensure specified quality outcomes are maintained during manufacture.

Both the contractor and the Project Office are required to maintain quality assurance systems that continually provide the Commonwealth with adequate confidence that all contracted requirements will be satisfied. The ANAO considers that the Project Office should be more circumspect in the confidence it places in the security of the fixed-price contract. For example, the contract provides for almost the full amount of the contract sum to be paid before the completed products are delivered. Also, the contract's performance guarantees and liquidated damage amounts are modest. In these circumstances the Commonwealth bears a significant risk in ensuring completion. These factors alone demand the adoption of a more business-oriented approach to project management including diligent monitoring of performance, quality assurance follow-up and formal systematic risk management on a project of such cost and complexity. Project management has to recognise the integration of risk, control and quality outcomes, hopefully in a genuine 'partnership approach' with the contractor. This approach should reflect a clear understanding of, and commitment to, the defence imperatives of time, cost and quality but also the commercial realities faced by the contractor.

13. The predominant underlying and ongoing issue that requires addressing by Defence is the need to improve its project management skills in order to obtain best value for the Commonwealth and assist Australian industry to produce an enduring local competence. Managers of major Defence capital equipment projects should have the knowledge and skills in all core business administration competencies to protect the Commonwealth's interests in negotiating with major private sector contractors. Defence may in some instances need to contract-in such skills. Defence have advised that it is responding to this need. All stakeholders require assurance that the contracted outcomes will be achieved. It is essential that tangible evidence be provided that they will.

14. Most of the submarines' systems are monitored or controlled by computer software. Some key mission-critical software systems have acknowledged deficiencies that need to be overcome. Of particular concern is the combat system's integration software which is still under development, and is not expected to be complete until 1999. Defence advise the remaining systems are largely complete and performing well. The available evidence does not support the Project Office's view that it has effectively managed risk and implemented strategies to reduce the impact of combat system delays on Defence capability at no additional cost to the Commonwealth. Because payments to contractors have far exceeded the value of progress achieved, the cost of delay has, in effect, been borne by the Commonwealth. Boeing advise that it has also borne substantial additional costs associated with software delivery delays. Defence advise that, in hindsight, problems were inevitable,

and it continues to look for better approaches for acquisition and delivery of software projects. Again, it is a matter of achieving timely and cost effective outcomes.

15. The completed submarines are now undergoing contractor sea trials and operational tests and evaluation without a fully integrated combat system. As a result, many tests and evaluations will have to be repeated with each successive release of software. Although the combat system has included some technological advances not envisaged in 1987 when its architecture was defined, proposed and contracted for delivery, its delayed delivery exposes Navy to the risk of having to operate and maintain other areas of the combat system that are in the mature to declining phase of their product life-cycle. The Commonwealth will need to fund increased in-service costs associated with this. Defence has also lost opportunities to install enhanced combat system capability developed by DSTO and others.

Key findings

16. The Project has some significant project management, engineering and construction achievements which in many ways demonstrate the capacity of Australian industry to produce to world-class standards. But there are management and technical problems that remain unresolved. Some problems result from immature design aspects associated with development of a large and complex 'first of class' submarine. This needs to be acknowledged and understood. However, problems also result from a combination of Defence's lack of contractual leverage and the Project Office's inadequate management of quality assurance issues, especially those related to software development and imported welded assemblies. In particular, this is due to a lack of determined commercially-focussed follow-up of Project risks discovered early in the design and construction phase.

17. There is the apparent capability for a fully independent survey and inspection at the critical stages (that is, design, construction, tests and trials, and acceptance) of a kind that other Navies have found useful in their major acquisition processes. There has been protracted carry-over of defects and contractor sea trials into *Collins'* and *Farncomb's* operational tests and evaluation program. Navy has introduced an Operational Test and Evaluation organisation independent of the contractor and the Project Office, which is responsible for post-acceptance of the submarines from the Acquisition Organisation (the Project Office) into naval service. However, it is not responsible for prior acceptance from the contractor. *Collins'* acceptance into Naval service is expected in 1999.

18. In the Budget context in 1996 Defence, in commenting on the Project and the progressive delivery of combat-system software, said *inter alia* that *Collins* had completed contractor's sea trials and that performance had at that time met or exceeded the specified requirements. Available evidence does not support this performance assessment. (See paragraph 1.32.)

19. There are many issues arising from the Project that should be highlighted as 'lessons learnt' for future Defence projects. Those cited in this report, particularly the ones dealing with project risks, are simply illustrative and therefore not exhaustive. Major issues are summarised below.

Sharing of contract risk

20. The contract provides only *modest* recourse by the Commonwealth by way of financial guarantees and liquidated damages for late delivery and under-performance. Liquidated damages for inadequate submarine performance are limited, particularly in relation to endurance, which is of critical importance to Navy. The Commonwealth should be able to do better in commercially-based contracts.

21. Contract funds still to be paid by Defence for construction total about five per cent of the contract sum, including only \$14 million (June 1986 prices) in contingency funds. Notwithstanding Defence's expectation that the Project will be completed within the approved cost, the ANAO considers that Defence should, as a matter of urgency, review the cost to complete the Project in light of unresolved contingencies and continuing schedule slip to provide assurance that there are sufficient funds available to complete the Project or to take early steps to address any deficiency.

Insurance and indemnity

22. The contract required ASC to obtain, at the Commonwealth's cost, insurance cover over its marine builder's risks and risks in respect of public liability, property damage, and contracts work policy. In 1991, after negotiation and litigation, the contract was amended to incorporate indemnities with terms similar to the commercial insurance covering the period between launch and acceptance of all *Collins'* successors. In 1994 it became apparent that delays in the insurance would cost the Commonwealth \$18.5 million more than Defence originally estimated. The remaining insurance was replaced by financially-uncapped Commonwealth indemnities covering the construction, launch and acceptance of each submarine.

23. The Project Office advised that the total contract price reduction resulting from the change from insurance to indemnities at that time was \$14.449 million (June 1986 prices). Of this amount, \$6.49 million arose from insurance deposit premium refunds and \$7.959 million from deletion of provisional funds allocated to future insurance adjustment premiums. Defence claim that the pro rata refund of the deposit premiums when added to the balance of the adjustment premiums required if the insurance had been retained would, at the time, have totalled \$21.7 million (December 1994 prices). This rationale indicates that 'savings' increase as the submarine program is further delayed. Hence Defence estimates that it saved in excess of \$50 million in insurance premiums.

24. The indemnities could well have significant downstream cost implications for the Commonwealth. It is difficult to make any assessment on the information available. Defence advised the ANAO that its decision to grant the 1994 indemnities was based on prolonged risk assessments including that used in the 1991 decision to self insure the submarines between launch and acceptance. The ANAO could only locate a qualified risk assessment completed after granting the indemnities, and could find no evidence of a sound analysis of the risks by a risk management expert with specialist qualifications and experience in statistical risk analysis and marine builders risks. Nor did the ANAO find that the Project Office, after the indemnities were granted, exercised more rigorous commercial-type follow-up of quality issues to protect the Commonwealth's interests or to minimise the Commonwealth's new exposure to risks.

25. As far as the ANAO has been able to determine, an amount of \$2.4 million in insurance premium refunds due to the Commonwealth was paid to ASC's broker. In the absence of complete records, the dimensions of the transaction are unclear as indeed are the benefits to the Commonwealth. On the face of it, the Commonwealth did not receive any benefit from the transaction and may well have been disadvantaged, raising the question of the legal authority for such a payment.

Project progress

26. The Project Office and ASC have had a formidable project monitoring task, given that submarine construction was well under way before all design work was completed. Despite many significant challenges faced by the Project, the first submarine, HMAS Collins, was launched on time on 28 August 1993. This was a significant achievement by ASC and its subcontractors. Some persisting design, imported welding and software problems detracted from this achievement. However, the New Submarine Project in many ways

demonstrates the capacity of Australian industry to produce to world-class standards.

27. The Project is now about a year behind schedule and reworks on *Collins* and *Farncomb* may result in a 20 month delay. Such a delay could, at least in part, be expected with such complex first-of-class submarines. *Collins'* delivery allows ASC to draw on the Commonwealth-provided \$75 million warranty package for all submarines. So far over \$47 million (June 1986 prices) or 64 per cent of the warranty package has been claimed for warranty work on *Collins* and *Farncomb* and the other submarines currently under construction.

28. Contractor sea trials and operational tests and evaluations of *Collins* and *Farncomb* are progressing more slowly than originally scheduled. As well, key endurance trials have not been contracted in *Collins'* successors' sea trials programs. These exclusions remove some contractual leverage over ASC without a corresponding benefit for the Commonwealth. This suggests a need for a more commercially-oriented approach to be taken to such arrangements.

Quality assurance

29. ASC received its Defence Quality Assurance accreditation in 1992. The Project Office was slow in reacting to a 1993 Defence quality assurance recommendation that ASC's quality management system needed improvement. A three-day review in mid 1993 by the Defence Quality Assurance Organisation may have brought about some change but there is no conclusive evidence it actually did. The numerous defects discovered late in the construction and trials period suggest that quality management and inspection, tests and trials system problems persisted despite the earlier accreditation. On the other hand, Defence considers that the number of defects found indicates that it has been diligently conducting its inspections and observing the contractors' tests and trials. Again this prompts the question of an effective risk management approach which is proactive as well as reactive.

30. There have been significant software quality management problems, that have probably resulted in delayed delivery of some integrated combat system capability. Also, the question of whether any safety-critical software exists within the submarines is still to be resolved and some mission-critical software issues also need to be resolved by Defence as a matter of priority.

31. In 1997 ASC replaced its Defence (second party) Quality Assurance accreditation with third party accreditation to the International Standards Organisation's ISO 9001 - 1994 quality standard for ship design and

construction. This exceeds the contract's requirements. Project Office staff are confident that ASC has implemented ISO 9001 - 1994 in a competent manner.

Submarine design

1. The ANAO considers that there are a number of submarine design issues that would benefit from examination by an *independent* team to provide assurance that the submarine design and the design's documentation are under appropriate management control and all technical performance specifications and objectives have been met. The need for this arises from design and construction issues and general quality assurance concerns raised throughout the report. This issue should be addressed in any risk management assessment. It would involve both business and technical judgement made by appropriately qualified personnel.

2. Prior to the expiry of a \$56 million performance guarantee, which occurs with acceptance of *Waller* scheduled for May 1998, Defence must satisfy itself in relation to the first three submarines that:

- all design and construction risks have been resolved to satisfactory levels;
- all technical performance specifications and objectives have been satisfied; and
- all systems are operationally effective and suitable for intended use.

3. As the remaining submarines will be completed without the performance guarantee in place, they must also be verified and validated with the same if not more rigour for stakeholder assurance.

Submarine construction

4. The audit focused on high-risk aspects of the submarines' construction, namely pressure hull construction and internal pipes. The Project Office quickly resolved submarine construction problems found in work done by local subcontractors and quickly increased preventative action. Local manufacture reduces monitoring and control delays and makes it easier to obtain required quality outcomes at reasonable cost to the Commonwealth.

5. Project Office records indicate that most platform construction problems have arisen in overseas-supplied items. The Project Office seemed to achieve little in its representations to ASC concerning the need to improve construction quality of some of *Collins'* imported hull sections despite early warnings of emerging problems in 1990. The ANAO is also concerned about the

protracted analysis of imported seam-welded pipes in all submarines. The Project Office's risk management tends to churn issues without apparent success in actually managing the risks effectively.

Combat system development

6. The software used to integrate, display and control the various combat system functions has experienced development difficulties. Project Office senior management seemed not to recognise or acknowledge the degree of the difficulties until 95 per cent of the combat system software development and test payments were made to ASC. Serious software and hardware deficiencies were later confirmed by external reviews in 1994 and 1995.

7. Had the Project Office used more effective progress monitoring standards and been more decisive in reacting to the problems as they became apparent, there may have been a better outcome. As indicated in other audits, payments should be made only on reliable and objective evidence of real progress. Payments limited to actual progress are a tangible way of clearly indicating dissatisfaction with any under-performance and prompting action to achieve full performance. While recourse to such action may be seen as a potential breakdown in contractual relations and only used as necessary, it is nevertheless one of the few effective ways by which a purchaser can achieve required outcomes.

Software-based systems

8. Some software-based systems are performing as intended, but others are under continuing review because of operational concerns. Defence quality assurance personnel carried out their audit responsibilities. However, Project Office follow-up should have been more vigorous in implementing quality assurance recommendations and addressing identified deficiencies with ASC.

9. There is a strong argument that the submarines' software-based systems that have safety implications or mission-critical functions should now be subject to high-level validation and verification by independent experts as an important element of risk management and overall control of the project to ensure all objectives are met. Expert assistance would seem to be a real issue for prudent management of the project to completion.

Australian Industry Involvement (All)

10. The Project's 'All' prime objective was to establish high levels of local content to ensure that Australian industry would be capable of providing through-life support to a uniquely Australian submarine. Local content expenditure appears to have exceeded the broad targets specified in the contract. It is unclear, however, whether the self-reliance, local capability and technology transfer envisaged at the start of the Project have been achieved.

11. Australian industry has manufactured submarines 02 to 06 largely from proprietary drawings. This is significant in that it demonstrates Australia's capability in manufacturing, assembling and integrating highly complex and diverse technology with the possibility of adding to its intellectual property and/or knowledge. This may reduce in-service support problems of the kind experienced with other Navy vessels and enhance industry capability for other projects.

Intellectual property (IP)

12. The Commonwealth has certain rights regarding 'IP' created on the Project. The Project Office, however, does not monitor fully all IP produced by the project and relies largely on the 'good faith' of the contractor regarding advice of third party IP usage outside the contract. There is no exhaustive and systematic process for identifying and recovering royalty payments due from the use of IP.

13. The ANAO considers that some opportunities for gaining IP benefits may be overlooked by Defence because Project Office practice does not seek to log all IP rights as a matter of course.

In-service support

14. The transfer of system operation and technical maintenance information from ASC to Navy needs to be improved. Despite over seven years of analysis, plans and reports depot-level contracts for in-service repair and overhaul of submarine systems by the equipment suppliers have not been established for all submarine systems. In 1991 the Project Office decided the purchase of depot-level maintenance data was not affordable. Consequently, Defence's work scope and cost estimates for in-service depot-level work to sustain the submarines' operations have been questionable.

15. Collins-class submarine in-service support contracts could prove to be some of the most costly set of service contracts ever offered by the Commonwealth. With costs of significant magnitude Defence should ensure that it is a fully informed customer equipped with appropriate information systems including specified performance measures. The ANAO understands (January 1998) that in-service support contracts have now been signed with Boeing and ASC.

Potential audit impact

16. As Appendix 1 illustrates, there are close parallels between Defence's management of the New Submarine Project and the JORN Project, which the ANAO audited in 1996.² Both projects are complex and high risk, incorporating expensive design and employing construction ventures using leading technologies. Both audits identify areas for improvement in project risk management as well as business management. The ANAO considers that the main messages from the two audit reports would be to encourage Defence to give high priority to improving the effectiveness of its contracts for major capital acquisitions and its project management capabilities.

17. The ANAO acknowledges the inherent complexities in managing such large projects but nevertheless considers that a more business-like and commercial approach by the department to project management would better protect the Commonwealth's financial and other interests. It is essential that the inevitable risks in projects of this nature be managed sensibly in the interests of all parties. This should be done in a strongly-disciplined and systematic fashion throughout the project which inevitably means having to take the difficult decisions which could lead to short-term criticism of the management of the project but would help ensure a cost effective outcome. Project management has to reflect the integration of risk, control and quality outcomes. This demands mutual understanding and commitment of all parties to ensure successful integration and is best achieved through a real sense of partnership based on goodwill by each party in a positive endeavour to help achieve their respective objectives.

18. These audit reports draw *particular* attention to the wide-ranging risks that the Commonwealth faces in major capital acquisition projects. Defence's view is that the balance of risks on a fixed-price contract lies with the contractor. As a general principle this is the case but the ANAO considers that on major Defence acquisition projects the Commonwealth carries substantial risks because of their inherent nature and importance to national security. Risk to

² Audit Report No.28 1995-96 *Jindalee Operational Radar Network Project* (JORN Project).

the Commonwealth also arises specifically because it has to:

- pay for work years ahead of deliveries;
- pay most of the contract sums before being able to test and operationally evaluate products;
- define products in the light of technology that may become superseded; and
- carry the risks that contractors may under-perform if the work becomes more costly than expected.

This risk is compounded when contractors and subcontractors, inexperienced in the particular work and inexperienced in working with each other, must collaborate to carry out highly-technical work extending over many years and incorporating unforeseen technical advances.

51. In these circumstances the Commonwealth bears the very real risk of additional cost or loss of delayed military capability and, in particular, the opportunity cost of the latter in national security terms. These factors underline the importance of skilled and experienced project management either in-house or contracted in.

Response to the audit report

52. The proposed report of the audit was put to Defence in October 1997 for comment. Defence provided extensive comments in late November and in subsequent correspondence indicating their reservations about findings and judgements in the report and querying the balance of the discussion in it. The ANAO had full regard to those comments in completing the audit report. In the end, Defence agreed or agreed in principle to eight of the ANAO's twelve recommendations designed to improve project management on the New Submarine Project and other major Defence projects. The recommendations were re-considered extensively in the light of Defence comments in an endeavour to ensure that they would be both relevant and useful to the project. The ANAO remains of the view that they meet these objectives.

53. Defence's general comments on major areas of the project are set out below.

Project Risk

It is a recognised fact that policies designed to increase Australian industry capacity and involvement can only be implemented if increased technical risk is accepted, particularly in projects which involve substantial design and development work, which this project does. Defence's view of the project risk was well documented and considered by the Government prior to project approval and contract signature.

The submarine project has always contained significant risk and Defence acknowledges that significant challenges remain. With one submarine commissioned into naval service and two submarines at sea undergoing a demanding trials program to demonstrate conformance to contracted requirements, the risk exposure that Defence now faces in completing this project is far less than the exposure at project commencement.

Technical Issues

This is a large and complex project. As noted in the 1992 audit review, the Project Office has sought external assistance when required to manage complex and technical issues. The 1992 report noted that the Project Office employed considerable resources to ensure that the quality of the submarine construction is to required standard by implementing an extensive quality system. This approach is continuing.

Defence Management

The submarine project represents a first time, in-country construction of a submarine in Australia and is more complex than any project previously attempted by Defence and Australian industry. It reflects well on the project, DSTO and Australian industry that they have been able to develop new procedures, adapt existing practice, and focus on delivering a product that meets the contracted requirements.

Defence continues to actively improve the skills and experience of its project staff as a matter of course. Project management requires a broad set of skills, commercial and business qualifications being but two. The Defence Acquisition Organisation has led the way in developing procurement and project management competencies endorsed by the Australian National Training Authority and has comprehensive training and development programs, including procurement and project competency standards to ensure that project managers have the necessary skills.

54. The ANAO also forwarded relevant parts of the proposed report to the main contractors involved in the Project - Australian Submarine Corporation,

Kockums AB, Kockums Pacific and Boeing - and had full regard to their comments in completing this report.

Recommendations

Set out below are the ANAO's recommendations with Report paragraph references and a summary of the Defence response. More detailed Defence responses and any ANAO comments are shown in the body of the report. (See also paragraph 52 in the Summary.) The ANAO considers that the Department should give equal priority to all recommendations.

Recommendation No.1 Para. 2.51 The ANAO recommends that, in view of unresolved contingencies and continuing slippages in the delivery schedule for the new submarines, Defence satisfy itself by means of regular project cost and schedule reviews that there will be sufficient funds to complete the Project.

Defence Response

Agreed

Recommendation No.2 Para. 4.22 The ANAO recommends that, to assist in management of the New Submarine Project, Defence seek from the prime contractor and its major subcontractors improvements in reporting schedule variations and early advice of corrective action.

Defence Response

Agreed in principle

Recommendation No.3 Para. 4.28 The ANAO recommends that future major Defence contracts provide the opportunity for direct access by the ANAO to records of transactions of contractors or major subcontractors which support the expenditure of Commonwealth funds.

Defence Response

Not agreed

Recommendation No.4 Para. 4.35 The ANAO recommends that Defence's annual Cost and Schedule Control System surveillance audit at ASC be increased in frequency to twice each year and also include the Project's Contract Management and Control System.

Defence Response

Not agreed

Recommendation No.5 Para. 4.39 The ANAO recommends that Defence review a larger proportion of ASC's work package progress claims in order to make a better assessment of overall progress.

Defence Response

Not agreed

Recommendation No.6 Para. 4.82 The ANAO recommends that, on major capital acquisition projects, Defence only consider for appointment project managers with appropriate commercial experience and business qualifications.

Defence Response

Agreed in principle

Recommendation No.7 Para. 5.25 The ANAO recommends that Defence continue to monitor software development standards and adopt the standards that offer the Commonwealth best value for money.

Defence Response

Agreed

Recommendation No.8 Para. 5.35 The ANAO recommends that Defence consider incorporating provisions for technical and performance audits in contracts of significant risk to give its project managers a means of identifying the source of problems and encouraging corrective action when contractors depart significantly from agreed cost, schedule and development requirements.

Defence Response

Agreed in principle

Recommendation No.9 Para. 5.50 The ANAO recommends that Defence consider the need to engage an appropriately qualified and experienced third party to participate with Defence in a joint assessment to decide whether the Collins submarines contain safety-critical software and if so to verify that the software provides the appropriate level of safety.

Defence Response

Not agreed

**Recommendation
No.10
Para. 6.24**

The ANAO recommends that Defence conduct an independent verification and validation of each submarine's design and construction, using both local and overseas specialists, with at least one such validation finishing before the expiry of the submarine contract's performance guarantee.

Defence Response

Agreed

**Recommendation
No.11
Para. 8.47**

The ANAO recommends that Defence:

- a) continue to seek the combat system capability the Commonwealth has already paid for; and
- b) conduct a cost:benefit analysis of the replacement of the current Tactical Data Handling System with products which are more technologically advanced and less costly to maintain and enhance.

Defence Response

Agreed

**Recommendation
No.12
Para. 10.13**

The ANAO recommends that on future major projects, Defence:

- a) should (subject to government policy) specify local industry involvement in the contract in terms of technology transfer as well as in terms of funds expended for work done locally; and
- b) monitor compliance with these requirements.

Defence Response

Agreed

Part Two

Audit Findings and Conclusions

1. Introduction

This chapter provides an overview of the New Submarine Project, sets out the main findings from the 1992 audit and the objectives and scope of the 1997 audit, comments on public accountability in respect to the project and provides the ANAO's technical consultants' overview.

1.1 This report follows on from Audit Report No.22 1992-93 *Department of Defence - New Submarine Project* tabled in Parliament in December 1992. In the five years since that report, three submarines have been launched and the first two submarines, HMAS *Collins* and HMAS *Farncomb*, have been commissioned and provisionally accepted into Naval service. This report covers significant Project issues that have developed since the 1992 report. The project involves the design and construction of six submarines employing complex interrelated technologies. This gives rise to major project management challenges for Defence. The management issues and risks cited in the report are illustrative and not exhaustive.

The New Submarine Project

1.2 On 3 June 1987 the Commonwealth signed a contract with Australian Submarine Corporation Pty Ltd (ASC) for the design and construction of six Collins-class submarines and associated supplies and services. Defence chose the Swedish Kockums AB type-471 design concept and a combat system to be supplied by a consortium led by Rockwell Ship Systems Australia (now Boeing Australia Limited).

1.3 The submarines were scheduled for delivery from January 1995 through to October 1999, in time to replace the Navy's ageing Oberon class submarines as they reached the end of their service life. Navy did not maintain the Collins-class submarines' acquisition strategy of coordinating Oberon class de-commissioning with Collins-class acceptance into Naval service. Defence records indicate that refits to extend the life of the last two Oberon submarines, *Otama* and *Onslow*, may cost a total of about \$100 million which has not been funded in the current RAN ship repair program.

1.4 The 1994 Defence white paper *Defending Australia*³ stated that a force of six Collins-class submarines would provide a very substantial capacity

³ *Defending Australia* - Defence White Paper 1994, AGPS Canberra, November 1994; p. 44.

for maritime patrol and response, maritime strike and support. The *Defence Corporate Plan 1996-2000* states that introduction of the Collins-class submarines into service is a key strategy in achieving Defence's foremost objective of making the ADF capable of defeating any attack which could credibly be mounted against Australia.

Project price

1.5 In June 1987 Defence approved expenditure of \$3.892 billion (June 1986 prices) for the six Collins-class submarines and associated supplies and services. Of this, Defence apportioned \$3.369 billion in three distinct fund packages to the submarines' design and construction prime contractor ASC. Paragraph 2.5 describes the price arrangements.

1.6 Defence also reserved \$523 million (June 1986 prices) to cover project elements not included in the contract with ASC, such as Navy associated costs, modifications and contingencies. The ANAO has not audited these elements of the Project.

1.7 Since 1987 movements in foreign currency exchange rates and the price of materials and labour have increased the approved project cost to \$5.05 billion (that is, the sum of payments made and to be made over the life of the Project). The Project Office's December 1997 quarterly progress report shows that the contract sum was \$4.377 billion. Progress payments to ASC to 31 December 1997 amounted to \$4.189 billion of which \$101 million was funded from the contingency element of the approved project funds. This means that 95.7 per cent of the contract sum has now been spent.

1.8 Elsewhere in the progress report the prime contract amount reported to Cabinet is shown as \$4.231 billion and that progress payments amounted to \$4.088 billion. The different figures for the contract sum arise from different ways of presenting contingency fund expenditure. An earlier internal report by accounting consultants noted that it was unclear from Defence records whether the contract sum was \$4.299 billion (June 1996 prices) or \$4.399 billion.⁴ The correct sum was later calculated with assistance from the Project Office. This suggests to the ANAO that there is scope for improving presentation of Project financial data. Defence states that there has been no real cost increase in the project since contract signature in 1987 and that the contract price has increased by only \$7 million. This is difficult to confirm given the uncertainty about aspects of the original scope (see paragraphs 2.5 and 2.6); the large

⁴ *Review of the ASC's financial statements for indicators of its ability to complete the submarine contract*, internal report by accounting consultants February 1997, p.16. The report was revised in April 1997.

number of contract amendments (see paragraph 2.7); the treatment of the contingency amount mentioned above; and the cancellation of the insurance arrangements (paragraph 3.15). The Commonwealth indemnity which replaced the commercial insurance is effectively a real cost increase to the Project.

1.9 The overall cost of the Project, including Navy associated costs, is expected to be \$5.05 billion. This Project and the \$5.10 billion ANZAC Ship Project are Defence's largest capital acquisition projects. They are among the largest construction projects attempted in Australia.⁵

Submarine construction and delivery

1.10 ASC was formed for the purpose of designing and building the submarines in Australia and managing the subcontractors. Ownership of ASC is as follows:

- 49 per cent - Kockums Pacific Pty Ltd (a subsidiary of Kockums AB of Sweden, which in turn is a subsidiary of Celsius Industries Corporation of Sweden);
- 48.45 per cent - Australian Industry Development Corporation (AIDC); and
- 2.55 per cent - RCI Ltd (a subsidiary of James Hardie Group).

1.11 ASC assembles the submarines at its site near Port Adelaide in South Australia from components built throughout Australia and from overseas. The site is known as the Australian Construction Facility (ACF) and is owned by ASC and mortgaged to the Commonwealth. The first submarine, HMAS *Collins*, was delivered on 15 July 1996 and provisionally accepted. On 27 July 1996 she was commissioned into service and is undergoing contractor sea trials and Operational Test and Evaluation (OT&E) in Western Australian waters. Navy has scheduled the OT&E to continue into 1999, after which *Collins* is expected to be formally accepted into Naval service. Navy is developing OT&E schedules for the remaining submarines from lessons learnt during *Collins*' tests and trials.

1.12 ASC launched the second and third submarines, HMAS *Farncomb* and *Waller*, on 12 December 1995 and 14 March 1997 respectively. In July 1996 Defence agreed to ASC's request to deliver *Farncomb* and *Waller* on 17 July 1997 and 21 May 1998 respectively. This schedule was later revised by ASC. *Farncomb* was delivered on 15 December 1997 and commissioned on 31 January 1998. ASC expects to deliver *Waller* by August 1998.

⁵ Expressed in 1997 prices, expenditure on the Snowy Mountains Hydro-electric Scheme amounted to \$4.76 billion.

1.13 Delivery of the remaining submarines, *Dechaineux*, *Sheean* and *Rankin*, has been delayed an average of 20 months, with the last due in May 2001, about 76 weeks later than originally contracted. (*Dechaineux* was due to be launched in March 1998.)

The Collins-class submarines

Overall performance

1.14 Defence states that the Collins-class submarines represent a major advance in submarine technology, particularly in the area of the combat system and submarine monitoring and control systems. They are designed to be available for sea 80 per cent of this time, to cope with Australia's 23,000 km coastal boundary and its wide variety of ocean conditions, and to achieve independent operation in a variety of 70 day missions. The submarines are designed for missions which include reconnaissance and surveillance, maritime strike and anti-submarine operations, mining and infiltration.

Submarine design

1.15 ASC has based the Collins-class submarine platform design on the smaller Kockums type-A17 and A19 submarine designs. The Collins-class are 76 metres long, 7.8 metres in diameter and have a displacement of approximately 3350 tonnes when submerged. Propulsion is provided by an advanced low-revolution skew-back propeller driven by a 5250 kilowatt electric motor. Power is supplied by high-capacity lead acid batteries recharged by three diesel generators. An automated monitoring and control system enables the submarine's functions to be operated by a crew of 42 and 5 trainees.

1.16 The Collins-class submarines are to have a combat system supplied by a consortium led by Boeing Australia Limited, and are to be armed with Mark 48 torpedos and Harpoon missiles.

New Submarine Project Office

1.17 Defence's Director General Underwater Warfare Systems (DGUWS) is responsible for the submarine project's performance, including cost, schedule and quality outcomes.⁶ DGUWS heads Defence's New Submarine Project Office in Canberra. The Project Office was created in 1982 and has regional offices at the submarine construction site near Port Adelaide and at the combat system contractors' offices in Sydney.

Project Office objectives

1.18 The Project Office's objectives are to ensure:

- the contract's requirements are precisely understood by the contractor;
- the design, and hence the specification, meets those requirements exactly;
- each component, sub-system and system is designed, built, tested and integrated into the submarines in a way that satisfies the overall design and specification;
- quality assurance activities are focused on incorporation of good design and production practices which prevent non-conformance to design and specification;
- adequate inspections, tests and trials are specified and carried out to demonstrate conformance to requirements;
- adequate financial controls are implemented; and
- the integrated logistic support requirements are satisfied.

Project Office running costs

1.19 The Project Office advises that its 1996-97 running costs include civilian salaries expenditure of \$3.028 million and uniformed staff salaries of \$1.692 million.

1.20 These direct salary costs, if calculated on a full cost basis using Defence's Commercial Support Program procedures, amount to an estimated total of \$7.4 million. After adding \$2.233 million for administrative support the ANAO estimates the Project Office's running costs to be about \$10 million per year. The Project Office also advised that \$0.301 million was spent on

⁶ DGUWS is a position created on 1 July 1997 as a part of a reorganisation of Defence under the Defence Reform Program. DGUWS reports to Head Systems Acquisition (Maritime and Ground), who in turn reports to Deputy Secretary Acquisition.

submarine project research and development work by DSTO, and that \$1.371 million was spent on fuel used by HMAS *Collins* and HMAS *Farncomb* during their trials.

Total Collins program running costs

1.21 Project running costs accruing in Navy, such as the Navy's Submarine Squadron submarine full crews of 42 each and part crews under training and Navy's Collins-class Logistics Office, may generate costs of the same magnitude as the Project Office's running costs. Hence the ANAO estimates the total Collins-class program now costs Defence about \$20 million per year, in addition to the capital cost of the submarines and their in-service support costs.

Audit Report No. 22 1992-93

1.22 The ANAO's first audit of the Project was reported in Audit Report No.22 1992-93 *Department of Defence - New Submarine Project*. The main findings were as follows:

- the contract did not adequately protect the Commonwealth against loss;
- the Commonwealth advanced funds (initially \$120 million) to the contractor without adequate information about the need for those funds;
- in its dealings with the contractor, the Project Office had frequently taken a position which would be more appropriate if it were dealing with a fellow Government entity rather than a commercial organisation with a primary responsibility to its shareholders;
- the Project Office had not given sufficient weight to the importance of the timing of the payments;
- the Project Office's assertion that the project was on schedule was not supported by the data obtained from the Contract Monitoring and Control System and the ANAO believed the slippage would be difficult to recover prior to the launch and commissioning dates for the first submarine; and
- contract amendment procedures may have resulted in excessive prices being charged by the contractor.

1.23 The ANAO made a number of recommendations primarily intended to ensure that future contracts overcome the problems identified.

1.24 The Department of Defence contested a number of the ANAO findings but agreed or agreed in principle with 15 of the 30 recommendations in that report.

JCPA Report 337

1.25 The Joint Committee of Public Accounts (JCPA) conducted an inquiry into the issues raised in the ANAO's 1992 report. The inquiry was reported in the JCPA's *Report 337, A focus on Accountability: Review of Auditor-General's Reports, 1992-93* (June 1995) pp.163-237. The JCPA was supportive of the audit report and said that, given the magnitude of the project and that much work remained to be done, it would be appropriate for the ANAO to revisit the project at a later date. The Department of Finance Minute on *Report 337* (the Government's response) was tabled on 27 June 1996 (HR Hansard p2997).

Follow-up audit

Audit objectives

1.26 The ANAO's objective in this audit was to assess the performance of the Department's management of the project in the light of accepted better-practice project management techniques. It also aimed to derive lessons to be learnt and recommendations that could be applied to the project and to similar Defence projects now and in the future. The ANAO considered Defence's management of the following issues:

- contract risk share;
- insurance and indemnity;
- project progress;
- quality assurance;
- submarine design;
- submarine construction;
- combat system development;
- software-based systems;
- Australian industry involvement;
- intellectual property; and
- in-service support.

Audit scope

1.27 Defence, through its Project Office, has the prime responsibility for overall management of the New Submarine Project. Consequently the audit focused on Defence's management of the prime contract with ASC. This was not an audit of the contractors' operations. Nor did the audit examine

Defence's evaluation and comparison of the New Submarine Project tenders, the technical specifications in the contract, or Defence's Submarine Safety (SUBSAFE) Program.

1.28 Compared with the 1992 audit, which focused on Project Office business practices before the submarines were being constructed, the 1997 audit was more product-oriented and considered both contract and technical risk as well as Project Office management practices as the submarines neared completion.

1.29 The ANAO began the audit in September 1996. The ANAO put issues papers to Defence during the audit, beginning with an issues paper in January 1997. The proposed report of the audit was put to Defence in October 1997 and revised having regard to Defence's comments (see paragraph 52). ASC, Boeing, Kockums AB and Kockums Pacific and also provided comments, which the ANAO had regard to when completing this report.

1.30 The audit benefited from expert advice from technical consultants Air Vice Marshall (retired) Brian Graf AO, Dr Raphael Dua, Mr Charles Yandell and Mr Roger Seymour, all from Micro Planning International Pty Ltd. Advice on ASC's Commonwealth indemnity was provided by the law firm Deacons Graham & James.

1.31 The audit was conducted in conformance with ANAO Auditing Standards at a cost to the ANAO of \$434,000 including \$72,000 for advice from the technical and legal consultants.

Public accountability

1.32 The *Portfolio Budget Statements 1996-1997 - Defence Portfolio* tabled in Parliament in August 1996, in commenting on the New Submarine Project, said *inter alia* 'Submarine 01 [*Collins*] has completed contractors' sea trials...To date, the performance of the submarine has met or exceeded the specified requirements'. The ANAO queried the basis for this comment since, at the time of the audit, available evidence did not support that assessment (see paragraphs 4.59 and 4.60). *Collins'* contractor sea trials program was experiencing considerable delays due to problems related to design, combat system software integration and trials facilities. Some of these problems have not been resolved.

⁷ Similarly the Defence Annual Report 1995-96, in commenting on the Project, said 'HMAS *Collins* completed sea trials in June...'

1.33 Defence explained that the comment was made in the context of reaffirming advice on the delayed delivery of the combat system and was made in the context of public knowledge that a significant trials program, which includes contractor trials dependent on specialist facilities and ranges not then available in the South Australian area, is necessary before *Collins* is accepted into service. The ANAO considers that Defence should take particular care in ensuring documents reporting on major projects for the Parliament portray clearly progress to date. (See also paragraph 8.43.)

ANAO's technical consultants' overview

1.34 As an overview of Defence's management of the New Submarine Project, the technical consultants engaged by the ANAO to assist in the audit (paragraph 1.30) provided the following comments (late 1997), which are consistent with this audit report:

The output of the project – the submarines – is most impressive, taking into account that similar technologies of hull structure and design and construction, systems electronics and weapons development have been undertaken by other nations over a long period of time, some forty years. Major nations such as the USA, UK and the USSR have used their nuclear submarines design and build programs to support these developments. No such submarine program has taken place in Australia and the product can be said to be a quantum jump from the 1950s Oberon class purchased from the UK since the 1960s.

The submarines have been constructed largely in Australia to an advanced specification by an ab initio company (ASC) and over 1400 Australian sub contractors. Innovations include Australian specified and produced steel for the pressure hull and Australian designed and produced anechoic tiles for the hull. In addition design concepts for the submarine systems management and combat systems were state of the art. In all the submarines have the potential to achieve the combat capability specified in the contract. However, significant project management, design related and technical issues remain to be overcome. The delivery schedule has slipped considerably with little hope of recovery. Full contract capability will not be achieved until some years later than planned. In addition, some concern is held for the cost of the project. From figures provided, the project is tight with Defence having paid 95 per cent of the contract sum. With three submarines to be completed and four yet to be accepted, completion within budget is not assured.

Some production delays are attributable to inevitable problems associated with development of a 'first of class' and not to the project office. However, a combination of Defence's lack of contractual leverage, inadequate management of quality assurance issues and lack of determined follow-up has contributed to some of the current project problems. Delays to the combat system software fall into this area.

The requirements for inspection, acceptance for inspection, identification and reporting of defects are detailed in well known and used Australian and overseas Naval construction manuals. The contract for the Collins-class submarines did not contain many of these requirements and as such the controlling influences so familiar to project and construction staff were not well established. This has contributed to some of the delays in the test and trials programs.

The issue of timely and adequate in-service support was also of concern. Naval Support Command has been pursuing this issue and expects to establish a satisfactory regime soon, but it should have been addressed earlier. This is now a pressing issue due to the present state of the submarine squadron. Other support concerns relate to the integrated logistic support (ILS) package, particularly its validity in the fleet. Initial usage of ILS data through the Ships Information Management System – Submarine Information System and Maintenance Requirements Records has disclosed deficiencies. In all, however, the concepts developed by the Project and Naval Support Command for the in-service support regime and for the ILS support package are considered sound but the effectiveness of the developed maintenance data will need to be confirmed by experience.

There are many issues arising from the Project that should be highlighted as 'lessons learnt' for future Defence projects.

2. Sharing of Contract Risk

This chapter outlines the risk allocation on the contract, the compensation available to the Commonwealth and the funds available for completing the submarines.

Introduction

2.1 The New Submarine contract's risk-share strategy attempts to assign risk management to the party better able to control the various risks. But, when implementing a major design and construction project involving leading technology and complex business arrangements, assigning and managing risk to the degree intended is not easily achieved.

2.2 Nevertheless, risk needs to be addressed either in terms of risk management strategies embodied in the contract such as financial guarantees, warranties, insurance and indemnities or by risk management initiatives applied as unforeseen risks emerge.

2.3 The ANAO's 1992 report commented (p.xv) that the contract does not adequately protect the Commonwealth against loss in the event of failure or default by the contractor. From the 1997 audit the ANAO is also concerned that the contract does not adequately protect the Commonwealth against the risk of delayed capability and the risk of cost increases related to Commonwealth indemnities and warranty concessions granted to ASC.

Risk share

2.4 The contract is essentially a performance-based contract which makes ASC responsible for the submarines' design, construction in accordance with agreed standards and achievement of all performance specifications.

Price risk

2.5 The \$3.369 billion (June 1986 prices) contract with ASC for the six Collins-class submarines and associated support originally contained three packages:

- \$2.687 billion (June 1986 prices) - fixed-price with escalation according to prescribed formulae that allow for 'rise and fall' changes in foreign exchange, Material and labour costs. This package places most price risk with the contractor and relieves the Commonwealth from liability related to later claims for unforeseen variations in contractors' work scope. However, the Commonwealth carries the risk for foreign exchange, material and labour price changes.
- \$152 million (June 1986 prices) - provisionally-priced to allow for work packages that at contract signature could not be precisely defined.
- \$530 million (June 1986 prices) - budgetary amounts set outside the contract with ASC for expenditure on project elements that could not be defined in terms of scope and price at contract signature, such as the submarines' Integrated Logistics Support (ILS) discussed in Chapter 12.

Since the Commonwealth's negotiating position was stronger before contract signature, the second and third packages put the Commonwealth at risk of excess prices and lesser performance because detailed work scope and prices were left for negotiation with the contractor in an environment largely free from competition.

2.6 The Project Office advised the ANAO that by March 1997 fixed-price items totalled \$3.376 billion (June 1986 prices). This \$689 million increase over the June 1987 fixed-price package was in the main funded by contract amendments that established ASC's entire work scope and converted:

- \$143 million of the \$153 million in provisionally-priced items to fixed price, and
- \$530 million in budgetary-priced items to fixed-price.

Defence advised the ANAO that the \$689 million increase in fixed price provides for significant additional scope for design changes and modifications, as well as the agreed scope which was originally priced on a provisional or budgetary basis.

2.7 The Project Office has received over 1250 contract amendment proposals from ASC and approved 1051 of these. Project Office records indicate that:

- 570 are administration amendments to clarify aspects of the contract and change price variation indices;
- 250 are for design changes and modifications to the submarines, which cost \$90.768 million (June 1986 prices);
- 130 are for ILS as discussed in paragraph 12.2; and

- the remainder are for Australian industry involvement changes and Navy required changes.

Schedule risk

2.8 The contract provides no explicit financial incentives for ASC to deliver the submarines early and relies on an implicit incentive for ASC to deliver products early in order to minimise its fixed costs. Consequently, as discussed in paragraph 2.24 below, there are limited provisions in the contract for dealing with contractor delay.

2.9 Contractors carry the risk and cost of maintaining their resources for longer than intended as programs are delayed. On this contract, the ANAO considers that the Commonwealth carries by far the greatest schedule risk. This includes delayed military capability (awaiting submarines) in which it has already invested significant resources (\$4.7 billion). Delays also incur increased project management costs and increased inspections, tests and trials costs.

2.10 In high technology projects, inordinate schedule delays not only add to costs but also put at risk Australia's potential competitive advantage. Proven or potential technology upgrades often must be shelved because of the risk of further delaying the program. Defence advised the ANAO, however, that the scheduled delays cause no greater loss of technical advantage than would occur if the submarine were delivered on original schedule.

2.11 Defence's view is that, although the Commonwealth suffers the impact of delays, the contractors have borne the true cost impact of the delays and this provides every incentive for them to solve the problems in a timely way. The ANAO notes the department's rationale but observes the contractors have received almost all the full amount due in the contract but have not completed the work. The ANAO considers the time cost of money - the opportunity cost of money that is outlaid but not yet providing a return - is effectively being overlooked by the Project Office, a factor which the ANAO reported critically on in the 1992 report.

2.12 In response to these points, Defence advised that it demonstrated, in the context of the 1992 ANAO report, that payment for progress was not made until progress was actually certified and that the number of work package activities advanced was offset by the number and value of those deferred. The ANAO considers that the Project Office has encountered difficulty in measuring progress, particularly software development progress, and has also undervalued the Project's quality assurance indicators. Progress payments to ASC exceed 95 per cent of the contract sum and Navy has provisionally accepted only two of the six submarines with many contractor sea trials

outstanding. Therefore it appears to the ANAO that progress payments have exceeded value earned.

2.13 Given the limitations in the contract regarding recourse by the Commonwealth for any under-performance, business-like management of the contract was all the more important. Defence advised the ANAO that the terms and conditions of the contract were extensively considered before contract signature by senior officers of the Departments of Defence, Finance and Industry, Technology and Commerce, and the Attorney-General's Department, and were determined to be best value for money for the Commonwealth.

2.14 A general aspect of Defence management - the practice of aiming to spend annual allocations of funds - is discussed at paragraph 4.96.

Contractor performance risk

Satisfactory progress

2.15 The contract provides that progress payments need be made only on satisfactory progress. The Project Office advised that some work package progress payments are conditional on completion of tests and that progress cannot be correctly certified until tests are passed.

2.16 ASC is responsible for providing objective evidence that quality control procedures and inspections are effective, but ASC need not provide satisfactory quality assurance reports with each progress claim. The Project Office advised that it can exercise the option of withholding payment when it is appropriate to do so, and that payments may be recovered where progress has not been made as claimed.⁸

2.17 The Project Office may reject only completed supplies, which are identified in the contract as certain discrete items varying in cost and complexity from completed submarines to a hand-held digital electronic multimeter. In terms of progress payments, the contractor is required to demonstrate compliance at six categories of testing for each component, sub system and system. Additional tests can be ordered by the Commonwealth if it considers this to be necessary.

⁸ Apart from the contract itself, the *Defence Act 1903* contains provisions regarding companies that supply the ADF with equipment not up to the standard specified in the contract. See sections 73C, 73D and 73E. Other statutes also apply such as the *Crimes Act 1914* section 29B, the *Trade Practices Act 1974* sections 52 and 53, and the *Occupational Health and Safety (Commonwealth Employment) Act 1991* sections 18 to 20.

Financial guarantees

2.18 In general terms the Commonwealth has purchased a range of performance guarantees as part of the overall contract price. Financial guarantees of ASC's compliance with the contract's performance provisions are not extensive, given the extent of Commonwealth risk exposure. ASC provided the Commonwealth with a Deed of Performance Guarantee for \$56 million guaranteed by a major bank to cover the due and proper performance of its contracted obligations. This guarantee expires altogether after the acceptance of the third submarine, which is scheduled for delivery in August 1998. This is a significant limitation given the financial and other risks that occur towards the end of complex design, development and construction projects. The risks are real - *Collins* has performance shortfalls attributed to first-of-class design which ASC is seeking to resolve.

2.19 The Project Office advised the ANAO that the Commonwealth holds performance guarantees from the parent companies of subcontractors where the sub-contract exceeds \$40 million. It advised these guarantees cover the completion of the subcontractors' work and were provided by:

- Celsius Industries Corporation of Sweden for Kockums Marine AB;
- Rockwell International Corp for Rockwell Australia;
- DRG (UK) for Strachan and Henshaw; and
- SAAB-SCANIA Combitech AB for SAAB Instruments AB.

2.20 The Project Office advised the ANAO that the only company exempt from providing a corporate guarantee but contracted for work exceeding \$40 million is Jeumont Schneider, which is a parent company not a subsidiary.

2.21 Other protection under the contract includes:

- advance payment guarantee for the period until acquittal of advance payments;
- general payment arrangements where payment is in arrears of verified progress;
- progressive Commonwealth ownership at each increment of work package payments;
- a charge over moveable items;
- a mortgage over the construction site; and
- a lease over the construction facility.

2.22 The contract expressly prohibits the Commonwealth from recourse against any ASC shareholder, beyond the performance guarantees mentioned above, which may arise out of any act or omission or default by the contractor. This reflects the *Corporations Law* provision that limits the liability of shareholders to the amount they invested in a company.

Compensation provisions

2.23 In general terms the Commonwealth has also purchased a range of compensation provisions as part of the overall contract price. The contract provides liquidated damages for contractor delay and, if submarine performance falls short of specified performance parameters, the submarine(s) may be rejected. The limits to liquidated damages are set out below.

Late delivery

2.24 The contract limits liquidated damages available to the Commonwealth for late delivery of submarines to \$125,000 per week - not escalated from contract signature. This compensation is capped at \$2.5 million per submarine or \$15 million total. Compensation for late delivery of a fully operational combat system is included in these amounts.

2.25 The 1985 New Construction Submarines Equipment Acquisition Strategy planned each Collins-class submarine's availability for service with the end of each Oberon submarine's service life. The ANAO would have expected larger liquidated damages amounts in the contract for contractor delay, given the Navy's need to ensure continuity in its Submarine Squadron capability, and the cost of maintaining a large acquisition Project Office for periods longer than expected.

Performance shortfalls

2.26 Depending on the type and extent of the performance shortfall, the Commonwealth may reject a submarine if it fails any performance specification by more than a specified amount or seek liquidated damages if it fails the performance specification by a lesser amount. In the case of specified performance relating to speed and endurance, liquidated damages are capped at either \$3 million or \$1 million (June 1986 prices), depending on which performance parameter was not achieved.

2.27 The contract caps ASC's total liquidated damages liabilities for speed and endurance shortfalls at \$15 million (June 1986 prices).

2.28 Given the Collins-class submarine mission profile, their performance - particularly in relation to endurance - is of critical importance to Navy. The

ANAO would have expected larger liquidated damage amounts in the contract than those provided by the contract.

Warranty for designs, workmanship and quality of materials

2.29 Under conventional warranty doctrines, manufacturers are responsible for product safety and performance, and they often offer warranties as a sign of good faith in their products. Generally when a breach of warranty occurs, contract law enables an injured party to insist on contract performance and sue for damages. ASC warrants to rectify any defects in design, workmanship and the quality of materials of each submarine for a period of 12 months from each submarine's acceptance. To invoke this warranty the Commonwealth must provide written notice of alleged defects or deficiencies within 30 days of their discovery.

2.30 The submarines' warranty provisions are funded by the Commonwealth through a \$75 million (June 1986 prices) fixed-priced work package. By August 1997 \$47.73 million or 64 per cent of this package had been claimed by ASC for warranty work on class-general defects on HMAS *Collins* and its successors. Defence considers that, by allowing warranty claims on incomplete submarines, they may suffer fewer defects after delivery, with an operational benefit to the Commonwealth. Given that the package is fixed-price, any warranty costs above \$75 million are to be met by ASC.

Warranty extended for HMAS Collins

2.31 The warranty on *Collins* was extended by contract amendment in 1996 from 12 to 18 months from delivery. This amendment was part of a negotiated settlement to compensate the Commonwealth for ASC's late delivery of *Collins* and other delays to the schedule.

2.32 The Project Office advised that it considers the six-month warranty extension of significant benefit to the Commonwealth because it covered all ASC and Boeing work.

2.33 ASC has subcontracted about 80 per cent of submarine design, development and construction work. The contract amendment makes special provision in cases where ASC was unable to negotiate the six-month warranty extension with its subcontractors. The ANAO considers that this special provision limits the benefit to the Commonwealth of the change to the *Collins'* warranty provisions, particularly as total warranty funding against the *Collins*

includes the cost of class-general defects discovered in Collins and rectified in the other submarines under construction.

2.34 The contract amendment also extends by six months the Commonwealth indemnity given to ASC for ship repairer's liability. The indemnity period would have covered HMAS *Collins*' shock trials, which at the time of the amendment were planned for late 1997. The ship repairer's liability indemnity essentially covers ASC for the loss of or damage to the submarines caused by ASC or subcontractors' unintentional but careless acts. (This indemnity is described further in paragraph 3.31.)

Latent defects

2.35 ASC is liable for a period of five years after acceptance of each submarine to rectify, at no cost to the Commonwealth, failures resulting from defective components which could not be discovered by reasonable care or inspection prior to acceptance of the submarine.

2.36 The latent defect liability is limited to components that suffer a continuing pattern of recurrent failures and that require a design or material modification. The cost of replacements, retrofit or modification in respect of each type of failure must exceed \$0.5 million (June 1986 prices) for the six submarines before the Commonwealth may make a latent defect claim.

2.37 Defence advised the ANAO that the rate of component failure is monitored and latent defect provisions apply to the design of the equipment not individual items. Defence advised that the provisions apply regardless of whether a component is replaced under Project Office management or after acceptance by Navy.

ASC's shareholders' dividends and retained profits

2.38 The contract is fixed price and hence does not assure ASC a specified level of profit. The Commonwealth is not privy to ASC's profit margins but contract amendments (that convert the provisional prices into fixed-prices) now total over \$680 million and these typically contain (with a compounding effect):

- contingency margins on ASC workshop production activities;
- profit margins and general and administrative expenses already built into ASC's hourly labour rates; and

- profit margins on subcontract work performed for ASC plus mark-ups on subcontractors' general and administrative expenses that demonstrates some ASC level of effort.

Defence advise that contingency margins are always related to the technical risk and are cost investigated and evaluated by technical managers.

2.39 ASC has continued to be profitable. It is in the Commonwealth's interests that such a company and its subcontractors remain economic while carrying out significant tasks for the Commonwealth. ASC's financial statements for 1996-97 (available through the Australian Securities Commission) show that its paid-up capital remained at \$10 million; dividends provided for or paid during the year were \$30 million leaving \$15.158 million as retained profits. Dividends paid to or provided for ASC's shareholders to 1997 are shown in Figure 2. ASC's net assets at 30 June 1997 totaled \$25.158 million.

ASC contingency and design verifications and test funds provided by the Commonwealth

2.40 Contingency funds are provided to cover cost uncertainties and risk management of unanticipated tasks within the contract's scope. Contingency funds remaining at project completion may be claimed as profit. The contract contains a number of fixed-price contingency and design verification and test funds or packages which at contract signature contained about \$382.184 million (June 1986 prices) as indicated by Table 1. These funds have been reduced to \$14.617 million (June 1986 prices), partially by contract amendments but mainly by drawdowns automatically linked to progress payments. Given the contingency provisions are fixed-price the Commonwealth's obligation to fund further contingency, including those listed in paragraph 2.42 below, is limited to \$14.617 million (June 1986 prices). Any additional contingency costs are ASC's responsibility.

2.41 Apart from the contract's contingency funds shown in Table 1, Defence maintains a submarine project contingency fund outside the contract with ASC. Project Office records indicate ASC has been paid about \$101 million from the Project's contingency fund through contract amendments.

2.42 Defence relies on ASC and its subcontractors' financial risk management to ensure that contingency and design verification and test funds have been preserved for the purposes intended. The contractors' achievements are impressive but contingency tasks still being managed by ASC and Defence include large numbers of defects listed in Reports of

Material State, defect and deficiency lists and Hazard Logs. These indicate a need to:

- resolve outstanding defects listed in each submarine's *Report of Material State at Delivery*;
- verify type-254 SMO pipes are defect free or replace them (paragraph 7.25);
- improve submarine performance, reliability and maintainability;
- investigate for shock damage and resolve any performance short-falls identified by HMAS *Collins*' shock trials planned for October 1998; and
- resolve numerous issues identified in Project Office and ASC Hazard and Design Logs.

Cable insulation risk

2.43 An example of an outstanding risk listed in the *Report of Material State at Delivery* and in the Hazard Log is a submarine design/material risk related to cables insulated with PolyEthane Ethyl Ketone (PEEK). A Project Office Hazard Log item of February 1991 indicated that PEEK-insulated cables presented an undesirable risk in that they could fail under 'wet arc' conditions several times in the submarine program with critical results. The item was reviewed from time to time over the following five years by the Project Office, in consultation with ASC and DSTO. The outcome was inconclusive. ASC's *Report of Material State at Delivery* for *Collins* (July 1996) states, under matters for Commonwealth resolution:

Almost all lighting and power cabling under 2.5mm have PEEK insulation. PEEK cabling is banned by RAF as shorting causes insulating material to break down into graphite - loss of whole looms has been experienced. No further action intended by SPD [Defence's Submarine Project Office].

2.44 The ANAO queried this entry. It was unclear why this cable risk was for the Commonwealth, not the ASC, to resolve. Defence advised:

- ANAO's 1992 Report on the project comprehensively discussed this issue and Project Office actions at Appendix 3 item 1;
- an effective risk management program identified the issue and decisive action was taken to approve a contract amendment proposal (CAP 321) to replace large-diameter electric cables with low fire hazard cables because the risk was assessed to be unacceptable. Power cables of under 2.5mm were not changed as the risk was considered acceptable. Those assessments remain unchanged; and

- the outcome is reported in the TI338 as a record of Project Office action in the matter. The issue was resolved in a decisive manner, so far as Defence is concerned, with the incorporation of CAP 321 in May 1990.

2.45 Notwithstanding Defence's view that the risk was fully considered in May 1990, the ANAO notes that there were continuing concerns about this issue in subsequent years and that the cable contract amendment discussed in the 1992 report is not satisfactorily resolved. Fixed-price design and construction contracts hold contractors responsible for arriving at designs and construction standards that meet the contract's specifications at no additional cost to the customer. Any agreed specification change that increases the contractor's work scope would normally justify a real price increase. Project Office records indicate that ASC and its design subcontractor were responsible for selecting electric cables that met toxicity, flammability and smoke index specifications embodied in the contract and were fit for their purpose. However, the contract amendment that Defence referred to specifically directed ASC to use low fire-hazard cable, compliant with an agreed technical specification in all applications including power and signal cables and in the majority of Combat System equipment to equipment cables, except in specified Marine Tefzel & Hytrel Shielded cable applications. This direction, instead of reinforcing what was already agreed in the fixed-price contract, generated a real price increase for the Commonwealth amounting to almost \$12 million. The designer-specified PEEK insulated cables for low fire-hazard applications now pose an undesirable risk, and it is unclear from records that the UK supplier's QA and the project's design QA activities established that all PEEK cables were fit for their intended purpose. The Project Office seems now to have accepted an undesirable risk embodied in the contractors' PEEK cable decisions. This does not indicate effective risk management by the Project Office. Defence maintain that the risk being accepted was fully considered. Another Hazard Log entry is discussed in paragraph 7.47.

Funds remaining to complete the submarines

2.46 The contract allows progress payments to ASC to draw on contingency funds, regardless of whether contingencies were encountered during the progress payment period. Table 1 indicates that most of the contingency funds have been paid. Noting the close monitoring of contingency funds that occurs on the ANZAC Ship Project, the ANAO suggested that it would have been preferable for the New Submarine contract to permit ASC to draw on contingency packages only as need arose, with the remainder paid at the project's end as final profit. Defence advised that this would be incompatible with a fixed-price contract.

2.47 The important issue concerns funds available to complete the submarines. Defence needs to be confident that the remaining funds are sufficient for ASC to do this. As discussed in paragraph 1.7, by July 1997 Defence had paid 95 per cent of the construction contract sum. The Project Office records indicate that the amount remaining to be paid to ASC is about \$188 million. As at June 1997 Defence believed that the amount remaining to be paid, together with funds available within ASC, would be sufficient.

2.48 The risks are nevertheless significant, for the amount of work still to be done is extensive, complex and difficult for Defence to quantify. As indicated above, little remains in the contingency packages although a significant amount of design and construction risk remains.

2.49 Additional costs may also arise from continuing project delays. At a late stage of the audit (August 1997), ASC produced a revised submarine delivery schedule that indicated a further six to eight months delay in delivering submarines 04 to 06 (see names at paragraph 4.14). The previous revised delivery schedule, approved by Defence in July 1996, contained delivery delays of five to thirteen months. If ASC's latest schedule estimates are correct, the Project's overall schedule has slipped almost 20 months since June 1987.

2.50 In the ANAO's opinion the remaining project risks are such that Defence should review the funds needed to complete the Project. Notwithstanding Defence's expectation that the Project will be completed within the approved cost, the ANAO considers that Defence should, as a matter of urgency, review the cost to complete the Project in light of unresolved contingencies and continuing schedule slip to provide assurance that there are sufficient funds available to complete the Project or to take early steps to address any deficiency. Such a review should be carried out more rigorously and conclusively than the reviews observed on Defence files so far. It could take account of the drawdown of contingency funds, and the likely cost of treating remaining contingencies as part of the cost and schedule estimates to complete the Project. (Cost and schedule control is discussed in paragraph 4.31.)

Recommendation No.1

2.51 The ANAO recommends that, in view of unresolved contingencies and continuing slippages in the delivery schedule for the new submarines, Defence satisfy itself by means of regular project cost and schedule reviews that there will be sufficient funds to complete the Project.

Defence response

2.52 Agreed. Defence conducts, and will continue to conduct reviews of all project costs and schedules. While acknowledging that there are certain unresolved contingencies and slippage from the original schedule, Defence does not accept that this is due to poor project management. This was, from the start, a complex undertaking for Australia and the current project performance remains ahead of bench-marked performance of comparable international projects. The newly established Defence Acquisition and Review Board will also review this project as part of its project review function. Defence is sensitive to ANAO concerns in respect of ASC having sufficient funds to complete the project. The Department monitors progress not only through CMACS but also through progress review meetings, physical verification of reported progress, and regular reviews of ASC's audited accounts.

Conclusion

2.53 Much has been achieved on the Project since it began in 1987. However, delays are occurring and the contract gives the Commonwealth little recourse for delays. The submarines have performance shortfalls attributed to first-of-class design which ASC is seeking to resolve. These present risks for the Commonwealth which the Project Office needs to take a firm hand in managing.

2.54 The contract provides only modest recourse by the Commonwealth by way of financial guarantees and liquidated damages. Liquidated damages for inadequate submarine performance, particularly in relation to endurance, are small given its critical importance to Navy. The Commonwealth should be able to do better in commercially-based contracts. Funds still available from Defence for construction are limited, and contingency funds have been substantially drawn down. Defence needs to provide assurance that there are sufficient funds available to reduce the submarines' risks to acceptable levels and complete the submarines.

3. Insurance and indemnity

This chapter outlines the allocation of construction and repair risks on the Project, and comments on the decision to amend the contract to replace commercial insurance of construction and repairs with Commonwealth indemnities to ASC and its subcontractors.

Introduction

3.1 Design and construction contracts normally require prime contractors to obtain comprehensive insurance to protect the principal against risks involved in design, construction and completion of the works. The contract for the new submarines provided some protection for the principal (the Commonwealth) by means of commercial insurance, funded by a provisionally-priced package included in the contract. In 1991 after four years of negotiation and litigation the contract was amended to incorporate an indemnity in terms similar to the commercial insurance covering the period between launch and acceptance (known as the 'wet' risk) of all *Collins*' successors. The Commonwealth in 1994 agreed to further replace the project's commercial insurance with financially uncapped Commonwealth indemnities covering both the wet risk and the submarines' construction period (known as the 'dry' risk). This chapter describes the events that led to the Commonwealth to protect ASC from the consequences of specified marine builder's and ship repairer's risks.

ASC's obligations for submarines under construction

3.2 The Commonwealth engaged ASC both to design and construct the submarines. ASC is obligated to carry out its work competently, to supply good and proper materials and to ensure that the completed submarines are fit for their intended purpose. ASC is responsible for correcting any materials, workmanship or design defects to ensure the submarines achieve their performance specifications and are fit for their intended purpose. ASC's liability extends to work done by its subcontractors. ASC's insurance brokers in 1995 provisionally valued the overall liability at \$3 billion. Defence advised the ANAO that it had valued the liability at \$1.685 billion as at September 1994, and that this liability would only accrue after a loss of all six dispersed submarines.

3.3 The contract required ASC to obtain insurance cover over its marine builder's risks and risks in respect of public liability, property damage, and contracts work policy. The contract's insurance packages contained \$62 million for insurance costs (provisionally priced in June 1986), of which \$52 million was in respect of the six submarines and \$10 million was for other insurances. Defence advised the ANAO that these amounts included insurance brokers' commission. The Project Office's 1992 insurance review indicated that \$43.147 million had been paid for insurance 'deposit premiums' and initial insurance for all submarines and \$15.427 million remained to be paid as 'adjustment premiums' payable at the delivery of submarine 01 (HMAS *Collins*) and the launch of submarines 02 to 06 (see names at paragraph 4.14).

3.4 In 1994 it became apparent that the insurance would cost the Commonwealth \$18.5 million (1994 prices) more than Defence originally estimated. Defence records indicate this cost increase was due to slippage in the delivery schedule. As discussed below, the insurance was replaced by financially-uncapped Commonwealth indemnities on 1 October 1994. The indemnities that relate to the submarines' construction and warranty periods are discussed below.

Concerns by insurance brokers

3.5 In February 1994 ASC's insurance broker in Adelaide advised one of ASC's insurance underwriters that ASC had discovered widespread cracks in the steel hull plates of submarine 01 (*Collins*). The broker advised the underwriter that it was difficult to estimate the project impacts but offered the following approximate values:

- testing and replacement of affected plates - \$5-10 million;
- reduced operational life of submarines 01 and 02 - \$100 million; and
- rebuild submarine 01 - \$500 million.

3.6 A month later Defence's insurance adviser in London advised Defence that he had picked up rumours that structural problems with submarine 01 could cost \$10 million to repair or \$100 million or more for replacement. The adviser said that it was vitally important that the impact of the rumours be contained and minimised.

3.7 The Project Office advised him that at no time was it considered that surface imperfections found in a batch of steel plate would have any effect on submarine 01. The Project Office also advised that problems found in hull section 600 of submarine 01 were minor and not in pressure hull welds. These

required grinding back to the specification excess weld material. That work was almost complete.

3.8 In mid April 1994 the adviser repeated his concerns and suggested to Defence that:

In view of the unfortunate rumours that have been circulating this market regarding welding problems and hull cracking you may wish to meet with an Underwriter or two to explain the reality of the situation.

3.9 Defence advised the ANAO that no claim was ever made and that the matter was finalised before the commercial insurance was terminated. Welding risks are discussed in paragraph 7.6.

Insurance options

3.10 At the same time (early 1994) the Project Office reported a nine-month delay to submarine 01 delivery (to accommodate late delivery of combat system software), which required an extension to the insurance duration. The Project Office assessed the prospect of completing all submarines within schedule and budget was still very good, and advised the Minister for Defence in March 1994 that ASC's revised schedule would not result in additional costs to the Commonwealth.

3.11 Project Office records indicate that in June 1994 options for insurance for the remainder of the project were discussed in London by ASC and its broker and Defence and its adviser.

3.12 After an ASC board meeting in Malmo Sweden in June 1994, Defence (which paid ASC's insurance premiums) considered three options:

- no change to the insurance arrangements, but with a consequential overspend on insurance of \$18.5 million;
- cancel submarine 01's insurance at next undocking in order to reduce expenditure by between \$4.5 million and \$9 million; or
- cancel the insurance to achieve a saving of \$20-30 million.

3.13 The Project Office's preferred option was to recommend that the insurance be cancelled and replaced by a Commonwealth indemnity.

Revised schedule and insurance costs

3.14 Defence in July 1994 had assessed that the revised schedule would add \$18.5 million (1994 prices) to the insurance premiums. A later Defence review assessed that the delay with submarine 01 and the revised schedule for the other submarines would result in insurance costs from October 1994 to the end of the project amounting to \$36.843 million (December 1994 prices), of which \$21.726 million would be funded by the provisionally-priced component in the contract with ASC and the remaining \$15.116 million funded through the Project Office's contingency fund. The delay in replacing the insurance with a Commonwealth indemnity was estimated to add about \$0.7 million per month to the Project's provisionally-priced insurance package.

The indemnity agreement savings

3.15 Defence decided not to try to recover increased insurance costs from ASC in liquidated damages for delay (liquidated damages for delay are capped at \$15 million). Instead Defence reached a negotiated position with ASC on the delay which revised the delivery schedule and replaced the insurance with a Commonwealth indemnity. Defence advised the ANAO that this resulted in:

- a total contract price reduction of \$14.449 million (June 1986 prices). This was achieved through a \$6.490 million insurance 'deposit premium' refund (from the total deposit premiums already paid), and the removal of the remaining provisionally-priced allocation of \$7.959 million for the submarines' adjustment premiums;
- removal of the contract's \$36 million (June 1986 prices) provisionally-priced management reserve fund and conversion of \$26 million of the fund into a series of fixed-price packages to be paid as incentives for submarine delivery in accordance with the revised schedule;
- ASC waiver of all outstanding force majeure claims together with an undertaking it would not pass to the Commonwealth any contractor costs from the schedule slippage;
- ASC agreement that the indemnity would contain some modifications of the original insurance cover; and
- insertion into the contract an 'equilibrium clause' to provide an obligation on both parties to confer if external circumstances beyond ASC's control change in such a way as to affect the contracted price.

3.16 The Commonwealth carries substantial risks through the indemnity granted to ASC and its subcontractors. Other risks that fall within ASC's responsibility and would be factored into the contract price, which contained

profit margins and over \$350 million (June 1986 prices) in contingency and design verification and test funds and \$75 million (June 1986 prices) in warranty funds.

3.17 Defence advised the ANAO that the change from commercial insurance to indemnities resulted in a price reduction of \$21.7 million (December 1994 prices), representing a pro rata refund of the deposit premiums already paid and the balance of the insurance premiums which would have been required if the insurance had been retained. Given that the submarine program was further delayed, Defence estimates that it has saved more than \$50 million in insurance premiums.

3.18 ASC's agreement to forgo the \$36 million management reserve fund, waive all outstanding force majeure claims and not pass on any contractor costs from the schedule slippage, indicate the value it saw in gaining the indemnities. The management reserve could have been seen as an incentive for ASC to delay the project and was financially an open-ended risk for the Commonwealth. It covered ASC's contingent costs for any project management, construction labour, fixed overhead and other miscellaneous expenses in constructing the six submarines after the contracted delivery date of the sixth submarine. Agreement to insert an 'equilibrium clause' added little to the contract.

3.19 The change from insurance to indemnity was attractive for the insurers too, who (after taking account of refunds of prepaid premiums - see paragraph 3.3), grossed about \$37 million in premiums in the early less-risky part of the Project, and were then relieved of the increasing risks later in the Project. The indemnity benefits related parties as it extends to any person associated with ASC or any of its subcontractors or related companies. The ship repairer's indemnity (see paragraph 3.34), covers acts of negligence (lack of reasonable care and attention). This means that, if such a person commits a negligent act in the course of repairing the submarines which results in damage to the Commonwealth, the indemnity would effectively preclude the Commonwealth from suing for damages.

Defence's investigation of pre-existing conditions

3.20 Defence did not conduct a 'due diligence' investigation of the indemnity proposal to clarify the risks that the Commonwealth was about to take on. Defence advised the ANAO that its decision to grant the 1994 indemnities was based on prolonged risk assessments including that used in the 1991 decision to self insure the submarines between launch and acceptance. The ANAO could only locate a qualified risk assessment

completed after granting the indemnities, and could find no evidence of a sound analysis of the risks by a risk management expert with specialist qualifications and experience in statistical risk analysis and marine builders risks. (See paragraph 3.26)

3.21 Given the risks involved, the ANAO believes it would have been prudent for Defence to have conducted a due diligence investigation of the project so that it could be reasonably sure that it had considered all material facts prior to cancelling the insurance. The ANAO would expect such an investigation to:

- extend into ASC and its subcontractors' operations and product liability insurance and the concerns raised by insurance brokers and underwriters;
- gather all facts considered important under the circumstances; and
- verify the data and information furnished by the investigations, using independent parties if necessary.

3.22 Instead, Defence used the contract's provision to require both parties to certify to the other that they had no knowledge of any circumstances by reason of which any claim could be made under the insurance policies other than those recorded on the certificates. There were no significant circumstances cited.

3.23 The ANAO considers that the Project Office should have also determined which subcontractors were able to cancel or reduce their product liability insurance once the Commonwealth indemnity was granted, and then sought an appropriate reduction in contract price.

Consultations with the Department of Finance and advice for the Minister for Defence

3.24 Defence in August 1994 consulted the then Department of Finance about the indemnity option. DoF expressed concern whether Defence would have 'effective control' of the project as understood under the indemnity provisions of the Finance Directions. After further advice, DoF agreed to the indemnity on the understanding that Defence would save premiums and maintain 'effective control'. DoF also commented that Defence should conduct a risk evaluation study of controls and inform the Minister of Defence that the indemnity represented best value for the Commonwealth.

3.25 The indemnity was put into effect on 1 October 1994. The Minister for Defence on 5 October 1994 noted a minute from Defence on the indemnity which advised of project delays. The minute advised that a contract amendment had been agreed with ASC to replace commercial insurance with

an indemnity, in order to gain savings and bring the insurance arrangements into line with those for the ANZAC Ship and Minehunter Coastal Projects. The Minister was also given advice about the contractors' initial estimates of the complexity of the submarine and its combat system which, in the ANAO's opinion, indicates that the Project Office should have given close attention to Project monitoring and quality assurance from the outset.

3.26 After the indemnity was granted, the Project Office's SUBSAFE Manager completed a risk assessment of the loss of supplies to be covered by the indemnity to assist in deciding whether the Commonwealth should assume responsibility for the risks.⁹ The risk assessment was heavily qualified by its author, who stated that resource constraints prevented both a qualitative and quantitative analysis and that it was a desktop assessment based on the experience and judgement of Project staff. Defence advised the ANAO that no decision remained to be assisted by the risk assessment.

3.27 Given the potentially very substantial exposure being undertaken by the Commonwealth (see indications at paragraph 3.2), the ANAO questions whether the Project Office applied sufficient resources to the risk assessment. The ANAO considers that the risks should have been assessed prior to the agreement by a risk management expert with specialist qualifications and experience in statistical risk analysis and marine builder's risks.

3.28 By December 1996 ASC had made 46 claims under the indemnity and 23 have been denied.

US experience of marine builder's risk insurance and indemnities

3.29 Defence's decision to grant the indemnity seemed not to take into consideration international trends regarding government indemnities to private corporations. In 1988 the Project Office was advised, by its insurance adviser in London, of the US Navy's policy change from providing indemnities to using commercial insurance. The adviser stated that according to UN Navy's policy, up until 1979:

there was little or no insurance requirement on naval vessels whilst under construction as these had previously been comprehensively protected by Government indemnities. It was following significant problems in the United States of America, during a submarine construction program that major problems were encountered particularly regarding welding, with respect to which the losses were recoverable under Government indemnities. The United

⁹ Risk Assessment of the Loss of Supplies to be Provided under Contract C218269, prepared by SUBSAFE Manager New Submarine Project, 26 October 1994.

States Government decided from that time to restrict its indemnities and as a result commercial insurance was sought from that time to protect similar problems occurring in the future.

3.30 The adviser mentioned a similar trend to insurance in respect of UK and Canadian navy ship and submarine building. Defence's change from insurance to indemnity seemed not to take account of these changes or that submarine construction involves risks higher than those associated with ships such as ANZAC frigates or the minehunters. Defence advised the ANAO that:

- trends in overseas shipbuilding insurance are towards principal controlled insurance, not contractor controlled insurance as originally envisaged in the submarine contract;
- there are different policy positions applied by overseas governments regarding acceptance of liability for risk of loss or damage to supplies; and
- in Australia, the preference has been to accept liability for these risks at the earliest possible stage under the government policy of self-insurance.

The indemnity cover

3.31 ASC's marine builder's risk for the submarines, including loss or damage is limited to the periods the submarines are in ASC's care, custody or control. This includes submarine construction and submarine movements within the limits of the port at which the work is being carried out and including trial trips.

3.32 The marine builder's indemnity does not cover risks related to design and construction, such as the cost of repairing, modifying, replacing or renewing any part of the submarines which may suffer material, workmanship or design defects, or errors in submarine operation or maintenance documents.

3.33 For example, the indemnity covered damage to HMAS *Collins* when it suffered propulsion difficulties and struck HMAS *Protector* and ASC's ship lift facility in June 1995. Even though this damage resulted from a propulsion system defect, Defence has so far paid ASC \$276,182 to repair the damage to *Collins* resulting from the faulty propulsion system. But it did not pay ASC to correct propulsion system defects.

3.34 ASC is also liable for ship repairer's liabilities from Defence's acceptance of each submarine until the end of each submarine's warranty period. The ship repairer's liability indemnity covers the loss of, or damage to, the submarines that may result from ASC's negligence as well as any negligence of its subcontractors. The previous ship repairer's liability

commercial insurance covered this risk for submarine 01 only, with the remaining submarines covered by a Commonwealth indemnity. The indemnity excludes the cost or expense of repairing, modifying or replacing any part by reason of faulty design.

3.35 Even though the ship repairer's liability indemnity covers loss of or damage to the submarines caused by contractor negligence, the contract holds ASC liable for loss or damage incurred by the Commonwealth as a result of wilful acts or omissions or a breach by ASC of contract provisions. The most significant contract provisions in this respect are the quality system requirements.

3.36 ASC's liability for any Commonwealth loss or damage, whether direct or consequential, that results from ASC's negligence is limited to \$100 million. ASC is subject to an excess/deductible for each indemnity claim to a maximum excess/deductible of \$1 million each year.

3.37 The indemnity underscores Defence's need to exercise systematic risk management of the Project by monitoring closely the construction program and following-up quality assurance issues rigorously when they first become apparent.

Commonwealth allowance to ASC's insurance broker

3.38 The deposit premiums that Defence had paid for ASC's insurance included commissions to ASC's broker in Adelaide. When the indemnity was granted and the insurance was cancelled, Defence became due for a refund of prepaid premiums and the insurers were protected against claims arising after the termination of the insurance.

3.39 ASC's insurance broker was concerned that the indemnity left them without the broker's commissions from the insurers that they had expected to receive for some years to come. Project Office records on this are incomplete. As far as the ANAO has been able to determine, Defence in 1995 allowed the insurers to divert an amount of \$2.4 million, from the refund of prepaid premiums due to Defence, and to pay that amount to the broker for services they may give to ASC in gaining the maximum benefit from the indemnity provided by the Commonwealth.

3.40 In the absence of complete records, the dimensions of the arrangements are unclear, as indeed are the benefits to the Commonwealth. The Commonwealth was not a party to this contract, which was apparently

between ASC and its insurance broker. On the face of it, the Commonwealth did not receive any benefit and indeed may well have been disadvantaged, raising the question of the legal authority for such a payment. The payment of \$2.4 million (negotiated down from an opening claim for \$3.7 million) was made despite advice from Defence's adviser that services of this kind should be paid for by ASC, not the Commonwealth, and that the broker's loss of commission on terminated insurance was just part of business.

3.41 In any event payment for continuing services should be made on a continuing basis as the services are performed, and not as a lump sum at the start of the agreement. Defence pays its own advising firm on submarine indemnity matters \$25,700 per year plus an hourly fee for claims management.

Conclusion

3.42 The indemnity could well have significant downstream cost implications for the Commonwealth. It is difficult to make any assessment on the information available. Defence's decision to grant the indemnity was not based on an in-depth analysis of the risks inherent in the construction program arising from the fact that ASC was a newly established company with the role of prime contractor over 1500 subcontractors, spanning three continents. Defence's analysis, completed after the indemnity was granted, was heavily qualified by the author because of resource constraints. Defence maintains that the nature of the risk was well understood.

3.43 Since the contractor was legally at arm's length, Defence could not have 'effective control' over the construction program, to allow self-insurance as indicated in (the former) Finance Direction 21. Nor did the Project Office, after the indemnity was granted, attempt to influence construction quality by exercising more rigorous quality assurance audit follow-up to protect the Commonwealth's interests or to minimise the Commonwealth's new exposure to risks.

3.44 Defence advised the ANAO that its control over the project was 'effective' because it has monitored ASC's implementation of QA and QC standards and safety standards and that it was satisfied that there was sufficient follow-up of discrepancies in the contractor's QA and QC arrangements to protect the Commonwealth's interest. Defence also advised that by the time the indemnity was granted almost all the remaining work was under the Project's constant monitoring in regard to safety, security and fire protection, or under operational control of RAN submarine crews. The ANAO considers that monitoring fell short of the generally accepted meaning of 'effective control', which provides for the capacity to dominate decision-making

directly or indirectly. The ANAO also notes that if the Commonwealth did exercise effective control over ASC's and its subcontractors' activities then the Commonwealth would carry the risk for any errors or omissions within that control.

3.45 The 1992 audit report indicated the ANAO's concern about the Project Office's business sense in protecting the Commonwealth's interests. The 1997 audit has shown little improvement. The Project Office would have better protected the Commonwealth's interests had it made a realistic and informed study of the risks before granting the indemnity. Similarly, the Project Office should have queried the need to pay \$2.4 million to ASC's broker to help ASC maximise its benefits from the indemnity

3.46 Work to remedy defects (at ASC's cost) is being postponed until *Collins'* first post-delivery availability work program scheduled to commence in June 1998. It is possible that at this time ASC could make further claims under the indemnity for damages that may arise as a consequence of defects in workmanship, materials or design. (See paragraph 3.33 for an example.) Such consequential costs would bypass the safeguards of the 'fixed-price' contract. Defence advised the ANAO that the indemnity will not be used to fund rectification of defects, deficiencies, warranty defects or latent defects. It will only be used to fund the repair, damage or replacement of losses.

3.47 The ANAO considers that appropriate action in future projects on issues raised in this chapter should be apparent without specific recommendations. Moreover there have been recent reports and guidelines to assist departments in granting indemnities. Audit Report No.6 1996-97 *Commonwealth Guarantees, Indemnities and Letters of Comfort* drew attention to the general issues and Defence responded positively to the recommendations in the report. Prompted by that report the then Department of Finance issued Finance Circular 1997/06 *Potential Liabilities and Losses* (April 1997) to provide departments with guidelines for issuing guarantees.

3.48 Audit Report No. 6 was the subject of an inquiry by the House of Representatives Standing Committee on Financial Institutions and Public Administration. In its report¹⁰ the Committee made recommendations and gave further guidance on granting indemnities.¹¹

¹⁰ *Report of the Inquiry into ANAO Audit Report No.6 1996-97 on Commonwealth Guarantees, Indemnities and Letters of Comfort*, AGPS September 1997

¹¹ Audit Report No.6 reported the outcome of an audit survey of guarantees, indemnities and letters of comfort issued by departments. The report did not include the indemnities granted to ASC because the Defence response to the audit survey omitted to include the indemnities. The ANAO drew attention to this

4. Project Progress

This chapter outlines the New Submarine Project's contractor performance monitoring system and the Project's progress. The Project has experienced irrecoverable schedule overrun, delays in test and evaluation and the omission of key sea-acceptance trials from HMAS Collins' successors' trial programs. This suggests Defence should focus on increasing its project management expertise.

Introduction

Contractors' achievements

4.1 Despite many challenges faced by the Project, the first submarine, HMAS *Collins*, was launched on time on 28 August 1993. *Collins* was said to be 87 per cent complete at the time and the ANAO recognises the significant achievements by ASC and its subcontractors. In six years these contractors:

- established over 1500 design and construction sub-contracts involving a wide range of advanced technology;
- established numerous submarine construction facilities from greenfield sites;
- established a Defence-specified Cost and Schedule Control System (CS²), Contract Management and Control Systems (CMACS), numerous accredited quality management systems and a range of corporate management information systems;
- recruited and trained a skilled work-force (this was made easier by the availability of skilled people in relevant Australian industries, including ex-Oberon submarine program personnel);
- developed and refined extensive submarine quality assurance and quality control processes and inspection tests and trials processes;

omission when the indemnities came to light in the audit of the New Submarine Project in 1997. Defence then provided the Committee with a submission on the indemnities, which the Committee published in September 1997 with its report. The Committee's report expressed concern about Defence's records regarding indemnities and made certain recommendations. The ANAO drew attention to various omissions from Defence's submission. Defence provided the Committee with a revised submission on the indemnities, which the Committee authorised for publication in November 1997.

- contended with construction delays and reworks caused by a backlog of designs, redesigns and quality control issues; and
- constructed one of the world's largest and potentially most capable diesel electric submarines.

4.2 ASC and its subcontractors managed the risks in establishing for the first time in Australia a consortium to manage the project and construct submarines. These risks were compounded by design work in Sweden and Australia progressing in parallel with submarine construction.

4.3 Risks which the audit found not to be well managed relate to software development and the quality of some material and designs and imported welded assemblies. Defence in 1987 recognised the software as a moderate risk in terms of schedule and performance. ASC is yet to resolve, to Navy's satisfaction, significant submarine performance issues relating to the combat system, design maturity, submarine endurance, imported welded assemblies and submarine noise signature.

Project Office achievements

4.4 The ANAO also recognises the formidable project monitoring task faced by the Project Office, given that submarine construction was well under way before all design work was completed. Project Office records indicate that, by September 1990, only 65 per cent of the submarine drawings were complete and that ASC's submarine design subcontractor Kockums was 6 to 12 months late in completing all expected design tasks. The design was finalised in March 1993, only 5 months prior to HMAS *Collins*' launch.

4.5 ASC assembled *Collins* in South Australia from components manufactured in Europe, North America and Australia, and has been assembling its successors in Australia largely from components manufactured throughout Australia. The Project Office monitors a wide range of technologies such as mature metal assembly technology and advanced electronic system design and development.

Measuring Project progress

4.6 To assess Project monitoring activities the ANAO relied on Project Office records and has not verified the data's accuracy through direct on-site observations at ASC.

4.7 Complex projects like the New Submarine Project require a range of methods to monitor progress. The Project Office uses:

- a Contract Monitoring and Control System (CMACS) to monitor work package progress in terms of cost and schedule;
- direct on-site work package progress verification;
- regular design reviews and Quality Assurance audits;
- Submarine Safety (SUBSAFE) audits; and
- submarine inspections, tests and trials.

Contract Management and Control System (CMACS)

4.8 CMACS is based on a commercial project management package adapted by Defence for use in the New Submarine Project and later in the ANZAC Ship Project.

4.9 CMACS defines ASC's statement of work and provides a basis for controlling payments to ASC. The submarine construction program contains over 2150 CMACS work packages. Each package has expected start/finish dates, late start/finish dates and activity milestones. This allows the Project Office to assess progress as claims for payment are recorded against each package.

Cost control

4.10 ASC uses CMACS to render monthly progress billings to Defence based on progress expressed as a percentage completed of each work package.

4.11 The ANAO's 1992 audit found that CMACS provided a reasonable means of measuring Commonwealth expenditure on work packages and the aggregation of that expenditure. However, the ANAO raised concerns about CMACS' suitability as the primary contract management and control system. These concerns were heightened by the Project Office's 1992 assertions that the project was on schedule, which were inconsistent with the ANAO's analysis of business and other aspects of the project indicating irrecoverable schedule slippage.

Schedule control

4.12 Current CMACS data at Figure 3 shows the project's actual progress to be behind the current schedule's late progress line. Other Project Office records indicate that delays caused by warranty work on HMAS *Collins* and HMAS *Farncomb* may result in their Acceptance Into Naval Service (AINS) slipping at least a year behind schedule. Diversion of ASC resources to carry

out construction reworks, defect resolution, warranty work on all submarines and ad hoc in-service support to *Collins* is causing an ongoing irrecoverable schedule slippage currently amounting to about 20 months (since 1987).

4.13 The ANAO is uncertain about the overall schedule's accuracy, because of uncertainty regarding the overall extent of ASC's resource diversions and weaknesses in CMACS outlined below.

4.14 CMACS data provided below shows, in respect of the contract sum attributable to each submarine, the proportion spent to June 1997:

Submarine	Percentage of funds expended
01 - <i>Collins</i>	98
02 - <i>Farncomb</i>	98
03 - <i>Waller</i>	97
04 - <i>Dechaineux</i>	96
05 - <i>Sheean</i>	91
06 - <i>Rankin</i>	87

4.15 Despite these high percentages there still seems much to be done to complete the submarines. CMACS data indicate that HMAS *Collins*' CMACS packages were 87 per cent expended when it was launched in August 1993, and that later submarines will be launched after greater levels of expenditure. For example, data on submarine 05 - *Sheean* - shows its CMACS packages are 91 per cent expended. However, physical distribution drawings of December 1997 show *Sheean*'s hull still in seven pieces indicating some of its systems are yet to be assembled fully, integrated into other sections of the submarine and set to work.

4.16 In 1991 a US Department of Defense expert on Cost/Schedule Control Systems (CS²) advised, in the context of the Submarine Project, that improved control and reporting resulting from CS² discipline would render CMACS detail redundant and excessive. The expert advised that CS² was superior to CMACS because it directly related to the product being built, whereas CMACS has no organisation scheme as to hierarchy of work package relationships or production sequence.

4.17 The expert also reported that there was no performance measurement flow-down to many of the Project's subcontractors. This resulted in a 'real

challenge to the visibility' with the prime contractor necessarily relying on CMACS. The expert recommended that Defence consider modifying the submarine contract to ensure Defence visibility of early-warning indicators being generated by the contractor's CS² system.

4.18 The contract was not amended in the way recommended because Defence believed CMACS's removal would be contractually too difficult to achieve. The ANAO found evidence that supports the US expert's advice and raises other concerns about CMACS' performance measurement capabilities. In November 1991 a CMACS reviewer reported to the Project Office that a subcontractor had increased the weighted values of its early work, decreased the values of later work, and had selected work package designation numbers which did not correlate in any way with the Commonwealth's CMACS work package designators. The ANAO considers this activity would inflate artificially the amount of work apparently done in the early stage of the project leaving later stages under-funded.

4.19 Other Project Office records indicate that by May 1992 over \$2.5 billion or 62 per cent of project funds had been expended. But at the time progress measurements on CMACS work packages were a source of concern for Project Office staff responsible for measuring progress. These concerns prompted the Project Office to give the following advice to a progress reviewer:

The package numbers you are verifying will and can change abruptly. However we try and ensure that you receive the new packages breakdowns or appropriate amendments to existing breakdowns. We do on occasions forget to notify that packages are being deleted, but this can be assumed from the package listing on your group curves. The fact that there are new packages listed to your group curves does not mean that we have increased the scope of your verification responsibilities but rather that ASC has seen fit to restructure their packages as they see fit...

4.20 This indicates to the ANAO that CMACS implementation at the time did not have the full management discipline expected within a cost and schedule control system. The ANAO would expect Defence Project Offices to control changes to cost and schedule control systems closely so that actual work accomplished can be measured objectively against the overall scope of work. Without such controls actual expenditure can be measured only against planned expenditure, with no objective indication of actual work against planned work. CMACS as presently implemented is not a reliable indicator of actual progress.

4.21 The Project Office advised that CMACS package details are contractual and cannot be changed unilaterally, and disagreed with the ANAO's comments in respect of CMACS. The Project Office maintains that

CMACS has been effective in showing actual progress. However, the ANAO remains of the view that given the Project's schedule delays and limited funds available to fund these delays, the Project Office should seek improvements in CMACS progress measurements so that Defence may be aware of early cost and schedule variations and the steps taken by ASC to maintain the schedule.

Recommendation No. 2

4.22 The ANAO recommends that, to assist in management of the New Submarine Project, Defence seek from the prime contractor and its major subcontractors improvements in reporting schedule variations and advice of corrective action.

Defence response

4.23 Agreed in principle. Defence will continue to seek improvements in reporting schedule variations and corrective action where this is considered necessary. Defence already has established mechanisms which it monitors, for reporting of all schedule variations and corrective actions taken by its contractor and major sub contractors. Defence has resident Departmental officers on some sites to physically verify reported progress. Visits to other sites take place at intervals of approximately six to seven months.

ANAO verification of Project Office's checks of CMACS claims

4.24 Rather than relying totally on a desk audit of CMACS claims verification by the Project Office, the ANAO proposed that two consultants with extensive submarine construction and submarine project monitoring experience assist with a physical audit of specific CMACS progress claims related to submarines 04 and 06.

4.25 The ANAO does not have statutory access to contractors' premises, but sought to exercise the Commonwealth's right of access under the contract. ASC, however, would not agree to provide access to the ANAO's consultants, and the physical audit did not proceed.

4.26 The issue of ANAO access to contractors' records was raised in the 1992 audit report, the JCPA's review of that report (*JCPA Report 337*) and in the ANAO's 1995 report on Defence contracting,¹² but on each occasion

¹² Audit Report No. 31 1994-95 *Defence Contracting* p.xiv.

Defence would not agree. Access to this kind is normal practice in major US Defense contracts, and the ANAO remains of the view that it would be in the Commonwealth's interest for the ANAO, including its authorised expert consultants, to obtain access on major contracts such as New Submarines to check that Defence has been diligent in protecting the Commonwealth's interests. This is particularly important where there are no market disciplines applying.

4.27 Access to contractors' records has become a more general issue recently with the increasing use, consistent with Government's directions, of third party service providers to deliver Government services. In that context the ANAO has written to agencies asking that, in making their contracts, they provide for:

- the agency to have access to contractors' records, information and assets directly relevant to contract performance to give the agency an adequate level of control and performance monitoring of contractual arrangements; and
- the ANAO to have an equivalent level of access (but not an unfettered access to contractors' premises) to enable the ANAO to fulfil its statutory responsibility to the Parliament.

Recommendation No. 3

4.28 The ANAO recommends that future major Defence contracts provide the opportunity for direct access by the ANAO to records of transactions of contractors or major subcontractors which support the expenditure of Commonwealth funds.

Defence response

4.29 Not agreed. The issue of ANAO access to contractor records was the subject of the 1992 audit report and Audit Report No.31 1994-95 *Defence Contracting*. In both cases Defence did not agree with this recommendation. Defence contracts already provide for adequate Commonwealth access for management of contracts. During this audit, ASC voluntarily gave ANAO officials reasonable access to their records. ASC opposed access to two of the four ANAO consultants on the basis that they were former ASC employees and ASC considered that there was a potential conflict of interest in allowing them access.

ANAO comment

4.30 Access to contractors' records was not the subject of the two reports mentioned but only an issue raised in them; Defence contracts give limited access for the Commonwealth but no specific access for the ANAO; and ASC did not grant the ANAO with audit access to records but provided some documents and information and discussed some issues with the ANAO. The consultants were appointed by the ANAO under the Audit Act to provide technical assistance on the audit and were subject to the provisions of the Act.

Cost and Schedule Control System

4.31 Defence specify the use of an accredited Cost Schedule Control System (CS²) in construction projects costing more than \$100 million. CS² was introduced into the USA in the 1960s, into UK Defence contracts in the 1970s and formally introduced into Australian Defence contracts, in terms of progress reporting to Defence, in the JORN contract of 1991. CS² requires contractors to have performance management control systems consistent with standards laid down by Defence. These standards are also recognised by the US Department of Defense.

4.32 ASC uses its Defence-accredited CS² as its internal primary cost and schedule management system for its entire construction program. ASC feeds work package progress data directly into CS² from the 20 per cent of the construction program under its direct control. Work package progress data for the remaining 80 per cent of the production program is drawn into ASC's CS² from subcontractors' CMACS data. Work package percentage complete data generated by ASC's CS² is then translated to CMACS data which is then passed to Defence within progress payment claims.

4.33 The ANAO considers that Defence should use ASC's accredited CS² as a major part of the monitoring and control process to determine the amount and timing of payments to ASC. The current CS²-CMACS arrangement represents only a partial implementation of the Joint Committee of Public Accounts 1986 recommendation that Defence's progress payments to contractors be geared to the submission of satisfactory CS² reports.¹³

4.34 Given that over 95 per cent of the submarine construction funds have been expended the ANAO is not proposing that CMACS be removed. However, the ANAO sees benefits in Defence's annual CS² audit at ASC also including an audit of CMACS. Both systems need to be verified for correct

¹³ Joint Committee of Public Accounts, *Report 243 Review of Defence Project Management*, February 1986, Volume 1, p.74, recommendation 32.

implementation and their cost and schedule data should be checked for accuracy.

Recommendation No.4

4.35 The ANAO recommends that Defence's annual Cost and Schedule Control System surveillance audit at ASC be increased in frequency to twice each year and also include the Project's Contract Management and Control System.

Defence response

4.36 Not agreed. Under the terms and conditions of the contract ASC is required to maintain a validated Cost Schedule Control System. Although the information from this feeds into CMACS, under the terms of the contract Defence does not receive information from ASC's Cost Schedule Control System. Therefore more frequent surveillance would add nothing to our ability to manage the project. In accordance with DEF(AUST) 5655, to maintain a validated system, surveillance audits of the Cost Schedule Control System are required annually, this is considered adequate but more frequent audits are conducted where this is considered necessary.

ANAO comment

4.37 The contract with ASC provides the Project Office with the right to review ASC's Cost Schedule Control System at least annually. The submarines' construction schedule is subject to ongoing risk due to ASC's resources being diverted to defect rectification on the completed submarines and ad hoc in-service support of *Collins*. This situation is understood to be having a significant effect on ASC's project scheduling and costs. The recommendation is based on DEF(AUST) 5657, *Australian Cost and Schedule Control Systems Criteria; Implementation Guide - 1994*, which states that Cost Schedule Control System surveillance audits must consider changes and improvements that contractors may wish to make to the accepted management control system. Such changes include rescheduling of the kind now frequently occurring in ASC.

Progress monitoring by Project Office representatives

4.38 The Project Office advised that it checks 15 per cent of CMACS claims per month. The ANAO considers that, because of the Project's cost and technical complexity, a review of only 15 per cent of ASC monthly

progress claims is insufficient to ensure accuracy and that Australian industry involvement targets are being met.

Recommendation No. 5

4.39 The ANAO recommends that Defence review a larger proportion of ASC's work package progress claims in order to make a better assessment of overall progress.

Defence response

4.40 Not agreed. Physical verification of progress claimed each month is done on an average of 15 per cent of that claimed, this has been maintained over a ten year period. This is an appropriate level of sampling when compared to guidance provided in Australian standard AS1199 - *Sampling Procedures and Table for Inspection by Attributes*, and, based on no errors in the sample, gives a probability of less than 1% error in the total batch.

ANAO comment

4.41 The ANAO notes Defence's response but remains of the view that there would be merit in review of a larger proportion of ASC's progress claims at least until results indicated it was not necessary. AS1199 is suitable for a continuing series of large production-run lots or batches of homogeneous items,¹⁴ and it contains a caution regarding its use for isolated lots or batches. Thus AS 1199 is unsuited to a fifteen-year six-submarine construction program with diverse and changeable cost elements in monthly progress claims. There are significant risks for Defence in checking only 15 per cent of progress claim items.

Other progress reviews

4.42 The Project Office utilises the contract's provisions for:

- formal major progress reviews at intervals of approximately six months;
- combat system monthly progress reviews;
- platform reviews;

¹⁴ For the purposes of AS 1199, homogeneous means that each batch or lot is assumed, as far as practicable, to consist of materials or items of a single type, grade, class, size and composition, and to have been manufactured under essentially the same conditions at essentially the same time.

- monthly senior management reviews; and
- other system/subject/issue reviews as required.

4.43 The Commonwealth has an opportunity to examine and comment only on design and development issues, leaving the contractors wholly responsible for design decisions. This ensures that risks in respect of errors and omissions in design and manufacture are not transferred to the Commonwealth.

4.44 However, the ANAO noted that, when materials, workmanship or design defects are discovered, little seems to be done by the Project Office to put commercial pressure on the contractors to remedy areas of significant risk for the Commonwealth. (See for example, the low fire-hazard cable issue discussed at paragraph 2.43, software and platform quality assurance discussed in Chapters 5 and 6, hull welding discussed in paragraph 7.7 and the SMO pipe case study discussed in paragraph 7.25.) The Project Office's practice is to register concern in the expectation that the contractors' internal processes will remedy the problem. This demonstrates that the Project Office is not exercising 'effective control' (former Finance Direction 21) over construction, to minimise the Commonwealth's exposure to risks covered by the indemnity discussed in paragraph 3.24. Defence advised the ANAO that, although some technical risks remain, the submarine Hazard Log and the Design Log are examples of the sophisticated risk management techniques applied to management of the technical risk.

Quality Assurance audits

4.45 The Project Office monitors submarine construction quality and has employed DSTO resources to assess quality of work and work procedures.

4.46 Defence's QA efforts primarily focus on review of contractors' quality systems, methods and procedures to ensure that the agreed quality systems and plans are being followed and are effective. These reviews include inspecting work-in-progress at designated Quality Control milestones. QA findings are discussed in Chapter 5 of this report.

SUBSAFE audits

4.47 Separate from the submarine construction contract is the Navy's Submarine Safety (SUBSAFE) program, which focuses on submarine design, construction maintenance and operation. The ANAO has not audited this aspect of the Project. Navy audited the SUBSAFE program in 1994 and

Defence's Management Audit Branch (MAB) completed a SUBSAFE audit in 1997.

4.48 MAB completed its SUBSAFE audit with assistance from consultants. The audit focused on the occupational health and safety dimension of SUBSAFE and safety management. Technical aspects of submarine construction were outside the scope of the audit. MAB's report had the following overall conclusion:

In general, SUBSAFE represents a sound basis for a comprehensive safety management system. Adoption and implementation of the [consultants'] recommendations should ensure that the SUBSAFE Program become an even more effective safety system which is subject to ongoing review and refinement to achieve continuous improvement and maintain international best practice. [Management Audit Branch, Report No: 97100, June 1997 (internal report)]

4.49 MAB's conclusion was based on the firm's finding that, after several Navy safety initiatives, Navy's SUBSAFE program achieved an overall grading of 51.7 per cent in an evaluation of 20 loss/control elements containing criteria representing world's best practice in terms of safety loss/control in merchant shipping. This grading put the program in the midpoint of the range 40 to 60 per cent, indicating that 'significant activity' had been undertaken towards meeting the loss/control requirements. The firm considered that a grading of 80 to 100 per cent would be optimal. In relation to the general duty of care required by the *Occupational Health and Safety (Commonwealth Employment) Act 1991*, the consultants found the SUBSAFE Program did not fully meet the functional requirements for a safety management system; that is, Level 1 of the International Safety Management Code¹⁵ requirements was not achieved. The consultants' findings indicate to the ANAO that, at the time, the audited elements of SUBSAFE required improvement.

4.50 The consultants' audit report also noted that senior officer concern about the rate of SUBSAFE Program personnel postings and the effect this was having on safety management. (The ANAO recognises that personnel postings is properly an issue for the department.)

¹⁵ The International Safety Management Code (ISM Code), according to the consultants who assisted MAB with the SUBSAFE audit, is the International Maritime Organisation's code for the safer operation of ships and for pollution prevention. The ISM Code is a basic, mandatory safety and environmental protection management system standard which is applied to all merchant shipping.

Inspections, tests and trials

4.51 ASC conducts all trials prior to each submarine's delivery. The principal controlling organisation for submarine harbour acceptance and contractor sea trials is the Submarine Trials Board. This board comprises ASC's inspections, tests and trials (IT&T) manager, representatives from ASC's subcontractors Kockums Pacific and Kockums AB, the submarine's Commanding Officer and the Project Office's IT&T manager.

4.52 Defence records indicate that the following submarine IT&Ts are conducted on each submarine:

- shore-based inspections and tests of submarine systems - these are part of ASC's responsibility to prove that equipment and system interfaces attain their specified requirements. Defence quality assurance and IT&T representatives attend these inspections at agreed witness points (where Commonwealth attendance is optional), and at hold points (where Commonwealth attendance is compulsory). ASC may not proceed past an IT&T hold point without Commonwealth attendance and may claim excusable delay if this attendance is not provided.
- harbour acceptance IT&Ts are managed by the Submarine Trials Board, conducted by ASC and attended by the Project Office's IT&T personnel. These IT&Ts include equipment installation inspections, setting to work of equipment and harbour performance trials. Their objective is to ensure the submarines are safe to operate on the surface and subsequently to commence dived trials;
- contractor sea trials are managed by the Submarine Trials Board, conducted by ASC and attended by the Project Office's IT&T personnel. ASC provides the Project Office and Navy with a comprehensive summary of submarine performance trials and any qualifications placed on trial results; and
- operational tests and evaluations (OT&E) are carried out after each submarine's acceptance by Navy to determine the submarine's effectiveness and suitability of operational service. At provisional acceptance of *Collins* and *Farncomb*, Navy programmed outstanding contractor sea trials into its OT&E program. The OT&E program is beyond the scope of this audit.

IT&T organisational relationships

4.53 The ANAO considers that on large complex projects it makes good business and engineering sense to ensure tests and trials organisations are drawn from independent third parties. This promotes a healthy independent relationship between the development and test organisations, preserves

objectivity and avoids possible conflicts of interest. This is not the case in this project.¹⁶

4.54 The ANAO notes the unusual arrangement whereby Kockums Pacific (ASC's major shareholder and subsidiary of the submarine design and design certification subcontractor Kockums AB) has been contracted by ASC to define, witness, review and report on the submarines' inspections, tests and trials, with the exception of the combat system.

4.55 The Project Office explained that Kockums Pacific was the most knowledgeable contractor available to provide ASC with IT&T services. Defence's organisational arrangements for submarine IT&T, discussed in the next paragraph, reduce some concern about Kockums Pacific's possible conflict of interest or loss of objectivity in its IT&T role.

4.56 The Project Office advised the ANAO that since 1987 the Project Office has conducted IT&Ts on the submarines with assistance from the Defence Quality Assurance Organisation, Navy's trials and assessing unit and DSTO. The Project Office and Navy Maritime Headquarters Collins-class Naval Test Evaluation and Acceptance Group have, since *Collins'* provisional acceptance in July 1996, integrated and focused their IT&T resources on putting each submarine through exhaustive inspections, trials and evaluations. The Project Office's IT&T team works closely with each submarine's crew to enable operational knowledge transfer into the IT&T organisation, on a day to day basis. (See related discussion at paragraph 6.19.)

4.57 The ANAO notes the August 1996 decision to downgrade the Project Office's Deputy Trials Manager's (Mechanical Engineering) billet from Lieutenant Commander (Mechanical Engineering - Submarines) to Lieutenant (Engineering [any specialisation] - Submarines). The Submarine Project Director's representative in Adelaide sought to have the position restored to a Lieutenant Commander's billet, citing that the downgrade:

- eroded the IT&T team's ability to ensure contractual compliance, help ensure submarine safety, provide high-quality engineering feedback to the

¹⁶ According to the US General Accounting Office, the US Congress in 1983 established the Director of Operational Test and Evaluation (DOT&E) to coordinate, monitor and evaluate operational testing of major weapon systems. As part of the Office of the Secretary of Defense, DOT&E is separate from the acquisition community that conducts developmental and operational testing and therefore is in a position to provide the Secretary and Congress with an independent view. Congress created DOT&E in response to reports of conflict of interest in the acquisition community's oversight of operational testing leading to inadequate testing of operational suitability and effectiveness and the fielding of new systems that performed poorly. (GAO report *Test and Evaluation - Impact of DOD's Office of the Director of Operational Test and Evaluation* GAO/NSIAD-98-22 October 1997.)

Project Office, and resolve engineering issues at a working level on site; and

- created personal disenchantment stemming from the removal of financial and professional recognition.

4.58 The ANAO notes the Project's IT&T team's valuable contribution to ensuring each submarine is fit for service, but also recognises that classification of positions is properly an issue for the department. The concern is primarily to ensure a credible outcome for all involved.

IT&T results

4.59 It is not a good sign that the Project Office's IT&T section is finding an inordinate amount of defects late in each submarine's construction program and contractor sea trials, as recorded in Reports of Material State at Delivery (TI-338) and defects and deficiencies lists. Defence records of November 1995 indicate that *Collins* would be presented for final inspection and delivery following completion of contractor sea trials and a six week maintenance period to correct any defects or deficiencies. Project Office records indicate that at delivery the *Collins* TI-338 had 972 defects and deficiencies listed as ASC's responsibility and 165 listed as the Commonwealth's responsibility to review and sentence.¹⁷ Even though Defence, in paragraph 4.61, advised the ANAO that the majority of the defects are very minor, the ANAO considers the volume of defects and deficiencies places doubt on the project's quality systems. It also results in a need for rectification of defects and deficiencies late in the construction program and repeated inspections, tests, and trials. These all add further expense and delay to the overall construction program and have been cited as a major contributor to schedule overruns. The ANAO considers that the Project has lost some momentum because of the amount of rework that has been necessary on *Collins* and *Farncomb*, which may in part be expected with such complex first-of-class submarines.

4.60 Project records indicate that when *Collins* was provisionally accepted by Navy in July 1996, there were 39 contractor sea trials programmed. *Collins* had satisfactorily completed only six at that time, and two of these were rated as satisfactory but with deficiencies. Of the remaining 33 outstanding contractor sea trials 18 were not started.¹⁸ However, the RAN considered that *Collins* had completed sufficient trials to enable the Naval Test Evaluation and

¹⁷ *HMAS Collins Provisional Acceptance Transfer Document*, New Submarine Project, 17 July 1996 (internal report), Executive Summary p.3.

¹⁸ *Ibid*, annex A – Table 2.

Acceptance (NTEA) program, now known as the OT&E program, to take up the outstanding contractor sea trials. December 1997 records of *Collins*' contractor sea trials show 32 trials had been conducted, 16 trials reports accepted and three rejected. The same records show that at the time of *Farncomb*'s provisional acceptance 24 of its 33 contractor sea trials had been conducted with four trials reports accepted and three rejected. This data show both submarines progressed through their trials schedule at a slower rate than first scheduled, and that Navy proceeded with the outstanding contractor sea trials as part of its OT&E program.

4.61 Defence advised the ANAO that the trials period of the submarine construction schedule is not progressing at a significantly slower rate than planned; the schedule delay has arisen due to construction delays prior to the commencement of IT&T, and therefore the schedule slippage does not add significantly, if at all, to Commonwealth costs. Defence also advised the ANAO that the majority of the defects identified during IT&T are very minor, and that the quantity is indicative of the exhaustive trials program conducted on the submarines and the diligence of the RAN IT&T organisation, and submarine crews.

4.62 Some of *Collins*' trials results relating to key performance parameters specified in the contract remain unreported by ASC. These include maximum submerged speed, full power snort (air intake), indiscretion rate (surface-subsurface ratio), full power surface and acoustic characteristics trials. ASC has conducted some endurance speed and transit indiscretion trials but has not released all results. In September 1996 *Collins* suffered main motor overheating, loss of power during low speed operation, and a transit indiscretion rate trial was abandoned due to diesel engine problems. Many combat system tests and trials were still outstanding due to software problems discussed in Chapter 8 of this report.

Omission of endurance trials for submarines 02 to 06

4.63 In April 1995 the last of six contract amendments converted the provisional-price and effort estimates of harbour tests and contractor sea trials for all the submarines to fixed-price and scope (see paragraph 2.5). The conversion included the Project Office's approval of a contract amendment which 'deleted the endurance trials for SM02-06 [Submarines 02 to 06]'. The 'deletion' was with respect to *Collins*' trials program which has already been converted to fixed-price.¹⁹ The overall reduction in the provisional sea trials'

¹⁹ Defence's view is that the endurance trials for submarines 02 to 06 were never contracted and therefore could not be deleted. The ANAO notes, however, that the contract at clause 52 and Annex M refers to endurance trials for all submarines.

effort and the expected increases in trials efficiency with successive submarine trials was expected to result in 'savings' of \$4.743 million within the overall \$49.221 million (June 1986 prices) provisionally-priced contractor's harbour tests and sea trials work package.

4.64 The contract amendment omitted a planned program of 26 days' endurance trials (for each submarine), leaving 175 to 198 days of sea trials for each of *Collins*' successors. Based on the Project Office's contractor sea trial cost estimate of \$16,055 per day, the endurance trials would have cost \$417,430 per submarine. Endurance trials were to provide the Commonwealth with empirical evidence of each submarine's ability to achieve the endurance parameters specified in the contract. Omission of endurance trials hinders the Commonwealth's recourse to liquidated damages or guarantees or warranties in the event that a submarine does not perform to contract specifications. (See paragraph 2.26 regarding compensation provisions for performance shortfalls.)

4.65 Project records indicate the \$4.743 million in expected savings arising from the reduced trials effort, was not retained by the Commonwealth. Instead the \$4.743 million was transferred from the provisionally-priced SM02-06 IT&T package to the following ASC fixed-price packages:

- General Contingency (described in paragraph 2.40) - \$2.591 million;
- Executive and Administration Group Management Services - \$1.076 million; and
- Project Management - \$1.076 million.

Project records indicate that the \$4.743 million increased the contract's provision for contractor's harbour tests and sea trials management and margins to \$16.247 million, which is 33 per cent of ASC's \$49.221 million fixed-price harbour test and sea trials program. However, the contract amendment had no overall effect on the contract price.

4.66 The ANAO considers that the Project Office should have consulted the Project's ultimate customer, Maritime Command, before agreeing to ASC's proposal to omit endurance trials for submarines 02 to 06 trials program. The ANAO is also concerned that the Project Office agreed to the proposal at a time when *Collins* had not completed its endurance trials and was experiencing propulsion system problems which justified on-going design reviews.

4.67 In April 1997 the ANAO requested the Project Office's advice on what trials were removed from the submarines' trials program and how the removal

benefited the Commonwealth. The Project Office replied with a large amount of financial data but did not mention the endurance trials omission. Later ANAO checks of the *Collins* and *Farncomb's* harbour tests and sea trials statistics indicated the results of *Collins's* endurance trials were incomplete and that the endurance trials had been removed from *Farncomb's* program. In reply to an ANAO query the Project Office advised that these trials for submarines 02 to 06 were not justified but added that, under the contract, additional trials may be ordered by the Project Office at any time.

4.68 The omission disadvantages the Commonwealth by removing an opportunity to establish each submarine's overall performance baseline jointly with ASC. It also removes a major contractual milestone that was to indicate each submarine is capable of achieving the 70 day missions that they are designed to perform.

4.69 This contract amendment, discovered late in the audit, supports a need for a more commercially-oriented approach to be taken to such arrangements. (The current audit did not focus on contract amendments to the extent that the 1992 audit did. Defence's Management Audit Branch reported on contract amendments in June 1996.²⁰) Defence advised the ANAO that the first of a class of ships undergoes more extensive trials than later ships, and that the gradual process of contracting for trials only as the need for them is positively determined is a sound business standard.

4.70 Defence explained that major capital equipment projects are approved by Cabinet and that variations to such approvals are in strict accordance with an approved delegations structure based on monetary limits. Defence advised that financial approvals within the agreed project cost ceilings are exercised by Defence officials in accordance with a well-established financial delegations process approved by the Minister.

4.71 Defence added that contract amendment proposals must be justified and approved in the same manner as all other procurement approvals and that the Minister is kept informed of all significant changes to contracts as a matter of course. The ANAO does not consider that these Defence comments address its concerns about a contract amendment that has a significance beyond its immediate financial implications.

²⁰ Management Audit Branch, Inspector General Division, Audit Report IG 91 - 12610/3 *New Submarine Project Production Contract Management and Contract Amendment Proposal Management*, Department of Defence, June 1996 (internal report).

Submarine Project risk management

4.72 Risk management is the good business practice of making decisions based on the structured collection and analysis of information. It requires careful monitoring and evaluation of performance trends and the use of risk abatement strategies that seek to ensure best use is made of scarce resources. Risk management procedures produce records available for review and comment by team members and contractors that enable a collective understanding of a project's risks and a team approach to developing risk treatment strategies.

4.73 The Project Office records risks in a variety of data bases, such as defects and deficiencies lists and a hazard log. The risk data is then linked to the Project Office's financial risk management system, which focuses on determining what Project risks may generate costs for the Commonwealth. These risks are then managed within the normal course of Project Office business with a view to conserving the Project Office's contingency funds and ensuring the Project's overall schedule is not compromised.

4.74 Risks that fall only within ASC's responsibility are left for ASC to manage without interference from the Project Office.

4.75 A risk assessment of the Collins-class combat system produced in August 1996 had provision for risk reduction/contingency plans, but the ANAO could not find evidence that such plans had been produced.

4.76 The Project Office advised that the Project's overall size, complexity and technical diversity precluded the use of a single systematic and detailed risk management process.

4.77 When agreeing to the Commonwealth indemnity in 1994 the Department of Finance had prompted Defence to carry out a comprehensive risk evaluation study to determine the adequacy of controls and safeguards, and the extent of the Commonwealth's exposure under the indemnity. It appears to the ANAO that little was done to strengthen the safeguards, and that ASC did not commence to improve its quality assurance until 1995 as discussed in paragraph 5.53.

4.78 Chapter 7 discusses the Project Office's management of submarine construction risks.

Project management expertise

4.79 This Chapter brings out several concerns about management of the New Submarine Project - the reliance on CMACS as a indicator of progress, omission of endurance trials, increasing numbers of defects and deficiencies, slow progress in completing contractor sea trials, general concerns about the submarines' operational capability and general lack of focus on systematic risk management.

4.80 The Joint Committee of Public Accounts, in its 1986 report on Defence project management, expressed concern about Defence's project management ability and recommended that Defence's project managers have experience and training in project management and that, if experienced personnel were not available, project management services be obtained from the private sector on a contract basis.²¹ In response Defence generally agreed.²² It is unclear to the ANAO that Defence implemented the recommendations. The audit of New Submarines and the 1996 audit of the JORN Project indicate continuing weaknesses in Defence's project management.

4.81 The ANAO still sees merit in the JCPA's 1986 recommendations. If Defence's major project managers had appropriate business training, expertise and skills, this would offer better protection of the Commonwealth's interests through more rigorous monitoring of contractor performance, better understanding of commercial reality and firmer negotiation with senior corporate executives. Such expertise may be expensive to obtain and may need to be contracted in.

Recommendation No. 6

4.82 The ANAO recommends that, on major capital acquisition projects, Defence only consider for appointment project managers with appropriate commercial experience and business qualifications.

Defence response

4.83 Agreed in principle. This recommendation is in line with current Defence policies, however, project management requires a broad set of skills, commercial and business skills being but two. Defence has a comprehensive training program in procurement and project management competencies. The

²¹ Joint Committee of Public Accounts *Report 243 Review of Defence Project Management* (1986) recommendations 53 to 55.

²² JCPA Report 267 *Response to Review of Defence Project Management Report* (1987).

Defence Acquisition Organisation has been at the forefront of public sector procurement and project management competency standards which have recently been endorsed by the Australian National Training Authority. In 1997, 69 Defence personnel participated in tertiary level programs relating to project management in addition to the 25 who attend the Army Technical Senior Officers Course. A strategic level procurement course was also instituted in 1997. The Defence Acquisition Organisation also recruits Graduate Acquisition Trainees with backgrounds in engineering, law, accounting and economics, and is providing comprehensive practical placements to prepare them for project management duties. In agreeing the principle of this recommendation, Defence does not agree the implication that the Submarine Project staff are insufficiently trained, skilled or experienced.

Conclusion

4.84 Despite many significant challenges faced by the Project, the first submarine, HMAS *Collins*, was launched on time on 28 August 1993. This was a significant achievement by ASC and its subcontractors. Some persistent design, imported welding, late discovery of defects and software problems detract from this achievement. However, the New Submarine Project in many ways demonstrates the capacity of Australian industry to produce to world-class standards.

4.85 Submarine construction is now about a year behind schedule and reworks on *Collins* and *Farncomb* may result in further slippage of the overall program. The progress of the last three submarines indicates a probably-irrecoverable schedule slippage of about 20 months. Weaknesses in the Project's Contract Management and Control System cast doubt on the actual schedule achieved, particularly in regard to combat system software integration and test.

4.86 The ANAO considers that the Project has lost some momentum, perhaps as a result of the amount of rework that has been necessary on *Collins* and *Farncomb*, which may in part be expected with such complex first-of-class submarines. However, much of the responsibility for this lies with Defence's project management which left quality assurance problems unresolved for an inordinate amount of time. These problems are discussed in the following chapters.

4.87 The Project Office, on behalf of Defence, has the main responsibility for the Project. When risks emerge such as lengthy defects and deficiencies lists and delayed trials programs, the Project Office should aim to take decisive action to put commercial pressure on the contractors to correct the situation

and protect the Commonwealth's interests. Leaving work to be done later in the program only adds to Project costs and risks at a time when funds are running low. Defence agrees that there is risk remaining but does not agree with the ANAO implication that the level is excessive.

4.88 The predominant underlying issue that must be addressed by Defence is the need to improve its project management skills in order to obtain best value for the Commonwealth and achieve its broader policy objective endeavour of promoting efficiency in Australian industry.

Annex A to Chapter 4

Project progress reports to senior management

4.89 Defence spends some \$2.2 billion a year on 200 major capital equipment projects with an approved value of \$35 billion. Of the latter aggregate, the New Submarine and JORN Projects account for \$5 billion and \$1 billion respectively. Clearly this is a major task for Defence project management. It also presents Defence's senior management with a complex task of monitoring to see that projects are proceeding satisfactorily and that Defence's project offices are adding value to the acquisition.

4.90 The ANAO found, however, that the contractors and Defence project managers on JORN and New Submarines were unduly optimistic about progress and completion times. More objective progress measurement would be gained by reports to Defence's senior management showing cost and schedule variations and achievement of monthly or quarterly major contract milestones. Such reports could contain short narratives on risk reduction and areas where project offices made tangible contributions to adding value commensurate with project office cost.

4.91 Major capital equipment projects are an area of risk to the Commonwealth because the equipment tends to be unique and high-technology and obtained from a narrow market with few competitive suppliers. These projects require interface with large corporate suppliers, including powerful multi-national corporations. Project management involves negotiation, preparation and management of complex contracts. Defence contracts that are nominally 'fixed-price', with the contractor bearing the risks of cost overruns, still pose a significant risk to the Commonwealth with substantial outlays of funds, of delayed military capability and sub-standard quality if the contract is long-term with complex technology changing along the way.

4.92 Defence's project management on JORN and New Submarines has been uneven and needed a firmer approach with contractors. A systematic approach to reporting project progress to senior management would help to improve project management. This is a 'corporate governance' issue for the Department.

4.93 Senior management in the Department also needs information to assess the performance of the Department's project office as distinct from the contractor's performance. The project office must be able to show that it has added value to the project. A rigorous and consistent format for project progress reporting to senior management would assist overall project management.

4.94 The present situation may reflect, at least in part, limited public accountability for progress on major projects. Defence reports little publicly on progress with its major acquisition projects. The situation is different in the UK where the Ministry of Defence publishes reports on major projects under cover of a National Audit Office commentary for the information of Parliament.²³

ProMis

4.95 The ANAO put these views to Defence, together with a suggested reporting format. In response Defence advised that project progress reporting requirements of senior managers have led to the development of the Project Reporting and Monitoring System (ProMis), which is progressively providing detailed information regularly. As well as reporting on the status of projects, ProMis will accumulate information to indicate trends and help identify potential difficulties that can be addressed at an early stage. Defence believes that its current reporting mechanism and the forthcoming ProMis will provide adequate visibility of project progress and achievement to senior managers. The ANAO will consider ProMis in the next audit of Defence project management.

Defence budget spending

4.96 The audit report on the JORN Project commented (p30) on the pressure that Defence applied to its project managers to spend their annual budget allocation in order to help Defence spend the annual expenditure estimates set into the Defence budget. The ANAO commented that this attitude to maintaining the Defence budget was not in the Commonwealth's interests either from a contractual or budgetary perspective. On the audit of

²³ See National Audit Office - Report by the Comptroller and Auditor General *Ministry of Defence: Major Projects Report 1996* August 1997.

New Submarines the issue was not of immediate relevance because, by the time of the audit, Defence had already spent over 94 per cent of the project budget and there was little left to spend. There were however, indications that this pressure had occurred in the past.

4.97 Nevertheless the ANAO notes that its report on the JORN Project has not prompted Defence to cease this practice. Pressure on managers to spend their appropriation came to light a year later in the Defence Efficiency Review. The *Report of the Logistics and Regional Support Sub-Review Team* submitted to the Defence Efficiency Review in February 1997 commented (at page 28) as follows:

A disturbing feature of current financial management practices is the impact on purchasing practices of the need to satisfy an annual performance indicator of total expenditure against allocation. Inventory profiling and expenditure profiling over time highlight decision-making resulting from satisfaction of that performance indicator that could be perceived as less than acceptable.

4.98 The Defence Efficiency Review report of March 1997 did not mention this aspect. The ANAO again raises budget spending as an issue of concern. Defence should encourage project managers to exercise business judgement in spending their annual allocation of funds. Protecting the Defence appropriation should not be regarded as an end in itself.

5. Quality Assurance

This chapter outlines the New Submarine Project's quality systems that relate to submarine platform construction and software development. It describes a number of significant quality system issues which have arisen since the 1992 audit report.

Introduction

5.1 Risk management and quality management systems focus specifically on satisfying consumer expectations for products and services of predictable uniformity, reliability and acceptable price. High-risk high-value products, such as submarines, require quality assurance (QA) activities to embrace design and materials and work procedures to provide adequate confidence that quality is built into products at each stage of the design and production process. Formal QA systems:

- address the production process as well as individual product samples;
- place the onus on manufacturers to demonstrate, with objective quality evidence, that their products comply with recognised quality standards and specifications; and
- assist in managing safety and performance risks, including risks which initially may not be apparent, or for which there may be no safe or practical tests or trials.

Contractors' quality control (QC) systems contain the operational techniques and activities used to ensure that required quality is maintained during manufacture. QA and QC are the contractor's responsibility. However, since Defence Project Offices are also responsible for quality outcomes, they have QA responsibilities.

Project Office quality assurance organisation

5.2 Defence Quality Assurance (DQA) administers the Project Office's quality assurance guidelines and provides the Project Office with quality assurance staff who are responsible to the head of the Project Office for the submarine project's quality assurance function.

5.3 The submarine contract allows Defence QA personnel to audit ASC's quality system and ASC's subcontractors' quality systems routinely. When complex QA and QC issues arise, the Project Office calls upon outside assistance from organisations such as the Defence Science and Technology Organisation (DSTO) to assist with a broad range of QC issues such as Material testing and defect analysis.

5.4 DQA policy does not require 100 per cent auditing or inspecting of ASC's QA system. This avoids interfering with ASC's production and QC and keeps QA responsibility with ASC. However, the Project Office is responsible to Defence for the Project's quality outcomes. Hence it is responsible for QA activities that ensure good design and production practices which prevent non-conformance to design and specification. (See Project Office objectives in paragraph 1.18.)

Submarine contract's quality assurance provisions

5.5 The contract requires ASC to maintain a quality assurance and control system which conforms to Australian standard AS3901/ISO9001-1987 *Quality Systems for Design/ Development, Production, Installation and Servicing*.²³ Defence accredited ASC to this standard in January 1992, some five years after the contract was signed.

5.6 All subcontractors are required to operate a quality system which complies with the relevant AS3901/ISO9001 to AS3903/ISO9003-1987 or an equivalent standard listed in the contract.

5.7 The contract requires ASC to provide objective evidence that it:

- maintains effective quality control over supplies offered for acceptance;
- provides test facilities and performs all inspections and tests required in the contract to demonstrate that the supplies conform to the requirements of the contract; and
- offers for acceptance only supplies that do conform.

5.8 The Defence-ASC Australian Construction Facility (ACF) for the Collins-class submarines near Port Adelaide has about 50 officers out-posted from the Project Office in Canberra to monitor submarine construction activities. This Commonwealth presence includes eight QA officers who cover the main technology disciplines used in Collins-class submarine construction.

²³ AS - Australian Standard; ISO - International Standards Organisation.

This group is known as the ACF QA section. Its primary task is to audit ASC's QA activities.

Quality system problems

5.9 ACF QA reported in its March 1993 Quarterly Report that its ongoing compliance auditing of ASC to the QA requirements of AS3901 had revealed compliance problems. An earlier ACF QA Quarterly Report to the Defence Quality Assurance Organisation (DQAO - now known as DQA) recommended suspending ASC's accreditation because of evidence that ASC's Quality Management System was not dynamic enough to cope with the ongoing evolution of activities within ASC.

5.10 The Project Office advised the ANAO that DQAO reviewed ASC's accreditation from 29 June to 1 July 1993 and reported that the overall result was satisfactory, except that three non-conformance reports were raised and the deficiencies were corrected by 8 July 1993.

5.11 In July 1995 ASC advised Defence that it was revising its quality system standard from AS3901-1987 to ISO9001-1994. That revision was significant in that it involved an independent third party certification of ASC's quality system.

5.12 Submarine construction quality is discussed further in Chapter 7.

Quality assurance - software development

5.13 The contract requires ASC and its subcontractors to implement software development procedures that comply with US Department of Defense standard DOD-STD 2167 *Defense System Software Development - 1985*. Even though DOD-STD 2167 was not replaced in the contract by its successor DOD-STD 2167A *Defense System Software Development - 1988*, a number of submarine software products were developed with the use of DOD-STD-2167A. The Combat System subcontract allows the use of US Navy Standard MIL-STD-1679A - *Military Standard Software Development - 1983*.

Quality assurance aspects of the development standards

5.14 In July 1992 the Project Office's software QA manager advised the Project Office that the general quality standard AS3901 was not well suited to the software development projects for which ASC has prime contractor responsibility. He indicated that AS3901 was not prescriptive in many areas

and ignored specific software development aspects, and for that reason it was difficult to raise software QA non-conformance reports against particular functions examined during software audits.

5.15 He went on to state that it was therefore important to interpret the intent of the AS3901 standard from this perspective during quality audits of ASC's management of software elements of the project.

5.16 The ANAO is aware that at the time Australian software development standard AS3563 - *Software Quality Management System - 1988* was closely linked to AS3901 and would supplement MIL-STD-1679A and DOD-STD-2167A. However, as AS3563 post-dated the submarine contract signing, its inclusion into the contract would have required a contract amendment. Although it would have enhanced QA coverage the contract was not amended. Defence advised the ANAO that MIL-STD-1679A contains a requirement to produce software quality management plans and these were the basis for much of the Project's Office quality review.

5.17 MIL-STD-1679A requires a Software Quality Assurance (SQA) system to be integral to the software development process. The SQA system should assist in:

- defining and logically grouping the software requirement specified in the contract;
- identifying software processes and data flow options;
- producing software test requirements and document and control test plans and procedures;
- documenting the results of software testing;
- incorporating changes in controlled code and documentation; and
- producing the deliverable software products from controlled code and documentation.

5.18 The above process would provide for quality to be considered at each of the key stages of software development, rather than treating quality as something which all parties expect will be confirmed at the end of the development cycle. The ANAO notes that DOD-STD-2167 contains software quality assurance provisions which were later removed from DOD-STD-2167A to form DOD-STD-2168 - *Defense System Software Quality Program - 1989*. Hence DOD-STD-2167A is more reliant on an external quality programs such as AS3563 and DOD-STD-2168. A more recent software development standard MIL-STD-498 - *Software Development and Documentation- 1995* (or

its industry equivalent (IEEE-1498) requires the developer to perform software product evaluations and incorporates key QA provisions from DOD-STD-2168.

Suitability of the development standards

5.19 The Project Office advised the ANAO that the software development standards specified in the submarine contract are highly prescriptive and that there is a growing belief by both the software community and managers of large defence software projects that these standards are not particularly effective. The Project Office advised that standards:

- place a high reliance on a tightly-regimented, highly-documented process;
- have been shown to incur high overheads and yet offer very little risk mitigation; and
- are far more prescriptive than the more recent MIL-STD-498.

5.20 The ANAO notes the Project Office's criticism of the dated software development standards. However, both parties to the contract were free to treat software development risks by tailoring the software development standards to meet the Project's particular needs and to amend the contract if better standards became available. Given the evidence of significant software development problems described below in this chapter and in Chapters 8 and 9, it would have been preferable had Defence formally agreed with ASC on software development standards tailored to suit the individual software products within the Project.

5.21 Both parties to the contract would then have had a formal baseline of tailored standards for monitoring software development and maintaining close management control. Instead, the Project Office permitted the contractor to proceed with software development with insufficient regard to the need to effectively establish and implement tailored standards. This denied the Project Office access to reliable progress indicators.

5.22 For example, CMACS expenditure data on the submarines' combat system software integration show that development ran ahead of schedule until 1993, by which time most of the funds had been spent but problems related to combat system software integration were becoming apparent.

5.23 ANAO considers that the Project's software integration process did not strike the right balance between minimising project overhead costs and

maintaining control over project risks. The right balance may best be achieved by ensuring software development processes:

- are well defined, understood and documented; and
- are kept under management control through periodic reviews and analysis of all interactions and dependencies between the Project's various development activities.

In this regard, Defence engaged software consultants to review the combat system software (see paragraph 8.31). Their 1994 report commented that, if the software system configuration item structure remained unchanged, there would be a real risk that an operational system would never be delivered to the RAN and, if it were delivered, the software would be 'brittle', extremely difficult, if not impossible, to maintain and costly to modify. A 1995 study commented that it was not evident that enforceable software development standards were being used across the program.

5.24 In large complex projects, poorly defined and managed development processes lead to customer-developer disputes and unexpected outcomes at the most critical stages of development. These often result in increased acquisition costs, delayed delivery and increased in-service support costs. Defence advised the ANAO that deficiencies noted by the Project Office in the software development quality management were not a major factor in the software development problems, and that to change the software development standard as proposed by the ANAO would have compounded the problems. Defence further advised that to direct the contractor to change standards would have left Defence vulnerable to claims that the intervention was a major contributing factor to the delay and significantly increasing risk exposure. The ANAO considers, however, that available evidence indicates that a combination of dated software development standards and quality system problems led to the current combat system software integration problems.

Recommendation No. 7

5.25 The ANAO recommends that Defence continue to monitor software development standards and adopt the standards that offer the Commonwealth best value for money.

Defence response

5.26 Agreed. This recommendation is in line with Defence policy. Software development is a very complex and challenging issue, as implied in the report. There is no simple solution, however, Defence devotes

considerable resources to software development issues through participation on a number of forums both nationally and internationally. Software engineering is a rapidly evolving field and several changes in the development standard can occur over the life of a lengthy project such as the submarines. Incorporation of different standards can cause considerable confusion and disruption and result in increased costs to the Commonwealth.

ASC's quality management system - software issues

Early concerns about software quality

5.27 Project Office records indicate that in the early 1990s ASC's software development subcontractors were within development environments where:

- quality management systems had still not encompassed the contract development standards. Important software development management documents were still under development;
- file information needed to demonstrate a close working relationship between QA and software engineering was still not available to the Project Office, nor was there any urgency to complete the contract specified Data Item Description issues upon which so many of the development ground-rules relied; and
- Project QA was not part of the design review process, and QA audits still concentrated on establishing viable quality and development systems as opposed to auditing the implementation of appropriate software development control mechanisms. This meant that Quality performance metrics relating to the software definition and development phases were unavailable for appropriate quality control of the formal test and setting-to-work phases.

5.28 This situation indicates that at the time there was likely to be little objective evidence of the effectiveness of the software development process.

5.29 The Project Office advised the ANAO that, late in 1994, problems emerged regarding ASC's procedures for tracking software deficiencies and that ASC resolved these quickly.

5.30 The ANAO considers that the Project Office should have monitored its software QA reports more closely, and reacted more decisively, given that software development quality assurance was found to be unsatisfactory before 1994.

Tracking and disposition of software problems

5.31 In June 1995 the Project Office expressed concern to ASC about its lack of complete and formal procedures within its Quality Management Systems to manage reporting, tracking and disposition of all software problems. The Project Office advised ASC that it was essential and a matter of urgency that a comprehensive process be put in place that:

- has the capacity to handle the technical and procedural interfaces associated with multi-contractor involvement with the analysis, disposition and correction of software problems and defects;
- ensures that all software problems are controlled in a manner that objectively supports viable problem analysis and disposition as well as accurate problem status accounting; and
- facilitates information correlation, manipulation and retrieval to the extent necessary to support fault trend analysis and identification of development process improvement opportunities for future software releases.

5.32 It seems to the ANAO that these requirements should have been enforced earlier than 1995, when Collins-class submarine software development was due to be substantially completed, integrated and operationally trialed in the first submarine.

5.33 The ANAO recognises there are significant project management challenges within software projects. Defence recognises it has software QA resource shortfalls caused mainly by competition from private industry. The Project Office contracts a large component of its software expertise. The ANAO considers that Defence should continue to periodically contract-in software development specialists where cost-effective, to review software projects that are showing early signs of cost and schedule overruns.

5.34 Defence would also benefit from contract provisions that would allow independent review of a contractor's progress when cost and schedule risks first become apparent.

Recommendation No. 8

5.35 The ANAO recommends that Defence consider incorporating provisions for technical and performance audits in contracts of significant risk to give its project managers a means of identifying the source of problems and encouraging corrective action when contractors depart significantly from agreed cost, schedule and development requirements.

Defence response

5.36 Agreed in principle. The submarine contract includes provisions for technical audits and/or other additional testing and these have been used where considered necessary. Defence includes these provisions in selected projects and will continue to consider the need for such provisions on a case by case basis.

Software acceptance

5.37 The Project Office advised the ANAO that, despite the above QA issues, it has successfully applied full Functional Configuration Audits (FCAs) and Physical Configuration Audits (PCAs) to establish product quality prior to software being delivered to each submarine. FCAs verify software performance against its approved documentation. PCAs formally examine the 'as-built' software against design documentation, including engineering specifications, test results, design documents, all quality control records and other engineering documentation.

5.38 The Project Office advised that these audits ensure that issues noted earlier in the development phase are not manifested in the end product. The Project Office went on to say that although the ANAO has identified issues that existed at various times, there is a process in place to ensure the end product reaches a quality level suitable for acceptance.

5.39 The ANAO considers that current combat system integration problems would not have persisted so long had a more effective quality system been applied.

Safety-critical software

Defence guidance on safety-critical software

5.40 Defence Material Division indicated to the Project Office in 1995 that any failure in software-intensive systems that were safety-critical could cause loss of life.²⁴ Defence Material indicated that as a result of a July 1994 Australian Ordnance Council initiative Defence formed the Software Safety Critical Working Group to:

²⁴ Defence Material Division, *Management Arrangements for the Development of Safety Critical Software*, 2 February 1995, p1 (internal report).

- develop guidance within Defence on software safety;
- establish and maintain a central information library on software safety; and
- provide a forum where members may contribute to the improvement of software safety within Defence.

A Defence Standard on safety-critical software envisaged in 1995 has not yet been published.

Safety-critical software in the submarines

5.41 The Project Office advised that a comprehensive program to identify safety-critical systems has been implemented in the Collins project, that first-level systems (as defined by SUBSAFE) are considered the critical systems and that there is no software included in these systems. The ANAO considers that the Project Office advice does not accord with the degree of reliability and safety that must be placed in the submarines' various software-based systems.

5.42 According to Project Office QA records, developers of any safety-critical software are required to:

- evaluate safety aspects of software systems and apply the results throughout the development cycle;
- include safety aspects in software specifications, interface specifications and throughout the software design, coding and test cycle;
- include safety analysis in the Software Development Plan, Software Quality Evaluation Plan and the Software Configuration Management Plan; and
- ensure safety is critical during all major review milestones and integral to the development process.

5.43 It was not clear to the ANAO that these requirements had been met on the Project. Project Office records indicate that the submarine contract's System Safety provisions specify that safety analysis must 'generally' comply with a US Defense standard, MIL-STD 882B *Safety Program Requirements - 1987*. The ANAO considers that 'generally' weakens the safety requirements, which is of concern given the risks involved. MIL-STD 882B relies on software development and software quality assurance standards DOD-STDs 2167 and 2168, and its section 300 specifically addresses software requirements hazard analysis, software safety testing, user interface testing, and software-change-hazard analysis.

5.44 The ANAO notes with concern the following recent DSTO advice to the Chief Defence Scientist, the Deputy Chief of Navy and the Inspector-General:

Finally we note again that the ASC Submarine Safety Programme Plan has been tailored from MIL-STD 882B to *omit* all references to software, which must be taken as an acknowledgment that the processes are *not* in place to deal appropriately with software should it in fact be safety critical [original emphasis included].²⁵

The DSTO review recommended an independent review of submarine systems safety management in the ASC and the Project Office.

5.45 The Project Office advised the ANAO that:

- a comprehensive program to identify safety critical systems has been implemented in the Project. Classification of systems was initially based on Oberon submarine experience;
- the First-level and Important Systems and Equipment have been identified in the Collins-class through engineering judgement and the development of a top-level fault tree with the top-level event being loss of submarine through flooding; and
- First-level systems are by definition the critical systems and there is no safety-critical software involved in these systems.

5.46 The ANAO did not audit the safety aspects of the Project. However, Project Office records indicate the submarines contain software-based systems that:

- assist the crew to monitor and control vital submarine systems by monitoring the submarine and providing warnings, alerts and initiating responses to alerts for critical systems;
- automatically monitor the submarine's atmosphere to check oxygen levels and the presence of toxic/dangerous gases;
- provide the submarine's manoeuvring control data; and
- provide target acquisition, tracking, target engagement and weapons control.

5.47 The ANAO considers that the submarines contain many systems that under normal operating conditions have relatively straightforward interdependencies that may not be safety-critical. However, under emergency situations interdependencies may change rapidly and become more complex and safety-critical.

²⁵ Report on DSTO Investigation into Collins Submarine Safety Issues, Defence Science and Technology Organisation, 4 March 1997 p24 (internal report).

5.48 The ANAO notes DSTO advice that, even though ASC has conducted a number of reasonably thorough Fault Tree Analyses, it was not clear that the analyses represent a complete account of the ways that hazards could result from faults in all the submarines' subsystems. DSTO cited one Fault Tree Analysis of the submarines' steering and diving control that assumed that software was 100 per cent reliable and excluded the impact of other software functions and other submarine systems.

5.49 The ANAO considers that the issue of safety-critical software on the submarines should be assessed by Defence jointly with experts in the field as a matter of priority, given:

- Defence's relatively recent decision to provide guidance on safety-critical software;
- the concerns raised by DSTO; and
- the many submarine quality assurance concerns raised in the course of the audit.

Recommendation No.9

5.50 The ANAO recommends that Defence consider the need to engage an appropriately qualified and experienced third party to participate with Defence in a joint assessment to decide whether the Collins submarines contain safety-critical software and if so to verify that the software provides the appropriate level of safety.

Defence response

5.51 Not agreed. Defence has considered and rejected the need for further third party review of software issues. Defence is acutely aware that disciplines needed to be developed to ensure that modern weapons systems which are heavily reliant on software are designed for safe operation. Defence is leading the way in this area with DSTO developing a standard DEF (AUST) 5679 for safety critical software. Further work is continuing to ensure that submarine systems containing software meet the intent of the new standard. The Project Office is conducting retrospective assessment of a number of software systems to ensure their conformance to the standard. This work is being managed within the project's comprehensive safety management structure.

ANAO comment

5.52 The ANAO notes Defence's advice that it is leading the way in developing a safety-critical software standard and that the Project Office is

retrospectively assessing a number of the submarines' software systems. Completion of these activities seems to be well overdue. However, given that retrospective review of safety-critical software is specialised work, the ANAO remains of the view that Defence would benefit from assistance from an independent third-party. As mentioned in para 4.49, an audit by a QA third-party accreditation firm found that Navy's SUBSAFE Program did not fully meet the functional requirements for a safety management system. The firm's audit did not cover operational software and quality system elements of the SUBSAFE Program. Therefore a separate independent review of the submarines' operational software would not duplicate work done in the SUBSAFE audit. An independent third-party could assist Defence in developing its safety-critical software standard to the benefit of other Defence projects.

ASC's quality system upgrade to ISO 9001 - 1994

5.53 In February 1996 the Project Office requested ASC to advise on long outstanding concerns about compliance with the quality standard, particularly quality management issues relating to software. In March 1996 ASC advised the Project Office that:

- there were QA management changes at ASC in October 1995;
- ASC expected to issue a draft Quality plan by 8 March 1996;
- it had employed a new Quality Assurance manager on 29 February 1996; and
- it had hoped to gain third party quality system accreditation ISO9001 -1994 through Det Norske Veritas (DNV) by mid-1996, but this date was being revised.

5.54 ASC advised the ANAO that on 15 April 1997 ASC received DNV accreditation to ISO 9001-1994 Ship Design, Ship Building, Ship Repair, Software Development Integration and Engineering; Integrated Logistic Support; Project Management and Submarine Escape and Rescue Services. The ANAO notes that by that date about 94 per cent of the Project's funds had been expended, indicating most of the work had been completed.

5.55 The Project Office's ACF staff indicated in discussions with the ANAO that they are confident that ASC had implemented ISO 9001 quality system in a competent manner.

5.56 Project Office representatives expressed confidence that ASC now have quality assurance procedures that will continue to improve the production process toward a goal of zero defects.

Conclusion

5.57 In a general conclusion, the Project Office advised the ANAO that:

- in a fixed-price contract the balance between quality assurance and quality control is an issue for the contractor;
- ASC's system was found compliant in July 1993 and the ACF QA (DQA) section invested considerable resources to maintain the accreditation of the system;
- as ASC's responses to non-conformance reports slowed, the Project Office effort was escalated until it produced the desired response; and
- appropriate timely measures were taken.

5.58 The ANAO concludes that the Project Office was slow in reacting to the ACF QA staff's 1993 recommendations that ASC's quality management system needed improvement. The three-day review in mid 1993 by the Defence quality assurance organisation may have brought about some change, but there is little evidence of such. As discussed in paragraph 4.59, persistent discovery of defects late in the construction program would suggest that quality management and inspection, tests and trials system problems have persisted despite earlier QA accreditation.

5.59 Software development standards require a sound careful development process which are backed by management reviews to ensure quality concerns were satisfactorily resolved.

5.60 When new software development standards become available, they should be assessed and where appropriate adopted through agreement between the parties. However, regardless of what standards are agreed, quality management relies on up-to-date plans and procedures to ensure development activities are identified and controlled, and documentation is available to demonstrate compliance with agreed standards.

5.61 The ANAO considers that the Project would benefit from an independent review of submarine software to provide additional assurance that submarine safety has been adequately addressed.

6. Submarine Design

This chapter outlines issues related to control over the Collins-class submarine design.

Introduction

6.1 As previously indicated, ASC's submarine design subcontractor is the Swedish firm Kockums AB. The Collins-class submarines are advanced versions of Kockums' earlier A17 and A19 submarines, but are significantly larger and heavier and must perform to significantly different mission profiles including operations in more demanding environments.

Design Development Reviews

6.2 The Project went through twelve formal Design Development Reviews (DDRs) and a larger number of other design reviews between contract award in 1987 and completion of the design in March 1993. Project Office records indicate that by September 1990, 65 per cent of the drawings were complete and that the design subcontractor was 6 to 12 months late in completing all expected design tasks.

6.3 The Project Office advised the ANAO that detailed design was part of the contract's scope and could not be completed before contract signature. As a general point the Project Office said that it was preferable to leave finalisation of design as late as possible in a project so that designers could incorporate leading technology.

Design changes

6.4 The contract requires ASC to seek written permission from the Project Office prior to making design changes that deviate from the specified technical standards or applicable specifications in the contract. ASC also provides the Project Office with access to lists of design changes that did not affect the contract's performance specifications. The Project Office advised that it has full access to the detail of these changes and reviews these records routinely.

6.5 The Project Office advised the ANAO that by July 1997 there had been approximately 390 Production Permit/Concession Requests submitted by

ASC, and 250 had been approved by the Project Office. Project records indicate ASC has made about 5600 other design changes but claim they do not affect technical standards or contract specifications.

6.6 The Project Office advised the ANAO that all changes to the configuration of the submarines are fully documented to the level that is practicable. All drawings, amendment details and any other configuration records are accessible by the Commonwealth at any time and have been or will be delivered to the Commonwealth. The Project Office states that the only issue here is that the Commonwealth may not be able to control the documents once delivered and therefore delivery is being delayed until the procedures are in place to ensure adequate control. The Project Office assured the ANAO that the configuration of each submarine can be uniquely identified and design changes are checked vigilantly. The ANAO has not verified the accuracy of this advice, because of the specialised nature of this work.

Quality assurance of the design process

6.7 The Project Office records of September 1994 stated that:

ASC's process for providing traceability of their internal concession engineering decision making was seen to be deficient. Relying heavily on personal notebooks and memory, there was no obvious way of recording minor calculations or facts taken into consideration when locally assessing a [design or production permit] concession. Likewise, Kockums attention to detail appeared questionable, no reasons were provided for apparently accepting stresses over the allowable limit and there were no responses to concession wording that should have evoked Kockum's immediate concern and a request for further information.

6.8 The Project Office's Platform Engineering Manager recommended that the quality assurance manager review the Kockums/ASC internal concession procedures with a view to ensuring traceability of design/engineering assessments. This request was put to ASC on 30 September 1994 and ASC replied that the Production Permit/Concession Request process had been subject to audits by QA representatives in the past with satisfactory results.

6.9 The ANAO has seen no evidence of these audits but notes that some Defence QA officers have a general concern about the lack of contractual right to audit the quality of the submarine design. The contract is essentially a performance based contract, which makes ASC responsible for the

submarines' design, construction in accordance with agreed standards and achievement of all performance specifications. The Commonwealth has no contractual right to recommend or instruct ASC to change the design process without assuming the risks of errors and deficiencies that may arise from such recommendations or instructions. Defence advised the ANAO that it maintained a strong presence alongside designers during the design [review] phase of the project, and sought external expertise from DSTO and other organisations where appropriate, and that this process is continuing.

Probable design modifications

6.10 The submarines' combat systems are still being developed and hence their design and development remain incomplete. However, the submarines' hull, control system and propulsion system design have been provisionally accepted by Navy. Design modifications of these systems often involve performance trade-offs concerning speed, endurance, manoeuvrability, explosive shock surviveability and noise emission. These trade-offs affect propeller, hull and control surface design. Compounding the design challenge is the need for ASC to launch the submarines at about yearly intervals, with some delivered prior to completion of the first submarine's trials program.

6.11 This presents risks for ASC and Defence, given that modifications may be needed on some or all of the submarines. Already the need for some modifications is being investigated by ASC and Defence.

6.12 An example of design modifications concerns the propeller shaft (stern tube) seals that a Defence Senior Engineer reported did not look fit for purpose. ASC and Defence later confirmed that they were not fit for purpose, and that ASC was changing the design. Navy records indicate that, during *Collins'* transit to Western Australia in September 1996, the stern tube seals had let in sea water at a rate up to 2000 litres per hour, far more than the specified limit of 10 litres per hour. Project records indicate that this rate falls far short of *Farncomb's* worst case stern tube leakage. Defence advised the ANAO that ASC took action in obtaining an improved design from another company. Project records indicate the improved design is performing far better than the specified limit quoted above.

6.13 The ANAO's technical consultants advised that some emerging design issues should have been discovered and corrected during the submarines' design verification and testing. The responsibility and cost of resolving design contingencies fall within ASC's responsibility (see paragraph 2.40).

6.14 Submarine design issues are quite diverse. The Collins-class submarines' sewage system design was reported by the Project Office's IT&T manager in October 1996 to have contravened the design philosophy of minimum manning and equipment automation. Also, the sewage system hull valve was reported to be manually operated and not protected by a Deep Depth Isolation. He considered this to be a serious design shortfall which requires a crew member to remain near the valve during sewage discharge operations so that the discharge valve could be quickly closed should the submarine dive deeply.

6.15 The ANAO considers that the prime design issue is that the Commonwealth must satisfy itself that ASC's quality system ensures the submarine design is appropriate and well managed. The Project Office assured the ANAO that it is satisfied that the design is appropriate and has been well managed.

Verification and validation of design and construction

6.16 Verification and Validation (V&V) is a function of specification and design control and progress monitoring. Verification programs assess in detail the degree to which the products of a given phase of the development cycle fulfil requirements established in the previous phase. Validation is the process of evaluating a product at the end of the development process to ensure compliance with the design requirements. V&V requires a skill set different from that of general QA.

6.17 The Project Office advised the ANAO that the Project has an extensive third party V&V program and draws upon the following organisations:

- DSTO - in the high-risk areas such as steel development, welding techniques and development of standards;
- Allied Navies - such as the US Navy under US Foreign Military Sales for assistance in assessing the design and development of the combat system;
- Defence departmental design areas external to the project and consultants; and
- Design centres such as the David Taylor Research Centre in the US on hydrodynamics.

6.18 These experts provide specialist advice on particular areas of the submarine design and construction, but there is no single group of independent experts that assess each submarine's suitability for acceptance

from ASC. US Navy vessels on the other hand are judged objectively to established standards by an independent organisation known as the Naval Board of Inspection and Survey which is accountable to the Chief of Naval Operations. Similarly, the Royal Navy has the Commodore Naval Ship Acceptance (CNSA) who independently accepts vessels from prime contractors.

6.19 The ANAO considers that there would be distinct advantages in having the submarines put to independent inspections, surveys and acceptance of this kind to assess the overall product of the contractor and acquisition organisation. Defence advised the ANAO that Navy has introduced an Operational Test and Evaluation organisation modelled on the organisation proposed by the ANAO to be responsible for acceptance of the submarines into service. (See also paragraph 4.53.)

Conclusion

6.20 The ANAO considers that there are a number of submarine design issues that should be examined by an independent verification and validation team to satisfy Defence that the submarine design and the design's documentation are under appropriate management control and all technical performance specifications and objectives have been met. This should be addressed in any risk management assessment. These issues partly relate to those listed in paragraph 2.42 and general quality assurance concerns raised elsewhere in this report. Verification and validation of this kind would involve both business and technical judgement, which should be made by appropriately qualified personnel.

6.21 The upgrade of ASC's quality assurance accreditation from AS3901 to ISO 9001-1994 included a review of ASC's design and construction function. Many submarine design and construction issues are still subject to ongoing Defence reviews. Despite these initiatives the ANAO considers that Defence should increase the submarines' design and construction verification and validation testing with assistance from independent specialists.

6.22 Defence advised the ANAO that during the design phase Defence representatives were collocated with designers to monitor the design progress and to allow the progressive review of high risk areas of the design, and that this monitoring is continuing. Defence further advised that independent agencies including Navy, DSTO and other design agencies are consulted during the review as appropriate and Navy also conduct a separate audit prior to the commencement of sea trials to ensure the submarine is materially safe to commence operations.

6.23 Prior to the expiry of the \$56 million performance guarantee (see paragraph 2.18) Defence must satisfy itself in relation to the first three submarines that:

- all design and construction risks have been resolved to satisfactory levels;
- all technical performance specifications and objectives have been satisfied; and
- all systems are operationally effective and suitable for intended use.

If the performance guarantee is not amended then as remaining submarines will be completed without the performance guarantee in place, they must be verified and validated with the same if not more rigour.

Recommendation No. 10

6.24 The ANAO recommends that Defence conduct an independent verification and validation of each submarine's design and construction, using both local and overseas specialists, with at least one such validation finishing before the expiry of the submarine contract's performance guarantee.

Defence response

6.25 Agreed. Independent verification and validation of the submarines is performed by the Naval Operational Test and Evaluation Organisation which is modelled on the US and UK organisations referred to at para 6.18 of the report. The Naval Operational Test and Evaluation Organisation is independent of the contractor and the Project Office and is responsible to the Chief of Navy in the same way that the Board of Inspection and Survey (US) is responsible to the Chief of Naval Operations. In the case of the submarines, this evaluation is well under way. Overseas experts are used by the Naval Operational Test and Evaluation Organisation as necessary.

ANAO comment

6.26 The ANAO notes that design and construction verification and validation (V&V) activities differ in focus to operational tests and evaluations. Hence the ANAO would expect the submarines' Operational Test and Evaluation Organisation to utilise personnel with the necessary technical qualifications and experience to achieve an appropriate balance of submarine design and construction V&V as opposed to operational performance and effectiveness evaluations.

7. Submarine Construction

This chapter gives a brief overview of some significant submarine construction issues that have arisen during the Project and indicates concern that several significant construction risk management issues have not yet been settled.

Introduction

7.1 This chapter draws upon Project Office records and Quality Assurance reports on the submarines' hull construction, to illustrate two examples of the Project Office risk management. The audit did not consider all hazards recorded in the Project's Hazard Log. The ANAO focused on the Project Office's management of welding quality issues that offer most risk to the Project, namely pressure hull construction and internal pipes.

7.2 Records indicate that Project Office staff maintained a careful and diligent watch on many critical engineering and quality-related issues, but the Project Office did not take decisive and effective action to treat some significant risks as they became apparent.

7.3 Most concern arises from imported welded assemblies. Project Office records indicate that since mid 1997 HMAS *Collins*' imported section 300 (escape section) underwent extensive weld surveys as part of an 'ultimate safety inspection'. The record indicated some deviations from welding standards were found but they did not require immediate rework. The records indicate that *Collins* will be subject to further welding surveys which will include the imported section 600. Also, some imported seam-welded pipes are scheduled for replacement during *Collins*' 16 week post-delivery availability (PDA) inspection and work program scheduled to commence in June 1998. Seam-welded pipes in the remaining submarines are also candidates for repair or replacement.

7.4 ASC and Defence are investigating design issues related to the propulsion system and design defects in locally-manufactured high-pressure hydraulic couplings. The Project Office is monitoring a number of other issues that indicate an immature design and a continuing need to reduce the submarine's noise emissions.

7.5 Project Office records contain few concerns about the vast majority of submarine platform construction work undertaken by ASC and its domestic subcontractors. This indicates a general satisfaction with subcontract work

done in Australia. However, HMAS *Collins*' Report of Material State at Delivery (TI-338) at acceptance listed many outstanding defects and deficiencies that should have been corrected by ASC before the submarine was offered to the Commonwealth for acceptance. The ANAO considers the Project Office was not fully effective in ensuring defects relating to design and construction were detected and corrected by ASC's quality management system working in concert with its inspections, tests and trials system.

Welding of hull sections 300 and 600 of HMAS *Collins*

7.6 Submarine hull integrity and welding quality are critical to performance, safety and submarine service life because of the stress cycles resulting from deep dive operations.²⁶ Some areas of most stress in the *Collins* submarines are the flat bulkheads in the forward section 600 and in the escape section 300. These sections present by far the most difficult welding tasks.

7.7 The Project Office's knowledge of problems in HMAS *Collins*' section 300 and 600 construction extends back to early 1990 when Project Office quality audits at Kockums in Sweden revealed unsatisfactory work practices and an inadequate quality system. Both factors at the time cast doubt on the quality of the pressure envelope of *Collins*, then known as Submarine 01.

7.8 Project Office records of August 1991 indicate that numerous severe welding undercuts and visually-poor welding were noted in sections 300 and 600 tanks for Submarine 01. In August and December 1992 ASC received the submarine's section 300 and section 600 from Kockums without the necessary objective quality evidence that these sections complied with the contract's quality standards.

7.9 These issues came to light in the ANAO's 1997 audit. After the 1992 audit, when *Collins* was under construction, the ANAO had queried Defence on welding of sections 300 and 600. Defence advised the ANAO in May 1993 that visual examinations of section 300 revealed a number of 'cosmetic weld imperfections' and that the Project Office was seeking documented assurance that production standards were consistent with the contracted specifications. Defence further advised the ANAO, in August 1993, that work done by ASC on section 300 was 'fit for purpose' and that inspections and work on section 600 was continuing.

²⁶ The *Collins*-class submarines have a diving depth stated officially as in excess of 180m. The external pressure on the submarine could therefore exceed 18.4 atmospheres; ie, 18.4 times the pressure at sea level or 1.861 Mpa (278 lbs per square inch).

ASC's response to hull quality issues on HMAS Collins

7.10 Project Office records of 29 June 1993 indicate that ASC, on receiving Submarine 01's section 300 from Kockums, rectified approximately 440 welding defects. ASC sent two specialists to Sweden to add to ASC's staff at Kockums to oversee the fabrication of section 600 and improve on areas of concern that had been identified in section 300.

7.11 Project Office records indicate that inspections in June 1993 of section 600 revealed welding defects that exceeded the limits specified in ISO/DIS Standard 5817 by over 300 per cent. To compound the Project Office's concern, some of the defects were in highly-stressed locations on the submarine's pressure boundary.

7.12 Project Office representatives at a meeting on 12 August 1993 at ASC reported that they observed data that confirmed Kockums had approved welding with defects considerably outside specified limits. The Project Office report indicated that ASC were accepting defects considerably outside specified limits as being 'fit for purpose' without reference to or approval of the Project Office.

7.13 At the time, the Project Office was concerned that Kockums as both major supplier and design authority were deeming 'fitness for purpose' to avoid ASC requiring them to rectify the defects. The Project Office considered that was a classic example of conflict of interest.

7.14 A Project Office report in September 1994 indicated that a full visual inspection of the tanks in sections 300 and 600 prompted ASC to repair 1378 surface defects by grinding. That grinding revealed 76 sub-surface defects which ranged from slag and porosity to large cracks. These required repair welds, and a further 57 defects required production permits described in paragraph 6.4. The Project Office report highlighted the fact that between 5 and 10 per cent of the surface defects were accompanied by significant sub-surface defects.

7.15 Project Office records indicate that in November 1994 ASC agreed to co-operate with ultrasonic inspections of the *Collins*' welding as an integral part of the post-delivery availability (PDA) inspection and work program.

7.16 In the ANAO's opinion these problems, apparent since 1990, could have been handled by the Project Office more expeditiously. Extensive investigative work at Commonwealth expense remained to be done as late as 1997 (see paragraph 7.3). Defence advised the ANAO that the contractor maintains that all welding is now to specification, and that the Project Office has questioned the evidence provided to support the contractor's position and has

acted decisively by using the provisions of the contract that allow Defence to order more trials. Defence further advised that should these trials show that there are in fact problems the contractor will need to meet both the cost of rectification and the extra trials.

7.17 Certain welding problems that arose on Submarines 02 and 03 (*Farncomb* and *Waller*) were handled more expeditiously.

Welding problems in Submarines 02 and 03

7.18 Project Office records of December 1994 indicate that significant welding discontinuity was discovered in section 600 of both Submarines 02 and 03 and that the affected welds had been previously inspected, tested and certified as compliant by the Australian hull fabrication subcontractor.

7.19 By February 1995 the welding defects discovered in section 600 of both submarines had been repaired in accordance with accepted standards. Project Office records indicate that ASC took the necessary action and had the welds back-gouged for several metres and re-welded. The records indicate that ASC investigated the failure of the first non-destructive tests to detect the defects, and directed the subcontractor to carry out an extensive series of weld investigations to re-establish the required level of confidence in the welding.

7.20 The Project Office report indicated that Defence then conducted its own audit of the subcontractor's ultrasonic evaluation and welding records and ASC's corrective actions. The results were reported as satisfactory. The Project Office record indicates that Submarines 04 and 05 were constructed with a different welding sequence to allow better access and the welder was retrained to reduce the incidence of stop-starts and wide welds.

Other Navies' submarine welding problems

Sweden's submarine welding problems

7.21 Project Office records of August 1994 outline the occurrence of welding problems during the construction of the first Royal Swedish Navy type A19 submarine *Gotland* during 1991 and 1992. A Project Office report indicated that frames and sections of the *Gotland* were reworked to overcome the problems.

7.22 The Project Office advised the ANAO that *Gotland* was built at Sweden's Karlskrona shipyard, whereas sections 300 and 600 of *Collins* were

built at Malmo under closer supervision by Kockums laboratory staff. The Project Office also indicated that *Gotland's* problems were caused by welding procedures which differed from those specified by the Collins-class submarine contract, and that it was kept informed of the Kockums' problems through DSTO's Ships Structure and Materials Division and Kockums. The Project Office advised that briefings by Kockums on the cause of the A19 *Gotland* welding problems indicated they were not related to *Collins*.

7.23 The ANAO considers that *Gotland's* welding problems, experienced during 1991 and 1992, should have prompted the Project Office to exercise rigorous risk management and quality assurance follow-up by taking the matter up with ASC to ensure that similar problems were not experienced on the *Collins*.

US submarine welding problems

7.24 Press reports of 10 August 1991 indicated that, during construction of the US Navy's submarine SSN-21 *Seawolf*, a limited number of cracks were found in hull welds. The cracks were interpreted as indications that the welds were too brittle for the harsh environment that the submarines must operate under and the welds had to be replaced. In 1992 the US government granted a \$US59 million contract to the prime contractor to fix the defective welds. (DSTO advise the welding problems experienced by Australia and other navies are not related.)

Type-254 SMO stainless steel pipe risks

7.25 Internal pipes subjected to sea water pressure need to be as water-tight as the submarine's pressure hull. Accordingly they are subject to a similar degree of design specification and quality assurance scrutiny.²⁷

7.26 In October 1995 ASC reported weld failures in type-254 SMO seam-welded pipe in Submarine O5's aft trim tank. The Project Office later learnt of excessive risk in a wide range of type-254 SMO stainless steel seam-welded pipes manufactured by a Swedish subcontractor and fitted throughout the submarines. Project Office records indicate that some of SMO pipes at risk form the hull boundary. (See also paragraph 7.36.)

²⁷ US Navy Submarine *Thresher* was lost at sea in 1963. The Naval Court of Inquiry concluded that 'the most probable cause of the loss was a flooding casualty in the engine room due to a piping system failure in one of the sea-water systems which, in turn, probably affected electrical circuits which caused loss of power'. The Court commented on the need to re-emphasise and improve quality assurance in ship building and repair yards.

7.27 The Project Office rated the pipes' risk factor (a product of probability and consequence) as being within the undesirable range of its risk matrix. The worst case result is the probability of a SMO pipe failure sometime in the life of the item with the consequence of sea water or diesel flooding. The Project Office advised that the worst case hazard that could arise from the SMO failure has been assessed as Critical. Operational control limitations for suspected failure of nine of the pipes call for the submarine to surface and, in the case of six pipes, to surface without the use of normal or emergency blowing of number 4 main ballast tank. Kockums in May 1997 rated some of the pipes as extreme risks (in terms of consequence only) and advised that these pipes be checked immediately and verified to be free of defects or replaced.

7.28 By August 1997 ASC had submitted an SMO pipe repair and replacement plan for the *Collins* and *Farncomb*, with similar plans for the remaining submarines still to be decided.

7.29 The ANAO selected this incident as a case study of the Project Office's risk management actions.

Specifications regarding use of stainless steel

7.30 The Collins-class submarines' specifications prohibit the use of stainless steel in any pressure boundary except in masts and other applications where essential. The specifications allow stainless steel to be used for commercial sanitary fixtures. Any deviations from this specification require Commonwealth approval (see paragraph 6.4). The prohibitions were to avoid problems experienced with stainless steel subject to high chlorine levels in tropical sea water. Defence records indicate that type-254 SMO stainless steel is less susceptible to problems associated with tropical sea water.

7.31 The Project Office granted ASC design deviations to allow the use of type-254 SMO stainless steel only in the diesel engine exhaust and air induction systems. ASC, however, also opted for type-254 SMO stainless steel elsewhere in the submarine rather than the specified cupro-nickel piping normally used by UK and US Navies. DSTO advised that ASC's wider use of type-254 piping was no cause for alarm.

Design change to replace cupro-nickel pipes with seam-welded type-254 SMO pipes

7.32 The original Collins-class submarine Required Ships Characteristics²⁸ specified cupro-nickel alloy should be used for sea water and hydraulic systems applications. Project Office records of September 1991 indicated ASC or Kockums changed the design to allow the use of type-254 SMO stainless steel piping in hydraulic systems but not sea water applications. Only short SMO pipes (flanged to cupro-nickel pipe) were to be used in tank connections owing (amongst other reasons) to exceptional circumstances during emergency ballast tank blowing.

7.33 Project Office records indicate that ASC or Kockums later specified the use of seam-welded type-254 SMO stainless steel pipe in cooling water and salt water applications in all Collins-class submarines without Project Office approval. The contract allows the contractor to select materials to meet its design requirements. But the ANAO notes that, besides personnel safety considerations, not all design risks lie with the contractor because the consequence of any design failure, depending on the exact circumstances of the failure, may be covered by the Commonwealth indemnity (see paragraph 3.31).

Specifications regarding use of seam-welded pipe

7.34 The Project Office advise the Collins-class specifications do not prohibit the use of seam-welded pipe. Seam-welded pipe is manufactured by rolling metal plate to form a pipe and then sealing the longitudinal seam with a weld. Solid drawn pipe does not have such a seam and is not subject to the same probability of weld failures that can occur in seam-welded pipe, especially when the pipe is bent.

7.35 In response to an ANAO query, DSTO's Maritime Platforms Division concurred with the ANAO's technical consultants' advice that seam-welded pipe is seldom permitted in submarine construction. DSTO advised that:

this is done mostly as a precautionary measure by suppliers, in the interests of saving their money in the long run however this does not preclude the use of seam-welded products. A decade ago when the Collins piping decisions were being made, seam-welded piping was more generally acceptable. ...Specifically, we know that seam-welded piping is not normally used in the UK or US. ...seam-welded pipe was in

²⁸ *New Construction Submarines - Required Ship Characteristics*, Chief of Naval Materiel 14 January 1983. This document formed part of the Project's Request for Tender.

general use when the pipe was selected.

US Navy experience with seam-welded pipe

7.36 The significance of problems with seam-welded pipe in submarines is well-known in the U.S. In December 1954 during hot water pressure testing in construction of the first US nuclear submarine *Nautilus*, a burst occurred in pipe found to contain a weld instead of the specified seamless pipe. All steel piping on *Nautilus* was then considered suspect. Emergency orders for replacement with seamless piping for all systems were carried out, despite the considerable cost and delays to schedule.²⁹ Follow-up action included scrapping all the shipyard's inventory stock of materials that could not be certified as to source or compliance with specifications. Major steps were then taken to advance QA, including specifying that only seamless steel pipe was to be allowed in the yard regardless of end use.³⁰ In response to this paragraph Defence advised that there is no seam-welded high-pressure piping in the Collins submarines. The ANAO notes, however, that Defence records indicate that some SMO pipes at risk run through a main ballast tank and are therefore subject to the pressure cycles experienced by each submarine's hull including increased pressure caused by ballast tank blowing.

Early Project Office concerns about type-254 SMO welding

7.37 The Project Office in November 1990 repeated to ASC its earlier concerns about quality assurance and failures in welded sections of type-254 SMO stainless steel in these terms:

The apparent lack of knowledge by [ASC] of the failures at KAB's [Kockums AB] laboratory of 254 SMO stainless steel is, in itself, cause for considerable concern, noting the amount of testing that took place and the discussions held during DDR-6 [Detailed Design Review 6] and subsequently. Some of these discussions dwelt on [supplier's] Quality Assurance and their ability to deliver to Specification.

The initial failure at KAB occurred when welded sections of 254 SMO were subjected to testing in accordance with US Specification test G48. Large sections of weld literally fell out. A sigma phase was identified as being the most likely reason for the failure. Later failures occurred in both as welded and post weld quench annealed conditions. It is

²⁹ *Evolution of modern US submarines from end of World War II to 1964 - Major problems and some solutions* Captain W D Roseborough USN (ret) in Naval Engineers Journal, November 1988.

³⁰ Lloyd Bergeson, *Shipbuilding and Shipbuilding Management, 1943-1993 One Man's Perspective*, SNAME Transactions Volume 101, 1993, p.150. (Journal of the Society of Naval Architects and Marine Engineers, New York).

understood that [Mr ...] is well acquainted with these tests and failures.

7.38 ASC reassured the Project Office that Kockums had very long experience in welding stainless steels, including type-254 SMO, in many sea water and exhaust gas applications, and that Kockums had cooperated with the supplier for many years in developing techniques for fabricating stainless steels including type-254 SMO. ASC advised the Project Office that this cooperation, product information sheets and Kockums' own techniques were integrated into Kockums' drawings, specifications and procedures as appropriate.

7.39 The ANAO noted that ASC was later able to use type-254 SMO seam-welded stainless steel pipe in place of cupro-nickel specified in the Required Ship Characteristics without being considered in a formal design change process. The ANAO's technical consultant expressed particular concern about this, but Defence advised that the Required Ship Characteristics do not form part of the contracted requirement for the Collins submarines.

Failures in type-254 SMO pipe

7.40 In November 1995 ASC reported seam weld fractures in type-254 SMO seam-welded stainless steel pipe installed in Submarine 05's aft trim tank. ASC and the Commonwealth immediately and independently conducted a risk assessment.

7.41 In July 1996 ASC reported that tests on selected SMO pipes in Submarine 04 revealed numerous weld deficiencies in thick-walled type-254 SMO pipe. ASC reported in technical terms that the deficiencies ranged from crater cracks, liquation cracks, porosity clusters and lack of fusion. ASC reported also there was evidence that the supplier had undertaken extensive repairs and that deficiencies occurred between the supplier's weld repairs. The report commented that essentially there was a quality problem with the supplier's inspections. Investigations into thin-walled type-254 SMO pipe found transverse cracks in welds placed under tension by the pipe bending process.

7.42 In October 1996 DSTO reported to the Project Office that all 3.6mm and 4mm (thick-walled) type-254 SMO piping in all submarines should be considered risky, that the matter should be addressed urgently and that safety-critical piping should be replaced or repaired before entry into service or as soon as possible thereafter. DSTO based this assessment on its view that:

- the absence of cracking in a bent [seam-welded] pipe is no guarantee that the pipe is fit for service because cracking may occur whenever accumulated service loadings exhaust any ductility remaining in the pipe; and

- there is embrittlement in all of the thin-walled pipe and the reserve ductility cannot be measured in any of these pipes. The risk to performance is significant and will remain so regardless of the extent of NDE (non destructive examination) undertaken by ASC.

Project Office advice to the ANAO

7.43 In response to an ANAO query in January 1997 the Project Office indicated that investigations and discussions on the piping were continuing with a view to determining a pipe replacement policy. The Project Office also advised that a number of factors were being considered and actions being taken to ensure the safe operation of the submarines.

7.44 In April 1997 the Project Office advised the ANAO that, as all pipework already fitted in the submarines has already passed the system testing, there is no immediate concern that the pipes will leak. The Project Office advised that the prime issue is fatigue life and further work is being done in this area.

Extent and severity of 254 SMO seam-welded pipe risks

7.45 A May 1997 SMO Pipe Failure Report by Kockums assigned one of four risk grades to 84 seam-welded SMO pipes in each Collins-class submarine. Over 30 other seam-welded SMO pipes in each submarine were not graded by Kockums because it considered these pipes were not in the risk group and so were not subject to risk analysis. Kockums considered only the consequence of any failures and not the probability.

7.46 Of the 84 risk assessed pipes Kockums rated 4 pipes as extreme risks and advised that they should be checked immediately and verified to be defect free or replaced. Of the remaining 80 graded seam-welded SMO pipes, 27 are graded as high-risk, 19 medium risk and 34 as low risk. Kockums advise that the low risk grade indicates that a failure has such a small effect that the pipe need not be replaced until it actually fails.

Project Hazard Log entries and risk management

7.47 The Project Office's Hazard Log records the perceived risk factors of quality and safety-related issues arising in the course of the submarines' design and construction. Hazard Log entries for type-254 SMO stainless steel pipe are in two groups. The first group are dated from July to November 1990 and cover Project Office concerns with type-254 SMO pipe quality as stated in paragraph 7.37 above. These entries were assigned a low risk index of twenty, indicating an improbable occurrence with a minor consequence. The second group, dated from October 1995, cover the failures of type-254 SMO

pipe welds found in the submarines as stated in paragraph 7.40 above. Because of the weld failures and renewed quality assurance concerns, the SMO issue was assigned a much higher risk index of six, indicating an occasional occurrence with critical severity.

7.48 The five-year interval between the Hazard Log entries and the significant change in risk index indicate that Hazard Log entries are a product of Project Office reactions to events and not prompts in a risk management sense. Also the Project Office advised that the 1990 and 1995 SMO pipe weld issues are not related. This indicates that hazards may be faithfully recorded in the Hazard Log without being subject to continuous pro-active risk management. The ANAO considers that the issues both relate to SMO seam-welded pipe quality and the Project Office lost sight of the SMO pipe issue after 1990 amid its concerns about other issues, recorded in the 1000 or so Hazard Log entries and the Project Office's 5000 file volumes. The type-254 SMO pipe issue shows that the Hazard Log does not prevent the Project Office from losing sight of significant risks - much seems to depend on the initial risk index and title assigned to the hazard.

Indemnity claim

7.49 As indicated above, welding defects were reported in SMO pipe in Submarine 05 in October 1995. On 16 November 1995 ASC submitted an indemnity claim against the Commonwealth for consequential losses in respect of possible removal and replacement of all suspect SMO pipe from the submarines, including schedule implications. The claim was not quantified but was significant. A year later DSTO called for urgent action on SMO piping. ASC, the Project Office and the latter's insurance/indemnity advising firm met on 6 November 1996 to discuss claims under the indemnity. One of the claims was in respect of the welding defects in SMO pipe.

7.50 Later in November 1996 the advising firm submitted a draft record of the meeting to the Project Office that indicated that the claim fell outside the indemnity scheme and that the file was closed. But, after consideration of the draft by Defence, the firm's record indicated that resolution of the claim would await determination by ASC and the Project Office on the rectification to be undertaken. The firm indicated that the record had been sent to ASC. The claim was listed as continuing with 'closed file pending resurrection of the issue under the indemnity'.

7.51 The inconsistency on such a fundamental issue between the two records of the 6 November 1996 meeting is unsatisfactory and leaves it unclear what was agreed at the meeting regarding this significant claim. The claim has financial implications for ASC. The ANAO considers that the claim

should have been rejected from the outset and should not have been left unresolved in a technical and financial sense. Work to rectify the piping problem was deferred, as was resolution of liability for the cost. The ANAO on 2 October 1997 put these views to Defence who advised that on 14 October 1997 the claim was agreed to be designated as 'closed'.

Slow progress in treating the risks

7.52 The ANAO sought DSTO's advice on safety issues related to the SMO pipe and raised specific concerns about Defence's apparent slow progress in resolving the issue. In response DSTO said that:

it is important to ensure the problem is adequately investigated and that resolutions are appropriate. This can take time. In our opinion, excessive delays have been caused by the slow responses of [the supplier] in Sweden to investigation of the problem, and by staff shortages in ASC.

7.53 DSTO's advice to the ANAO appears not consistent with its advice to the Project Office of October 1996 that the matter should be addressed urgently. It is also not consistent with Kockums' May 1997 advice that the extreme risk pipes should be checked immediately and verified to be defect free or replaced.

Conclusion

7.54 The SMO pipe welding case study provides an example of uneven and unsystematic risk management. The ANAO considers that the Project Office correctly identified type-254 SMO welding and quality as being a risk in 1990. But it lost sight of the risk, amongst the 1000 or so Hazard Log items and its 5000 file volumes, until the risk eventuated and affected all submarines. On finding that all submarines had been affected, and with expert advice that the matter needed urgent attention, the Project Office left risk treatment largely to ASC's timing, rather than requiring ASC to deliver the submarines defect-free as specified in the contract. The issue was churned in exchanges of correspondence and reports without resolution.

7.55 Large complex projects can lose sight of important matters if they are not resolved promptly and conclusively. Thus sound information, prompt decisions and follow-up are integral parts of effective project management.

7.56 The Commonwealth indemnity given to ASC covers consequential loss of or damage to a submarine (prior to expiry of the warranty period), that may result from defective workmanship, material and design. Accordingly any

SMO weld failure may, besides personnel safety considerations, lead to greater costs to the Commonwealth. Hence effective risk management by the Project Office was necessary because all risks that relate to materials, workmanship and design do not lie exclusively with ASC or its subcontractors.

Project Office comments on ANAO findings

7.57 The Project Office advised the ANAO as follows:

...it is not surprising that the dominant issue in its QA files is welding quality assurance. In the main the issues are not defective welding but deficiencies in the documentation of the traceability of the objective quality evidence from the drawing to the weld and subsequent testing. This requirement imposes an enormous documentation management load.

There is little evidence to question the weld quality. By industry standards the requirements imposed on ASC are demanding. Few construction tasks require the quality of welding being performed in this project, and 100 per cent testing is extremely rare. For example in ship construction 10 per cent or less would be typical. For the submarine the requirement is that all defects are to be repaired. In addition the material being welded is difficult to work with. Despite these factors, the weld quality is outstanding by industry standards. Nearly 24.5 km of welding has been completed and inspected with a defect rate of just 0.2 per cent. Industry standards are around 1-2 per cent. There have been no weld failures and while defects have been discovered the discovery rate is at less than industry best practice.

Conclusion

7.58 This chapter draws upon Project Office records and Quality Assurance reports on the submarines' hull construction, to illustrate two examples of the Project Office risk management. The audit did not consider the 1000 or so hazards recorded in the Project's Hazard Log. The Project Office quickly resolved submarine construction problems found in work done by local subcontractors and quickly increased preventative action as necessary. Local manufacture reduces monitoring and control delays and makes it easier to obtain required quality outcomes at reasonable cost to the Commonwealth.

7.59 Project Office records indicate that most platform construction problems have arisen in overseas supplied items. The Project Office seemed

to achieve little in its representations to ASC concerning the need to improve construction quality of submarine 01 sections 300 and 600, despite the early warnings of emerging problems in 1990. The ANAO is also concerned with the protracted analysis of the SMO pipe quality issues which also date back to 1990.

7.60 The Project Office's risk management was not effective in managing the section 300 and 600 welding and SMO pipe weld risks.

7.61 As a last resort design, materials and work risks should be managed by invoking contract conditions that allow the Commonwealth to recover payments it made for design, materials and work later found to be outside contract specifications (see paragraph 2.16). This accords with Project Office objectives, which seeks to ensure that adequate financial controls are implemented in order to satisfy the Project's quality goals.

7.62 Project Office management of issues concerning imported hull sections 300 and 600 and type-254 SMO piping indicates a propensity for Project Office staff to spend considerable time and resources analysing and reporting problems with quality without executive decisions being made to resolve the problems.

7.63 The ANAO considers that issues raised in this chapter underscore the need to conduct a review of the project as discussed in paragraph 6.24.

8. Combat System Development

This chapter outlines the New Submarine Project's combat system development process and describes a number of significant management issues that have contributed to its delayed completion.

Introduction

8.1 The combat systems operational specifications were settled with the contractors during the contractors' fifteen month \$32 million Project Definition Study (PDS) funded by the Commonwealth. The PDS was completed in November 1986 and provided:

- a basis for selecting an Australian consortium to construct and supply the selected submarines; and
- an agreed design baseline and costed production proposals for a contract (which was awarded to ASC in June 1987).

8.2 In September 1987 ASC signed a contract with Rockwell Ship Systems Australia (RSSA), now known as Boeing Australia Limited, for the design, development and installation of a Commonwealth-selected automated combat system for the six Collins-class submarines. The combat system is a major and critical part of the New Submarine Project. Defence advised the ANAO that the Project contains the largest software development program that it has ever attempted and that, by world standards, was, for its time, very ambitious.

8.3 The contract price for the combat systems fitted to all six submarines is \$837 million (June 1986 prices). Price and currency rate variations increased the price to \$1084 million (December 1996 prices). This price included all hardware, software, shore facilities, including testing and training sites in Sydney and HMAS *Stirling*. By December 1996, 97 per cent of the combat system's contract funds had been spent.

8.4 The combat system software was scheduled for delivery and integration into *Collins* by September 1993. However, software-related system integration problems prevent its completion until at least 1999. Until then ASC have scheduled the delivery of successive releases of the combat system software.

Combat system hardware

8.5 The combat system suite is divided into the following functional areas:

- Navigation, which includes, global positioning system inertial navigator, speed depth and position equipment. Navigation data is passed to the integrated ship control management and monitoring system (ISCMMS) as part of the ships manoeuvring control data.
- Surface systems, which include a surface search radar, a ship identification system, and two periscopes - search and attack.
- Sonar system, which consists of multiple acoustic arrays of active and passive types, together with a data processing system capable of providing information to allow tracking of multiple targets.
- Tactical data handling system (TDHS), which manages the electronic data and provides the means by which targets are engaged.
- Electronic surveillance measures, which provide the means to receive general or specific electronic signals.
- Weapon discharge system.

8.6 The Collins-class submarine combat system design utilises multi-function operator consoles to overcome the disadvantages of dedicated process-unique operator consoles found in earlier submarine combat systems. The Collins design integrates all sensor and weapon information to enable each of the seven combat system operator consoles to be used at any time to control the sonar sensors, tactical data acquisition and analysis, and navigation. Besides minimising the effect of single points of failure, this integrated design makes possible large reductions in system volume, weight, cooling and power.

8.7 A more capable operator console, designated as the command plot, provides a central point for monitoring the submarine's tactical situation and exercising key combat and operations decisions.

8.8 The combat system sensors (with their internal software) were delivered to ASC mainly as completed packages. The Project Office advised many of the combat system's major equipment are unique to the Collins program.

8.9 The Project Office advised the ANAO that most of the combat system hardware has been delivered and has been subjected to stand-alone testing, and that the equipment on the submarine is meeting expected performance. The ANAO notes, however, that the Commonwealth takes formal delivery against the contractors' Category 5 sea trials that must demonstrate the

combat system's fully integrated performance. Until the final software is delivered, a fully integrated system cannot be trialed. Consequently, the Project Office advised that against a measure of completed sea trials it appears that a very low percentage of the combat system's final integrated performance has been delivered.

Combat system software development

8.10 The software used to integrate, display and control the various combat system functions has struck serious technical difficulties. Known as the Tactical Data Handling System (TDHS), it is priced at \$61 million (June 1986 prices).

Combat System Software requirements and system design

8.11 The software development processes specified in the combat system contract is the US Defense standard DOD-STD 1679A - *Military Standard Software Development* and DOD-STD-2167 - *Defense System Software Development*. These standards provide a structured top-down systems analysis and design method to ensure the development of fully functional software that may be tested, integrated, maintained and quality-verified in a cost effective manner.

Doubts about requirements and design allocation

8.12 Project Office records indicate that the system design requirements were allocated to the contractors and full-scale development of the TDHS commenced before there was evidence that all of Defence's requirements were correctly interpreted by the contractors.

8.13 The Project Office advised the ANAO that it took appropriate steps to clarify system requirements at an early stage in the design and that Project Office personnel are still collocated with software design teams. The Project Office advised that as the designs proceed it sometimes becomes apparent that further specification of design requirements are necessary, which is inevitable in large software development projects.

8.14 The Project Office added that there will always be debate when an additional requirement needs to be specified in a fixed-price contract. Contractors will argue that clarifications are really scope changes; the Commonwealth will maintain that it is a clarification of the agreed scope.

8.15 The Project Office further advised that the need to develop additional specifications late in the development process has not been solely due to incorrect understanding of the high level of development. The visibility of the implementation has revealed areas that were not specified and now need to have performance limits set. This could only be undertaken when the implementation became visible.

TDHS software development and test schedule and payments

8.16 Defence first became aware of combat system integration problems during TDHS software quality assurance audits early in 1991. Project Office records indicate that, at the time, the TDHS software development plan did not reflect the actual development process, there was no procedure in place for regression testing, software was integrated into the built environment without first being tested, and there was no traceability between changes to software in the built environment and the change documentation.

8.17 The Project Office received reports of TDHS schedule slippage in mid 1991. Slippage continued and by May 1993 only about 40 per cent of its fully integrated functionality had been achieved. At the time the Project Office had approved progress payments that exceeded 90 per cent of the TDHS development and test price, and by January 1994 had paid 100 per cent of the TDHS development and test work package.

8.18 Despite the slippage the Submarine Project Director in September 1993 expressed confidence to the Minister that the combat system's scheduled delivery date of January 1995 would be achieved at no additional costs to the Commonwealth.

8.19 By 1995 Project Office records indicate the development teams were taking one year to integrate each 10 per cent of functionality into the TDHS software. Furthermore there were high-risks that development past 60 per cent of the specified requirement would be hampered by memory and data processing and distribution limitations already built into the TDHS system. Boeing advised the ANAO in December 1997 that it has borne substantial additional costs associated with software delivery delays.

Progress to date

8.20 In April 1997 the Project Office advised the ANAO that Navy had agreed that by the end of 1997 the capability provided by the combat system will represent 86 per cent of the final Release 2 system requirements to be delivered against the contract.

TDHS software development quality assurance reviews

8.21 A Project Office report of July 1992 indicated that TDHS testing revealed clear indicators that the system was driven by schedule rather than any overriding commitment to achieve the requirements of quality standards. The report indicated that this comment was not intended to suggest an intent to produce anything less than quality software, but was more an indication that the subcontractor felt they it could produce the required quality based upon their judgement of what is required. The report commented that unfortunately world experience shows this to be a temptation not likely to lead to success, since it introduces a risk factor intended to be managed by contractual quality and development standards.

8.22 The report considered that the subcontractor needed to:

- improve its technical review process associated with software testing activity;
- conduct very thorough reviews of its test documentation; and
- produce detailed reports on errors, omissions and weaknesses found in test philosophy etc.

8.23 The report hoped these corrective actions would convey the need to maintain the standards required by Defence and the relevant software development standards, and that identifying the significant problems [early] added considerable value to the test readiness review process and the integrity of the product.

TDHS software performance failure

8.24 Project Office records indicate that a March 1993 software quality test of the combat system software revealed problems with integration of the software in the Submarine Weapons System Centre's combat system Land-Based Test Site (LBTS) equipment. The difficulties were reported to be of a timing nature and were expected to take some weeks to resolve. The contractors have not fully resolved all TDHS integration problems despite five years of concerted effort. Project Office records indicate that the contractors have not claimed payment for their post-January 1994 TDHS integration development and test efforts because they had already claimed the work was largely complete.

8.25 The Project Office advised the ANAO that there are always problems in integrating software and this is why the land-based test site was established. It is apparent to the ANAO that leaving the TDHS integration until May 1993

indicates insufficient planning for the time needed to integrate and test the TDHS in conjunction with other combat system elements.

TDHS software documentation and testing deficiencies

8.26 Project Office records of a TDHS documentation review in June 1994 indicated that it was impossible to determine with any reasonable degree of certainty the actual composition of the TDHS Release 1.5.1 build and that the practice of carrying forward into later versions large numbers of untested software packages was technically risky.

8.27 The Project Office's QA reviewer stated that this practice was magnifying the risks involved in integrating the increased functionality of progressive software builds. The reviewer assessed that the process was out of control and there was doubt that the software subcontractor would have the capacity to produce a product containing the quality attributes intended by DOD-STD 1679A.

8.28 Project Office records of March 1994 indicated that TDHS Release 1.5.4 contained a significant number of Trouble Reports [TRs] which had not been closed out to the necessary formality to sustain the product quality accreditation. By February 1995 decisions concerning the approach to product testing were deviating substantially from that required by the development standard. The Project Office reviewer reported that:

- there was a danger that the developers were losing the concept of progressing the software through the test cycle sequence in a manner that ensures precise control and test confidence level, particularly between product builds;
- the whole concept of carrying over unresolved or unproved trouble reports and fixes from one test activity to another was extremely risky;
- the level of analysis was not sufficiently thorough to give a high level of confidence that the consequence of each trouble report was understood;
- the analysis behind resolving trouble reports had been unsatisfactory and required close monitoring; and
- the testing strategy was being determined by circumstances and the design was not being subjected to the scrutiny (review) that would otherwise apply.

8.29 This indicates to the ANAO that the integrity of the acceptance testing program was under threat, and that the software development standard's minimum management procedures and requirements were not being followed by the software developer.

Project Office comments

8.30 The Project Office advised the ANAO that, although there have been problems with the quality management of the combat system design process, this has not contributed significantly to the current delay. The Project Office went on to say that the contract requires *Collins* and *Farncomb* to be delivered with TDHS release 1.5.5. *Collins* was delivered with 1.5.5. This release was subjected to exhaustive testing at the land-based test site, and following installation on *Collins* it was tested by ASC and Navy prior to acceptance of the submarine.

Reviews of the combat system software

8.31 The Project Office commissioned Rational Software Corporation to produce the New Submarine Project *In-service Support Readiness Study*. Completed in November 1994, this study covered the major software items on the submarines.

8.32 The Rational study was followed in November of 1995 by a study of the combat system communications infrastructure by a team of representatives from Team Rockwell, ASC, US Naval Undersea Warfare Center and DSTO. Their report known as the *NSMP Communications Infrastructure Study*, focused on the combat system's Tactical Data Handling System (TDHS).

8.33 In 1996 and 1997 there were a number of Software Metrics reports produced for the Project Office. These focused on Release 1.5.5 of the TDHS and its progress toward maturity.

Project Office advice regarding the studies

8.34 The Project Office advised the ANAO that the findings of the studies have now largely been overtaken by major design changes that allow delivery of the full combat system capability. The Project Office advised that this has resulted in:

- dramatic improvements in system stability;
- introduction into the design technology not available at the commencement of the contract; and
- confidence by Boeing (who acquired Rockwell) that its design is adequate for the requirement.

Current delay and risk to the Commonwealth

8.35 According to the Project Office the delays to the delivery of the combat system are well documented and Boeing still intends to deliver the full functionality to the specification within the original contract price.

Refining system requirements

8.36 Project Office records indicate that the basic combat system design is now ten years old and there is pressure from the contractors to refine the specifications to:

- remove ambiguities in interpretation;
- increase the systems processing capacity; and
- reconsider highly complex and costly functions versus actual operational value and remove functions that are no longer appropriate.

8.37 The Project Office advised the ANAO that the specification review has been completed, and a contract change to formalise the amendment to the specification will be processed in due course. The Project Office further advised that fundamentally the specification remains largely unchanged and will deliver the full requirement of the original contract.

TDHS Releases

8.38 The original submarine construction schedule contained only two releases of combat system software. Release 1 was scheduled for delivery in August 1991 and the final release (Release 2) was scheduled for integration into *Collins* by 9 September 1993. Neither was delivered. The submarine contract has been amended to enable the combat system's TDHS to be installed into the submarines through a series of evolutionary software releases that provide increased functionality at each release. The Project Office considers this will enable the submarines' inspection, tests and trials program to proceed.

8.39 On 6 October 1995 ASC advised the Project Office that Rockwell proposed the following revised dates for combat systems software releases:

- Release 1.5.5 - rescheduled from 30 April 1995 to 29 November 1995 (a day before delivery of *Collins*);
- Release 1.8 - rescheduled from 31 October 1995 to 31 August 1996; and

- Release 2.0 - rescheduled from 31 May 1996 to 31 December 1996 (a year before *Waller's* delivery).

Combat system Release 1.5.5

8.40 Earlier versions of Release 1.5.5 suffered quality problems, which persisted at least until October 1996. The Project Office advised the ANAO that Release 1.5.5 is performing to expectations on HMAS *Collins* and *Farncomb*.

Combat System Release 1.7 and 1.8

8.41 The Project Office advised that Release 1.7 and 1.8 have been replaced by 1.5.5 Drop 6 which contains some stand-alone equipment to supplement the software. Release 1.7 was defined as a stand-alone build of the *Collins* Combat System software which would provide an Oberon-equivalent capability to support initial patrols of the *Collins* submarines.

Combat System Release 2.0

8.42 ASC advised Defence in October 1995 that data collection necessary for Release 2.0 specification review had begun and would be completed by the end of 1995. However, the revised schedule for Release 2.0 will not support installation before delivery of Submarine 03 (*Waller*) now scheduled for August 1998. The contractual status of the proposed Revision 2.0 specification is still being negotiated. Boeing advised the ANAO in December 1997 that it has provided some “stand-alone” sonar processing software and hardware, alternative MK 48 torpedo firing capability and other activities which support an interim combat system until the fully-operational combat system is available. Figure 4, produced by the Project Office, shows graphically that the submarines’ ‘estimated actual’ combat system capability has continued to fall below planned capability.

Advice to Minister

8.43 The Minister for Defence, in answer to a question in the House of Representatives, informed the House in November 1996 that:

I was advised by the Chief of the Defence Force, General Baker, that the situation is as follows. The combat equipment system hardware currently fitted in the Collins-class is compliant with contract and meets the design criteria. The combat system software currently fitted in both Collins and Farncomb allows the submarines to operate safely for the conduct of platform and limited combat system trials and associated operational tests and evaluations. The current software augmented by stand-alone equipment should provide sufficient functionality to commit submarines to some operations by mid-1998.

While this interim system is expected to meet the Navy's minimal operational requirement, full functionality of the software as required by the current contract will not be available in this time frame. The department is currently conducting negotiations to clarify the configuration of the final combat system. [HR Hansard 6/11/96, p. 6417.]

8.44 The ANAO has some reservations about this advice to the Minister. In April 1997 the ANAO asked the Project Office whether the combat system hardware was compliant with the contract and met the design criteria. In reply the Project Office stated that:

- the hardware element of the combat system is generally compliant with the contract;
- there are a number of deficiencies outstanding and issues will continue to arise as more experience is gained and more complex testing is conducted; current issues are well documented (for example the T1338);
- it is agreed that software is preventing the full demonstration of integrated performance and the formal acceptance of the combat system; and
- full testing will take a long time but much of the hardware performance was demonstrated during system testing.

Future combat system upgrades

8.45 It is unclear whether the current TDHS design concept is cost-effective given the nine-year effort to achieve a combat system performance specification largely developed in the mid 1980s. Combat system display technology has advanced rapidly since then and, according to Navy, has left the TDHS's operator interface dated with some operating functions cumbersome. Navy believes that the TDHS closed-system architecture will probably prove costly to support and enhance in the long term.

8.46 Australian industry competence in data fusion and graphical interface technology has increased significantly during the last decade through Defence

projects such as the Collins program, Jindalee and JORN over-the-horizon radar projects, a range of DSTO projects and privately-funded projects. Given the continuing delay in TDHS delivery, its dated architecture and costly in-service support outlook, it would be appropriate for Defence to make a cost:benefit analysis to decide whether the TDHS should be replaced by other products.

Recommendation No.11

8.47 The ANAO recommends that Defence:

- a) continue to seek the combat system capability the Commonwealth has already paid for; and
- b) conduct a cost:benefit analysis of the replacement of the current Tactical Data Handling System with products which are more technologically advanced and less costly to maintain and enhance.

Defence response

8.48 a. Agreed. This recommendation supports action already in hand and current Defence policy.

b. Agreed. The Defence Capability Committee has recently taken an issues paper on major capability enhancements for the Collins class submarines through the next decade. This issue is in the early stages of development and consideration. A study will be conducted as Phase 1 of this proposal.

Project Office's response to the ANAO's findings

8.49 The Project Office advised that the contractors have borne the true cost impact of the delays and have had every motivation to get it right. Leading software development carries very high schedule risk. The Navy's of US, UK and France all embarked on submarine combat system development projects at about the same time as the RAN, and each encountered similar problems and delays. The Australian project may be unique in that it has managed to resolve the issues without additional funding by government and, at the same time, largely negate the impact of the delays on the submarine capability.

8.50 Although there are delays, the final capability will be delivered to the original requirement and cost. No money could have been saved as there has been no additional cost to the Commonwealth and the impact on capability has been minimised. The costs of delay have been carried by the contractors and provide every incentive for them to solve the problems in a timely way. The Project Office advised the ANAO that 86 per cent of the final integrated capability would be available by the end of 1997.

Conclusion

8.51 The software used to integrate combat system functions has struck technical difficulties. Major projects cannot be expected to be free of problems, but a risk management strategy can be used to assess risks and try to anticipate problems and deal with them promptly if they emerge. It seems to the ANAO that despite many early warnings of software quality assurance failures the Project Office's senior management did not react in time to prevent serious combat-system integration software development problems from emerging.

8.52 Had the Project Office used more effective progress monitoring and been more decisive in reacting to the problems as they became apparent, a better outcome may have been obtained for the Commonwealth. As indicated in other audits, payments should be made only on reliable and objective evidence of quality and real progress. Payments limited to actual progress are a tangible way of clearly indicating dissatisfaction with any under-performance and prompting action to achieve full performance. While recourse to such action may be seen as a potential breakdown in contractual relations and only used as necessary, it is nevertheless one of the few effective ways by which a purchaser can achieve required outcomes.

8.53 The ANAO does not concur with the Project Office's view that it has effectively managed risk and implemented strategies to reduce the impact of combat system delays on Defence capability at no additional cost to the Commonwealth. Because payments to contractors have significantly exceeded the value of progress achieved, it seems to the ANAO that the cost of delay has also been borne by the Commonwealth. Boeing reports it has borne substantial additional costs associated with software delivery delays.

8.54 In the short term the Commonwealth must fund retention of Project Office staff and contractors to monitor the combat system development activities that were scheduled to be completed in January 1995. The submarines are now undergoing operational tests and evaluation without a fully

integrated combat system, and many tests and evaluations will have to be repeated with each successive release of software.

8.55 Navy is exposed to the risk of having to operate and maintain some parts of the system that are in the mature to declining phase of their product life-cycle and so the Commonwealth must fund the increased in-service costs associated with this. Defence has also been denied the opportunity to install enhanced combat system capability developed by DSTO and others.

9. Software-based Systems

This chapter outlines the development of most of the Collins-class submarines' software-based systems, and discusses the most significant management issues that have arisen since the 1992 audit.

Integrated Ship Control Management and Monitoring System

Introduction

9.1 The Integrated Ship Control Management and Monitoring System (ISCMMS) provides automated control, monitoring and limited automatic management of major systems including manoeuvring, displacement, power, propulsion, support and supervision of system failures including warnings and alerts. The ISCMMS allows each submarine to be operated and maintained by a crew of 42, considerably less than an Oberon class submarine crew of 64.

9.2 The ISCMMS software was developed using a modified version of the US Defense standard DOD-STD-2167A - *Defense System Software Development* (which superseded DOD-STD-1679A - *Military Standard Software Development* and DOD-STD 2167- *Defense System Software Development*).

Development reviews

9.3 Project Office records of November 1992 Functional and Physical Configuration Audits (FCA/PCA) of the ISCMMS software revealed that:

- software source code was poorly annotated and that annotations were often wrong;
- in effect there was no detailed design and, during maintenance, detailed design would have to be back-engineered, adding to the maintenance burden; and
- requirements traceability from the Software Requirements Specification to the code was poor.

9.4 Project Office records of September 1993 indicated a significant improvement in the ISCMMS software FCA/PCA results. The record stated there was documentary evidence to demonstrate that the development of each configuration item had been completed satisfactorily and achieved agreed

performance requirements. This improvement continued and by October 1994 the Project Office was pleased that the responsible subcontractor was applying considerable effort in revising the control system equation and to recalculate all the submarine's manoeuvring Autopilot coefficients. The Project Office believed that it would now be in a better position to start the Autopilot 'tuning' process. However, the Project Office expressed major concern at the very large number of errors, especially sign errors, that were not detected in release testing of the Autopilot. The errors were such that segments of the Autopilot equations were totally unstable, resulting in an unsafe system that was subject to increasing depth and pitch oscillations.

9.5 Project Office records of February 1995 indicate that a noticeable initialisation software error survived through Category 1 (subsystem) tests to be detected later by ASC's Category 3 (system integration) tests. Another bug rendered the manoeuvring system on *Collins* unusable in normal or automatic modes. The Defence reviewer commented that this critical defect potentially affects the essential architecture of ISCMMS and that, if the reliability of the Autopilot is in question, operation of the Autopilot should be severely limited to manual override by the operator to maintain the SOE (Safe Operations Envelope). The reviewer went on to say, that this would degrade a number of tests, and require regression tests when the 'bug' is fixed.

9.6 The Project Office complained to ASC in January 1996 that ISCMMS Version 1.2 had been installed on *Collins* without being subject to an updated [delta] Functional Configuration Audit and Physical Configuration Audit. The Project Office advised the ANAO that an audit verified compliance in May 1996.

Project Office advice

9.7 The Project Office advised that issues raised above have now been addressed and that, prior to installation ISCMMS software was:

- extensively tested at the System Test and Software Support Facility (STSSF), also known as 'Staysafe'; and
- subject to independent (IV&V) testing by a Navy crew through a full range of operational scenarios.

9.8 The Project Office said that, although the Autopilot's final tuning is yet to be completed on the tracking range off Western Australia, its performance is said to be exceeding expectations. The Project Office considers the ISCMMS to be a major success of the project to date and reports the system is performing well at sea and meeting all expectations.

Conclusion

9.9 Notwithstanding the Project Office's confidence in the ISCMMS, the ANAO considers that its critical importance to the submarines and the late discovery of a significant deficiency in its software development indicate flaws that would warrant independent expert review of the kind proposed at paragraph 5.50. In response to this assessment Defence maintained that ISCMMS is exceeding expectations, has been extensively tested and in constant use for the equivalent of 3 submarine years, and that the risk that there could be fundamental flaws is considered very low.

Propulsion System Software

9.10 The submarine propulsion system consists of a 5250 kilowatt direct current electric motor monitored and controlled by a software-based system.

Software development reviews

9.11 Project Office records of February 1995 indicate that the propulsion system software was developed using standards like DOD-STD-2167 and that the software documentation neither identifies nor addresses any propulsion system safety aspects. The Project Office reviewer concluded that there would be a need to conduct a safety analysis on the current product, including its architecture design and use of programming languages etc. Only after this was completed would the results of the audit and documentation become useful for quantifying any identified risk areas.

9.12 Project Office records of March 1995 indicate that there were no audits of the propulsion software development by project QA staff. A Project Office report commented that the only way to gain a degree of assurance that the propulsion system meets safety expectations was:

- to identify and quantify the safety criteria necessary to determine the measure of safe design and safe use;
- to have the outcome of this activity independently reviewed for completeness and accuracy; and
- to use the resulting criteria to conduct a design review of the as-built product against the identified safety criteria by a software design expert.

9.13 A review of this kind would also indicate the level of process discipline and quality culture operating within the contractor environment. The ANAO is not aware of whether this suggested review was undertaken.

9.14 Defence advised ASC in June 1996 that, as with all other software intensive systems onboard the *Collins*, it was imperative that the quality pedigree of the propulsion system software is unambiguously established before it can be considered acceptable for use onboard the submarine. Defence sought ASC's urgent advice on when outstanding corrective action notifications would be dealt with.

Project Office advice

9.15 The Project Office advised the ANAO that the propulsion system is not a safety critical system as defined in Navy's SUBSAFE document ABR 6103, and that:

- the limitation referred to regarding manual control is no longer relevant;
- Project Office QA staff have had access to results of FCA/PCA reviews and the Objective Quality Evidence of design data;
- issues regarding the propulsion system FCA/PCA were resolved and a full design review of the propulsion system was conducted in 1996; and
- a number of audits have been conducted on the propulsion system, the most recent in May and November 1996. These audits were conducted on new releases of software. Also a formal Design Review was conducted during November 1996. The review involved staff of ASC, the Project Office, Navy and the Design Authority (Jeumont Industries). At the end of the review there were no outstanding software safety issues. The investigation of the cause of the collision with the wharf (see paragraph 3.33) showed that software did not cause the propulsion failure.

Conclusion

9.16 The ANAO notes that serious doubts concerning propulsion system quality assurance were raised after more than two years of contractor sea trials. The ANAO suggests that Defence seriously consider a review of the propulsion system by independent experts as proposed in paragraph 5.50.

Weapon Data Converter (WDC) software

9.17 The WDC provides data exchange between the combat system and the MK 48 torpedo and Harpoon missile system. It commands the weapon launch systems and controls the torpedo and missile pre-launch and post-launch calculations.

9.18 Project Office records of September 1995 indicate that a QA audit of WDC software evoked a very unsatisfactory result for a variety of reasons, mainly involving a lack of quality control over the product. There seemed to be a lack of contractor's QA management interest in the audit, together with a lack of objective quality evidence despite the notice of requirements.

9.19 Other Project Office records of September 1995 indicate ASC had serious concern about the numerous deficiency reports outstanding against [TDHS] Release 1.5.4v1, particularly the WDC deficiencies.

9.20 Project Office records of the Physical Configuration Audit [PCA] conducted on the WDC during September 1995 indicated serious deficiencies in this product and that its development did not comply with the requirements of DOD-STD 1679A. The auditor recommended that, unless objective documentary evidence could be produced to demonstrate that the product was developed in accordance with the requirements of DOD-STD 1679A, an independent technical review of the product be undertaken. This would establish objectively the fitness of the WDC product for its intended purpose.

9.21 Project Office records of October 1995 indicate ASC's serious concern regarding inadequate preparation for the WDC PCA, inadequacy of WDC CAT 1 testing, product documentation, non-conformance with DID [the contract's data item description] requirements and inability to verify that all functional requirements had been flowed into WDC design and code.

Project Office comments

9.22 The Project Office advised the ANAO that independent oversight and active support, including specialised personnel and test equipment, has been in place since 1989 for all of the Weapons System design, development and test activities, and continues to be in place. The Project Office indicated that this involvement provided independent verification and validation (IV&V) of the products being developed.

9.23 The Project Office further advised that to ensure that all activities and issues concerned with weapons firings have been adequately addressed, a series of Weapon System Qualification meetings involving all relevant officers and contractors, was initiated in mid 1996. The Project Office advised that the Weapon System Qualification Plan produced by ASC as part of the Supplementary Weapons Integration Program (SWIP) documents the scope, schedule, resources, responsibilities and pre-requisites for *Collins* First of Class weapon firings and has been endorsed by the weapons system qualification group (IV&V).

9.24 The Project Office advised that:

- the SWIP was instigated by the Project Office via a contract amendment with ASC to document the integrated weapons system and to identify any perceived safety or operational deficiencies; and
- issues and recommendations from the study reports have been addressed through normal project processes including the Hazard Log, Safety Management Meetings, Engineering Change Proposals and specification reviews.

9.25 The Project Office advised the ANAO that ASC audited the combat system including the WDC in late 1995. This audit was preceded by a series of low-level checks and tests by the Project Office and third party US Navy personnel.

Conclusion

9.26 In view of WDC quality assurance issues arising at this late stage in the combat system development program, the ANAO suggested that Defence consider a review of the WDC system by independent experts as proposed in paragraph 5.50. Defence advised in response that it has engaged independent experts to review the WDC design.

Launcher Control System

9.27 The MK 48 torpedo and Harpoon missile Launcher Control System was developed by a subcontractor using US standard DOD-STD-2167A - *Defense System Software Development*, and the originally contracted quality standard AS1822.

9.28 By April 1992 there were serious quality control problems at the submarine launcher Control system software development facility. The Project Office requested ASC to increase its surveillance involvement significantly in the subcontractor's efforts to identify and rectify weaknesses within its quality management system.

9.29 Project Office records of the April 1992 software quality verification of the Launcher Control Software revealed serious non-compliance with quality system standards. Most notable were:

- a twenty-five month gap between audits which indicated insufficient monitoring of subcontractor work to the satisfaction of the contracted

quality standard (AS 1822), and lack of evidence of audit schedules or audit reports;

- lack of evaluations of the software development library or the configuration management (non-compliance with DOD-STD 2167A); and
- absence of special measures to manage software risk areas, indicating that safety may not have been designed into the software.

9.30 The Project Office record stated that the risk of establishing an unsafe state, directly or as a contributing factor, had arisen through the designers being kept unaware of any consequences of interdependencies of the system design. There were no internal system procedures to cover requirements traceability, and it appeared that requirements traceability rested on successful completion of system tests.

9.31 The Project Office advised the ANAO that the subcontractor that supplied the Weapons Discharge System had undertaken an extensive safety study of this equipment. The study was developed in line with UK Defence Standard 00-56 and was independently audited by the Atomic Energy Authority of UK.

9.32 The evidence suggests that when the system is fully integrated Defence should consider a review of the weapons launcher control system by independent experts as proposed in paragraph 5.50.

Overall Project Office comments

9.33 The Project Office advised the ANAO that:

- most of the software has been successfully developed and delivered;
- where delays have been experienced quality assurance issues have not been a significant factor; and
- at all times the primary risk has been with the contractors who have suffered significant cost penalties from development delays.

9.34 The Project Office went on to say the submarine project has taken effective steps to mitigate any impact of software delays on the program and to safeguard the quality of the final products.

Conclusion

9.35 The evidence suggests that the Project Office's software QA specialist fulfilled his software QA reporting responsibilities. However, Project Office efforts to improve software quality were largely ineffective and should have been more vigorous in implementing quality assurance recommendations and addressing identified deficiencies with ASC.

9.36 The submarines' software-based systems that have either safety implications or mission-critical functions should now be subject to high-level validation and verification by independent experts as proposed in paragraph 5.50 as an important element of risk management. Expert assistance would seem to be a real issue for prudent management of the project.

10. Australian Industry Involvement

This chapter comments on the requirements in the New Submarine Project contract for Australian Industry Involvement and the significance of the level achieved.

10.1 A key strategy in the Project is to maximise Australian Industry Involvement (All) in the design and construction of the submarines to achieve a high degree of self-reliance within Australia in maintenance and support of the Collins-class submarines. Defence's Equipment Acquisition Strategy (EAS) for the Project sought a local industry capability for the long-term support of the submarines in Australia, and appropriate transfer of technology for developing new products or enhancing the product lines of Australian companies.

10.2 The All provisions of the contract require ASC to achieve a local content of 70 per cent of expenditure on submarine design, construction and integrated logistic support and 45 per cent of expenditure on the combat system.³¹ Offsets of \$144 million representing another 30 per cent of the imported element of the combat system were also specified.³² The contract price includes about \$53 million as premiums for specific work to be done in Australia to achieve self-reliance in selected technologies.

10.3 Contractors' records in the Project Office indicate that these spending targets have been exceeded by over \$95 million. It is unclear, however, whether the self-reliance, local capability and technology transfer envisaged by the EAS have been achieved.

Local content definitions

10.4 The New Submarines contract defines Australian Industry to include an Australian company or other business incorporated in Australia and Local Content to mean work undertaken by Australian Industry (clauses 1.8a and 1.3). Annex A of the contract specifies that subcontract packages shall be undertaken wholly in a single country.

³¹ If the achieved local content is less than that nominated, the contractor would be liable to pay liquidated damages of 5 per cent of the shortfall to a maximum of \$5 million.

³² When defence systems are sourced overseas reciprocal trade may be sought by Defence. This trade may be in the form of direct participation in the production of the imported equipment or indirect participation in trade-related activities known as 'offsets'. Offsets may include; technology transfer, licensing, research and development cooperation and training.

10.5 As indicated in the 1992 audit report, the ANAO notes that these definitions are so broad as to allow work to be undertaken overseas and classed as local content if the supplier operates through a company incorporated here. The ANZAC Ships contract has a better definition, that is, local content is work undertaken in Australia and New Zealand.

10.6 Since the broad objective of the local content definition is to benefit local firms and to produce an enduring local competence available in the future, it would have been preferable to have the Submarine contract define local content as work undertaken locally.

10.7 Current government policy requires agencies to ensure that they promote international competitiveness and the development of Australian and New Zealand industry, including small to medium enterprises. Defence advised the ANAO that the Price Report into Defence Industry Policy (1992) recognised Defence's significant achievements towards government industry policy.

Technology transfer

10.8 A consequence of the acquisition strategy is that technology transfer to many of the participants in the Project is the responsibility of major foreign partners or foreign parent corporations. The spirit of All is in the value of technology transferred to local industry and the competencies captured by industry that should flow from the significant sums expended by the Commonwealth on acquisition and service contracts. Defence advised the ANAO that responsibility for technology transfer rests with local industry as much as foreign parent operations. The acquisition strategy was that generally local companies with the will and ability to be self-sustaining would successfully identify and seek, to the extent of their capabilities and intentions, the skills and knowledge which each required to enable its continued participation.

10.9 Under the contract All achievement is measured in terms of funds expended. The ANAO considers that meaningful technology transfer envisaged by the EAS for the Project could have been gained by specifying the technology to be transferred and then monitoring the competencies developed in local industry. To measure All simply in terms of expenditure may lead to misconceptions as to the true value of All.

10.10 An example of technology transfer is the flow of submarine design competence to ASC from its Swedish design subcontractor Kockums. Project Office records indicate that local content achievement in Collins-class submarine platform design and engineering is valued at \$45.48 million. A

Project Office engineer's report of September 1996 indicates, however, that the amount of submarine design knowledge transferred from Kockums through ASC leaves Defence with such little knowledge of *Collins* that it has to rely on ASC. The report indicates that ASC itself has not derived sufficient technology transfer to enable Defence to feel confident in ASC's submarine platform design and engineering competence. (Defence expressed some reservations about the relevance of the engineer's comments in this context, but offered no clarification on the engineer's overall concerns.)

10.11 Another significant technology transfer failure relates to some of the submarines' combat system and software-based system development. This work required local contractors to increase their competence in advanced system engineering and software development. The required technology transfer to meet this need seems not to have occurred rapidly enough to prevent the local firms from experiencing software system development problems. Defence advised the ANAO that problems with the combat system's development are not related to technology transfer, but are inherent in development of a complicated highly automated system to meet the high expectations of the original concept.

10.12 The ANAO considers that Defence should monitor more closely areas of projects that require significant technology transfer into local industry.

Recommendation No. 12

10.13 The ANAO recommends that on future major projects, Defence:

- a) should (subject to government policy) specify local industry involvement in the contract in terms of technology transfer as well as in terms of funds expended for work done locally; and
- b) monitor compliance with both these requirements.

Defence response

10.14 Agreed. This accords with current Defence All Policy. While the submarine project was progressive in the development of its All plan, Defence All Policy has continued to evolve since the letting of the submarine contract in 1987 and currently focuses on: development of specific industry capabilities that are considered to be strategically important for sustaining the defence of Australia including modification, adaptation and through-life support of key assets; and broadening the capability and capacity of defence-related industrial infrastructure to further enhance our Defence self-reliance. The new

Defence All Manual clearly states the monitoring and reporting requirements are to be against qualitative outcomes.

Local content monitoring

10.15 All is monitored in expenditure terms through the CMACS audit process to verify monthly progress claims, which are then aggregated and incorporated in separate quarterly All reports by ASC and the combat system contractor Boeing. In May 1995 the Project Office's All Manager reported to the Business Manager that:

No [Submarine Project All Manager] has ever formally visited a contractor or subcontractor to audit local content or offsets obligations performance by physical inspection of products. Therefore no [Project Office] procedure exists for a 'confidence check'. Currently the verification of All is reliant on:

- *desk audits (from Canberra) of documents produced by ASC or subcontractors; and*
- *CMACS and [Quality Assurance Technical Management] groups advising the All Manager of anything they consider unusual during their inspection.*

10.16 The All manager referred to a draft Defence contracts instruction proposing that All managers carry out random audits of 3-5 per cent of total line items. In responding to the draft the Project Office's Business Manager indicated that Project Office practices were sufficient to provide confidence in the reported All achievements. The ANAO understands that the draft instruction did not proceed.

10.17 The Project Office advised the ANAO that:

- the then All manager was clearly not aware of the site visits made by previous All manager in the formative period of the All program under the contract; and
- monthly audits of the certified progress of work reveal if work has not taken place in the location where it is contracted to occur.

10.18 Boeing advised the ANAO that early in the program Project Officers were extremely thorough in assessing progress and establishing the validity of Australian work packages assigned to two of its subcontractors, but program surveillance later declined, which was reasonable as the local content activities need to be verified and corrective action initiated early in the program.

10.19 CMACS auditors told the ANAO that they do not audit All when verifying progress claims and that no instruction requires them to consider All formally as part of their audit activities. The QA manager told the ANAO that All checks are not part of QA audits and there has been no specific instruction that they should be included. Defence's QA manager at ASC in Adelaide indicated that ASC's QA system data provides no confidence that it could be used for local content monitoring and so there was a need for physical audits of All compliance.³³

10.20 The ANAO considers the checking of All was given insufficient priority by the Project Office toward the latter stages of the construction program, when valuable system integration, test and in-service support lessons may be available for local subcontractors. The ANAO considers that the Commonwealth would have benefited from a more disciplined approach to All monitoring especially in terms of measuring:

- local industry capability concerning in-service support of the equipment being developed; and
- appropriate transfer of technology for developing new products or enhancing the product lines of Australian companies.

Conclusion

10.21 The Project's All prime objective was to establish high levels of local content to ensure that Australian industry would be capable of providing through-life support to uniquely Australian submarines. Local content expenditure has exceeded the broad targets specified in the contract.

10.22 Australian industry has manufactured submarines 02 to 06 largely from proprietary drawings. This is significant in that it demonstrates Australia's capability in manufacturing, assembling and integrating highly complex and diverse technology with the possibility of adding to its intellectual property and/or know-how. This experience may reduce some in-service support problems of the kind experienced with other Navy vessels manufactured overseas and enhance industry capability for other projects.

³³ The ANAO itself does not have access to contractors' records; accordingly the ANAO could not verify All expenditure.

11. Intellectual Property

This chapter outlines the New Submarine Project Office's management of intellectual property arising from the contract.

Introduction

11.1 Intellectual property (IP) rights provide owners with limited legal monopolies in inventions, design, trademarks and literary, musical and artistic works to facilitate commercial exploitation of that property. Defence advised that, consistent with Defence policy being developed at the time and with a value-for-money focus, the key objectives for the submarine program were that Intellectual Property (IP) rights should remain with industry and only those IP rights that were actually needed were purchased. In addition, the submarine contract provided for the Commonwealth to collect royalties for foreground IP first developed under the contract (known as foreground IP) and sold to other customers.

11.2 The main objectives of Defence's IP policy are:

- to facilitate the cost-effective acquisition, operation and through-life support of Defence equipment; and
- to promote development of defence industry, with the consequent benefits of stronger industry support, by facilitating industry exploitation of IP.³⁴

11.3 To help give effect to the policy the Project Office introduced the *Rights Acquisition Logging* procedure, which states that the purpose of logging rights, such IP, is to ensure that:

- potential benefits to the Commonwealth are recognised, and advised to external entities, and
- the benefits are exploited in the Commonwealth interest.

11.4 Defence advised the ANAO that the logging procedure was initiated by the Project and accepted by the Defence IP Manager to be an effective process to implement the policy within the Project.

³⁴ Department of Defence *Intellectual Property Guide* 1995

11.5 The procedure recommends that selected IP rights associated with capital equipment acquisition contracts be logged and that at the end of a project a complete and accurate Rights Acquisition Log be passed to Defence's Intellectual Property Management. Defence advised that rights are to be selected for logging whenever logging is considered necessary to ensure that the benefits of the rights will be realised. The procedure then specifies the principles to be applied in the selection process. Defence advised the ANAO that its IP Rights Acquisition Logging procedure has not yet been introduced.

11.6 When the New Submarine Project contract was prepared there was no obligation or intention to identify all IP relating to the contract. The Project Office did, however, set up a register (or log) of IP developed under the relevant contracts.

Intellectual property rights and monitoring

11.7 The contract states that the party that produces or provides the information in a material form under the contract retains any and all IP rights. However, the Commonwealth has an irrevocable, but non-transferable, right to use or adapt all information provided under the contract which is proprietary to the contractor (and its subcontractors). This is in recognition of the substantial Commonwealth investment in the Project and its national importance.

11.8 The Project Office identifies and logs IP when it is considered appropriate. Given this approach its register is not a complete record of IP rights for the Project. However, Defence advised that, by culling rights with no potential benefit, the log focuses on those rights which have the potential to gain full royalty and other benefits for the Commonwealth.

11.9 The Project Office has no IP usage monitoring program and relies largely on the 'good faith' of the contractor regarding advice of third party IP usage outside the contract (ie, IP provided by ASC or the subcontractors to other parties). Also, there is no systematic process for identifying and recovering royalty payments due from the use of its IP.

11.10 The Project Office advised the ANAO that the contract provides an enforceable right to a fee for use of IP first developed under the submarine program, and that:

- the market for such systems and equipment is small and highly competitive and returns are expected to be limited;
- in the few opportunities that have arisen for companies to offer such systems and equipment to other navies, the contractor and relevant

subcontractors have initiated negotiation of the fee which might become payable; and

- Defence's reliance on 'good faith' is a recognised standard in industry generally and the concept has legal recognition and force.

11.11 Defence is satisfied that the Project approach to IP logging procedures is sound from a business point of view. Defence considers that marketing in applications where foreground IP may be applied is specialised and submarine and related developments throughout the world are well known within the submarine and wider defence community. As well, Defence consider the nature of the business means that most systems and equipment are designed ab initio to meet highly tailored specifications; and there is no foreground IP in generic systems/equipment such as standard pumps and the like which have been incorporated into Collins submarines.

12. In-service Support

This chapter outlines the New Submarine Project Office's efforts to assist Navy establish in-service support arrangements for the submarines.

Introduction

12.1 The prime objective of in-service support is to assist the submarines achieve their operational availability specifications efficiently and effectively. The contract specifies that each submarine shall achieve availability for sea of 80 per cent over its whole-of-life. ASC predicts these figures will be exceeded, but qualifies its prediction by stating that availability figures depend upon depot-level maintenance requirements, which have not been determined. Defence advised that the ASC qualification is entirely reasonable given that availability is a mathematical calculation which includes depot-level repair times as a factor and will therefore be dependent on depot-level repair times.

Integrated logistic support

12.2 Central to in-service support effort is the Integrated Logistic Support (ILS) tasks awarded to ASC. These tasks contained six key elements:

- logistic engineering, which evaluates safety, reliability, maintainability and determines the most effective through life support plan;
- maintenance engineering, which determines maintenance procedures and schedules;
- technical documentation, covering equipment operation and maintenance manuals and parts lists;
- supply support analysis, which determines the range and depth of spare parts, test equipment items, and provides the initial spares support. This analysis leads to what maintenance will be done at:
 - a) the organisational-level – by the submarine's crew;
 - b) intermediate-level – by Navy's Fleet Intermediate Maintenance Authority; and
 - c) depot-level – by contractors.
- training for operators and maintainers; and

- information technology development to support each of the above five ILS elements.

12.3 As indicated at paragraph 2.5 the contract included a budgetary amount of \$530 million for supplies and work that could not be detailed sufficiently to allow a fixed price to be agreed. This \$530 million set outside the contract with ASC allowed the Commonwealth to develop its ILS requirements as the detailed design of the submarines progressed. Project Office data shows \$406.7 million (June 1986 prices) had been converted to fixed-price and placed into the ASC contract for the purchase of ILS elements.

12.4 Another \$209 million from the approved project funds outside the contract has been spent on Collins submarine ILS - mainly on spare parts, performance trial ranges and performance trials. The Project Office advised that the total of \$615.7 million spent on Collins submarine ILS has not amounted to a real cost increase in the ILS budget for the project and is in line with the ILS budget for the project.

12.5 The ANAO cannot verify this statement given the difficulties in determining whether or not the funds expended are commensurate with the original ILS scope, and are sufficient to enable the submarines to achieve their specified operational availability.

Submarine operation and maintenance information transfer

12.6 The major means of transferring submarine operation and maintenance information from ASC to Navy is Ships Information Management System (SIMS), developed by ASC. SIMS has experienced a number of quality assurance problems related to hardware, software and data.

12.7 The Project Office advised the ANAO that it accepted SIMS in July 1996, and since then all QA, engineering, software and ILS issues had either been resolved or transferred to the Project's Defects and Deficiencies List (DADL). The Project Office uses the DADL as a management tool to track SIMS and other submarine system deficiencies and ensure they are corrected.

12.8 Navy advised the ANAO that the quality of information contained in SIMS was poor. This was attributed to ASC's not implementing its quality system's requirement to validate maintenance data with the various equipment subcontractors. Defence's Fleet Intermediate Maintenance Authority (FIMA), as end-users of SIMS, advised the ANAO that SIMS problems increase the difficulty of their support function, and that it was not able to assess the validity

of data contained in SIMS. Project records indicate that by September 1997, 300 problem reports had been forwarded to ASC for rectification under the warranty provisions. Defence advised that a recent review of SIMS has shown that initial problems attributed to data quality were to a large part due to a lack of familiarity with SIMS, and that training is being improved to resolve this issue.

12.9 The Project Office confirmed to the ANAO that SIMS was accepted with a number of known deficiencies, but said that none of these deficiencies prevented the use of SIMS as intended. The Project Office assured the ANAO that it is tracking the information deficiencies and ensuring they are corrected.

Depot-level support information

12.10 Depot-level support involves the repair and overhaul of the submarines' systems by equipment suppliers. Project Office records indicate that during the 1989-90 negotiations to settle the scope and cost of ILS the Project Office agreed to delete the need for ASC to provide the Commonwealth with depot-level maintenance (DLM) information, because the Project Office considered it was not affordable. The Project Office advised Navy Support Command in 1993 that the deletion was reflected in the absence of the requirement for DLM information in the many hundreds of work packages following the relevant contract amendments. Defence advised the ANAO that the purchase of depot-level maintenance information was judged to be not necessary or justified in terms of value for money and, in hindsight, this has shown to be correct. Defence further advised that the contractor is obliged to provide support for eleven years after the last submarine delivery but Defence is not obligated to purchase specific services or levels of support and will purchase only those DLM products shown to be necessary and cost-effective.

In-service support outlook

12.11 The Project Office and Navy, in 1990, commenced planning the Collins-class submarines' transition into service. Since then the Project Office has produced many in-service support reports which have overall themes consistent with Defence's Commercial Support Program guidelines for contracting out non-core activities to private industry.³⁵ A joint Project Office-

³⁵ *New Submarine Project Transition Plan*, New Submarine Project, 12 October 1992 (internal report). This plan now needs to be revalidated, as indicated by a later internal report *An Examination of Whole of Life Management Arrangements for Collins-class Submarines*, Director General Naval Engineering Requirements 15 November 1996.

Navy in-service support working group formed in 1993 with the mission of developing and implementing in-service support contracts.

12.12 By 1995 prospective in-service support contractors were expressing concern about Defence's slow progress in providing them with a clear understanding of the scope of work they might be contracted to undertake. The issues were churned in correspondence and discussions since the early 1990's until late 1997 when an in-service support contract was signed with the submarines' combat system subcontractor Boeing Australia.

12.13 Defence advised the ANAO in late November 1997 that:

- the process is behind the original schedule but, progress is not incompatible with the present submarine program;
- the organisational and intermediated-level products are delivered and in use and competence in both levels is maturing with increased experience and with each improvement in maintenance data provided through the SIMS and each submarine's Ships Information System (SIS);
- *Collins* was within its extended warranty period, and ASC remains responsible for maintenance of other submarines not yet delivered; and
- one of the three management contracts intended has been let, and the other two are being negotiated.

12.14 Defence also advised the ANAO that efforts by potential contractors to hasten the process is not surprising and signifies a keenness for a contract. Support Command Navy is responsible for developing the ISS environment including ISS management and other contracts with industry.

In-service support costs

12.15 Defence has not been able to assess accurately the submarines' overall in-service support costs, but it is generally accepted that the cost would exceed \$110 million a year (about 2 per cent of overall project cost per year) over the 30 year life of the *Collins* submarine program. Therefore the *Collins*-class submarine in-service support contracts could form the most expensive set of service contracts ever offered by the Commonwealth.

12.16 Defence reports reveal that submarine systems reliability and design suitability are of ongoing concern within Navy. However, the outlook may improve with design changes and as Navy gains further technical knowledge and operational experience with the submarines.

Conclusion

12.17 The ANAO considers that Defence would benefit if its capital equipment acquisition project offices gained timely detailed technical knowledge of equipment being acquired so that knowledge transfer to support and operational organisations is optimised. This is particularly important for new capability acquisition, where Defence needs to ensure that capability can be maintained in the long-term, without significant cost premiums being charged by suppliers. Defence advise that every attempt is made to obtain timely technical information for all capability procurements.

12.18 Given the magnitude of the costs involved Defence should ensure that it is a fully informed customer, equipped with the lessons learnt from the acquisition program and appropriate information including performance measures. The ANAO learnt in February 1998 that the in-service support contract with Boeing was followed by a contract with ASC in January 1998.

Canberra ACT
24 March 1998

P. J. Barrett
Auditor-General

Part Three

Appendices

Appendix 1

External reviews of Defence acquisition project management

This appendix outlines the ANAO's perception of the major project management themes that underpin recent audit reports of Defence acquisition projects.

Introduction

1. Set out below is an outline of external reviews of Defence project management and related issues, together with a comparison of findings from the ANAO's recent audits of major Defence projects.

JCPA review of Defence project management

2. Tabled on 20 February 1986, the JCPA's Report 243 Review of Defence Project Management (two volumes) presented the findings of the Committee's inquiry into the Department of Defence's management of sixteen major capital equipment acquisitions.

3. The inquiry arose partly from the Utz Report on the Higher Defence Organisation, which noted 'a history of criticism and complaint surrounding Defence procurement', and partly from a 1983 report by the Auditor-General on ten major Defence projects.³⁶ The audit report had commented that Defence project management practices were unsatisfactory, contributing to: significant additional costs to the Commonwealth; the need for scarce resources to be engaged in rectifying project problems; and a diminution of the Defence capability through late delivery of equipment and facilities and through equipment and facilities not meeting technical performance objectives.

4. The JCPA inquiry found that, of the sixteen projects, eleven failed or threatened to fail to be completed on time, to budget or to technical requirements. A multiplicity of factors contributed to this unsatisfactory record. Many were factors over which the Department had little control, including: the inexperience of Australian industry; budgetary restraints and the effects of

³⁶ *Department of Defence - Project Management Review* in Report of the Auditor-General, September 1983.

other government decisions; international economic conditions; and the actions of the US and other foreign governments.

5. Notwithstanding these influences, the Committee found that inefficient and ineffective Defence project management was directly responsible for most of those poor results. In a number of instances, better Departmental management could also have ameliorated the adverse effects of some of the external factors mentioned. In the sixteen projects the most common project management shortcomings were:

- inadequate evaluation of project proposals;
- under-estimates of project costs, time scales and risks;
- incomplete project planning;
- inadequate evaluation of tenders;
- contracts which did not specify all contract requirements or provide effective incentives for contractors to minimise cost or perform to schedule;
- inadequate monitoring of contractor performance;
- contract supervision which did not submit the (sometimes) large number of contract changes to sufficient scrutiny to preserve project budgets and schedules; and
- generally slow Departmental decision making processes.

6. The Committee found that, behind these observed shortcomings, there were several serious structural deficiencies in the Department's approach to project management, including:

- a dispersal of project management responsibilities and authority;
- inadequate project management resources, especially in numbers of staff and computer support;
- a shortage of experienced project managers;
- limited training in project management at all levels;
- low retention of project knowledge due to a high staff turnover; and
- inadequate management information systems within project offices and throughout the Department.

7. The Committee was encouraged to find increasing agreement within the Department as to these deficiencies and that significant steps had been taken towards rectifying them. It was unhappy, however, about the adequacy of specific reforms and the priority given to improving Defence project management. The Committee believed that the procurement function should

be independent of the Services to avoid a tendency for Service sponsors to maintain undue control leading to technical specification changes with adverse effects on project costs and schedules.

8. To improve the effectiveness of Defence project management the Committee recommended:

- firmly delineating the different responsibilities of the Capital Procurement Organisation and the Service sponsor or client organisation;
- assigning the procurement function more autonomy by giving the Capital Procurement Organisation increased authority and control;
- delegating more authority to project directors, especially over technical and administrative aspects;
- increasing the level of staffing and computer support given to project offices;
- making greater use of project management expertise outside Defence, especially that in the private sector;
- implementing proposed improvements in Defence project management information systems; and
- improving the quality of Defence contracting and contract administration.

9. The Committee believed there was scope to improve efficiency by:

- modifying Departmental procurement approval procedures to speed decision-making, and improve the quality of information available to decision-makers to allow a fuller consideration of cost-saving options, and to avoid costly changes after contracts have been let;
- increasing the level of project management skills within Defence by giving greater emphasis to project management experience in selecting key project personnel, and expanding project management training at all levels;
- increasing the retention of project management skills by developing career paths in project management and related areas;
- consolidating Defence project management procedures and practices;
- providing stronger contractual incentives for suppliers to meet requirements on time and to cost; and
- reducing the potential for post-contract delays by simplifying procedures governing design approvals and contract changes and disputes.

10. The Government's response to Report 243 and the JCPA's comments on it were tabled in JCPA Report 267 *Response to Review of Defence Project Management Report* (1987) The Committee welcomed the response and

noted that 50 of its 68 recommendations had been accepted. But it was disappointed that important recommendations relating to scrutiny of major defence equipment proposals, contracting matters, selection of senior project management personnel and reporting to Parliament on the defence capital equipment program had not been accepted or only partly accepted.

JCPA review of Supply System Redevelopment Project and DESINE

11. In response to a request by the Senate in 1988 the JCPA reviewed Defence's Supply System Redevelopment Project (SSRP, a project for a common core computing system for the ADF) and its conformity to DESINE (Defence EDP Systems Integrated Network Environment).

12. JCPA Report 317 *A champagne appetite but only a beer income - Defence's Supply Systems Redevelopment Project* (June 1992) commented adversely on progress and management of SSRP. The Committee's assessment was that project slippages were to a large extent the result of poor administration and management of the Project. The Committee reported that a contract like the DESINE contract with IBM must never be entered into by the Commonwealth again and that significant problems arise when the negotiating skills of the Commonwealth are not up to scratch. The Committee was of the view that its inquiry contributed significantly to progress on SSRP and to Defence's commitment to it.

13. At the JCPA's request the ANAO in 1993 examined developments on SSRP since the JCPA inquiry. Audit Report No.19 1993-94 reported that Defence's arrangements provided a reasonable basis to expect that budgetary and event milestones targets would be met.

Other reviews

14. The Industry Commission conducted an inquiry into Defence procurement at the Government's request in 1993-94. It was requested to report on the effectiveness and efficiency of Defence procurement arrangements in achieving value for money and the impact of defence procurement programs on particular industries. Its report *Defence Procurement* (Report No.41 30 August 1994) commented that defence procurement had been made more efficient in recent years and identified three areas where efficiency gains were available: Australian industry involvement, Commercial Support Program and the procurement process (particularly industry's cost of tendering). The report did not deal specifically with project

management. The report analysed the regional impact of expenditure by the New Submarine Project.

15. The Strategic and Defence Studies Centre at ANU published a commentary on aspects of Defence project management in 1990: *The Amateur Managers: A Study of the Management of Weapons System Projects* by F N Bennett.³⁷ The Australian Defence Studies Centre at ADFA has published a collection of practical lessons from experience on Defence project management: *Defence Project Management - Pitfalls and Pointers* (volumes 1 and 2, Alan Hinge and Stefan Markowski eds.)³⁸

16. Other published reports that touch on Defence project management are:

- *Department of Defence - DSTO Contracting - Effectiveness in Resources Management* (KPMG Peat Marwick Management Consultants, July 1992);
- *A Report on Contracting for Services within the Department of Defence* (Department of Defence and Attorney-General's Department, June 1994);
- *Department of Defence - Review - Contracting Practices of the Defence Science and Technology Organisation* (KPMG Management Consulting, November 1994);
- Audit Report No.31 1994-95 *Efficiency Audit - Defence Contracting* (ANAO June 1995); and
- *The Australian Frigate Project*, Dr P. Earnshaw, Department of Defence, in *Australian Defence Journal*, No.126, September/October 1997.

ANAO audits of the JORN Project and New Submarine Project

1. While the JCPA reviews mentioned above were in progress Defence was commencing major capital equipment projects for construction of ANZAC Ships, New Submarines and JORN, which were later reviewed by the ANAO. The ANAO was particularly critical of management of New Submarines and JORN.

2. The \$1 billion JORN Project and the \$5 billion New Submarine Project are different kinds of project. JORN involves construction of a radar network that cannot be assessed as successful until project completion in 2001 or later.³⁹ New Submarines involves construction of six submarines that can be

³⁷ *Canberra Papers on Strategy and Defence* No.67 - Strategic and Defence Studies Centre, Research School of Pacific Studies, Australian National University, Canberra 1990.

³⁸ Australian Defence Studies Centre, Australian Defence Force Academy, 1995 and 1997.

³⁹ Audit Report No.28 1995-96 *Jindalee Operational Radar Network Project* (JORN Project).

assessed individually during successive inspections, tests and trials. In many areas ASC and its subcontractors have produced a world-class product, but much needs to be done to resolve lingering deficiencies. Both projects involve development and integration of software-intensive systems, in which key elements have not been managed well. The ANAO identified several common weaknesses in Defence's business management of the projects. These can be summarised as follows:

- The project offices lacked a sense of the time-cost of money by allowing payments in key areas of the projects to exceed actual value earned. They were reluctant to determine the true state of progress on the project, and came to regard the amount of money paid to the contractor as the value of the work completed. They were not firm in quizzing contractors on progress measurements and failed to pursue deficiencies in quality of product deliveries or to insist that contractors meet their contract deliverables. (In some areas the contracts were weak from the Commonwealth's viewpoint in terms of progress measurement and providing recourse for under-performance.) The real extent of progress within the advanced technology areas of the projects seemed not to be fully appreciated by Defence until detailed progress reviews were conducted by the contractors themselves.
- The project offices, knowing that the contractors were inexperienced (Telstra had no experience in over-the-horizon radar and ASC was a newly-formed company), were not active enough in trying to minimise risks on these inherently risky developmental projects. The Commonwealth would have benefited had project office management been experienced in all core competencies of business management and the particular engineering field of the project.
- The project offices appeared over-confident that Defence was protected by a fixed-price contract. Even with payments to the contractors running ahead of effective progress on the projects, the project offices remained unconcerned on the grounds that the contractors would be required to deliver the final product for no more than the total contract price. There was little appreciation of the extent of development work still to be done on these complex software-intensive projects, and this remains a high-risk area requiring firm and expert management in both projects.
- Located mainly in Canberra, the project offices had limited day to day knowledge of actual project progress in Melbourne or Adelaide. This affected their ability to monitor and control early departures from the agreed development and quality standards. This adversely affected the value added by the project offices. Even with a large staff (JORN had 45 staff and New Submarines had 113) the project offices lost sight of

significant issues which remain unresolved as they engaged in churning of issues in meetings, reports and correspondence with the contractor and others in Defence. The same output of work could have been achieved with fewer staff, had the project offices been better located and more decisive and focused in dealing with the contractor.

- Senior management in Defence lacked a clear view of actual progress on major projects and risks that were emerging on them. Since Defence spends some \$2.2 billion a year on 200 major capital equipment projects with an approved value of \$35 billion, senior management monitoring of such projects is a major corporate governance issue. Project managers should be required to provide regular reports in a prescribed format that set out clearly the salient issues for senior management. These would include data on scheduled and actual progress and scheduled and actual expenditure to date, expected and achieved milestones, emerging or expected risks and summaries of quality assurance and other expert reports. Senior management needs such information not only to monitor project progress but also to check that project offices add value commensurate with project office cost. On New Submarines and JORN the prime contractors and Defence project managers were unduly optimistic about progress and completion, but this optimism was eventually moderated by critical internal reviews by the contractors themselves.
- The project offices were under pressure from senior management in Defence to keep spending the Defence Budget appropriation. This was reported in the 1996 JORN audit report (p30). There were indications that this had occurred on the New Submarine Project. Defence Efficiency Review papers in 1997 indicated that there was still pressure on managers elsewhere in Defence to spend their annual appropriation. This issue must be resolved; payments should be made only on reliable and objective evidence of real progress. Payments limited to actual progress are a tangible way of clearly indicating dissatisfaction with any under-performance and prompting action to achieve full performance. While recourse to such action may be seen as a potential breakdown in contractual relations and only used as necessary, it is nevertheless one of the few effective ways by which a purchaser can achieve required outcomes.
- The *Defence Annual Report 1994-95* tabled in the Parliament, in commenting on JORN, said inter alia that design activity was nearing completion and that confidence that the specifications would be met was high. The *Defence Portfolio Budget Statements 1996-97* tabled in the Parliament, in commenting on New Submarines, said inter alia that 'Submarine 01 [*Collins*] had completed contractor's sea trials ... To date, the performance of the submarine has met or exceeded the specified

requirements'. The ANAO queried the basis for these comments and believes that Defence needs to give more attention to public accountability for expenditure of public funds. This issue also compromises Defence's ability to properly manage its risks through appropriate public disclosure of contractor performance.⁴⁰

ANAO audits of the ANZAC Ship Project

- 1.** The ANAO noted in earlier audit reports that Defence's other \$5 billion project, the ANZAC Ship Project, appeared at the time of those audits to be progressing well.⁴¹ This is in contrast to progress on JORN and New Submarines. Probably the main reason for the better progress is that both parties established early an agreed set of business rules that complemented the contract and dealt with each other firmly and fairly. Also the ANZAC project contractor (Transfield), is experienced in heavy engineering and is building the ANZAC frigates to an established design that involves far less developmental work than is needed on JORN and New Submarines.
- 2.** The better progress is partly attributable to the project office too, for several reasons. The ANZAC Ship Joint Project Office is staffed by Australian and New Zealand officers, and the latter scrutinise the Project carefully on behalf of the New Zealand Government, which is purchasing two of the frigates and regards this as an important acquisition.
- 3.** The Project is also subject to a different regime of internal audits. The ANZAC Ship Project Joint Audit Board, which comprises the Inspector-General in Defence and his New Zealand counterpart, decides on a program of internal audit work specifically on the Project. Although not published, the internal audit reports are formally reviewed by the Board.

⁴⁰ For an audit perspective on Defence acquisition procedures in UK, see *Securing Value for Money in Defence Procurement* by Sir John Bourn KCB (Comptroller and Auditor General), RUSI Whitehall Paper Series 1994, Royal United Services Institute for Defence Studies, Whitehall, London. For a US perspective see *Defense Weapon Systems Acquisition* US General Accounting Office High-Risk Series, February 1997 GAO/HR-97-6.

⁴¹ Audit Report No.11 1993-94 *ANZAC Ship Project - Monitoring and Contracting* and Audit Report No.29 1994-95 *ANZAC Ship Project - Contract Amendments*.

Defence Reform Program

4. In October 1996 the Minister for Defence established the Defence Efficiency Review under the chairmanship of Dr Malcolm McIntosh. The report of the Review was released in April 1997 and made many recommendations for change in Defence management and program structures with a view to achieving significant savings.⁴² When releasing the report the Minister announced that a Defence Reform Program based on the findings and recommendations of the Review would be implemented as quickly as possible.⁴³

5. The Minister's statement listed the key features of the Defence Reform Program. One of them concerned the Acquisition organisation, which would be collocated and reorganised into functional groups focusing on common industry sectors or equipment types (eg., submarines) rather than being divided by Service. Industry specialists would be integrated with these functional groups and there would be a substantial progressive reduction in military staffing.

6. The Minister's statement indicated that other findings and recommendations of the Defence Efficiency Review relating to acquisitions would also be given effect in the Reform Program. In summary they are as follows:

- many specialist aspects can be outsourced but the core procurement task must be internal;
- new procurement approaches should be adopted in the acquisition of software-intensive systems;
- the head of the Acquisition organisation should be the employing delegate for all staff employed in the organisation; and
- the Acquisition organisation should be collocated, with savings of 15 to 20 per cent.

7. The reforms do not deal specifically with Defence project management and do not address the issues of the kind identified by the ANAO in the audits of JORN and New Submarines.

⁴² *Future Directions for the Management of Australia's Defence - Report of the Defence Efficiency Review* 10 March 1997 and associated volume *Future Directions for the Management of Australia's Defence - Addendum to the Report of the Defence Efficiency Review - Secretariat Papers* Directorate of Publishing and Visual Communications - Defence Centre Canberra.

⁴³ Minister for Defence statement MIN 61/97 11 April 1997 *McLachlan Announces Defence Reform Program*.

Defence response to Appendix 1

8. Defence has responded to previous reports, contesting findings or implementing recommendations as appropriate.

Appendix 2

Performance audits in the Department of Defence

Set out below are the titles of the ANAO's performance audit reports in the Department of Defence tabled in the Parliament in recent years.

Audit Report No.22 1992-93
New Submarine Project

Audit Report No.5 1993-94
Explosive Ordnance

Audit Report No.11 1993-94
*ANZAC Ship Project -
Monitoring and Contracting*

Audit Report No.19 1993-94
*Defence Computer Environment
Supply Systems Redevelopment
Project*

Audit Report No.27 1993-94
*US Foreign Military Sales
Program
(follow-up audit)
Explosives Factory Maribyrnong*

Audit Report No.2 1994-95
*Management of Army Training
Areas
(follow-up audit)
Acquisition of Additional F-111
Aircraft*

Audit Report No.13 1994-95
ADF Housing Assistance

Audit Report No.25 1994-95
ADF Living-in Accommodation

Audit Report No.29 1994-95
*Energy Management in Defence
ANZAC Ship Project Contract
Amendments
Overseas Visits by Defence
Officers*

Audit Report No.31 1994-95
Defence Contracting

Audit Report No.8 1995-96
*Explosive Ordnance (follow-up
audit)*

Audit Report No.11 1995-96
*Management Audit
Defence Quality Assurance*

Audit Report No.17 1995-96
*Management of ADF
Preparedness*

Audit Report No.26 1995-96
*Defence Export Facilitation and
Control*

Audit Report No.28 1995-96
*Jindalee Operational Radar
Network Project (JORN Project)*

Audit Report No.15 1996-97
Food Provisioning in the ADF

Audit Report No.17 1996-97
Workforce Planning in the ADF

Audit Report No.27 1996-97
Army Presence in the North

Audit Report No.34 1996-97
ADF Health Services

Audit Report No.5 1997-98
*Performance Management of Defence
Inventory
Defence Quality Assurance Organisation*

Audit Report No.34 1997-98
New Submarine Project