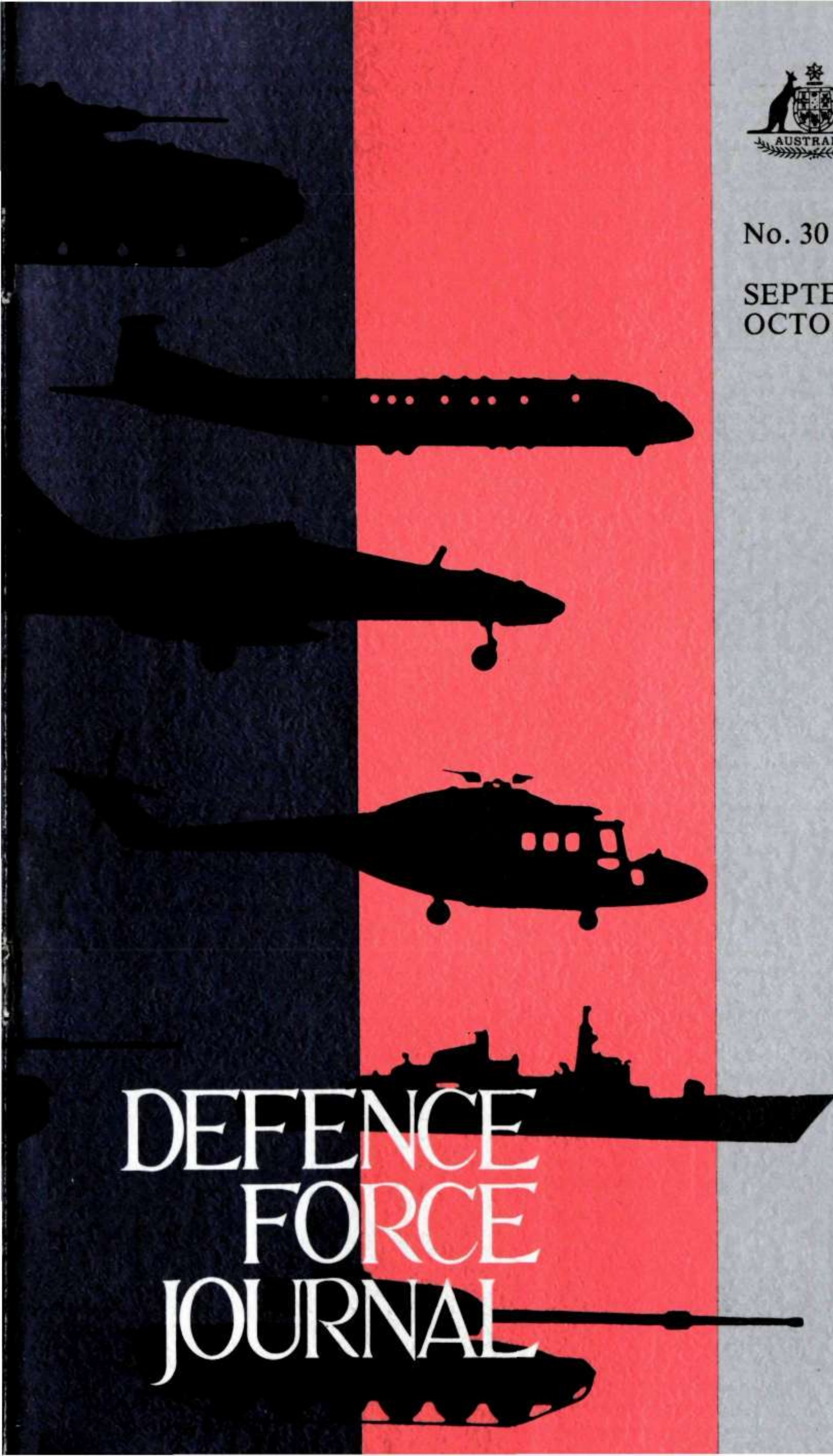

No. 30

SEPTEMBER/
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A Journal of the Australian Profession of Arms

Cover:
Artwork prepared by the Army Audio Visual Unit and photographer SGT David McCamley, RAAF, Defence Public Relations, for the article *Exercise K81: The Stage is Set.*

Contents

LETTERS TO THE EDITOR

EDITORS NOTE

It is *Defence Force Journal* policy to give the author of an article the right to reply to letters of a critical nature. In some cases, however, it is impossible to contact all of these people. I have therefore decided to publish some of the letters in this section without the author's reply.

Due to the length of some articles and the number of letters received, the Editors Comment has been ommitted from this issue.

DEFENCE CAPITAL EQUIPMENT

Dear Sir,

I have only just read the article by Squadron Leader Hayes dealing with capital equipment acquisition (DFJ No 27), and apologize for this delayed comment.

My concern is that such a generally well-researched article should have repeated the canard that 'the French threatened to cut off spares support for the Mirage if those aircraft were used in operations in Vietnam.' In the early part of my tour in Paris as Air Attache (Jan 77-Feb 80), I was involved in the preliminary negotiations concerning the construction and follow-on support of a 'Durance' class vessel for the RAN. I noted that the French Defence Ministry officials concerned were singularly unaware as to the existence of such a threat or even the possibility that such a threat could have been made.

My curiosity aroused, I then made a thorough search of all the relevant Embassy files and questioned the principals involved with Mirage support. I could find no evidence that any such threat had ever been made, and was finally forced to conclude that the rumour must have been the product of elements within Australia opposed to Australian involvement in Vietnam.

I would be very interested to know if Squadron Leader Hayes has any authorative reference which could contradict my findings.

M. McDOUGAL
Group Captain

AUTHORS REPLY

Dear Sir,

Thank you for the opportunity to comment on Group Captain McDougal's findings contained in his letter of 24 July 1981.

I invite Group Captain McDougal's attention to the book *"The Future of Tactical Airpower in the Defence of Australia"* edited by Dr Desmond Ball. For the convenience of your readers, I would like to quote from Chapter 3 of page 86.

> **"War-time support from source**
>
> Because of the high attrition rates prevailing in modern war, Australia needs to be assured of war-time support from the source to replace attrited aircraft, provide spares and ammunition, etc.
>
> Air Forces of other countries have sometimes found that this is not always forthcoming. For example, it was the embargo placed on subsequent military sales to Israel by the French following on from the Six Day War in 1967 that prompted the Israelis to develop the Kfir; during the Yom Kippur War the British actually violated an agreement with Israel on spares for arms.
>
> Australia has already suffered similar, though far less serious experiences. There was, for example, **the difficulties with France over the 30 mm ammunition for the Mirages in the late 1960s.** And, of course, the experience with the Swedish Carl Gustav anti-tank missiles for Australian forces in Vietnam in 1966 has made many RAAF officers wary of the Viggen."

Dr. Ball supports his statements with Source References. In this case articles published in 1968 in a number of leading Australian newspapers are the source material.

If your readers have any further to contribute to this very important issue, I would be most grateful.

R.P. HAYES
Squadron Leader

COASTAL SURVEILLANCE

Dear Sir,

A recent edition of your journal (DFJ No. 27) contained an article, entitled *"A Solution to Australia's Coastal Surveillance Problem"* by Wing Commander Trewartha. The article described the operational and administrative arrangements for coastal surveillance, and concluded that the "admittedly low effectiveness" of the current arrangements necessitated the replacement of the present inter-departmental Australian Civil Coastal Surveillance Organisation with an autonomous "Maritime Control Agency."

This article, haveing been reprinted from an earlier publication in the RAAF Staff College Papers, contains operational details of the arrangements for coastal surveillance which have been significantly changed over the past three years. I would therefore like to correct the more important errors of fact, without commenting on the possible effects these might have on the author's original conclusions.

Government initiatives in July 1978 and November 1978 have resulted in five major changes. These are:

(1) Light civil aircraft are no longer chartered by specific government departments on an *ad hoc* basis, and the "essentially visual" search capability is no longer only available "on an irregular basis." Daily surveillance of the littoral zone from Karratha to Cairns is undertaken by twelve aircraft, all operating under long-term contracts between the private operator and the Department of Transport, Australia. These twelve aircraft comprise five Nomad Searchmaster 'B' and seven Shrike Commander ACS99. A further six Nomad Searchmaster 'L' aircraft, all fitted with Litton radar, are chartered by the Department of Transport and the Bureau of Customs.

Two of the three Transport aircraft cover the refugee vessel approaches to Darwin and the Melville/Bathurst Islands littoral area while the third carries out surveillance of the Great Barrier Reef. The three Customs aircraft are dedicated to response activities in support of Customs investigations, although they may on occasion be diverted to the performance of special coastal surveillance tasks and search-and-rescue operations. In addition, RAAF Orion P3 LRMP aircraft cover the Australian Fishing Zone two to four times every month.

(2) RAN S2G Tracker aircraft are no longer used for surveillance of the North-Western approaches to Darwin. These have now been replaced by the civilian manned Nomad Searchmaster 'L' aircraft referred to earlier, which cover the approaches two out of every three days.

(3) There are now nine (rather than seven) RAN patrol vessels available to patrol the Australian Fishing Zone. In addition vessels, aircraft and helicopters owned or chartered by the Departments of Transport, Health and Customs, the CSIRO and the State and Territory Departments of Fisheries undertake secondary surveillance and response to sightings.

(4) The "untapped" potential surveillance capability represented by the scattered residents of Northern Australia, which Wing Commander Trewartha referred to, has been the subject of a concerted public information effort by the Department of Transport over the past two years. This has involved the distribution of a regular newsletter and production of an audio-visual program, posters and leaflets describing the objectives and methods of coastal surveillance, as well as a radio advertising campaign and addresses by departmental officers. There is also the phone (062 47 6666) in the ACSC for members of the public to phone in sightings and information of interest to coastal surveillance from anywhere in Australia free of charge.

(5) The author described the administrative arrangements for civil coastal surveillance as "demonstrably inefficient" and "an unjustifiable waste of resources," and in particular he referred to the need for "a properly manned and equipped control centre . . . to sift and collate reports, to evaluate information and to co-ordinate any required action."

The Government's upgraded arrangements included elevation of the Standing Inter-Departmental Committee on Coastal Surveillance to a senior policy level comprising the Departments of Transport, Defence (including a senior Defence service officer), Health, Customs, Immigration, Primary Industry, Administrative Services (including Australian Federal Police) and Prime Minister and Cabinet. It also authorised the Department of Transport's Marine Operations Centre (then renamed the Australian Coastal Surveillance Centre) to provide functional co-ordination of the routine surveillance program and a focus for the collection and dissemination of intelligence and statistical data.

In announcing the upgraded coastal surveillance program in July 1978, the Government directed that arrangements be kept under continuous review and that a reassessment of requirements be undertaken once sufficient experience of the new arrangements had accumulated. That reassessment is now in progress, and for this reason I have not attempted to comment on the impact the changes might have had on the conclusions reached in Wing Commander Trewartha's article. Your readers, however, might now have available to them a clearer picture of the current structure and resources of the Australian Civil Coastal Surveillance Organisation.

BRIAN VOCE
Director Public Relations
Dept. of Transport Australia

ARMY RESERVE

Dear Sir,

Mr Trevor Cook's interest in improving instruction for the recruit in the Army Reserve (DFJ No. 27) is appreciated. It is unfortunate, however, that Mr Cook in stating his case has neither established the need to alter current instructional practice nor has he provided a sound academic argument for change.

Mr Cook's phenomenological perspectives, supported as they are by what I assume to be hypothetical scenarios, provide scant evidence of a deficiency in instructional methodology for ARES recruits. Indeed, the student problems postulated in the article, if they were as is stated, appear to stem from a weakness in the detailed conduct of instruction, rather than from a deficiency in instructional methodology.

Apart from this fundamental issue, the author appears to be confused in his application of several basic educational concepts. The article treats motor skills and intellectual skills as higher and lower order capabilities of the same type, when in fact they represent two distinct categories of performance, which differ considerably in the conditions most favourable for their learning (Gagné 1977, Briggs 1977).

The weapon training example that is given in the article may be divided into three main educational components, and if I might be excused from teaching Grandma to suck eggs these components are:

a. **Discriminations.** These are lower-order intellectual skills which enable the learner to identify the different parts of the weapon.
b. **Cognitive Functions.** The development of higher-order intellectual skills enables the learner to understand the operational mechanism and firing cycle of the weapon.
c. **Motor Skills.** The physical acts of cocking the weapon, turning the gas regulator etc. comprise the motor skill component.

At the level of recruit weapon training, there is clearly a dependent relationship between the discrimination and motor skill components. However, there is no such dependency between the various motor skills and the cognitive elements of weapon handling, or between the individual motor skills themselves, which can be learned effectively in isolation. It is therefore, wrong to state, as Mr Cook has, that it is necessary to understand the firing cycle of the SLR at the cognitive level in order to load, fire and unload the weapon effectively, just as it is wrong to argue that an understanding of the mechanism and cycle stage of a gas stoppage is an essential prerequisite for the performance of an Immediate Action.

Despite the deficiencies outlined above, Mr Cook has presented the reader with a broad but acceptable instructional strategy and an effective model for the planning of a lesson. It is suggested, however, that in doing so Mr Cook has offered nothing new, as these procedures are explained in far more detail in Army Training System Pamphlet 6 — Instructors Handbook, and are presently in use throughout the service.

A.B. Garland
Brigadier
Chief of Staff

References:

1. Briggs L.J. Ed, *Instructional Design — Principles and Applications*, Englewoods Cliffs, N.J., 1977
2. Gagné R.M., *The Conditions of Learning*, 3rd Ed, Holt, Rinehart and Winston, N.Y., 1977

CONTAINED TERRORIST INCIDENTS

Dear Sir,

You printed an article I wrote titled *"Contained Terrorist Incidents in Australia"* in the May/June issue.

There are two printer's errors in the text on page 55, column one, which would confuse the reader: "maximum" should read "minimum" and "policy" should read "police." I would be grateful if you could possibly include a brief erratum in the next issue to placate my police friends.

COG WILLIAMS
Major

EXERCISE KANGAROO 81

THE STAGE IS SET

By Brigadier R.A. Sunderland,
Deputy Exercise Director,
Joint Exercise Planning Staff

IN October 1980 the Joint Exercise Planning Staff (JEPS) assembled in Canberra. Our task was to plan one of the largest combined and joint exercises ever conducted by the Australian Defence Force (ADF); an exercise involving the three services and forces from the United States and New Zealand, with minor participation by the United Kingdom. The operational phase of the exercise is about to start and the results of planning will be put to the test. This article describes some of the differences between KANGAROO 81 and previous exercises in the series, and how our planning has been influenced by these differences.

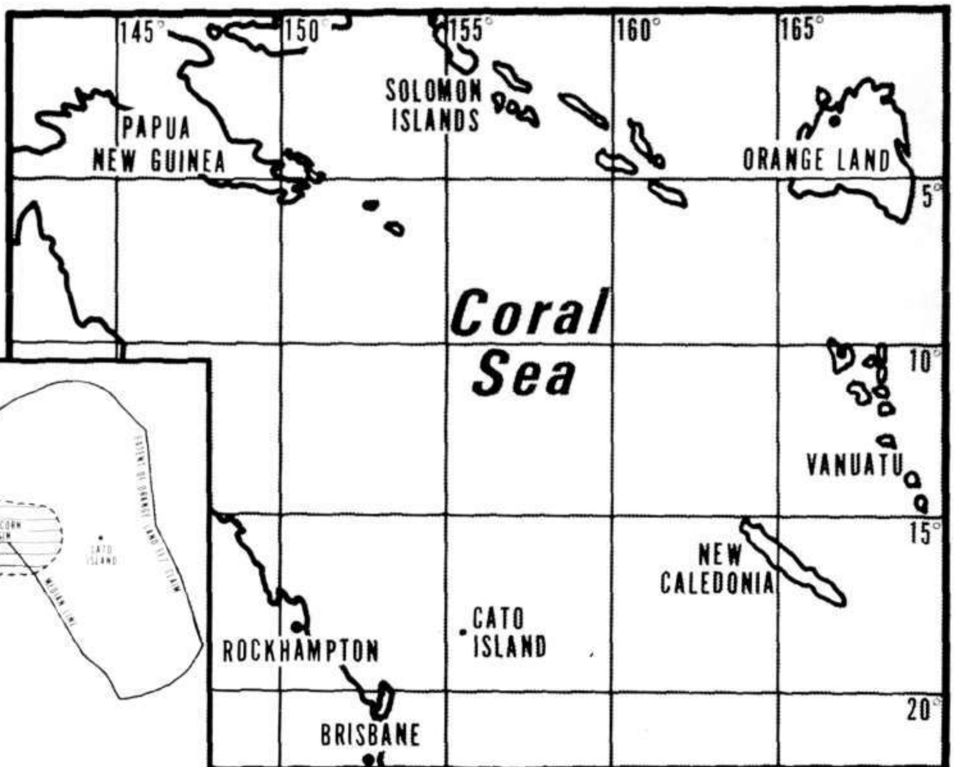
Exercise KANGAROO 81 is the fourth in a series of Australian sponsored combined exercises and builds upon lessons learned from previous exercises in the series. The aim of the exercise and the objectives and the tasks to be achieved have been established by the Chief of Defence Force Staff (CDFS) in his directive to the Exercise Director. The aim is to exercise participants in a conventional low-scale[1] mid-intensity[2] conflict in defence of Australia. There are 63 objectives and tasks to be achieved. Two of these objectives have not been included in previous exercises in the series and have had a fundamental influence on exercise planning. I will return to these two key objectives later.

The aim of the exercise required us to develop a scenario where the scale of operations could be handled to conclusion within the peace-time organization of the ADF, and fought with limited objectives and limitations relating to weapons and the extent of the geographical area involved. The first step in developing this scenario was to construct an enemy order of battle (ORANGE Force) by dividing the forces made available for the exercise, including allied forces, and making allowance for manpower and equipment required for the control and umpire organisation.

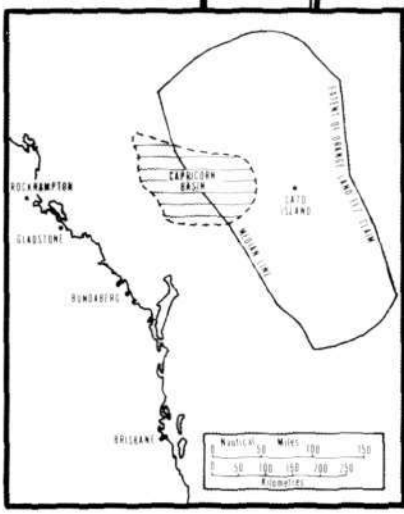
Our next task was to describe an imaginary enemy which would have the population, infrastructure and notional order of battle capable of projecting a force equivalent to the actual ORANGE Force order of battle we had previously selected. We were assisted in this task by the Joint Intelligence Organization who produced a hypothetical Military Study on the imaginary country of Orangeland descibing the government, infrastructure, intelligence community, military and para military forces. The notional order of battle of ships, land forces and aircraft was carefully constructed to provide intelligence analysts with a realistic enemy.

The CDFS Directive required the land battle to be conducted in the Shoalwater Bay Training Area near Rockhampton, with maritime operations off the east coast of Australia. We therefore situated our imaginary country, Orangeland, in the Coral Sea, so that it was within striking distance by air and sea, of the Shoalwater Bay Training Area (see map 1). We also declared Townsville and Mackay as 'safe havens' to simulate Orangeland air and naval bases.

Consideration of the strategy and tactics that might be employed against Australia led to an examination of our strategic environ-



MAP 1



MAP 2

ment. We noted that in situations short of major military attack on Australia, or the implications of global war, two broad strategies could be employed — the *fait accompli* or the persuasive strategy. The *fait accompli* strategy is achieved by a relatively small number of troops employing shock action and gaining total surprise. The strategy of persuasion is a strategy of psychological attrition, with a progressive increase in political, economic and psychological pressure. If political and economic pressure is not successful an aggressor might consider limited military operations which are part of a psychological plan[3]. We therefore decided to describe a political dispute that would provide a vehicle for the employment of these strategies against Australia.

In developing this scenario we wanted to create a situation where the hypothetical military operations against Australia were directed towards achieving a decision in favour of some political objective. This situation would then allow us to depict a persuasive strategy where all the resources of the aggressor were harnessed to achieve their aim. We described increasing political and economic pressure and a psychological campaign which included covert low-scale military operations which were psychological in character. We also wished to have scope for the employment of a *fait accompli* strategy in order to exercise the ADF in counter-lodgement operations.

Orangeland is portrayed as an island nation of 30 million people which achieved its independence in 1956. In 1965 Orangeland laid claim to a small island named Cato Island, situated some 500 km east of Rockhampton, on the basis of historical precedence established through occasional occupation during visits by whaling ships. Australia's claim is based on discovery by the British. We have been advised that there is some validity for this notional claim by Orangeland under international law because effective occupation may be accepted by the International Court as overtaking discovery in disputes over sovereignty. Further, visits by whaling ships have formed the basis of many real sovereignty claims to Pacific Islands by non-regional powers.

We have described tensions between Australia and Orangeland increasing considerably when geological surveys indicated the presence of oil and gas resources in the Capricorn Basin. In 1975 Orangeland claimed a 200 nautical mile exclusive economic zone (EEZ) around Cato Island and pointed out that a large segment of the Capricorn Basin lay within this EEZ (see map 2). In developing this scenario we received assistance from Naval Legal Services on the international law issues that might be involved. It should be noted that both Cato Island and the Capricorn Basin actually exist, although we have altered some of the geographical descriptions for exercise purposes.

This then is the basis of the political dispute between Australia and Orangeland. Throughout 1980 and the early part of 1981 we depict Orangeland as becoming increasingly threatening as they pursue their objective, first by political, economic and psychological means and then by covert military operations in support of their psychological plan. The operational phase of KANGAROO 81 starts when Orangeland is about to commence overt military operations using a *fait accompli* strategy to improve their bargaining postition.

Earlier I mentioned that two key objectives had shaped the exercise. The first of these was the requirement to exercise the higher defence machinery including the ADF Command Centre and the Joint Intelligence Organisation (JIO). This is the first time that this objective has been included in the KANGAROO series; indeed it is the first time in the history of the ADF that it is proposed to command combined forces from a headquarters in Canberra. The requirement to exercise, JIO is another 'first', and as far as I am aware this also has not been attempted before.

The CDFS will exercise his command of the combined forces (BLUE Force) through three joint force commanders; a Maritime Defence Commander, a Joint Force Commander who is also the Land Component Commander and an Air Commander. Four headquarters are to be exercised; the ADF Command Centre, Canberra; the Maritime Headquarters, Sydney; a Joint Force Headquarters (JFHQ) based on Headquarters 1st Division in the area of operations and RAAF Headquarters Operational Command, Glenbrook.

The requirement to exercise the higher defence machinery means that the exercise is being 'driven' by the flow of intelligence. This flow is required in order to exercise JIO, initiate contingency planning and eventually lead to a decision to deploy the BLUE Force. In February 1981 JEPS started this flow of notional intelligence. JIO established a cell to deal with Orangeland matters and make assessments. Each month an intelligence report is published and in May, JIO published an estimate of Orangeland's intentions and military capability against Australia. Part of this flow of intelligence includes notional internal security matters within Australia. Each month these incidents are summarised in a security intelligence report which together with the JIO assessments describe the total intelligence picture.

One of the difficulties JIO experienced in making these assessments was the fact that JEPS had to represent the many sources of intelligence and the many organisations not being exercised, such as the Department of Foreign Affairs, Defence attaches and national intelligence and security agencies. Another difficulty concerned the proper representation of those departments and the administrative machinery which would, in reality, be involved in advising Government, and also representing Government action as a result of this advice. As the events developed the Government would certainly have reviewed national strategy and made contingent preparations and responses to events as they occurred. The strategic options considered could have included diplomatic responses to reinforce Australian sovereignty, attempts at some negotiated settlement or some assertive counter strategy. The contingent preparations could have included expansion of our intelligence and surveillance capabilities, enhancement of the ADF and civil infrastructure, economic measures, internal security, morale, civil defence and national administration. JEPS could only represent these issues to the extent necessary for contingency planning to proceed.

Contingency planning also had an air of unreality. The planners (BLUE Force) knew when the exercise was to start and that a land battle would be conducted in the Shoalwater Bay Training Area. This implied that assertive strategies to deter a lodgement could not be employed, or had failed. The planners also knew the order of battle of both BLUE and ORANGE Forces. However, they soon realised that apart from developing a contingency plan they also had to develop a planning organisation and a planning process.

The ADF Command Centre was developed around the Defence Operations and Intelligence Centre (DOIC), the latter being the hub, or operations room of a complex which includes joint communications, operations, intelligence, electronic warfare and logistics cells. The ADF Command Centre will be manned for 24 hour operations when the tempo of the exercise so demands, however, the Joint Intelligence Cell has operated almost continually since July, issuing operational intelligence reports and raising tasks to obtain additional intelligence.

During the conduct of the operational phase of the exercise the CDFS will have regular consultations with the Chiefs of Staff and senior Defence advisers. These officers will therefore need to be kept fully informed. To meet this requirement a group of one star officers has been formed who collectively provide the appropriate level of staff support to the CDFS. This concept of staff support and the organisation of the ADF Command Centre will be fully tested during this phase of the exercise; I have no doubt that many lessons will be learned.

The second key objective that shaped the exercise is the requirement to exercise logistics in an operational setting. Planning to achieve this objective proved to be extremely difficult, because apart from the usual peace-time constraints, the ADF was required to provide the logistic support for the visiting forces as well as a large exercise control and umpire organisation. We decided to concentrate on exercising BLUE Force logistics, but to achieve this aim it was necessary to separate BLUE Force logistics from Control Organisation logistics. A separate neutral organisation for the logistic support of both the ORANGE Force and Control Organisation in the Shoalwater Bay Training Area was created for this purpose. This organisation will be prestocked with all maintenance items except POL and perishable rations and, when working forward of its neutral base in the resupply of ORANGE Force, will operate tactically.

Two other areas caused us difficulty in planning the logistic concept. The first of these was time. The land operations were planned to last only 10 to 11 days and if we adopted the normal pattern of deployment for such a scenario, that is combat units first, then the third line logistic units (Logistic Support Force (LSF)) would have insufficient time to deploy and practise logistic operations. We therefore decided for the purposes of the exercise, to deploy third line logistic units first to allow the full range of logistic support, including ammunition resupply, to be exercised.

In solving the first problem we created a second. At the same time as the LSF was being deployed and stocked we were required to achieve a movements objective of deploying the land force within five days using ADF and limited civil resources. We judged that we would have insufficient movement resources to achieve both thése objectives simultaneously because of exercise constraints. We therefore decided to prestock the LSF to free the movement agencies for the deployment of the balance of the land force. As there was no requirement to exercise fourth line logistics, beyond exercising the LSF points of interface with fourth line, all logistic support outside the Joint Force Area of Operations is to be under normal peace-time arrangements.

Taken together, our planning to achieve these two key objectives, that is, the exercise of the higher defence machinery and the logistics organisation, lead us to devise a unique plan for the control of the exercise. In previous exercises in this series the JEPS represented the higher defence machinery and issued orders to the BLUE Force in the name of the CDFS. JEPS therefore had total control of the exercise, because the Exercise Director was also able to issue orders to both Blue Force and the Control Organisation, which included ORANGE Force and umpires.

The requirement to exercise the ADF Command Centre, J10 and those functional areas of the Department of Defence normally associated with the planning for and conduct of combined and joint operations, meant that the only way we could influence BLUE Force activities was through the distribution of notional intelligence and representing other agencies not being exercised; for example,

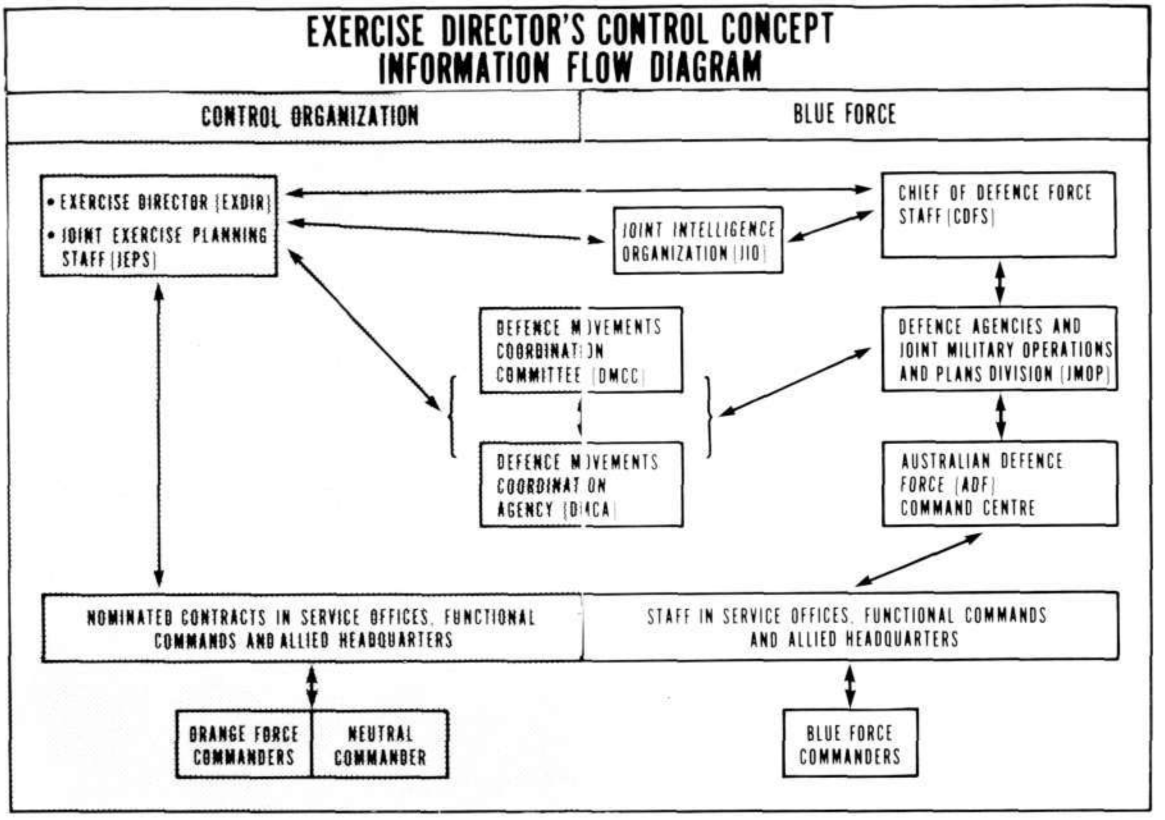


FIGURE 1

Department of Foreign Affairs. There was also a requirement to separate BLUE Force planning from Control Organisation planning, preserve exercise security and separately analyse BLUE Force planning to measure the achievement of exercise objectives.

In the initial stages there was a requirement to include the Service Offices, functional commands, and allied headquarters in the chain of command, so that supporting plans could be produced. Even after the appointment of Joint Force Commanders these organisations had to be retained in the chain of command for the day to day support of the combined forces. Finally there was a problem of peace-time constraints, in particular the need to provide early warning (ahead of BLUE Force planning) of long lead-time logistic requirements for the exercise. To resolve all these conflicting exercise control and planning requirements we devised the concept shown in outline in Figure 1 — The Exercise Director's Control Concept.

The Control Organisation is commanded by the Exercise Director and JEPS provides the necessary staff support. JEPS is, in fact, the higher formation headquarters for the Control Organisation. The Control Organisation comprises the ORANGE Force and the Neutral Organisation. The ORANGE Force comprises maritime, land and air elements. The Neutral Organisation comprises exercise control, umpires and military observers and other neutral agencies such as the Visitors and Public Relations Unit.

The command and control system is designed to allow for a flow of information, both vertically to commanders and laterally between the BLUE Force and the Control Organisation. In the BLUE Force chain of command, direction will flow from the CDFS through operational staffs to BLUE Force. Service Offices and functional commands drop out of this direct chain of command when Joint Force Commanders are appointed, although single

Services remain responsible to the CDFS for the support of the forces to be deployed.

For the Control Organisation, commanded by the Exercise Director, the information flows through JEPS to ORANGE Force and neutral agencies. Since all these units are raised from the force-in-being, the existing chains of command are used until such time as the units are deployed to their respective operational areas. At an appointed time operational command of these units is passed to the Exercise Director.

To achieve this concept certain nominated officers or staff, who are not required on the BLUE Force staff of Service Offices, functional commands or allied headquarters, represent the Control Organisation throughout the exercise. In this way we are able to separate BLUE Force planning from Control Organisation planning while at the same time co-ordinating the long lead-time support for the whole exercise.

The requirement to exercise JIO and the higher level military staffs in co-ordinating national defence contingency planning made it necessary to start the exercise much earlier than before to allow for a realistic build-up of intelligence. There was also a requirement for different levels of control as the tempo of the exercise increased. We therefore decided to divide the exercise into five phases so that we could effectively manage the changes required. The five phases are:

- Phase 1 — Contingency Planning
- Phase 2 — Exercise Grindstone 81. A Command Post Exercise
- Phase 3 — Deployment
- Phase 4 — Exercises with Maritime, Land and Air Forces
- Phase 5 — Redeployment

A key factor in achieving a smooth and realistic transition from one phase to the next is the way in which intelligence is provided. Earlier I explained that the exercise is being driven by the flow of intelligence depicting a deteriorating strategic situation which will eventually lead to a decision to deploy the BLUE Force. Because of this requirement for a gradual build-up of intelligence, we decided to conduct Exercise GRINDSTONE 81 against a low-level contingency situation of small raids along the Queensland coast.

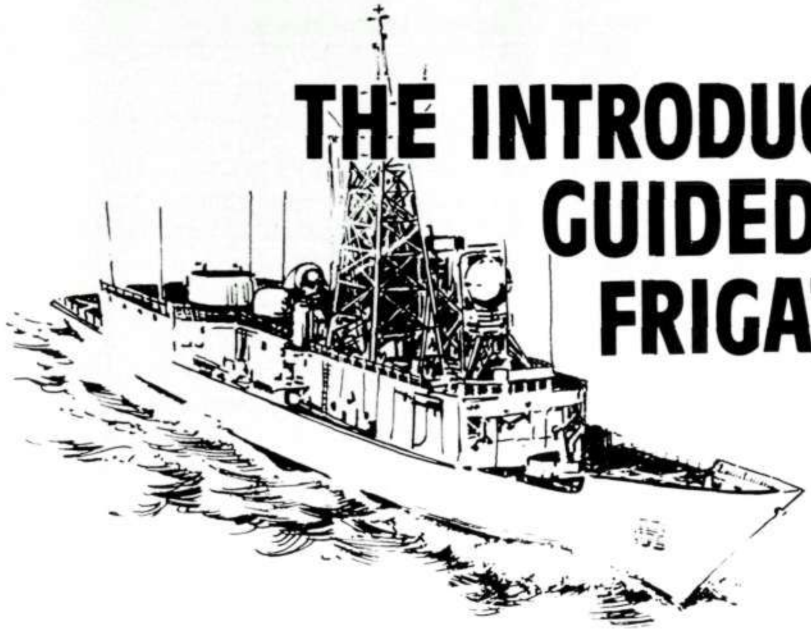
The aim of GRINDSTONE 81 was to exercise staff procedures and the CDFS Communications System in preparation for KANGAROO 81. Four headquarters were exercised; the ADF Command Centre, Maritime Headquarters, JFHQ and Headquarters Operational Command. During the exercise weaknesses were identified, staff procedures refined and the CDFS communications system tested. All is now in readiness for the operational phase of the exercise.

Exercise KANGAROO 81 is the major Australian combined and joint service exercise for 1981 and has been accorded a high priority for the allocation of resources after operational commitments. It is therefore essential that we make the most of the training opportunities it provides. For the first time since the re-organisation of the Department of Defence we are testing the CDFS command and control system; for the first time in many years we are testing our logistic system under operational conditions and for the first time we are testing the concept of a joint force headquarters based on a divisional headquarters.

During the next few weeks elements of the ADF and allied forces will deploy to concentration areas. First a Sector Air Defence Operations Centre will deploy to Rockhampton to establish air space control over the Shoalwater Bay Training Area. A Terminal Group will embark in HMAS *TOBRUK* to operate terminal facilities at Port Alma and a road, rail and air head at Marlborough in central Queensland. Ships will put to sea and air forces will deploy to forward bases. The stage is set. All that now remains is for the actors to play their part — 20,000 troops, 25 ships and 100 aircraft. The success or failure of KANGAROO 81 now depends on you — the participants.

NOTES

1. Low scale situations are those which can be handled to conclusion within the peace-time organisation and structure of the Defence Force.
2. Mid-intensity conflict is an armed conflict fought with limited objectives under definitive policy limitations as to the extent of destructive power that can be employed and the extent of the geographical area that might be involved.
3. For a more detailed description of these strategies see Beaufre, Andre, *Strategy for Tomorrow*, (London, McDonald James, 1974).



THE INTRODUCTION OF GUIDED MISSILE FRIGATES INTO THE RAN

By Commodore N. R. B. Berlyn, A.M., R.A.N., M.I.E.Aust. Chief Staff Officer, Naval Technical Services, Department of Defence.
R. C. M. Hurt, M.I.E.Aust. Director of Engineering Management Systems Coordination — Navy, Department of Defence.

Commodore Berlyn entered the Royal Navy in 1952 as an engineering Cadet. Qualified at the Royal Navy College Manadon in 1957. After sea service and post graduate level studies in the Royal Navy, joined the Royal Australian Navy in 1965. Following service in HMA Ships VAMPIRE and MELBOURNE and as senior project planner at Garden Island Dockyard, he was posted in December 1973 as the inaugural project director for the FFG Project. He left the project early in 1978 to join the RAN Fleet Commander's Staff. In June 1978 he was made a member of the Order of Australia for 'exceptional service as project director of the RAN FFG Project'. In November 1979 he was posted as Chief Staff Officer to the Chief of Naval Technical Services and at the end of 1980 commenced his present role as a member of the Advisory Committee on Management and Operation of Williamstown Naval Dockyard.

Mr. Hurt qualified as a Naval Architect in 1947 while employed at Vickers Cockatoo Ltd. Following engineering experience in the private sector and at Garden Island Dockyard, he was the Navy's engineering representative on the Joint Armed Services EDP Feasibility Study which commenced in 1959 and in the subsequently established Defence Computing organizations. From 1966 Mr. Hurt spent three years in Engineering Management Systems research in Boston USA. He joined the FFG Project team early in 1973 as the Management Information System Coordinator and moved to his present appointment as Engineering Management Systems Coordinator on the staff of the Chief of Naval Technical Services in September 1977.

Published in the transactions of the Inst. Engrs. Aust. Engineering Conference, March 1981.

INTRODUCTION

THIS article concerns management of the introduction into the RAN of Guided Missile Frigates (FFGs) constructed in the United States. The first two RAN FFGs, HMA Ships *ADELAIDE* and *CANBERRA*, were commissioned in late 1980 and early 1981, within a few weeks of the target dates originally set at the beginning of 1976.

The FFGs are of some 3700 tons powered by two aircraft derivative gas turbines driving a single controllable pitch propeller through reduction gearing. Weapons fit includes surface-to-air and surface-to-surface missiles, as well as guns and surface launched anti-submarine torpedoes. Provision is made for an anti-submarine system comprising shipborne long range sensors and two large helicopters. Reaction time to counter hostile threats has been minimised by integration of the weapons, senors and command systems. Relative to their size, the FFGs are very capable escorts and require a surprisingly small crew.

Acquisition and introduction of these ships into the RAN is being managed as a Navy Project using a coordinative, or matrix management approach. The total value of this project is some $1000M at 1980 prices. Dedicated Australian project staff are about 16 Australian based and 12 US based servicemen and civilians. The need for this level of effort is frequently questioned, even within Navy, where it has only been provided at the expense of other important activities. It seems that buying a ship from the US is seen by some as only slightly more challenging than buying a motor car. Apart from paying money, what else is there to do?

Perhaps it is not surprising that the work to be performed in engineering projects needing matrix management is not widely understood. Firstly, there is a generally held view within our profession that what engineers do is not really appreciated by the community. Secondly, the traditional structure of engineering education which divides us into separate disciplines seems to be reinforced in the functional groupings of engineers which exist in many organisations, including Navy.

Proponents of functional groupings point to their advantages in ensuring strength and continuity of expertise within disciplines. In military terms, this could be likened to the principle of the concentration of force. Borrowing further from military experience, history is littered with causes lost by alliances between small armies. It seems that the essential difficulty of producing a fully integrated effort from a combination of forces has, more often than not, been seriously underestimated.

In a sense, functional groupings are like small armies and the difficulties of integrating the efforts of several such groups seem to be no more readily appreciated by engineers than by the military. In short, the wish to combine efforts towards a single objective will not, in itself, produce the desired result. This article relates some of the experiences and insights gained in the process of translating such a wish by the Department of Defence into a practical reality.

Some knowledge of the USN FFG programme and the environment in which it was developed is necessary to understand what has been done by Australia.

THE USN FFG PROGRAMME

The USN FFG Programme was initiated in November 1970 as the Patrol Frigate Programme with a directive that study begin towards the development of a new class of ocean escorts needed to replace some World War II destroyers. The requirement for rapid delivery, coupled with the need for large numbers of ships made low cost and risk absolute necessities. A project team, initially of some thirty people, was assembled to manage the programme.

In November 1977 FFG-7, the lead ship of the Class, was delivered to the US Navy free of any unresolved contractual issues and ready for operational evaluation.

As at June 1980, the FFG Programme comprised 58 ships, including four for Australia, with an estimated end project cost of $US11,490M. Four ships had been delivered and construction had started on 29 of the 42 ships then ordered. The Programme is producing the ships as planned. The management methods used appear to have overcome many serious problems that were clouding the future of US Naval shipbuilding. These problems concerned cost over-runs or cost growth, schedule slippages and failure of performance living up to expectations. During the 1960s and early 1970s, they were accompanied by large claims by shipbuilders which, in 1976, had an accumulated unresolved backlog of over $US2 billion. Many man years of Government and Contractor effort were involved in their preparation, assessment and negotiation.

Mr Clements, US Deputy Secretary of Defense, told the US House of Representatives Armed Services Committee in May 1976 that the cause of this claims problem was slippage in delivery from the original contract date which, among 11 contracts he referred to, varied from one to four years.

In this context, the US Defense Department had already introduced a new policy which placed increased emphasis on hardware development and testing in lieu of paper studies, recognising high technical and cost uncertainty associated with an insufficiently defined product. US DOD Directive 5000.1 *"Acquisition of Major Defense Systems"*, first issued in July 1971, contains the fundamental rules and procedures for two new concepts:

- Design-To-Cost; and
- Fly-Before-Buy.

The first USN ship application of this new approach was to the FFG Programme. Its impact on the design process is described by Leopold, Jons and Drewry in their paper *"Design-To-Cost of Naval Ships"*. They point out that, within the past 20 years, the cost of defence weapons systems and manpower has been rising at more than five times the rate of inflation. In addition, they stress the unique difficulties of Naval shipbuilding programmes caused by the combination of the following peculiarities:

- bigness, nonhomogeneity and complexity;
- platform/payload life-span disparity;
- long development period; and
- small numbers accompanied by high unit cost.

As far as ships are concerned, some impacts of the new policy are revealed in *"The Changing Nature of the USN Ship Design Process"* by Johnson. In relation to Figure 1, he says that the Conceptual Design for the FFG absorbed about 12 men per day for two to three months, the Preliminary Design 25,000 man days and the Contract Design 51,000 man days more. The design work through Contract Design was completed in April 1973 and cost $US10M. He concludes — "we are now doing orders of magnitude more work and producing substantially more documentation than we did 30 years ago. This is due to our modern Navy ships being very complex". The necessity for this level of effort to produce an adequate design definition is covered by Leopold in his paper *"Should the Navy Design Its Own Ships?"*.

To a large extent, the USN placed the responsibility for incorporating the Design-To-Cost and Fly-Before-Buy concepts with the FFG Project Manager. The main strategies or risk reduction measures are discussed in *"The FFG-7 Guided Missile Frigate Program — Model for the Future?"* by Beecher and DiTrapani. These included:

- early establishment of Design-To-Cost constraints in terms of average follow ship acquisition cost, full load displacement and accommodations for ship manning;
- procurement arrangements covering early involvement of shipbuilders in the design — different price, incentive and escalation bases for lead and follow ship contracts — two year gap between lead and first follow ship — very extensive system testing ashore and at sea;
- strong management of change;
- centralised procurement and standardisation of equipment and systems;
- Government provision of validated working drawings and test procedures for the lead ship which are warranted to satisfactorily fulfil the requirements of the follow ship specifications if followed without deviation and good quality control; and
- attention to life cycle costing considerations.

Whilst Beecher and DiTrapini conclude that the approach has been correct and the elements have broad application, they point out that — "Each ship procurement has its own character and each acquisition strategy must be tailored to the type of ship, to the economic environment, and pragmatically, to the management policies in vogue at the time".

It is instructive to note that little comment on FFG project management concepts is evident in available US literature. It seems to be taken for granted that prime authority and accountability will reside in the project manager and that appropriate resources will be allocated to him. Perhaps this is not surprising as the US Armed Services are under Government direction to follow a strong project management system. The extent to which they have followed these processes is recorded in the US Senate Congressional Record — 6 June 1974 (pp S9830-S9836).

The Canadians adopted a similar strong approach to their four destroyer (DDH 280) project after initial difficulties.

THE RAN FFG PROJECT

The Project Investigation Phase

The RAN Light Destroyer (DDL) programme of the late 1960s and early 1970s showed that firm boundary conditions are essentiial if size and cost are to be contained. What had started as a relatively simple 1500 ton ship to be designed and built in Australia, eventually grew to over 4000 tons.

Following cancellation of the DDL Project in August 1973, the project team was reformed to focus Navy's efforts towards acquiring new destroyers. At that time the need for cost and risk reduction were large in the Government's mind, hence efforts were concentrated on selecting a suitable ship from a relatively large number of proven designs then available.

During this phase of project definition, the main project office role concerned arranging information about the contenders, contributing to studies aimed at quantifying the capabilities and pros and cons of each, and generally coordinating inputs from many parts of Navy into a coherent picture. The number of ships to

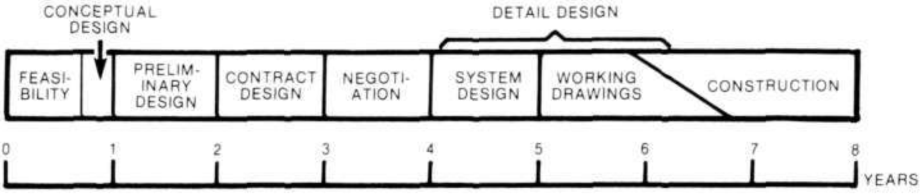


Figure 1: Phases in the USN Ship Acquisition Process (the time scale refers to a typical destroyer)

be studied was large, in part because there was no formal "acquisition to cost" constraint.

Management tasks fell mostly into the information and entrepreneural categories. The project team was shaped accordingly. Inevitably, we were drawn into the pursuit of ship rankings based on more than subjective judgement. It is generally assumed that even the most complex products of technology can be broken down into measurable areas of performance which can be individually scored and aggregated to indicate the most effective buy. Typical characteristics might be grouped in the areas shown in Figure 2 as suggested by Graham in *"The Operator and Engineer — Partners in Ship Design"*. Obviously, increases in one area can only be had at the expense of another, unless the overall cost is allowed to grow.

Difficulties in producing a valid ranking arise because destroyers are multi-role vessels into which many sub-systems, often themselves multi-purpose, have been integrated after lengthy trade-off processes. It is dangerous to be rigid about the relative importance of major capabilities since this implies very positive

Figure 2: Notional allocation of funds to major areas of warship performance

assumptions about the threat. Historically, such assumptions have often proved disastrous. On top of this is the problem of dealing with characteristics having different natures such as rate of fire, shock resistance and habitability.

Whilst active, passive and peacetime features can be individually measured and scored, there are obvious difficulties in combining them by a process of weighting into a valid score. Decision makers are rightly cautious of such results and experienced judgement must prevail. However, the numerical approach which involves seeking management decisions on weightings can help show the real priorities and sensitivity to change.

The net result of the investigation stage of the project was a series of reports covering operational capabilities, design, production, costing, Australian Industry Participation (AIP) potential and long term support features of all contenders. These provided background to a ministerial statement in April 1974 that the Government had decided:

> "to acquire two Patrol Frigates, subject to acceptable performance, capability, satisfactory offset programmes and agreed financial and contractual terms and conditions."

The Project Definition Phase

The above statement marked the start of the project definition phase where key features such as price, delivery, performance and support requirements for the selected ship had to be determined in some detail. At that time, the construction of the USN lead ship was still in progress, no follow ships had been ordered and the shore and sea based testing had not completed. So there were many unknowns.

The project team was involved in a broad range of planning activities, including preparation of a negotiating position in cooperation with other departments. In August

1974, a US-Australian Memorandum of Arrangements (MOA) was signed. This document provided a framework and set ground rules for the acquisition. It included the following passage on management arrangements:

> "The Australian Department of Defence has established the RAN Patrol Frigate Project Office to coordinate Australian management of this Project. This Office, the Office of the CNO, and the USN Patrol Frigate Project Office, as appropriate, shall be responsible for the management of the acquisition of the RAN ships, support material, training and services, and for the exchange of information relating to the RAN ships and the USN Patrol Frigate Project. Any costs associated with Australian participation in the USN Patrol Frigate Project Office will be borne by Australia.
>
> The Australian Department of Defence may place Australian liaison personnel representing the appropriate Australian Department, or Departments concerned in the implementation of the Arrangements, in such places as are agreed with the United States Department of Defense."

Subsequently, the management arrangements outlined above were developed into a detailed working agreement between the USN and the RAN Project Offices. It is worth noting that from time to time there has been a need to refer back to these ground rules. This supports the value placed on firm management guidelines from the start by Knight in his paper *"Matrix Organisation — A Review"*.

Looking back on the definition phase, it is hard to overstate the value achieved from locating some of our people in the US Project Office and from face-to-face discussions during visits between the US and Australia. Because of the many differences in the terminology and practices of the two countries, mutually satisfactory arrangements depend firstly upon reaching a common understanding. A case in point is provided by the US method of expressing cost estimates in "then year dollars". Essentially, such a system takes account of a schedule of payments and utilises a projection of the effects of inflation over the period from placement of order to delivery. If the "then year" estimate proved accurate, it would represent the actual number of dollars to be paid by the customer in a series of progress payments over the whole period. In contrast, Australian Government estimates are expressed in monetary value at a particular time, even though the money may not be spent for several years. The need for a consistent translation exercise between the two systems is therefore obvious. Similarly, it is not always appreciated how important it is to define the basis for a ship cost estimate eg, exclusion of ammunition and missiles could substantially reduce the apparent price.

A useful way of appreciating the relative proportions of the Project budget is shown in Figure 3. The project involves more than just ship construction.

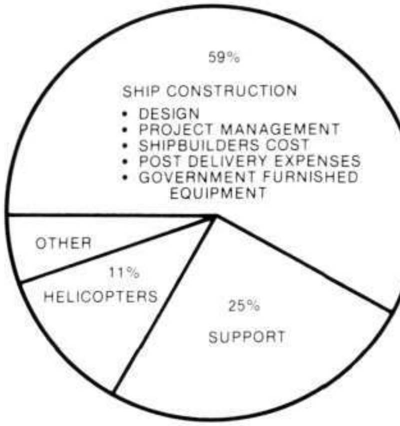


Figure 3: RAN FFG Project Budget June 1977 (2 FFG's)

The end objective of the definition phase was the production of a comprehensive statement covering the timing, implications and risks of joining the USN programme, specification of the RAN ships, and a detailed estimate of total project cost. This estimate catered for modifications, spares, training, ammunition and missiles, facilities, AIP, and management and royalty charges etc.

With risk reduction high on the list of priorities, and remembering the state of the USN programme, we had to rely heavily on the evidence available from the test and development programme, including the two land based test sites. The sheer volume of data was staggering and a RAN officer was located in the US

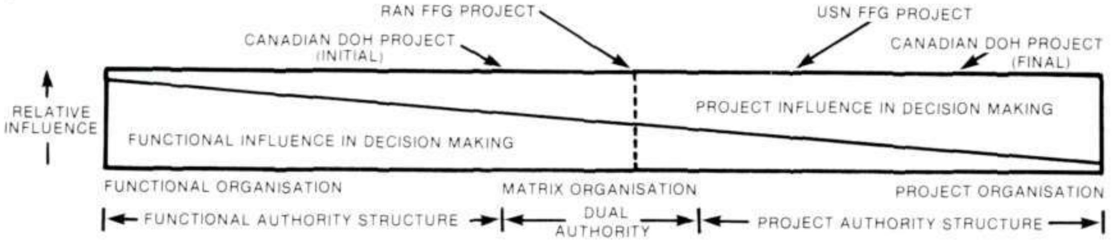


Figure 4: Project Responsibility — The range of alternatives

Project Office to assist in ensuring that key material reached us in a timely manner. The Project Office in Australia was very much involved in its automatic distribution to appropriate Australian authorities for review and the collation of results into an overall Australian estimate of the likely performance of the ship. At the same time, plans for the implementation phase of the project were being developed.

The project definition phase lasted from August 1974 until January 1976. Investigation and input to design, ship production, ship and equipment contracts, AIP, in country support and financial matters were the major fields of endeavour. The final phase was marked by Australia's acceptance, on 19 February 1976, of a US Letter of Offer (LOA):

> "To provide for the total ship procurement of two FFG-7 Class ships, for the Royal Australian Navy (RAN) in accordance with the Memorandum of Arrangements (MOA), between the governments of the United States and Australia dated 30 August 1974."

The close cooperation and exchange of ideas with the USN Project Office allowed under the MOA was absolutely vital to clarify Australia's purchase and commitments. At the same time, this dialogue provided a useful sounding board and second opinion for the USN Project Office.

The Project Implementation Phase

The management approach adopted for the RAN FFG Project superimposes a project coordination organisation on the established Departmental Divisions, Branches and Sections responsible for separate functions. It lies in between Departmental control of the Project solely by the existing functional organisation and the other extreme of assigning full responsibility to a dedicated organisation fully staffed with all necessary expertise. It is worth noting that it had been estimated a Project team of over 170 would have been required for this latter approach if adopted for the DDL.

Figure 4 is adapted from one included by Galbraith in his book *"Designing Complex Organisations"*. It shows where the RAN FFG Project Director's responsibilities lie in the spectrum between the pure functional and the dedicated project organisations. It also suggests the degree of formal responsibility and accoun-

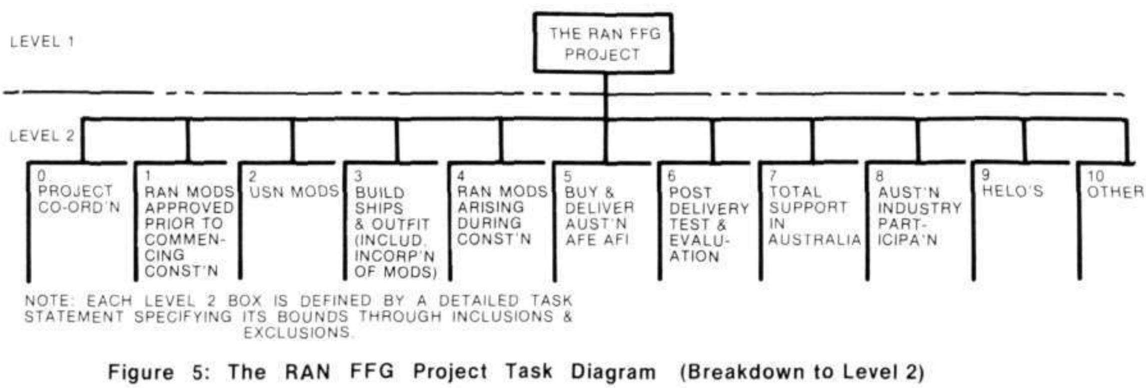


Figure 5: The RAN FFG Project Task Diagram (Breakdown to Level 2)

tability assigned to Project Directors in the RAN compared with their contemporaries in US and Canadian defence weapons systems acquisition projects.

The executive document, assigning responsibility to the RAN FFG Project Director and defining the management method to be followed is the Management Plan. It was first issued in June 1974 and was a development of the Plan prepared for the DDL, reworked to cater for the different circumstances and incorporating some lessons learned. The DDL Management Plan had been based on the work of consultants and recommendations by the Defence Industrial Committee which were approved by the Minister for Defence early in 1972.

Some important concepts, established by the RAN FFG Project Management Plan, are:

- breaking down the total work involved in the Project into a heirarchial pattern of groupings of work tasks at various levels;
- clearly defining, in a standard format, the work involved in each work task and what it includes and excludes;
- fixing responsibilities for performance of nominated Project work tasks within the requirements of the Project Management Plan;
- requiring participants to formally acknowledge responsibility for the assigned task;
- requiring participants to prepare and agree with the Project Director, plans for the method of undertaking and completing their allocated tasks; and
- provision of reports of achievement against planned progress at various levels and at required frequencies.

A description of the way these features have been implemented is included in the paper *"RAN FFG Acquisition"* by Berlyn.

Figure 5 shows ten major areas that together make up the RAN FFG Project implementation task. It was the first major step towards implementing the above features. The diagram is deceptively simple but its development involved a lengthy history of unresolved debate going back to the DDL days covering work breakdown structures and associated coding systems. In retrospect we were mesmerised by the pursuit of a universal WBS coding structure equally convenient for all areas. The breakthrough was when we realised belatedly that the way in which a total project should be divided into tasks depends on its nature rather than the existing structure of an organisation.

RAN FFG PROJECT TBS ELEMENT / PARTICIPANTS	RAN FFG PROJECT OFFICE	NAVAL DESIGN BRANCH	NAVAL PROD'N BRANCH	NAVAL SUPPLY BRANCH	NAVAL OPERL REQTS BRANCH	ILSMT	DEFENCE CENTRAL DIVISIONS	AUST. EMBASSY WASHINGTON	USN	OTHER
0 PROJECT CO-ORDINATION	P	A	A	A			A	A		
1 RAN MODS APPROVED PRIOR TO COMMENCING SHIP CONSTRUCTION	A	P	A		A				P	
2 USN MODIFICATIONS	P →	THROUGH THE CCP →	→	→	→	→			P	
3 BUILD SHIPS AND OUTFIT (INCLUDING INCORP OF MODS)	P	A		A	A				P	
4 RAN MODS ARISING DURING SHIP CONSTRUCTION	P →	THROUGH THE CCP →	→	→	→	→			A	
5 BUY AND DELIVER AFE, AFI	A	A	P	A			A			
6 POST DELIVERY TEST AND EVALUATION	A	A	A						P	
7 TOTAL SUPPORT IN AUST	P →	THROUGH THE ILSMT →	→	→	→	→	→	→		
8 AUSTRALIAN INDUSTRY PARTICIPATION	A		A	A		A	P		A	
9 HELICOPTERS	A		A	A			A			A (NAVAL AIR ENG)
10 OTHER	A						A			

CONFIGURATION CHANGE PANEL (CCP)
CHAIRMAN — FFG PD
REPRESENTATIVES — DESIGN, PROD'N FLEET MAINT., SUPPLY, OPS REQTS

INTEGRATED LOGISTIC SUPPORT MANAGEMENT TEAM (ILSMT)
CHAIRMAN — FFG, ILS MANAGER
MEMBERS — DEPARTMENTAL FUNCTIONAL BRANCH REPRESENTATIVES

LEGEND
P — PRIMARY RESPONSIBILITY
A — SIGNIFICANT ASSOCIATION WITH WORK

Figure 6: Task Breakdown Matrix

The important result is shown in Figure 5 which was promulgated as part of the Project Management Plan in June 1974, and remains valid today.

Having arrived at a breakdown of the Project task, the elements were analysed against the previously described management concepts. The result was Figure 6 which shows conveniently the matrix relationship between major participants and the ten major tasks. Detailed description of these tasks is beyond the scope of this article but the control of modifications, provision of total support in Australia and AIP warrant further comment.

Before considering these points, it is worth noting from the MOA that an important innovation had been mutually agreed. This involved placing Australian personnel in key positions in the US organisations concerned with the construction and delivery of the ships. The task of these personnel is not a normal liaison role. They work in, and for, the USN Project and are involved when required with matters concerning the US ships as well as those for the RAN. The arrangement has provided excellent experience for the officers concerned and has facilitated interchange of information between the US and RAN Project Offices as depicted in Figure 7.

Modifications

During the Project investigation phase, the desirability of making some changes to the USN design to suit special RAN requirements had been established. A firm cost limit was set. Proposed changes were investigated both here and in the US. Some of our proposals were eventually adopted by the USN, for example, the fitting of a fourth main generator, and some were made an integral part of the tender package for our ships.

Strong management of change has been emphasised by the USN for modifications arising during construction. Configuration Management is the fashionable term for this process which requires:

- an approved configuration definition — ie, up-to-date and complete technical documentation identified in a configuration record;
- management of changes to that definition by formal assessment, rejection or approval processes; and
- monitored implementation of approved changes.

It is arranged that a senior Australian representative is a member of the USN FFG change control panel and participates in decisions affecting the USN and RAN ships. Approval of any changes the RAN may propose is coordinated in Australia by the RAN FFG Project Director through his change control panel prior to being proposed to the USN.

An important consideration is that Australia must pay the full cost of any accepted changes. Serious consequences could arise if one of these could be shown to impact the tight schedule for delivery of the US ships.

The progressive maintenance and expansion of the configuration record and the associated detailed drawings, specifications and other technical documentation for the RAN FFGs up to entry into the RAN is being done in the US. Comprehensive computer systems process the identification of the equipments, systems and associated technical documents. Most of the

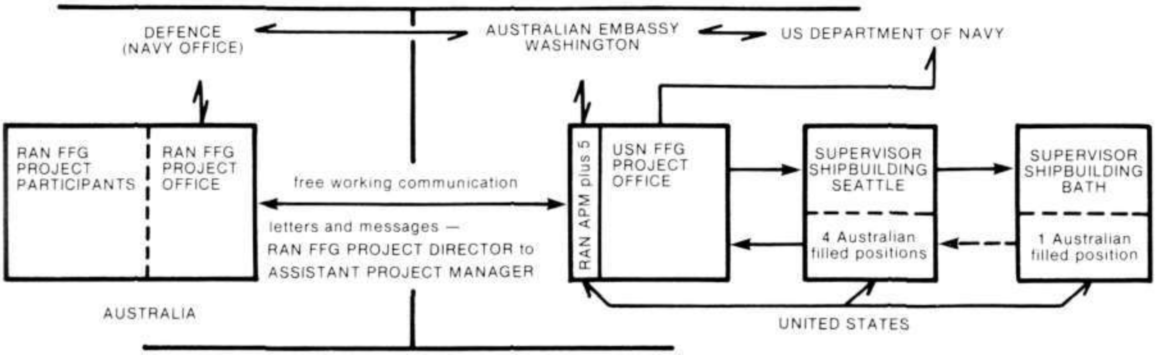


Figure 7: RAN FFG Project Management and Communication Relationships

RAN FFG PROJECT — TASK BREAKDOWN STRUCTURE DEFINITION	
Short Title of TBS Box: TOTAL SUPPORT IN AUSTRALIA	**Number Assigned:** 7

Definition:
This is the task of identifying and acquiring the initial support material, training and facilities in Australia to support the Guided Missile Frigates after delivery.

Support material in this sense is all items of supply required for RAN inventory stockholdings, including: reserve equipments; rotatable items of equipment; repair pool items; insurance items; breakdown spares; ammunition and missiles; complete documentation/handbooks etc; general consumerables etc; and equipment to outfit the dockyard, other government and commercial repair and maintenance establishments, the destroyer tender and training establishments as required for the operation, maintenance, training and support of the ships.

Includes:
The task includes developing the maintenance concept, policies and plans for the ship and its equipments, together with the ship's Planned Maintenance System and Refit Specification; developing the ship's complement and quarter bill; developing and implementing a training plan for naval and civilian operational, maintenance and service personnel; implementing Supply procedures to develop ship board allowance lists and storekeeping procedures; developing procedures to assess the funds required for the ship's logistic support, instigating action in respect of providing follow on-supply-and-technical-support for the ships; and other associated logistic support aspects.

Exclude:

Figure 8: Scope and Extent of RAN FFG ILS Task

provision and maintenance of the technical documents is being done for the whole US FFG Program by the Class Design Agent who, even in the first half of 1980, still had over 200 people working full time on this task.

Total Support in Australia

As previously stated, FFGs have a very small crew. For this reason they require more support from ashore than earlier ships. It is thus no accident that its provision is being attempted by the first thorough application of the concept of Integrated Logistic Support (ILS) to a RAN surface ship. Essentially ILS requires that long term support considerations should permeate the entire design, contract and construction process from the start. Such early involvement and development of support plans should foster economy in many ways, for example, by facilitating ordering of spares with prime equipment, or by ensuring that equipment replacement routes really have been included in the design.

The scope and extent of the support task is described in Figure 8. Note that training and facilities are involved as well as material.

A project ILS management team was set up at the start and soon produced a comprehensive ILS Work Breakdown Structure, and detailed plans and estimates. Implementation inevitably involved several levels of matrix management since many funtional/specialist groups contribute to the support of ships. Some key functional personnel were co-located with project ILS staff in what has amounted to an FFG ILS sub-project. Economic use of people and good communications have resulted from this arrangement.

Some of our US based personnel are employed in the support field to ensure a proper meshing of our plans and requirements with the USN's. They also assist in injecting consideration of the vastly different support infrastructure upon which our ships must rely. This has wide implications for example in the use of the USN computer-based configuration record as the basis for listings of proposed holdings on board each ship and in initial inventory in Australia. Our conditions are different to those in the US on which the computer-processed formulae were based. This requires a large RAN effort to assess this documentation to determine final need for spares and their ordering and receipt in Australia.

Returning to Figure 3, it will be seen that support involves some 25% of the Project cost. The work of securing the most cost effective support packages for this amount involves many disciplines particularly engineering, supply and training. Whilst the composition of our ILS team was carefully arranged to reflect this situation, it occurs as a matter of course in the US where a logistics specialisation, drawing people from many backgrounds, has long been recognised.

Australian industry participation

The Australian Government requires that for overseas procurements of military equipments, vendors undertake to provide "offset" business with Australian industry of at least 30% of the contract price. The background and approaches to meeting this objective are briefly outlined by Eltringham in *"Australian Industry Participation in Defence Procurement"*.

The project office acted as a convenient focus for efforts by Defence, other Departments and Industry working in this area. In the early part of the programme, it was difficult to achieve much progress. One reason was that AIP in a ship programme involved relatively new concepts. Also there was ignorance within Australia of many US business practices and the subtle effects of US legislation and Defence procurement procedures and regulations.

A more fundamental limitation on the practical level of AIP in the RAN FFG programme is the inherent conflict with the Government's objectives of risk reduction. Referring to Figure 9, it will be seen that realistic opportunities to influence the FFG design to facilitate AIP had generally evaporated well before even our commitment *in principle* to the programme in 1974.

It would seem, if we wish to ensure a reasonable share of the action in acquisition of major warships as part of the programme of another country, we will need to be prepared to put out risk money and people at a very early stage. There would then be increased opportunity to influence the design and equipment tendering/selection process to our needs. Naturally, there would have to be trade-off between these advantages and early loss of the competitive situation.

Despite firm support of AIP objectives in US Defense circles, the practical difficulties of incorporating non-standard equipments and materials into a major production run of ships are very great. Similarly, complete satisfaction of "form, fit and function" requirements by Australian suppliers can only occur in special cases. Even then, the Australian product must be competitively priced and with a margin sufficient to persuade the ship-builder, where a contract has penalties for late delivery, to accept the risks of departing from validated drawings and test procedures.

Despite the above difficulties there have been some successes including supply of fire extinguishing systems, manufacture of some electric cables, propeller shafts, large steel forgings, castings and fabrications for USN and RAN ships, as well as manufacture and supply of a range of equipments and materials for our own ships.

From a management viewpoint in the project office and in industry, pursuit of AIP is a highly demanding, time consuming, long term endeavour. It follows that even where there is a good prospect, achievement levels are likely to be in direct proportion to the resources applied and the will to succeed. The FFG experience has contributed to a better understanding of what is required.

SOME OBSERVATIONS

It is hard to overestimate the importance of the project's inheritance from the DDL experience. Two aspects were particularly vital.

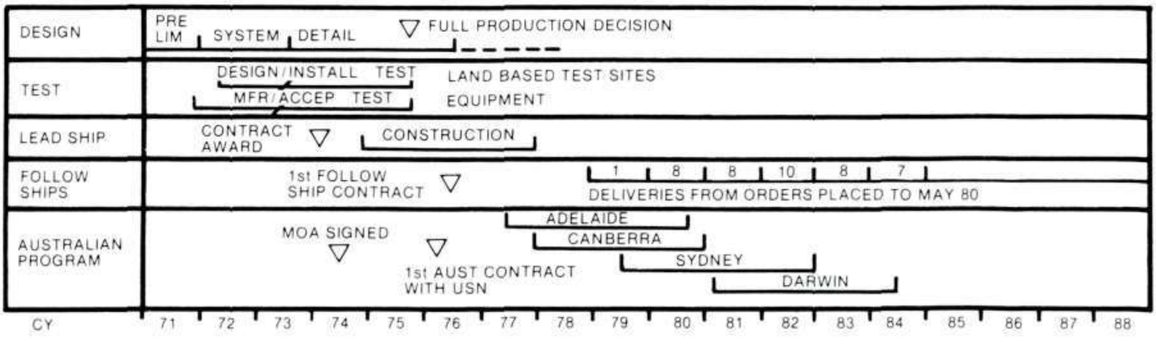


Figure 9: FFG Acquisition Program

The first resulted from the extensive high level management consideration which had been given to the way in which the DDL project should be managed. This clearly outlined the style of management thought to be most practical in the Naval administrative environment of the time. In effect, it fixed the Project Director's position on the horizontal axis of Figure 4 and provided a solid foundation on which to build. Of equal importance was the existence of established positions filled by well qualified people.

Most Navy projects start with a very small skeleton staff of one or two people. Had the FFG investigation phase commenced with this level of effort, it would have proved grossly inadequate to undertake the required work whilst also pursuing the procedures required to create and fill positions in the Public Service. Programme slippages would have been inevitable. To overcome this situation, some reservoir or pool from which project orientated personnel can be drawn is needed. The employment market can probably be regarded as such a pool in the private sector, but a sufficiently flexible and reactive mechanism does not seem to exist in the Commonwealth Public Service.

The need for rapid reaction and adherence to time scales is particularly important when, like the RAN FFGs, the project forms part of a larger programme under independent control. The penalties for 'missing-the-bus' can be particularly painful and this is further justification for adoption of a pool concept. Another reason can be found in the changing nature of the work to be performed as the project proceeds from investigation through definition to implementation. Different numbers of people, levels and skills are required at each stage. In practice, neither the changing needs nor the full content of most projects can be totally defined at the start. There is a process of gradual unfurling and it is not always possible to see resource requirements far enough ahead to meet time scales for normal administrative action.

The matrix management approach which has characterised our project, is not without its difficulties. As previously suggested, some of these are to do with deeply ingrained behavioural patterns. Others more properly relate to translation of elegant theory into practical reality. Reaching agreed task statements provides an illustration. Unless these are kept to a fairly general level, months of effort will be required for negotiation and agreement. Yet it is well known that generalised agreements make poor contracts when things go wrong. Proper understanding and communication with principal participants leading to a climate of goodwill is therefore essential. Provided this is achieved, the task statement need be no more than a background trading agreement providing insurance for future harmony.

The authority and roles of members of a matrix project team are not as clear cut as in pure functional or pure project organisations (Figure 4). This can cause additional work and stress. Nevertheless, despite the different level of authority, our project engendered the same strong motivation and team work which characterises the USN FFG Project. It seems that the project group with its limited size, clear objectives and defined schedules, really does provide opportunities for individual initiative and identification with achievement of each milestone. Staff efficiency and productivity increase in such a climate.

The project has made use of second and third level matrix managers similar to those described by Pywell in his *"Engineering Management in a Multiple (Second and Third Level) Matrix Organisation"*. The RAN Assistant Project Manager in the FFG Project Office (Figure 7) falls into this description as does the Technical Manager located in our own project office with his dual responsibilities to the Project Director and the Director General Naval Design.

It is worth noting that the strength and success of matrix management depend very much on discipline. Work breakdown structures and task statements are, by their nature, organised but without regular review and appraisal of progress they will fail. We found it helpful to conduct routine project office business around a formal weekly meeting of senior project staff and chief participants. Problems of the moment were discussed and progress towards project milestones in the next three months was invariably reviewed. A summary of discussion and actions outstanding was distributed the next day.

In a longer time scale and at a higher plane, the quarterly report prepared for Top Management provided another essential discipline. As for all participants, our Assistant

Project Manager in the USN Project Office was required to provide input against a previously agreed structure, which in his case was set out in the Project to project agreement. The process of condensing the normal 20 pages of the main report into less than two pages of executive summary really did force the Project Director to identify the main issues and take most careful stock of his progress against approved objectives.

Another feature of the quarterly report is the identification provided for the source of all

HMAS *Adelaide*

statements included. This has provided a convenient history and audit trail of a complex, long running and expensive project as well as the short term advantage of assisting senior readers to call up more material if required.

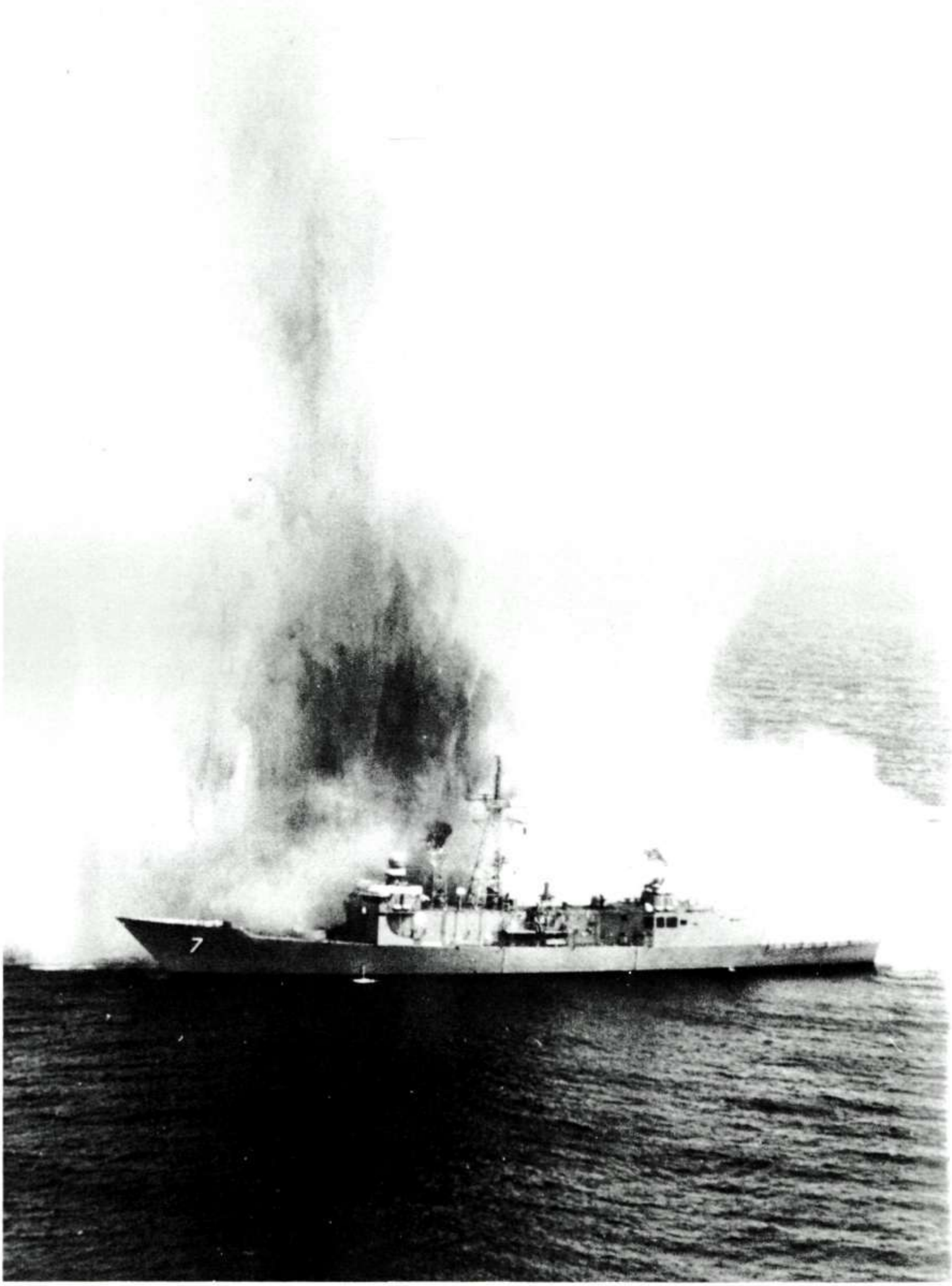
At this stage it can be safely said that the application of matrix management concepts to the RAN FFG acquisition has produced the desired result. Apart from timely delivery of the ships in which Australian efforts have played a relatively minor part, all other areas of the project are on schedule. For the most part these are the tasks which arguably can only be done for Australia by Australians. In the project office we saw orchestration of this effort and appraising management of progress as our major challenge from the start. For this reason, and as distinct from practice in previous overseas ship acquisitions, the centre of gravity of the RAN FFG Project has always remained firmly in Australia.

Another area of comment concerns the value and insights achieved from working closely with the USN Project. There are many messages in the practical application of 'Design-to-Cost' and 'Fly-Before-Buy' principles which, with appropriate modification, should impact on our thinking. Additionally, our people working in the US have gained priceless experience.

There is of course an order of magnitude difference between the US and Australian Defence procurement systems. It follows that procedures which are successful in the former will not necessarily be suitable for direct transplant. But study of the US system is valuable because the sample size is so much bigger, and in consequence there are many well documented procedures, regulations and experiences upon which we can draw. The widespread use of contractors gives great flexibility (an alternative pool concept) and their method of developing estimates in "then year" terms seems to us to have much to commend it. In inflationary times especially, it could assist politicians and the public in differentiating between real price rises as distinct from those merely reflecting inflation.

Despite the size of the USN system, it seems to be capable of more rapid reaction than our own. Typically, the process involved in providing new works facilities in Australia can require three times the lead time needed in the US. If we wish to work closely in a larger overseas programme, it seems important to be able to react in the dominant time scale.

Facilitating timely reaction from Navy and other large organisations has been the overriding endeavour for the RAN FFG Project Office. This should be no surprise. It was after all the reason for setting up such a team in the first place. Despite this, the implications have not always been appreciated. In such cases unilateral action such as introduction of our own document identification and management system, has sometimes been taken in order to maintain momentum. when this occurred, we hoped that downstream success would eventually provide a climate of acceptance for



USS *Oliver Hazard Perry* undergoing Shock Tests new procedures where initially our eloquence had failed.

At the conclusion of this review of a pioneering effort, it may be appropriate to note that well staffed project management teams are being planned for a number of recently announced Defence hardware acquisitions. Project management is accepted and being strengthened. Referring to Figure 4, the Project Director's position is being moved to the right.

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HMAS *Canberra*

MANAGEMENT OF AUSTRALIA'S GUIDED MISSILE FRIGATE PROJECT

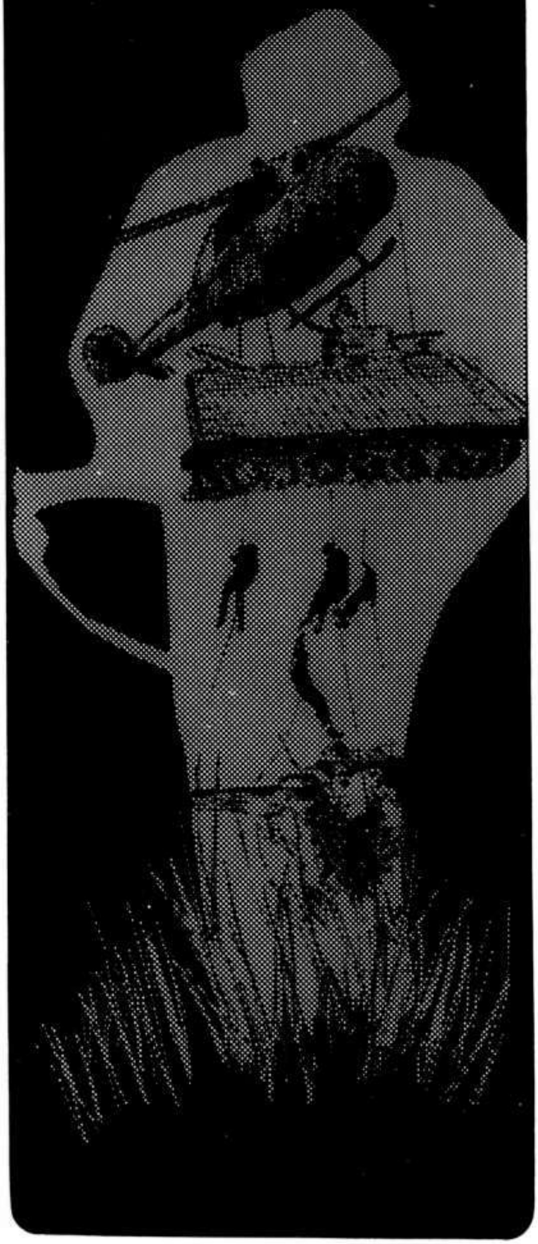
KEYWORDS: Project Management; Managerial Coordination; Naval Procurement; Management Engineering; Management Methods.

ABSTRACT: The RAN FFG Project exists to manage a $1000M programme for acquisition of US built Guided Missile Frigates (FFGs) and their support for the Royal Australian Navy. The first two ships, which were ordered in 1976, joined the Fleet early in 1981. Some key background and external factors which shaped the form of matrix management being used are examined. Management arrangements and experiences are discussed including interaction with the USN FFG multi-ship programme. Some major features of the US approach to management of design and construction in this pioneering programme are outlined. The content and changing nature of the project are reviewed together with some problem areas. Observations and insights provided are based on practical experience.

AWARD: ISSUE NO 29 (July/August 1981)

The Board of Management has awarded the prize of $30 for the best original article in the July/August 1981 issue (No 29) of the Defence Force Journal to Squadron Leader L. J. Egan for his article *The New Guard and the Defence Department: Conspiracy and Collusion.*

THE MOBILITY OF INFANTRY a letter to a friend



Article received February, 1981

Lt. Col. J. Wood ED, BA, MA,
Royal Australian Infantry,
Australian Army Reserve

My dear friend,

I AM afraid I have been preoccupied with other matters and not had the time to return to a subject we touched upon once before — The Mobility of Infantry.

I hear there are changes abroad in your army and I have been prompted to search through the memories of my own experience.

For many years we pitted ourselves against a technically superior enemy. It seemed at the time that he had every advantage while we were reduced to the age old method of movement on foot. We took great pride in our ability to move long distances undetected, to strike and then to move away with minimum loss. Such movement however became a matter of pride with us and naturally we played down the obvious disadvantages. We overlooked the fact that movement on foot, although cheap in transport resources, is expensive in terms of manpower and time wasted. We ignored the fact that flexibility in space does not compensate for inflexibility in time and access. We emphasised our fitness but discounted the drain on our strength.

As the war turned in our favour we received new resources and these helped us forget those earlier days when so many of our best soldiers were lost because we had been technologically outclassed. We revelled in the speed and convenience of vehicular movement and sang the praises of the transport people and the wonders of modern technology. But then the realities caught up with us. We passed the blackened remains of transport columns caught by enemy air on the few routes available. We lost battles because the movement of troops by vehicle invariably signalled our intentions and smothered our watchwords for success — speed

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This is the fifth article in the series "A letter to a friend", written by Lt. Col. Wood. The last article was published in DFJ March/April 80:

Lt. Col. Wood recently completed his posting as CO Melbourne University Regiment and is now SO1 Co-Ord HQ 3 Div FF Gp. He is also a part-time student at Monash University where he is completing requirements for a PHD on the subject of Australia's military involvement in Asia and the Pacific 1945-1949.

and surprise. We also discovered that the vehicles were not available at the time we most needed them — as we closed for the assault.

You will recall what happened next in our climb to technological parity — we obtianed some APCs. We were simply amazed — we had been savagely scarred by these weapons — and time and again had been outmanoeuvrerd by their speed, access, fire power and flexibility. Then we captured some and the problems started. There were never enough to go around; they were expensive to use; we took a long time to get used to them; and couldn't get enough time in on them; we couldn't see where we were going. You can draw your own conclusions as to our response — we preferred to walk because we failed to build up our trust in this wonderful machine. Some of my friends who did get involved tried to jerk the rest of us out of our inertia but then paid for their initiative in the remains of gutted carriers outclassed by the enemy's superior technology and experience. To put it simply, we just didn't keep abreast.

My response was to creep back into my shell. I just gave up at the time we received helicopters, the ultimate infantry carrier. As I said to my few surviving friends — "Why bother — it is not worth the effort — all you do is to multiply the problems." My later observations confirmed we could never get enough helicopters to train our troops in sufficient numbers and over sufficient periods to make the tactics second nature. Worse still, we couldn't train our leaders to use these wonderful machines boldly and effectively.

You see — the cynic had triumphed. The prisoner of experience continued to fight his wars on his feet. Invariably I returned to the dismounted mode as the most likely means of assault. Invariably I failed to think boldly enough and I could not cope with the speed of modern warfare. I had forgotten many of the lessons of my earlier days — when I tried to pause or merely hold ground, my soldiers were bypassed and allowed to wither or were obliterated by some device. I failed to realise that I would never have enough resources and that I would be obliged to constantly manoeuvre what I did have and to commit it again and again.

What demands these changes in warfare placed upon us; we had not anticipated the cost in mental and physical attrition. The grind and savagery of the infantryman's war was accelerated by constant threat and constant movement. So many of us could not handle the pace — the older men broke down and the younger men had not been prepared. We had become accustomed to the unreality of unreality.

As a result of successive disasters I was pushed to one side to meditate and with time I could see more clearly where I had gone wrong. Certainly I had seriously underestimated the enemy's use of shock action. I recalled from the earlier days of the war how the enemy had battered us day and night and we had countered this by digging more deeply. That worked pretty well until he developed infra red and the laser and pin-point accuracy in all weathers and conditions. He also introduced weapons which we had regarded merely as the figments of someone's imagination. The more horrible the weapon the deeper we dug. Instead of moving we stayed.

We fell for the same trap in our attacks. In the early days we only attacked when we had the advantage but, as our numbers and confidence increased, we attacked more frequently the enemy occupying a defensive position. In other words, we began to limit our tactical mobility to the opportunities offered by the enemy's location. We found then, to our cost, that the enemy dictated the key features of our plan, i.e., our objective; our options concerning direction and type of approach; the resources we had to deploy against him. He also had a pretty good idea of what we were likely to do.

Eventually our losses forced us back upon our experience. We returned to the tactics by which we had made our early reputation. We hit the enemy when he was not sitting comfortably; when he was on the move; before he had the time to establish himself. He manoeuvrerd in order to avoid his confident combat element by improving our mobility, our surveillance, our re-supply and our communications and we also retrained our officers to regard the target of opportunity as the rule not the exception. It is said there is nothing new under the sun and all we had done was return to the tactics of our illustrious predecessor who had roamed much of the world with his flying columns striking at will.

We discovered mobility! You will say that I am too fond of quoting from the past. Let me use a modern example. Infantry has the opportunity now not to be bound by space and to remove some of the constraints of time. The battlefield should be likened to an ocean upon which tactical units move like warships fighting independent actions or coming together as a battle fleet to fight a major action before again dispersing. I could also see these units or fleets resupplied across hostile waters by fast moving convoys relying on speed, deception and minimum local protection. It should be possible to also restock from prepositioned resources or from elements operating with the units or the fleet. It should become normal to have very few home ports and for resupply to be dependent upon making the next rendevouz.

How would I translate the rediscovering of the principle into everyday training? Not for a moment would I stop pressing for more helicopters and APCs (or whatever) nor for their use as my primary assault weapon. However, you must recognise you will never have enough of either and invariably will be training a technological step behind. What you need is a method to bridge the technological gap and to redevelop mobility as a tactical byword.

I have in mind a basic platform sufficient to carry whatever you finally decide upon as your basic infantry section and its requirements for an agreed period. The platform should have an uncomplicated motor designed to move it at a reasonable pace through a sufficient range of terrain conditions. I don't think you should aim for a scaled down APC. You could probably give this VEHINF centre seating, mountings for machine guns and radios, storage facilities, a low silhouette but with a collapsible frame for weather protection and camouflage and for out of contact movement, I suggest tyres not tracks and possibly a trailer to carry fuel and second line. You may suggest some armour plating but I think you should concentrate upon speed to move you out of trouble. I don't know what to do about NBC protection.

Maybe then you will be able to move at will — constantly seeking out advantage. If you produce enough of these vehicles cheaply and make them available permanently to your infantry battalions then you will be a big step forward in your efforts to introduce mobility.

I return to the offensive spirit theme. As I have already suggested, much of the damage should be done to the enemy before he gets himself properly organised (i.e. the advantage of the ambush). You must follow up the advantage of the initial shock with further shocks before he can recover his composure. If you apply these proposals to the defence phase of war you will realise I am advocating more attacks during his advance to contact, more attacks during his preparations for attack. Not only this, but you must give more thought to the weight of these attacks, build up your covering forces and screens.

You will argue against depleting the strength of your main position to carry out these actions. Why give up the advantages of fire power, concealment, protection, and so on. Why go looking for trouble?

Until I gave some deeper thoughts to the defence I had not realised how much we, as infantry, had sacrificed mobility. For example, we arrange for firepower to suit our defence and to protect it we dig in knowing that by so doing the enemy, given time, will know precisely where our firepower is located. I remember watching with horror the destruction of one of our well dug in and camouflaged field batteries. I saw the flames of an incendiary strike strip away its camouflage and to reveal gallant men serving the great god gun for only as long as it took the enemy fire to search them out over a well marked graveyard some three hundred metres square. I cringed more closely to the earth conscious of my fragile overhead protection. How I prayed that someone would give our gunners a fighting chance — some form a self-propelled gun which allowed them to hit and run with a reasonable chance of protection and survival. I saw the same problem with our precious mortars. We seldom had more mortars but when we were able to provide them with mobility we multiplied their effectiveness and survivability. However, economy caught up with us, we lost our mobility and finally our men and equipment.

I also learned that mobility is not merely a matter of the method; it is very much one of attitude. We had to keep moving. The longer we stayed in the one spot the more opportunity we gave the enemy to kill us. We had to abandon "the deeper we dig the better off we will be" concept and replace it with "the sooner we move the better".

What an opportunity I have given you to attack me. What a massive effort my proposals would require — digging a new set of holes every night or so. Yet I recall the Roman

Legions would move often and each time constructed not only a trench but a palisade to protect their whole camp. Despite the passage of time, your infantry seem little better off than those legions — you still rely on the shovel and the sandbag ignoring the fact that the enemy's technology has outstripped your capacity to protect yourselves. Why on earth haven't you developed a simple device for digging holes quickly and easily? Why haven't you issued such a device to your infantry? Why haven't you also re-examined the roles and equipment of your pioneers and engineers in terms of what they can do for your infantry soldiers? Over sixty years ago your infantry dug great trenches across Europe with the same simple tools, yet in an age when technology can put a man on the moon, your soldiers are no better equipped to save their lives. Time and again I have watched with envy and annoyance as an engineer with a simple piece of kit sorted out a task upon which I had literally wasted days.

So much for digging, what about field defences? I am reminded of the knight in his castle. There he sat surrounded by beautifully constructed field defences — works of art in stone.Things were not too bad for the knight for, as long as the attacker stupidly battered himself to death on the castle's defences or until the attacker acquired the capacity to smash through a weakness or unsportingly came up with some new scheme for digging out entrenched knights. Unfortunately, some of the smarter attackers would also turn their attention to plundering the countryside or terrorising hostages until the knight, weakened by the constant battering or by a lack of supplies or boredom or embarrassment made a desperate sally across his only drawbridge. By that time he was doomed. The knight, whose castle had been built on the success he had enjoyed when he harnessed a technological innovation of his day, the horse, eventually became so embroiled in his castle that he forfeited the mobility his horse had provided.

For the modern knight there are some glimmers of hope. The scatterable mine promises to be not only a great labour saving device but also allows a greater degree of tactical flexibility; ideally you will not need to lay your mines until he attacks. I wonder whether someone could come up with scatterable wire. Mind you, you bend all the rules when you put up your wire. You tell the enemy what you want him to do and expect him to do it. How disconcerting for him it would be if you had wire that was triggered and laid during his attack — a return to the gladiator's net vertical and horizontal development by wire. Surely, in these days of powerful springs and fine steel, you could come up with a jack in the box device which was only initiated when you needed it.

The other advantage you now have is the armoured personnel carrier — you now have the capacity to extract your forces and are able to rethink your commitment to established positions. Should the enemy survive your defensive fire, your mines and wire, how quickly he can turn the odds against you by reducing the fighting to a one for one basis where so often he will enjoy the advantage of superior numbers. Maybe you should give more thought to pulling your forces out before they become too ensnared. You will point out how sticky things would be at this stage and who in his right mind would leave the sanctuary of his weapon pit? However, once the enemy is through killing ground, your soldiers' chances of survival diminish. Perhaps you should consider keeping your APCs in your sub-unit positions, using them as a centre piece in much the same way as you have used your section machine guns. If your APC had some form of back hoe it could not only dig itself in, it could also help with your other digging problems. At a crucial point of the battle, your infantry sections, using their communication trenches could concentrate upon the nearest APC and depart at speed. As you already practise fire and movement at all levels, you should be able to find some answers to the enemy's anti-armour activities at this time. You will now accuse me of sacrificing the mobility of the APC at the expense of gaining admittedly valuable fire power. Well, possibly the APC should best use its firepower from alternate positions and still, at the right moment, carry out its primary task — provide mobility for your infantry.

Actually, I wish to be so bold as to suggest that,provided you had the armour and anti-armour resources to hand, there would be times when the best direction of extraction would be straight into the enemy's line of attack. What a mess such an act would create but you may well regain the initiative and when one is caught in an ambush there is little other choice than to attempt to break out. Probably you will think I have gone too far with that one.

Another option you have is to make better use of your reserves. You tend at the moment to use your reserves to plug the gaps and to prevent further failures in your plans. You don't countenance reinforcing failure in the attack so why not make better use of your reserves to reinforce success in the defence. I think you wait for too long before committing your reserves. How unpleasant it would be for an enemy who has survived your killing ground to find himself caught between the stonewall of your defensive position's firepower and the combined mobility and firepower of your attacking reserve. In other words, hit them at the worst possible moment for him. We have used this tactic for years.

Now what should be the size of the reserve? This has always been a problem for you. You have to be a general before you get a decently sized reserve to play with and then would only use it for the big battle. I think, to return to my theme of mobility, that you could, in the defence, use fewer battalions to hold key points and use more battalions to constitute your reserves. When attacking, maybe you should concentrate against one or two key points only and, as these crumble, pile on your reserves to exploit the advantage. Maybe in this way you will take out of the enemy's appreciation the predictability of your employment of reserves and force him to spread his forces against a greater number of options. By doing so, you will be taking more risks but also, I suggest, increase the likelihood of success.

I must close — you have had more experience than I and will no doubt set your mind to correcting my brashness. Please do.

Your old friend,

INTEGRATED DEFENCE SUGGESTIONS SCHEME

The prime aim of the scheme is to provide an administrative means by which both the department and proposers of suggestions may profit from the introduction of new ideas. It is designed to:

a. encourage all Defence personnel (both Service and civilian) to use their initiative and ingenuity;

b. ensure that their ideas are thoroughly investigated, without undue delay, by specialist staff; and

c. recognize suggestions of merit with appropriate awards.

The scope for suggestions covers subjects relating to improvements which will result in savings in expenditure manpower or improved safety standards. The few restrictions on eligibility refer to proposals concerning grievances, salaries, wages and certain matters which are normally the subject of a defect reporting system.

The following statistics are an indication of the size and nature of the scheme: submissions now approximate, annually, to 450; 52% of which are of a technical nature, 32% administrative and 8% safety. Contributions from Service and civilian elements are evenly balanced: 56.53% being of Service origin and 43.46% civilian.

This year, five exceptional suggestions, for which amounts totalling $69,933.00 have been awarded, were submitted by Navy, Army and RAAF Servicemen. Implementation of these suggestions will result in savings in excess of $1,600,000.00 over a three-year period. Additionally, the Efficiency and Safety Suggestions of the Year Awards were won respectively by a sergeant and a corporal in the RAAF. These awards, which are comprised of a $300.00 monetary award and a commemorative plaque, are sponsored by the Public Service Board.

Contact Officer is: Mrs. M. Reed (062) 66 4318, Secretary, Defence Suggestions Committee, Campbell Park, 4-4-02, Canberra, A.C.T., 2600.

Task Force on Review of Unification of The Canadian Forces

By Major J. G. Holford, BSc, BE, PhD.

SYNOPSIS

"IT is dubious whether unification has achieved the intended goals," concluded the *Fyffe Task Force on Review of Unification of the Canadian Forces.* The Task Force did not advocate any overall structural change in the Forces but identified problems within the unified structure and recommended changes.

INTRODUCTION

On September 6, 1979, the Canadian Minister of National Defence announced:

> "It has now been some 11 years since the Royal Canadian Navy, the Canadian Army and the Royal Canadian Air Force were merged into what are known today as the Canadian Armed Forces . . .
>
> I believe the time has arrived to review the process of unification and its results to determine whether the benefits which had been hoped for have been achieved and whether the full effectiveness of our armed forces has been maintained.
>
> To explore this matter I have today appointed an independent five-member Task Force to go into the subject in detail . . . The members of the Task Force are, Mr. George Fyffe . . ."

The report of the Fyffe *"Task Force on Review of Unification of the Canadian Forces"* was released during 1980 and represents the only comprehensive review of the Canadian unification experience that has been made public.

During the review, the Task Force received opinions from 1,110 individuals at public and private hearings. Groups represented at the hearings were:

* Serving general officers and senior civilians in the National Defence Headquarters.
* Serving officers and other ranks in the Canadian Forces.
* Retired general officers.
* Former Defence Ministers and other invited individuals.
* Interested Canadian defence associations and organizations.
* The public at large.

The Report of the Task Force describes the setting and processes leading to the unification of the Canadian Forces, states its goals and reviews their achievement, summarizes the views expressed to the Task Force, and offers conclusions and recommendations on problems identified with unification.

This review of the Report outlines the reorganization of the Canadian Department of National Defence, presents parts of the views expressed to the Task Force and gives the major conclusions and recommendations contained in the Report.

Major Holford has served in the Sydney University Regiment and Headquarters 2 Division. Currently a consulting engineer in Canada, he has been attached to the Canadian Forces Reserve and has attended the Canadian Land Forces Command and Staff College, Kingston.

Article received March, 1981

REORGANIZATION OF THE CANADIAN DEPARTMENT OF NATIONAL DEFENCE

The reorganization of Canada's armed forces into a single unified force originated in the early 1960s and became effective on February 1, 1968, after a lengthy legislative process and intense debate.

GOALS OF REORGANIZATION

* **Financial Savings**
  The duplication and triplication of functions among the original services (logistics, communications, transport, recruiting, training, pay and finance, personnel administration, building maintenance) were to be reduced by the creation of a single Canadian Forces Headquarters, functional commands and the base system. In turn, the reduced overhead costs were to provide more funds for the acquistion of modern operational equipment.
* **Increased Operational Effectiveness**
  Flexibility to react swiftly was to be increased by the unified force under the direction of a single Chief of the Defence Staff instead of the co-ordinated response of three separate services. Conflicting loyalties and competition among the three services were to be reduced by providing more objective analysis and assessment of defence requirements, and ultimately a more effective defence programme within a limited defence budget. Reorganisation would permit more objective assessment of defence technological needs and the modernization of management processes for the support services.
* **Common Identity**
  Unification was to create a common identity and engender a higher loyalty beyond that given to a particular service, a loyalty to the entire force and its total objectives on behalf of Canada.
* **Enhanced Career Opportunities**
  More challenging and rewarding careers were to be offered to officers and other ranks by the removal of artificial barriers created by the three services. Greater opportunities would be provided for the development of skills and professional talent throught greater avenues for service and more opportunty for personal advancement.

Integration 1964

"... the process by which the three services are brought together under single control and management with common logistics, supply and training systems, operating within a functional command and organizational structure but retaining the legal identities of the three Services and the legal barriers between them."

Integration was initiated by the Canadian Government's 1964 White Paper on Defence and necessitated amendments to the National Defence Act. Implementation was effected in two phases.

First, National Defence Headquarters was reorganized along functional lines by eliminating the three separate Chiefs of Staff and creating a single Defence Staff and a Single Chief of the Defence Staff with executive authority over the three Services.

Second, a new integrated field command and base organization was introduced and charged with carrying out the defence roles within the available resources and within the context of an integrated force rather than one organized in accordance with the tradition of the Navy, Army and Air Force.

Unification 1968

"Unification is the end objective of a logical and evolutionary progression. Although integration and unification are someimes regarded as alternatives, and, inherently different, they are, in fact, different stages in the same process. Integration was actually the term applied to the first stages of the unification of the Canadian Armed Forces."

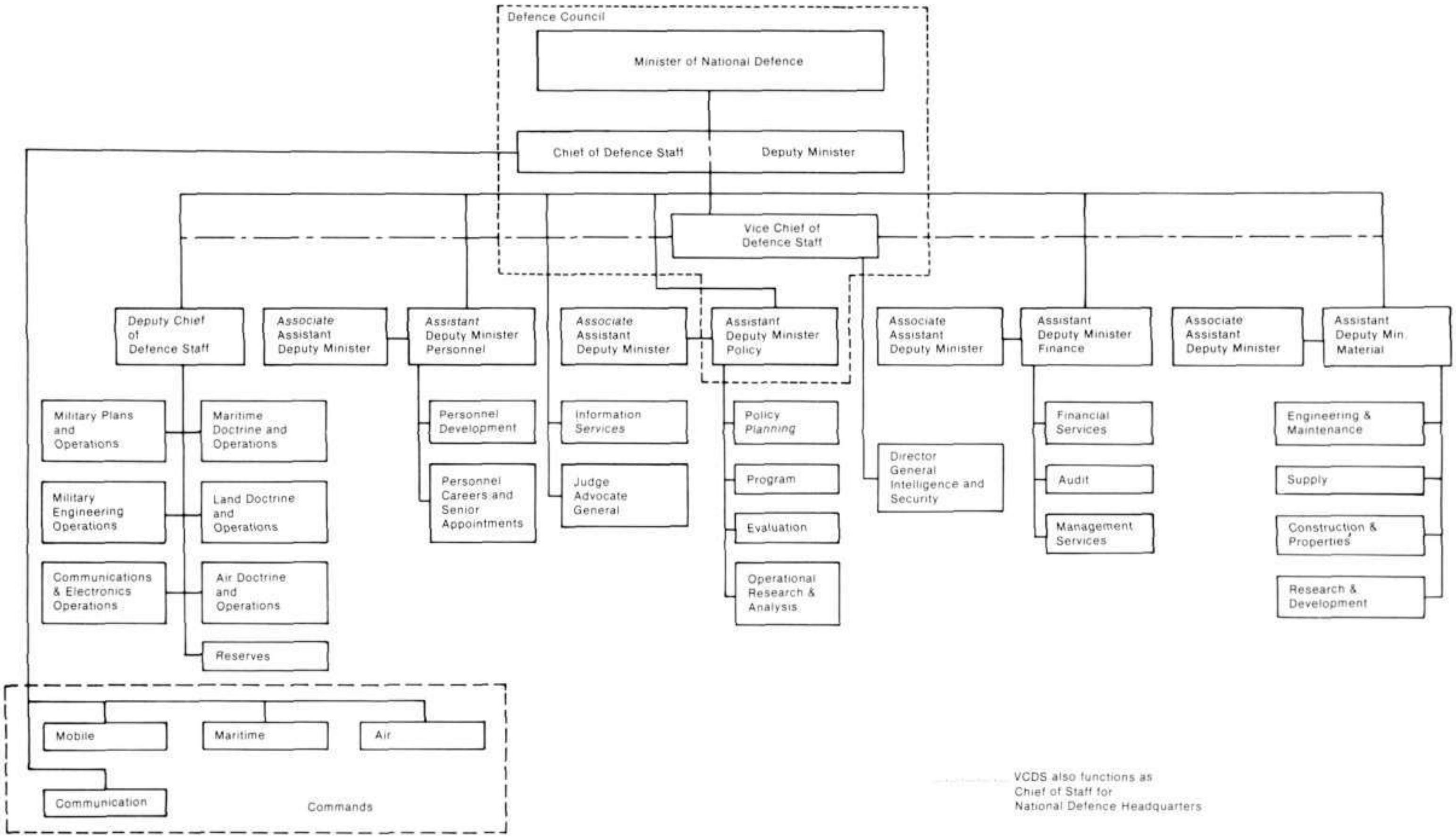
A second legislative change, the Canadian Forces Reorganization Act, became effective on February 1, 1968. The Act abolished the three existing services, the Royal Canadian Navy, the Canadian Army and the Royal Canadian Air Force and instituted a single service called the Canadian Forces with a common uniform and common rank designations.

After some evolutionary changes, the resulting organization of the unified Department of National Defence is shown in the diagram.

SUMMARY OF VIEWS EXPRESSED TO THE TASK FORCE

The Task Force was presented with public and private opinions on a wide range of topics and their Report gave a spectrum of the views expressed including:

DEPARTMENT OF NATIONAL DEFENCE ORGANISATION 1979



Command and Control

* **National Defence Headquarters**

The general thrust of opinions was that there had been insufficient sea, land and air environmental expertise available to the senior decision makers in the councils in which they serve. It was held that the Commanders of the three environmental Commands acted as advisers only when asked for advice and that consultation usually occurred after a major decision had been made.

Senior personnel both at National Defence Headquarters and in the field were concerned about the advice given to the Minister of National Defence with respect to Navy, Army and Air Force procurement programmes and other matters of policy execution, administration and organization. The viewpoint frequently expressed in this regard was that the senior sailor, soldier and airman should have access to the Minister of National Defence where matters concerning their forces had not been resolved to their satisfaction.

National Defence Headquarters was viewed as not being responsive to operational requirements. A Joint Chiefs of Staff organization was frequently advanced as an appropriate solution to a perceived lack of environmental sensitivity in the present Headquarters structure. Evidence from a majority of retired and serving general officers supported this solution.

In general, the opinions stressed the need to retain the centralized personnel and material systems in recognition of the economic benefits that had been derived from their centralization.

Views in support of the existing structure were also expressed. Such views held that during a period of resource constraint, the exsting system was successful in ensuring the survival of the Canadian Forces and in allocating scarce funding under appropriate strict controls.

* **The Staff System**

The lack of a common, well defined staff system was a subject of concern for Army officers. They perceived that the existing structure was not supporting the Army's requirements and was in violation of a number of military organizational principles. The criticism centered on the National Defence Headquarters and the presumed prevailing influence of civilian management philosophy and techniques. Weaknesses in the decision making process were attributed to the lack of an appropriate staff system. Members of the Navy and Air Force did not express as much concern in this respect although there were problems cited particularly in technical matters.

* **Civilianization**

Many opinions were expressed regarding a perceived civilianization of the National Defence Headquarters. It was held that at senior levels, civilians were making or were contributing to the making of decisions of a military nature and that control by the civil power should not mean control by the Public Service. Some witnesses claimed that too many decisions affecting the daily lives of service personnel were being made by civilians who were not sufficiently familiar with the details of service life.

* **The Base Concept**

The base system was viewed as an Air Force concept. The adoption of this concept was held to have adversely affected the operational effectiveness of the Army and to have been unsuitable for the Navy.

Army opinions focused on the questions of support to mobile units. It was represented that support services at bases were double-tasked as personnel were assigned to support both the base and the operational units when deployed. Double-tasking had made operations and training extremely difficult for Army units.

The supply system was viewed as being generally efficient. It was considered that it offered substantial economies as a result of the consolidation of supply depots and the merger of inventories. Favourable comments referred to the improvements made in the provision of material to the operational units in the Navy and to the Air Force base activities. There was a general concensus that centralized supply be retained.

However, the opinion was frequently expressed that the supply system for the Army did not extend beyond the base. To properly support mobile units away from bases, there was a need for supply procedures to be developed and for the system to be adequately manned by trained personnel.

* **Unit Commanding Officers**

Many Army witnesses perceived an erosion of the authority and control of unit commanding officers. The main contributing factors to this erosion were believed to be the centralized personnel system and the implementation of the base concept.

It was the view of the Army, and to some degree that of the Navy, that there had also been an erosion of the unit commanding officer's ability to provide leadership. In this vein, it was stated that the commanding officer must be seen to be the leader. The existence of support services which do not have affiliation at bases — that is, social, legal, spiritual and financial — has changed the image of the commanding officer in that he now has to refer his personnel to someone else. From a career and training point of view, the commanding officer has been supplanted by the career manager.

*** Mobilization**

A considerable body of opinion suggested that the present unified structure could not adequately meet the requirements of mobilization. The lack of a mobilization plant was cited as a serious deficiency and as an example of the lack of emphasis placed on operational matters. Requirements for mobilization training were considered by operational personnel to contradict the philosophy of common training since the demand in an emergency would be for short specialty courses to produce in a minimum period of time an effective sailor, soldier or airman.

Identity

Many serving personnel stressed a need for greater identity, for a return to some of the traditions of past achievements and for closer association with members of the Canadian Forces who have similar tasks and operate in the same environment. In the opinion of most witnesses, uniforms for the Canadian Forces should have a strong Canadian identity to ensure that military personnel are not mistaken for those of Great Britain, the United States or other nations.

A large number of members of the support services wanted to be identified with an environment. It was their opinion that his environmental identity would give them a better identity than does that of the Canadian Forces as a whole. Some members of the support services, particularly those who have spent lengthy periods of time on static bases, were satisfied with the Canadian Forces identity. It was the opinion of most members of the support services that they did not wish to be recognized as members of a fourth service with a separate identity.

A high proportion of serving individuals who had joined since unification expressed a desire for environmental identification and they stated emphatically that members of the Canadian Forces serving in a combat role wished to be recognized as either Navy, Army or Air Force. It was considered by many to be of great benefit, when serving with other military forces, to be clearly and quickly recognizable as members of the Navy, Army or Air Force.

In general, naval personnel desired closer identification with the Navy and the ships in which they serve; Air Force personnel desired closer identification with the Air Force as a whole; and Army personnel desired more identity with the branch, regiment or unit of the land forces in which they were serving.

Support Services

Many in the operational components and some in the support services felt that members of the logistics, administrative and finance groupings had lost sight of their primary role of providing support to the operational forces. The quality of support to operational units was severely criticized by some Army witnesses. It was stressed that the lack of emphasis on environmental training produced logistic and administrative personnel who did not have the necessary knowledge to operate under field conditions.

A major theme of testimony was that the knowledge required to perform effectively in all three environments could not be acquired by one individual. It was held that environmental specialization within the support services would increase the operational effectiveness of the Canadian Forces and correct the perceived alienation of the support services from the operational forces.

Some witnesses suggested that support personnel such as medical, chaplains, dental and postal should be attached to one service; in most of these briefs, it was suggested that this should be the Army. In addition, some witnesses expressed the view that unification had further enhanced the integration of these services.

Training

Following enlistment, all recruits receive an initial 12 weeks of recruit training prior to environmental or trades training. In the opinion of many, this recruit training represents the lowest common denominator of the various service requirements. Many operational personnel expressed the view that time spent on initial recruit training could be better spent on specific environmental training. Army and naval personnel considered early socialization in any environment to be important in order to indoctrinate the recruit into service life and to preclude a first impression which would not fit the environment to which he would be posted.

Many held the opinion that management was emphasised at the expense of leadership and, although the difference between management and leadership in training programmes had been difficult to assess, the importance of leadership in combat units could not be overestimated.

Some expressed the opinion that the Canadian Land Forces Command and Staff College had filled a unique need in the development of Army officers. Nevertheless, it was felt that this College was being increasingly downgraded and that action should be taken to restore course length and increase the prestige of the College. The Canadian Forces Staff College and Staff School were seen to have provided valuable joint education for junior and middle rank officers, as did the National Defence College for senior military and civilian officers.

The Personnel System

The Canadian Forces have a highly centralized, computerized personnel system which handles all personnel promotions and postings through National Defence Headquarters. It was the opinion of many service personnel that the centralized system has had an adverse effect on leadership, and has eroded a commanding officer's ability to deal with his subordinates' personal problems. It was considered by many that the personnel system elevated even minutiae to the National Defence Headquarters level, thereby leaving little or nothing to be resolved at the unit or command level.

It was felt that the personnel system could not meet mobilization requirements and that in the event of a large scale expansion of the Canadian Forces, it would be necessary to decentralize much of the existing system.

Many witnesses maintained that the military trade structure of the Forces was a reflection of the civilian labour force. Some serving personnel were viewed as civilians in uniform with a nine-to-five attitude to work. It was felt that the military ethic had been downgraded to a parity with the Public Service. The potential for unionzation within the Canadian Forces was stated to exist.

REVIEW OF GOALS OF UNIFICATION

The Task Force summarized its findings with respect to the attainment of the stated goals of unification as follows:

> "It is dubious whether unification has achieved the intended goals. In some instances, the Task Force felt it could not compare the situation in 1979 to what existed before. In other instances, it had no hard evidence on which it could base its judgment. Finally, it is to be noted that there has been an evolution in the application of the policy of unification, which had made it more than difficult to relate the present form of unification to the stated goals."

The Task Force indicated that over the period 1964 to 1979, the total personnel at the National Defence Headquarters were reduced from 7,747 (3,261 military, 4,486 civilian) to 7,400 (3,083 military, 4,317 civilian) or by 4.5 per cent of the 1964 total. However, it was concluded that it was questionable whether this decrease could be attributed solely to unification when during the same period the overall reduction of military personnel in the forces was 34 per cent and of civilian personnel, 20 per cent. Due to changes in structures and functions over the period considered, the Task Force also found that it was impossible to identify the aggregate savings that may be attributable solely to unification.

It was concluded by the Task Force that the Canadian Forces had performed extremely well with regard to the fulfilment and achievements of the tasks they have undertaken but it observed that "operational land units are undermanned, aircraft are in reserve because of financial restraints and ships have been placed in reserve because of the manpower shortage".

No conclusive evidence was found to show whether or not the goal or swifter decision making or swifter reaction capability had been achieved.

Increased flexibility in the employment of support personnel was found to have been achieved but with a loss in efficiency since cross-environmental postings for support personnel required additional on-job training to achieve effectiveness.

It was observed that concessions had been made to unit and environmental identity by the approval of badges and insignia to be worn on the common green uniform. This process had allowed distinctive identity down to the unit level of the Army while for the Navy, Air Force and members of the support services, the need for identity with the environment, branch, or trade/classification had not been satisfied by the concessions.

The Task Force indicated that unification had enhanced career opportunities for support personnel but not for operational personnel. There was a clear orientation of the support services away from their prime objective of support to the operational forces. Also, there had been an adverse effect on the field/static and sea/shore ratios in the Army and Navy.

TASK FORCE CONCLUSIONS AND RECOMMENDATIONS

In addition to the general "Review of Goals of Unification" the Task Force made specific comments on particular aspects of the unified force identified as problems.

The Support Services

* **Conclusions**

The lack of emphasis on environmental training for members of the support services trades and classifications has produced personnel without the necessary environmental knowledge to perform adequately under operational conditions.

Preoccupation with solving problems of branch identity amongst communications, logistics, administrative and engineering personnel has led to a loss of operational orientation.

There is a lack of flexibility in the supply system to provide first-line support for field units.

* **Recommendations**

The common central support systems be retained.

Support services personnel rotate between the central systems and their particular environment.

Direction be given to address the recognized inadequacies in the supply system including organization, depot locations, system/component relationships and first-line support to field units.

Personnel System

* **Conclusions**

Cross-posting of personnel between environments is detrimental to the efficiency of operational units. Unless it occurs voluntarily, it can result in a dissatisfied serviceman.

Promotion as an inducement to accept an undesirable posting has caused much resentment. Equal opportunity for promotion has created an imbalance between operational and support personnel.

The common rank structure has created rank distortions in the Army and Air Force. It has also created superfluous ranks in the Navy and a junior leadership problem for the Army. The association of rank with trade skills has diluted the authority of leadership of non-commissioned officers.

The unsatisfactory sea/shore or field/static ratio has adversely affected the conditions of service for operational personnel.

Unit leadership has been adversely affected by the orientation of the career management system towards individuals as opposed to the collective needs of units.

* **Recommendations**

Cross-postings between environments be used only for volunteers or to meet special personnel requirements.

Offering promotions as an inducement to personnel to accept undesirable postings be avoided.

The rank structure for non-commissioned officers be re-examined.

The existing study of the separation of rank and trade skill be accorded a high priority.

A more balanced sea/shore and field/static ratio be developed for Navy and Army operations personnel.

Greater reliance be placed on the formal lines of authority within the chain of command between the central personnel system and the unit commanders.

Training

* **Conclusions**

Environmental training, indoctrination and socialization processes are not sufficiently emphasized in recruit training.

Support services personnel receive inadequate environmental training prior to serving with combat units.

Collective operational training at the sub-unit, unit and formation levels has been degraded by support inadequacies, priorities which have been placed on individual training, and lack of resources.

* **Recommendations**

Sea, land and air operational trades personnel undergo environmental training and socialization during both recruit and trades training.

Environmental training take advantage where practicable of existing common training facilities such as Cornwallis, St Jean, Borden and Chilliwack.

Greater emphasis be placed on environmental training for support services personnel.

Greater priority be given to collective training.

Recruiting

* **Conclusions**

The unified Canadian Forces recruiting system does not allow applicants for the support trades to join an environment of their choice.

Applicants misunderstand the trade reassignment possibilities.

* **Recommendation**

The Canadian Forces continue with common recruiting by trade but with greater attention to environmental preferences.

Base Concept

* **Conclusions**

The base concept, as the focus of activity under the principle of centralized administration of resources, is in contradiction with the traditional principle of unity of command.

Bases are unable to give adequate support to Army operational units.

* **Recommendations**

More flexibility be exercised in the application of the base concept for the Army in such matters as personnel administration, pay and social services.

More resources be devoted to the solution of the "double-hatting" problem of the Army service battalions.

Further consideration be given to the departmental study evaluating the Canadian Forces base system.

Mobilization

* **Conclusions**

The Task Force recognized that low priority had been given to augmentation plans.

There is no doubt as to the ability of the training system, the common recruiting system and the unified structure to cope with augmentation/mobilization.

Current defence policy does not included a mobilization plan.

* **Recommendations**

The highest priority be given to the subject of mobilization planning.

The current National Defence Headquarters study on mobilization deal with all of the problems previously defined including those aspects that go beyond augmentation: the organizational structure of the Reserve Force, the viability of a common training structure, and the ability of a unified structure to respond mobilization.

Command and Control

* **Conclusions**

There is a lack of environmental input into the decision making process at the senior National Defence Headquarters level.

There are too many sources of direction to commands, bases and units.

There is a lack of environmental direction to the National Defence Headquarters central systems.

* **Recommendations**

As an urgent priority, Commanders of Commands be made members of the Defence Council and the Defence Management Committee and that measures be taken to ensure their influence is fully recognized pertaining to operations, training, personnel administration and support to the operational forces.

If the above recommendations proved to be insufficient to solve the problems identified by the Task Force, it was further recommended that three environmental Heads of Service be re-established at the National Defence Headquarters to be responsible to the Chief of the Defence Staff for the command of the Navy, Army and Air Force.

Identity

*** Conclusions**

Although the common green uniform may have contributed to a better understanding of some of the problems within the Canadian Forces, it does not meet the need for further identity.

If given the choice, all three environments would insist on a separate environmental identity. The Army's requirements for identity have been met to a great extent with the changes that have been made to the green uniform. Naval personnel have a need for further identity through a dark blue uniform. Air Force personnel to a lesser degree require increased environmental identity.

The Task Force concluded that support service personnel needed increased identity. However, they were unable to assess whether or not the support services be considered as a fourth force, be attached to one of the three environments, or be divided among the three services.

In all cases, there is a requirement for identity at the unit, ship or squadron level and there is a requirement across the Canadian Forces for increased trade identification. There is a need to recognize throughout the Canadian Forces, the rank nomenclature for naval personnel. There is a need for rank insignia on an environmental basis, except for some classifications such as chaplains and legal.

*** Recommendations**

Further identification be provided in the Canadian Forces for environment, ship, squadron, unit and trade.

Rank nomenclature for naval personnel be recognized throughout the Forces.

The Army retain the green uniform. Naval personnel be allowed to select and wear a dark blue walking out uniform as soon as possible. Air Force personnel be allowed to select and wear a light blue uniform. Any uniform modification take into account the overriding principle that uniforms be distinctively Canadian.

The need for further support services identity be the subject of further study.

The retention of the green uniform, in the context of the above recommendation, include a complete, rationalized system of identification by environment, unit, rank and trade to be developed and applied by the Department of National Defence in a controlled manner.

CONCLUSIONS

The Fyffe Task Force was dubious about the achievement of the intended goals of unification of the Canadian Forces. It also identified problems within the unified organization, but did not advocate any overall structural change. Indications from the Canadian Government are that they will maintain the present unified structure of the Canadian Forces though with changes based on the recommendations of the Task Force.

The major structural concerns of the Task Force with the present organization were the lack of adequate environmental influence at the centre, a blurred chain of command from the centre to the units and bases, and a conflict in the allocation of resources between the centralized administration of bases and the requirements of operational units.

The key command and control recommendation of the Task Force was the urgent need to strengthen the environmental influence at the highest decision making level of the National Defence Headquarters, with the possible re-establishment of three environmental Heads of Service within the Headquarters.

Since its inception, the unification of the Canadian Forces has been questioned, and the very existence of the Fyffe Task Force shows that concern about the viability and efficacy of unification still remains. The Task Force indicated that the Canadian experience of unification was inconclusive and their report will provide evidence for both sides of the argument. The continuing but evolving existence of the unified Canadian Forces demonstrates the Canadian Government's confidence in the viability of unification but does not necessarily confirm its efficacy. Alternatively, advocates of non-unified defence organizations should be demonstrating real progress in their economy and operational efectiveness, and that their diversity does lead to vitality, mutual tolerance and co-operation.

ESTIMATING THE UNMEASURABLE BY MEASURING THE MEASURABLE - REGRESSION ANALYSIS, A TOOL FOR POLICY-LEVEL DECISION-MAKERS

By Wing Commander K. Goody, BSc, Dip Ed, AFIBA, MIIE, psc, RAAF.

INTRODUCTION

PROFESSOR E. S. QUADE, in writing on *'Analysis for Public Decisions'*, defines policy analysis as 'any type of analysis that generates and presents information in such a way as to improve the basis for policy-makers to exercise their judgment'.[1] Elaborating on his definition, Quade continues with: 'Some policy analyses are informal, involving nothing more than hard and careful thinking whereas others require extensive data gathering and elaborate calculation employing sophisticated mathematical processes.'[2] The range of such mathematical processes is extensive, many of them becoming practical only with the advent of efficient digital computers. Included among them is a direct and powerful approach to the effective formulation and solution of a wide variety of . . . problems',[3] known variously as regression analysis, multiple linear regression, and linear mathematical modelling.

Quantitative techniques are by no means a panacea for decision-making. Quade issues the following warning:

> 'We have not been and never will be able to make policy analysis a pure rational, coldly objective, scientific aid to decision-making that will neatly lay bare the solution to every problem to which it is applied. There are always considerations that cannot be handled quantitatively, maybe not analytically, and there may be problems with no solution. In the end, politics and intuitive judgment must rule.'[4]

This warning is no exhortation to avoid using policy analysis in general and, implicitly, quantitative techniques in particular. Indeed, Quade goes on to say:

> 'Nevertheless policy analysis can be a splendid tool to help in the making of . . . decisions, but there must be decision-makers who appreciate its limitations and who know what to expect from it. Unfortunately, many managers do not yet appreciate how policy analysis can help them'.[5]

An excellent appreciation for the limitations and capabilities of policy analysis as a macrocosm can be gained by studying Quade's

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Wing Commander Goody joined the RAAF in 1966 as an Education Officer. After postings to RAAF School of Technical Training, Headquarters Support Command and Base Squadron East Sale, he spent 1975-76 as an exchange officer with the United States Air Force. During this period he worked as a Behavioural Scientist with the Occupation and Manpower Research Division of the Air Force Human Resources Laboratory. On return to Australia he served two years in Computing Services Division and then completed RAAF Staff Course. His current appointment is as Director of Information Requirements in Defence Information Services Branch.

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book. He does not, however, address many individual quantitative techniques in detail, one of his reasons being that 'there are many fine textbooks that do'.[6]

Perhaps texts suitable for managerial consumption do exist on operations research, microeconomics, decision theory, and so on, but regression analysis tends to be imbedded within relatively technical statistics texts which are of more use to analysts than to policy-level decision-makers. Monograms and professional journal articles do exist on various aspects of the applications of regression analysis, but again they are directed more towards the analyst.[7] What seems to be missing is a short treatise, written in non-technical language, that will convey to policy-level decision-makers an appreciation for the power of regression analysis along with its limitations. This article seeks to redress this deficiency. It will succeed to the extent that it enables the reader to recognize when regression analysis may help, and to interpret the results of such analysis.

The power of regression analysis as a problem-solving tool can best be communicated by discussing a variety of problems to which it has been applied, but such examples can be appreciated only after the concept of the regression equation has been established. This article will therefore be presented in two complementary segments. The first will be devoted to a description of the regression equation and a discussion of some key considerations pertinent to its derivation and interpretation. Having established this foundation, a selection of suitably illustrative applications of regression analysis will then be presented. Those technical terms that must be used for clarity and brevity will be explained as they arise.

THE REGRESSION EQUATION

From Data-Points to Regression Equation

The aim of regression analysis is to compute an approximate mathematical equation relating a variable of interest (known as the 'criterion' or the 'dependent variable') to one or more other variables (called 'predictors' or 'independent variables') when the true mathematical relationship is unknown, extremely complex, or non-existent. By way of illustration, regression analysis could be used to compute an equation for predicting the adult height of a 5-year-old boy from three predictors, namely his present height and the heights of each of his parents. This is an example where the true mathematical relationship does not exist, but the approximate relationship computed by regression analysis could be used to provide an estimate of the boy's adult height, albeit an approximate estimation. The equation would take the form

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3$$

where Y is the estimate of the boy's adult height (the criterion) and X_1, X_2 and X_3 are the predictors (his present height, his father's height and his mother's height). The constants a_0, a_1, a_2 and a_3 are called 'regression coefficients' and, once they have been determined, the adult height of any 5-year-old boy can be estimated by measuring his present height and the heights of his parents.

The regression coefficients are determined by gathering data which is fed into a computer program.[8] On the basis of the data provided, the computer calculates appropriate values of the regression coefficients (a_0, a_1, a_2 and a_3), thus completely specifying the equation which can then be used to estimate the adult height of any 5-year-old boy (subject, of course, to the limitations of the linear mathematical model). To gather the required data in this example, a sample of typical 5-year-old boys would be selected and their heights and the heights of their parents would be recorded. Some years later their adult heights would be measured thus giving, for each person in the sample, a set of four measures (his adult height, his height when he was five years of age, his father's height and his mother's height). Each such set of four measures is called a 'data-point'.[9] In general a data-point is a set of values for all the variables involved in the problem, one value for each predictor plus a value of the criterion known to relate to that particular combination of the values of the predictors. Data-points are required for input to the computer program which uses them to compute the regression coefficients for the 'equation of best fit' to the data. The equation so derived can then be applied to any combinations of the values of the predictors to estimate the value of the dependent variable (criterion) that corresponds to that particular combination of values of the predictors.

Precision of Estimates Made Using the Regression Equation

Note that the equation the computer program calculates from the data-points is called the 'equation of best fit'. This implies, and is meant to imply, that estimates of the dependent variable (criterion) made using the equation are indeed estimates, and they must be accepted as approximations of the true values which are usually unknown at the time the equation is applied. The manager who must make decisions on the basis of the analysis needs some measure of the precision of such estimates. Some indication of the accuracy of such estimates can be obtained by studying how well the equation fits the data-points from which it was computed. If the equation were applied to the predictor values in each data-point, and if the fit of the equation was perfect, then the estimate of the criterion so computed would be exactly equal to the actual value of the criterion for that data-point. This, of course, is rarely the case. Consider the example of predicting the adult heights of 5-year-old boys. Should the values of the predictors (height at five years of age and parents' heights) for any one of the people in the sample be substituted in the equation, the estimate of his adult height so obtained would probably differ from his actual adult height as measured. The difference, or 'deviation', would generally be small, but occasionally it would be quite large: while tall parents usually have tall sons, sometimes they have quite short sons.[10] The equation of best fit computed during regression analysis is the one that minimizes these differences between the actual values of the criterion and the estimates of it that would be obtained by applying the regression equation to the predictors for each data-point.[11] The measure usually provided to indicate how well the computed equation fits the data-points is known as the 'correlation coefficient'. It is automatically computed by the program that calculates the regression coefficients for the equation of best fit.

A feel for the nature of the correlation coefficient can be obtained by considering the situation where there are only two variables involved, a criterion and one predictor. This has the advantage that the complete situation can be depicted pictorially in the form of a graph. Figure 1 presents six examples of possible relationships between a predictor (X) and a criterion (Y). In each case there are 35 data-points, each of which is represented by a dot on the graph. Such a display is called a 'scattergram'. Each graph includes the line that represents the equation of best fit as computed by regression analysis. The actual equation in algebraic form, and the value of the correlation coefficient (represented by the symbol 'R') have also been added to the diagram.

a. Figure 1(a) and 1(b) represent correlation coefficients of + 1.0 and -1.0 respectively. All data-points lie exactly on the line of best fit. Correlation coefficients of + 1.0 and -1.0 therefore represent perfect fit, the negative sign merely indicating an inverse relationship in that as the predictor (X) is increasing the criterion (Y) is decreasing.

b. More typical of what occurs in practice are Figure 1(c) and 1(d). The correlation coefficients have been computed as + 0.93 and -0.93 respectively, the negative sign again indicating an inverse relationship between the two variables. The fit of the equation to the data-points is good, but not perfect.

c. As the goodness of fit of the regression equation to the data-points deteriorates, the correlation coefficient (R) moves closer to zero. Figure 1(e) and 1(f) illustrate correlation coefficients of, respectively, +0.43 and zero. The zero correlation represents the worst possible situation where there is no relationship between the two variables.

The correlation coefficient (R) is therefore a number somewhere between -1.0 and + 1.0 (both inclusive), the further it is from zero the better the fit of the regression equation to the data-points. When there are only two variables involved, the criterion and one predictor, we also refer to the correlation coefficient as the 'correlation between the two variables'.

When the number of predictors exceeds one it is not possible to display all the data contained in the data-points on a simple

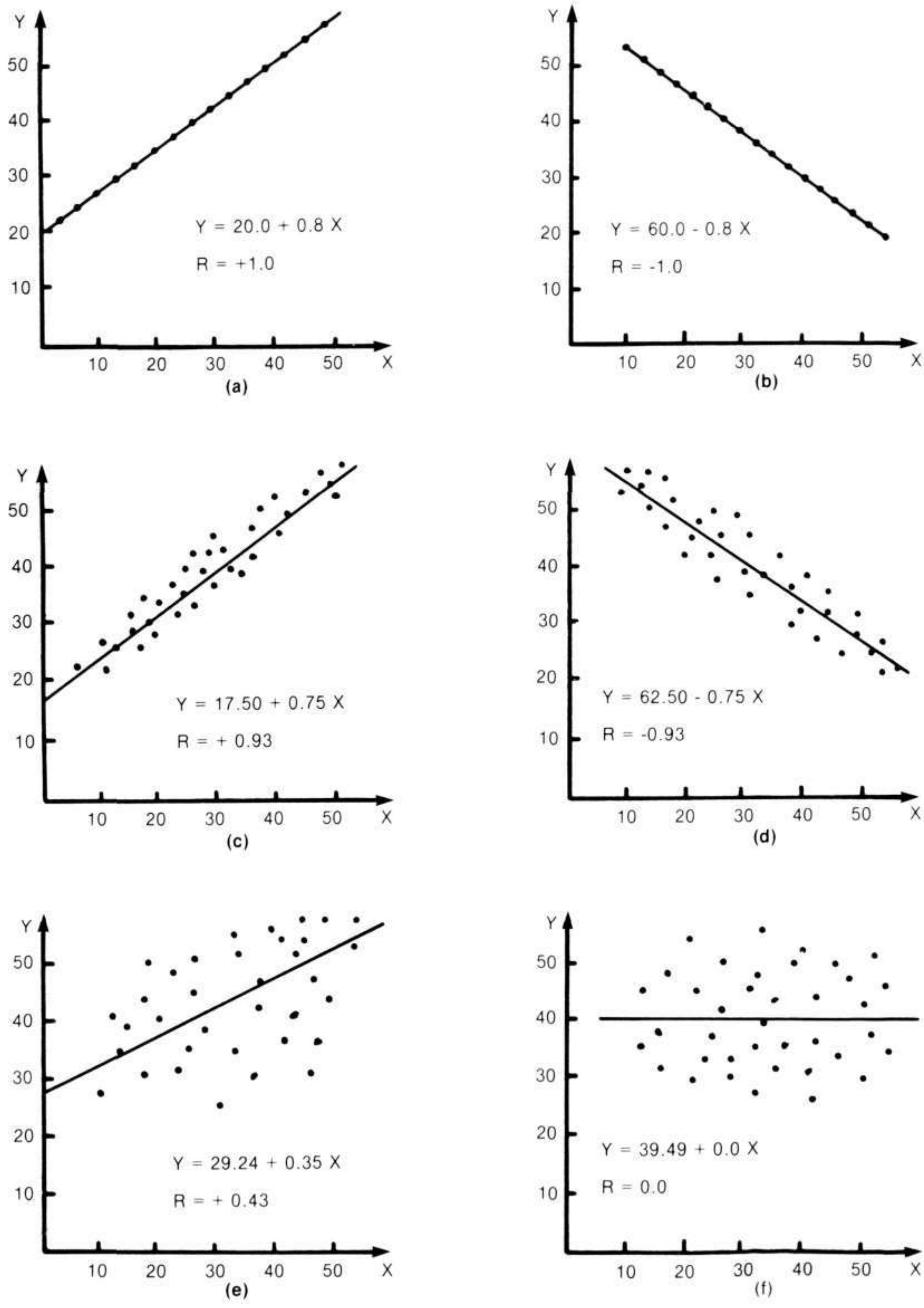


Figure 1. Six Examples of Possible Relationships Between Two Variables.

scattergram, nor can the regression equation be represented by a straight line on a two dimensional graph. None the less, the measure of the degree to which the computed regression equation fits the data-points is still a correlation coefficient, sometimes referred to as the 'multiple correlation coefficient' or as the 'multiple-R'. The relationship between a multiple-R and the simple correlation coefficient discussed in the previous paragraph can be illustrated by means of a simple, hypothetical example. The columns to the left of Table 1 present 10 data-points for two predictors (X_1 and X_2) and a criterion (Y).

	Criterion (Dependent Variable)	Predictors (Independent (Variables)		Estimates of Y (Computed from the Regression Equation)
	Y	X_1	X_2	Y′
Data-point 1	10	2	4	13.499
Data-point 2	10	1	6	14.378
Data-point 3	25	4	7	30.304
Data-point 4	35	8	2	34.743
Data-point 5	30	3	8	28.531
Data-point 6	25	1	9	22.333
Data-point 7	25	5	2	21.469
Data-point 8	35	7	4	35.622
Data-point 9	25	2	6	18.802
Data-point 10	30	7	2	30.319

$Y = -5.959 + 4.325\,X_1 + 2.652\,X_2$
$R = +0.91$

Table 1. Data Points and Criterion Estimates for Hypothetical Multiple Regression Problem

Regression analysis was applied to compute the equation of best fit for estimating Y from X_1 and X_2. The equation is

$$Y = -5.959 + 4.425\,X_1 + 2.652\,X_2$$

and the value of the multiple-R is +0.91. The column to the right of Table 1 contains the estimated values of Y obtained by applying the regression equation to the predictor variables in each of the data-points (eg, the value of 13.499 for the first data-point is equal to -5.959 + 4.425 x 2 + 2.652 x 4). This variable has been given the symbol Y′ to distinguish it from the actual values of the criterion (Y). There is no reason why we cannot now draw a scattergram showing the relationship between Y and Y′. This has been done in Figure 2, and the line of best fit to the points on the scattergram has been included. The line of best fit (Y = Y′) simply indicates that Y′ is the best estimate of Y. This is logical as Y′ was computed by applying the regression equation that was derived to produce the best estimates of Y. Note that the correlation between Y and Y′ (R = +0.91) is exactly the same as the multiple-R calculated by the original regression analysis. This is no accident: the multiple-R is indeed the correlation between the actual values of the criterion and the estimates of it obtained by applying the regression equation to the values of the predictors in the data-points. Further, the line of best fit relating Y to Y′ must always be as drawn in Figure 2. That is, there is no possibility of an inverse relationship and so multiple correlation coefficients must always be positive.[12]

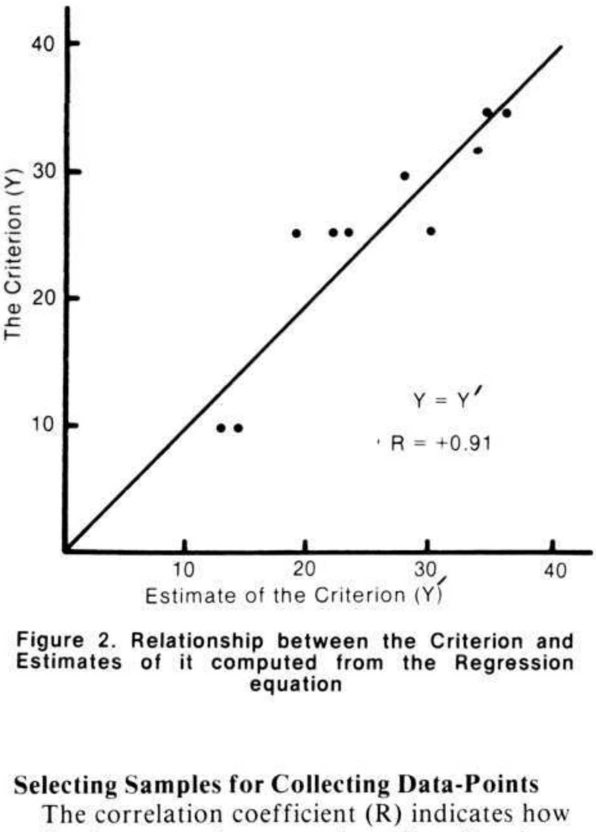


Figure 2. Relationship between the Criterion and Estimates of it computed from the Regression equation

Selecting Samples for Collecting Data-Points

The correlation coefficient (R) indicates how well the regression equation fits the data-points. How well it fits the 'population' depends also on the degree to which the data-points represent the population. In this context, population is used not with its normal geographic connotations but rather in its statistical sense where it refers to the 'total group of items under consideration'.[13] Provided that the data-points are a good representation of the population, the correlation coefficient is also a measure of the precision with which the regression equation can be applied to other data to estimate unknown values of the criterion.

To be representative of the population the sample of data-points must be free from bias. Deliberate bias, the result of the investigator's deliberately selecting a sample that will support his case, is relatively rare because when it occurs it is generally fairly evident. The infiltration of bias is usually a more subtle process. For example, in the previously cited model for predicting the adult heights of 5-year-old boys, the data-points could be obtained by selecting a sample of men for whom records exist of their heights when they were five years of age (and for whom it is possible to obtain their parents' heights). This would result in a biased sample if there is anything special about such a group that could affect their heights. Could it be, for example, that men whose records are available have been better cared for on the average and that in turn has caused them to tend to be taller? Such subtle bias often stems from selecting the more readily available data-points for the sample.[14] A typical example would be to draw a sample from only one military establishment or operating environment when the model is intended to apply throughout the Service. There is a definite potential for bias when the subjects are people if the investigator simply calls for volunteers or, worse still, asks the local management to provide 'people who can be spared'.

Perhaps it is impossible to eliminate all possible potential for bias. What is crucial is that the investigator records how the sample was selected and notes any obvious potential for bias. Furthermore, conclusions drawn on the basis of the regression model should be restricted to the population that the sample actually represents. If the model is extrapolated to other populations, due caution must be exercised. To again cite the model for predicting the adult heights of 5-year-old boys, if the data-points for deriving the equation were drawn entirely from Australians, the derived equation should not be applied to, for example, a Japanese boy. Particular care should be exercised when applying a regression equation when the value of any predictor falls well outside the range of values of that predictor in the data-points from which the equation was derived.

Several techniques exist for selecting samples which represent the population. If an ordered list exists or can be made of all items in the population (such as a nominal roll of all officers in the RAAF or a list of all spares associated with a particular weapon system), and if for example the size of sample required is about 10 per cent of the population, then the sample could be drawn by selecting each tenth item on the list. Random sampling is often used to obtain a satisfactory sample. 'The best definition of random sampling is that it is selection of cases from the population in such a manner that every individual in the population has an equal chance of being chosen. The selection of any one individual is also in no way tied to the selection of any other.'[15] Where there are known differences among the members of the population, better representation can be obtained by drawing a stratified sample. For example, if the population under consideration is all RAAF officers the prudent investigator will ensure that the proportions of officers from the respective branches are the same for the sample and the population.

Another consideration in selecting the sample of data-points is the size of the sample. Generally, the larger the sample the better it represents the population. Further, small samples associated with large numbers of predictors introduce a very important technical consideration sometimes known as 'over-fitting'. To illustrate over-fitting in its most obvious form, consider the situation when only two data-points are being used to derive an equation for predicting a criterion from one predictor. Regardless of whether or not there is any true relationship between the two variables, the equation derived will be a perfect fit because a straight line can always be drawn to pass through any two points on a graph. Mathematicians can show that a similar, and equally useless, perfect fit can be obtained using 99 predictors when there are only 100 data-points or, for that matter, in any situation where the number of data-points is only one more than the number of predictors. Correlation coefficients will always be spuriously high when the number of data points is not large relative to the number of predictors, and decision-makers should be particularly wary of giving too much credence to the results of such regression models.

An investigator can demonstrate that his sampling technique is satisfactory by conducting a 'cross-validation' test. Cross-validation can also be used whenever there is doubt about the utility of a regression model for making estimates of the criterion. To apply cross-validation, two samples are drawn instead of one. The regression equation is derived from one of the samples, and it is then applied to determine how well it fits the data-points in the second sample. If the correlation between the actual and estimated values of the criterion in the second sample is essentially the same as the multiple-R obtained while deriving the equation from the data-points in the first sample, then the cross-validation is said to 'hold-up' and the equation can be used with the degree of confidence the magnitude of the multiple-R suggests. On the other hand, a significantly lower correlation indicates that the equation has been derived by over-fitting and that it should be used with extreme caution.

The Nature of the Predictors

The primary product of regression analysis is a mathematical equation that expresses the dependent variable (criterion) as a linear function of independent variables (predictors). This simply means that the equation must be expressible in the form.

$$Y = a_0 + a_1X_1 + a_2X_2 + \dots + a_nX_n$$

where Y represents the criterion and X_1, X_2, . . ., X_n represent predictors. 'This restriction is more apparent than real.'[16] The analyst actually has considerable flexibility in selecting the form of the predictors, and much of the power of regression analysis flows from this flexibility. A predictor may be in the form of a measure in the sense of some 'size or quantity found by measuring',[17] but not necessarily so. Other possibilities for predictors are mathematical transformations of such measures, or numerical scores representing some qualitative property.

When some measure is thought to have a curvilinear relationship with the criterion, the curvilinear effect can be captured by including one or more transformations of the measure as predictors in the linear model. To illustrate, a scattergram for nine data-points involving a criterion (Y) and a measure of some kind (x) is presented in Figure 3(a). The line of best fit, the regression equation in algebraic form and the correlation coefficient (R = 0.690, a modest fit) have been included. Figure 3(b) represents a linear model which provides an almost perfect fit (R = 0.994) for the same data. Two predic-

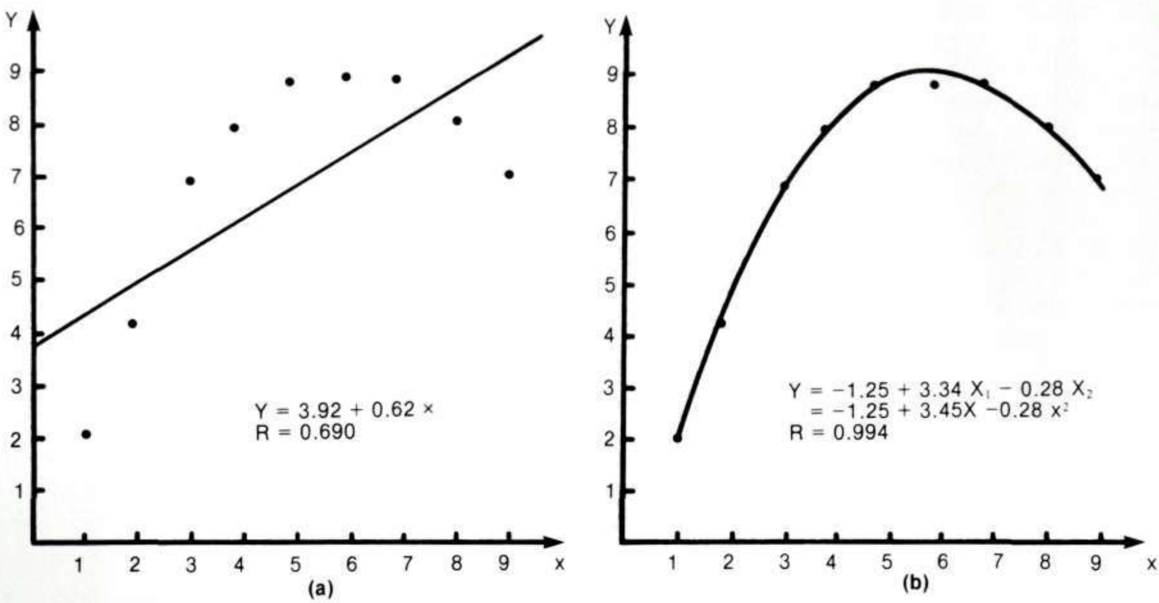


Figure 3. Fitting a Linear Model to Curvilinear Data

tors are used: the first (X_1) is simply equal to x while the second (X_2) is the square of x. Each data-point is therefore expanded to contain three values; for example, the point on the extreme right of the graph changes from [Y = 7, x = 9] to [Y = 7, X_1 = 9, X_2 = 81]. Standard regression analysis then determines that

$$Y = -1.25 + 3.34\,X_1 - 0.28\,X_2$$

is the two-predictor equation of best fit, and the familiar quadratic form of

$$Y = -1.25 + 3.34\,x - 0.28\,x^2$$

is obtained by substitution the respective derivatives of x for X_1 and X_2. Differently shaped curves can be approximated to by using higher order polynomials (ie, by also including x^3, x^4, . . . as predictors). Other transformations such as logarithmic and trigonometric functions may also be used.

Two previously issued warnings, specifically over-fitting and extrapolation, have particular significance when fitting polynomials, or for that matter any curvilinear functions. Each extra power term added to the model is a predictor in every sense and small numbers of data points can very easily lead to over-fitting. A perfect fit can be obtained to any set of data-points by using enough power terms (one less than the number of data-points), and spuriously high multiple-Rs are obtained if too few data-points are used. Concerning extrapolation, the regression equation is computed to provide the best possible fit to the data provided and it should therefore be applied only to the range of values represented in the data points. In striving for a better fit within the range of data supplied the regression equation can adopt a form which gives meaningless shapes when projected beyond that range, the higher the powers used the more dramatic and ridiculous can be the shapes generated beyond the valid range. Decision-makers must therefore be very cautious in interpreting curvilinear functions based on few data points and in extrapolating beyond the range of data represented in the sample.

As will become evident when illustrative applications of regression analysis are being discussed later in this article, many properties used as predictors in regression equations are essentially qualitative in nature and cannot be measured in normal size or quantity terms. None the less, their use as predictors in regression analysis is quite valid. This is achieved by quantifying the qualitative property in some systematic fashion. When the qualitative property is a dichotomy, a binary variable ('1' or '0') is used to differentiate between the two states of the property. A binary variable in this sense is one that must be equal to either '1' or '0'; it cannot have any other value. When the requirement is to quantify the degree to which some abstract qualitative concept exists, ratings or rankings can be used.

Binary predictors are used to represent qualities for which there are only two, mutually exclusive possibilities. Typical examples are male/female, Serviceman/civilian and Mirage IIIO/Mirage IIID. One of the alternatives is arbitrarily assigned a value of '1' and the other a value of '0'. For example, to include the subjects' sex in the regression model, the predictor would be given the value '1' for males and '0' for females, or vice versa. Another use of binary predictors is to indicate the presence or absence of some attribute. Thus, the existence of tertiary qualifications could be represented by setting the predictor equal to '1' if the subject has tertiary qualifications, and to '0' otherwise. A binary predictor could similarly be used to indicate whether or not an aircraft had undergone a major servicing during a specified period. When the analyst's concern is restricted to whether or not some normally measurable variable falls within a predetermined range, a binary predictor is of more value than the actual measured values of the variable. If, for example, there was a need to identify those aircraft missions that exceeded, say, four hours, then a binary predictor would be used. Binary predictors are also used to include categorical information when there are more than two categories. In a tri-Service investigation, for example, there may be a requirement to distinguish among Navy, Army and Air Force. As illustrated in Table 2, three separate predictors (X_1, X_2 and X_3) would be generated, each indicating membership or otherwise of one of the Services. In the example in Table 2, Data-points 1 and 4 are from Navy, Data-points 3 and 5 are from Army, and Data-point 2 is from Air Force.

	X_1	X_2	X_3
Data-point 1	1	0	0
Data-point 2	0	0	1
Data-point 3	0	1	0
Data-point 4	1	0	0
Data-point 5	0	1	0

X_1 = 1 if a member of the Navy, 0 otherwise
X_2 = 1 if a member of the Army, 0 otherwise
X_3 = 1 if a member of the Air Force, 0 otherwise

Table 2. Use of Three Binary Predictors to Distinguish Among the Three Services

Many qualitative properties that are required as predictors in regression analysis occur in varying degrees among the items of the population. For example, in the USAF Officer Grade Requirements study discussed later as an example of regression analysis, there was a need to measure the degree to which individual USAF jobs involved factors such as communications skills, judgment and decision-making, and risk.[18] That is, there was a need to assign a score to each job for each factor so that a low score signified that a job was not very demanding on that factor and a high score signified it was very demanding. Such qualitative factors can be quantified by having an expert judge assign each item a score relative to a numeric scale provided. Better still, a number of judges can rate each item and the average rating on each item can be used as the quantitative value for the qualitative factor. This was indeed done for the USAF Officer Grade Requirements study. Such group ratings are used extensively in personnel and occupational studies, and sophisticated techniques have been developed to analyse the judgement of individual judges and to measure the reliability of the scores derived.[19,20,21]

Rather than have the judges provide measures of qualitative concepts by rating each item against a numeric scale, they could be required to rank-order all the items being used according to the degree they exhibit the factor under consideration. This is referred to as ranking, and it can give results suitable for use as predictors in regression analysis. For example, if 100 jobs were to be rank-ordered on degree of risk involved, the safest job would be ranked '1', the second safest '2', and so on until the most dangerous job which would be ranked '100'. As with ratings, rankings can be averaged over a number of judges. While rankings provide a convenient medium for quantifying qualitative concepts, providing them can be quite onorous on the judges if several items are to be ranked. Further, subtle mathematical problems can arise because to the distribution of the scored obtained. Using the rank-ordering of 100 jobs on degree of risk to illustrate, rankings assume that the difference in degree of risk between the 49th and 50th job is the same as the difference between the 99th and 100th, whereas one would intuitively suspect that the difference in degree of risk between successive jobs would be less near the middle of the distribution than it is out at the extremes.[22]

Further Considerations in Fitting and Interpreting Regression Equations

We have now discussed the concept of a regression equation derived from data-points and of correlation coefficients as measures of goodness of fit. The need for the methods of avoiding bias in selecting samples to gather the data-points have been discussed, along with the concepts of over-fitting and cross-validation. Further, we have seen that curvilinear relationships can be fitted using polynomials or other mathematical transformations, and that qualitative concepts can be quantified and used as predictors. Before going on to discuss a selection of illustrative applications of regression analysis, however, a few general considerations in fitting and interpreting regression equations must be addressed. For example, how complex should the regression model be? Is there a trade-off between simplicity and goodness of fit? What tools are available to help select the best set of predictors? Are there any restrictions on what predictors can be included in the same equation? Finally, just what does it mean when regression analysis indicates that there is a useful relationship between a predictor and the criterion?

Figure 3 illustrates how increasing the complexity of the regression model dramatically improves the fit of the equation to the data-points. The analyst must decide, however, what degree of complexity is acceptable in striving for higher multiple-Rs. Certainly he must be wary of over-fitting, but 'questions of convenience and simplicity should also be considered.'[23] The more complex the model the harder it is to apply and interpret. Statistical tests exist which will indicate whether or not adding further predictors significantly improves the fit of the equation, and such tests are important. However, it is perhaps more important to decide on 'what degree of variability about the regression model [goodness of fit or multiple-R] is acceptible, and this decision will be based on practical rather than statistical considerations.'[24] In the final analysis, 'the number of variables to include in a multiple regression, or the degree of polynomial to be applied, is to some extent a matter for judgment and convenience.'[25]

Another aspect of simplicity of the regression model is the precision with which the regression coefficients are stated, and this also depends on the ultimate use of the model. If the purpose is solely to compute estimates of the criterion, and the equation will be applied by a computer, then the coefficients as derived should be used (expressed to a suitable number of decimal places). However, if the relative weightings to be applied to the various factors are to be visible to management or if the equation is to be applied without the aid of a computer or a powerful calculator, there may be a case for rounding-off the regression coefficients to more convenient values. 'It can be shown that we may substitute weights that approximate the regression coefficients, even very roughly at times, and still not affect the degree of correlation very much.'[26] By way of illustration, should the equation derived for the data in Table 1 be simplified from

$$Y = -5.959 + 4.325 X_1 + 2.652 X_2 \text{ to}$$
$$Y = -6 + 4 X_1 + 3 X_2$$

the correlation between the actual values of the criterion and the estimates of it obtained by applying the simplified equation is 0.89. For many applications this may be considered close enough to the multiple-R of 0.91 for the exact equation of best fit. Whether or not a rounded-off equation is adequate is a matter for judgment in each instance, but if the regression coefficients are rounded-off the decision should be documented, including the reduction in predictive efficiency.

Having decided that the number of predictors to include in the regression model must be the optimum blend of simplicity and predictive efficiency, how do we determine which predictors to use? Once the analyst has decided on the pool of all the predictors he wishes to consider, including any mathematical transformation of primary predictors, a number of techniques are available to supplement his judgment and intuition.[27] Among the most useful and convenient are the step-wise techniques which select 'the best predictor from a nominated group of predictors, and then progressively [add] predictors one at a time in such a way as to maximize the improvement in prediction at each step.'[28] Each step is usually printed, including the new multiple-R and improvement in multiple-R, so that the analyst can decide which is the best model. Sometimes the step-wise technique is reversed in that the first step includes all predictors and one is dropped at each step in such a way that the loss in predictive efficiency is minimized.

There is a very important restriction on which predictors can be included in any particular regression equation, namely that 'no one variable should be expressible as a linear combination of the others.'[29] In one of the illustrative studies which are discussed later,[30] for example, the suitability of different university degrees for training for service in various USAF utilization fields was being predicted from, *inter alia*, the numbers of semester hours in various subject areas. Among the predictors considered were the numbers of semester hours in calculus (X_1) in probability and statistics (X_2) and in other mathematics (X_3). Also considered was the total number of semester hours in mathematics (X_4) but these four predictors could never be all included in the same equation because each can be expressed as a linear combination of the other three (eg, $X_4 = X_1 + X_2 + X_3$; $X_2 = X_4 - X_1 - X_3$; etc). Ignoring this requirement for linear independence will either cause the computation to fail or give meaningless results depending on the method of computation used. Many multiple-regression programs therefore check for linear dependencies before proceeding with the computation. A type of linear dependency easily overlooked occurs when binary predictors have been used to represent categorical information and all possible categories are included. In the example of Navy, Army and Air Force presented in Table 2, assuming there are no other possibilities such as civilian, the three binary predictors (X_1, X_2 and X_3) are linearly dependent as each can be expressed as a linear combination of the other two ($X_1 = 1 - X_2 - X_3$; $X_2 = 1 - X_1 - X_3$; $X_3 = 1 - X_1 - X_2$). All three predictors could not, therefore, be included in the same regression equation.

As a final consideration pertinent to the interpretation of regression equations, the distinction must be made between a useful relationship and causation. By selecting the equation of best fit, regression analysis identifies a set of predictors that have a useful relationship with the criterion, and the equation can be used to estimate the value of the criterion for any combination of values of the predictors. However, the relationship between the predictors and the criterion does not need to be a cause-and-effect relationship. The predictors and the criterion may all be changing in response to something else, perhaps something not even considered for inclusion in the regression model. Regression analysis is used even when changes in the criterion actually cause the changes in the predictors. This is done when the criterion is difficult to measure and the predictors are relatively easy to measure. The regression equation is used to estimate the more elusive criterion in much the same way a doctor uses symptoms to diagnose an illness. Whatever the underlying cause-and-effect interactions, regression analysis detects the existence of relationships between the variables; what causes what is a matter for judgement, perhaps supported by further analysis.

ILLUSTRATIVE APPLICATIONS OF REGRESSION ANALYSIS

Selecting a Harem — An Introduction to Policy-Capturing

Now that the concept of the regression equation has been established, a feel for the applicability of regression analysis to managerial problems can be communicated through a brief discussion of a variety of illustrative applications. One type of application that should be of interest to policy-level decision-makers has to do with quantifying human judgement by expressing it in the form of a linear regression model. Data-points are gathered by noting the decision-maker's decisions and by measuring potential predictors; and from these data-points a regression equation is computed which duplicates the decision-maker's judgement. This regression equation can then be used whenever, for some reason or other, the decision-maker does not make the decisions personally. The decision-making strategy, or policy, of the decision-maker is captured in the form of a regression model, and this application of regression analysis is often called policy-capturing.

An excellent illustration of the policy-capturing model is contained in a fable created by Dr. Raymond E. Christal of the USAF

Human Resources Laboratory.[31] Apparently there was once an Oriental King who decided to 'select a harem larger than King Solomon's.'[32] Accordingly, thousands of candidates were assembled. 'Early one morning the King began his selection process. As each girl filed by, he looked her over very carefully and expressed his judgement.'[33] The Court Recorder quantified the degree of the King's approval by relating it to a 9-point scale. At the end of the day, with 300 candidates assessed, the King's 'eyes and . . . imagination were beginning to tire,'[34] so he delegated the assessment of the remaining 8000 candidates to the Most High First Counsellor. The task was immediately passed to the Chief of Royal Psychometricians who quantified the 'girly characteristics'[35] of the 300 candidates already processed. This gave him 300 data-points, with these girly characteristics as predictors and the King's expressed approval as the criterion, from which a regression equation was computed and applied to the remaining 8000 candidates. 'The King was very pleased with the results, and as a reward, he gave the Most High First Counsellor and the Chief of Royal Psychometricians their choice of the leftovers.'[36]

The fable of selecting a harem is cited here because it illustrates many of the points already made about fitting and using a regression equation. Data-points containing known values of the criterion were used to derive an equation for estimating unknown values of the criterion. A second-order polynomial (a quadratic as illustrated in Figure 3) was used for girly characteristics such as height; apparently the King preferred girls of medium height rather than very tall or very short ones. To include variables such as hair colour, each colour was represented by a binary predictor, similar predictors being used for eye colour. Combinations of hair and eye colour were included by using binary predictors; for example, one such variable was given the value '1' for blue-eyed blondes, '0' otherwise. Ratings by a board of judges were used as a predictor to include the extent to which each girl resembled the King's mother. As several heads would roll if the King was not satisfied, cross-validation was used to ensure over-fitting had not occurred. That is, the equation was derived using 150 of the data-points and then tested to ensure it also fitted the other 150 data-points. Having illustrated so many of the principles of regression analysis in the one hypothetical example, we can now consider more probable applications of policy-capturing.

Job Evaluation — Applied Policy-Capturing

Job evaluation is 'a systematic and orderly process of determining the worth of jobs in relation to other jobs',[37] but as the worth of jobs is a multi-faceted concept job evaluation is not restricted to the context of pay determination. Using policy-capturing as a basic tool, USAF researchers have pursued two aspects of job evaluation, namely merited grade (rank) and merited pay:[38,39] they have found that a single job evaluation plan cannot be used for both grade and pay determination.[40] 'The Officer Grade Requirements (OGR) Project is probably the largest effort on record involving the capturing and implementation of policy in an operational setting.'[41] This statement, although made 12 years ago, is reason enough to begin with the OGR Project when considering applications of policy-capturing. The OGR Project began in late 1963 and sought to develop a 'scientific system for determination of officer grades.'[42] Job descriptions were developed for 80,000 officer jobs across the Air Force, and a representative sample of 3575 of them was selected for generating data-points for a regression model. The regression equation was then applied to determine the appropriate distribution of grades across the various USAF officer utilization fields.

Measures of the criterion (merited grade) were obtained by convening a board of 22 experienced colonels from across the USAF. Over a five day period and under strictly controlled conditions, the board determined 'the appropriate grade level for each of the 3,575 jobs in the criterion sample.'[43] Their judgement was recorded as a number from a 16-point scale containing three levels for each grade of lieutenant through colonel, and one level for general. For example, ratings of '16', '15', '14' and '13' represented, respectively: a general, a senior colonel, a colonel with average time in grade, and a junior colonel. Each job was rated by five of the judges who also recorded the confidence they had in each assessment. 'The board had access to any information needed to make accurate judgements',[44] including telephone access to special air staff consultants in Headquarters USAF and to the supervisors of the incumbents of the positions. The ratings were, however, independently made; the judges were denied knowledge of the currently authorized grade and of the grade of the incumbent of any of the positions, and they could not discuss their ratings with each other. Extensive analyses of these merited-grade ratings revealed that they were suitable for use as the criterion. The agreement amongst the judges was found to be high, as were the degrees of confidence they expressed in their assessments; and an absence of bias towards utilization fields and commands was demonstrated. The results indicated that the members of the policy board agreed that many officer jobs were inappropriately graded.

Having obtained measures of the criterion, the next phase was to develop the policy-capturing equation. Nearly 200 variables were progressively hypothesized and evaluated as predictors. Eventually a relatively simple 9-predictor equation, with a multiple-R of 0.92, was derived. The predictors included five job-requirements factors, two organizational-level factors, a merited-grade rating from field judges and the grade recommended by the supervisor of each position. The five job-requirements factors were management, planning, special training and work experience, judgment and decision-making, and communication skills. They were measured, along with the merited-grade rating from field judges and other job-requirements factors like risk and working conditions, by having lieutenant colonels and majors selected randomly from throughout the USAF rate the jobs against appropriate scales. The two organizational-level factors were the level of the organization in which the job occurs (eg, major command headquarters, wing, squadron, etc) and the level of the job within the organization (eg, command, directorate, division, branch, etc). Cross-validation was applied to ensure the derived equation could be applied with confidence.

The policy equation was then applied to determine the merited grade for a further 10,000 jobs, and these results were projected to determine the appropriate distribution of grade for various utilization fields throughout the USAF. An excess of higher grades was found for various utilization fields, and a deficiency in others. Although the findings of the study 'have never been applied across-the-board',[45] considerable changes were made as a result of the study. Implementation in toto would have conflicted with the rank structure required to serve career planning objectives and would not have recognized the need to keep aircrew officers 'in the cockpit in order to amortize the cost of their training.'[46] In 1966, better scales were developed for measuring the job-requirements factors, and the regression coefficients were rounded-off to integer values with a minimal loss of predictive efficiency. More recent work has sought to develop and validate the application of the policy equation by management engineering teams 'to determine appropriate grade requirements for all officer positions, excluding those to be filled by line pilots and navigators, physicians, dentists, and personnel not subject to constraints of the Officer Grade Limitations Act.'[47]

The OGR Project is a thorough, well documented example of the use of policy-capturing for job evaluation. As such, it had an influence on local research which strove to develop a system of job evaluation for determining the relative worth of other-ranks jobs to the Australian Defence Forces.[48]

Policy-Capturing to Identify Inconsistent Policy

In applying policy-capturing to job evaluation, the aim was to gather data-points for developing a policy equation for application to other data. This is the more usual use of policy-capturing. A useful variation on policy-capturing is to apply the equation to the data-points from which it was derived and note which data-points display the greatest deviation from the captured policy. In this way, the items in the sample to which the general policy has been inconsistently applied are identified. Perhaps two simple examples will clarify this concept. The first example tests the consistency of train/don't train decisions and the second, while not describing any specific instance of such use of the technique, indicates how regression analysis can be used to validate personnel establishments.

Table 3 contains semi-hypothetical data extracted from a study conducted for the Texas Department of Public Safety in consultation with the USAF Human Resources Laboratory. The objective was to 'recommend for consideration certain modifications to course content [for state highway patrolmen] and to support these recommendations.'[49] The statements to the left of Table 3 describe 14 tasks performed by patrolmen, and the first four columns of figures indicate, respectively, whether or not each task is currently being taught (Y), the percentage of patrolmen who actually perform each task (X_1), a measure of the delay that can be tolerated before the task must be performed (X_2), and a measure of the consequences should the task not be performed adequately (X_3). To illustrate these data, the task 'conduct frisk-searches' is taught currently (Y = 1), 85 per cent of patrolmen do it (X_1 = 85), when the need arises it must be done almost immediately (X_2 = 1.6), and the consequences of not doing it properly are quite serious (X_3 = 7.6). Y was

	Y	X_1	X_2	X_3	Y'	$(Y'-Y)$
Conduct frisk-searches	1	85	1.6	7.3	1.14	0.14
Subdue subject resisting arrest	1	69	1.1	7.6	1.10	0.10
Engage in high-speed pursuit-driving	0	69	1.1	7.0	1.09	1.09*
Fill in theft-report forms	1	81	5.6	5.5	1.00	0.00
Advise suspects on their legal rights	1	68	2.1	6.6	1.00	0.00
Issue moving-traffic citations	1	89	2.4	5.8	0.91	-0.09
Check autos against stolen car lists	1	87	4.5	4.5	0.89	-0.11
,,	,,	,,	,,	,,	,,	,,
,,	,,	,,	,,	,,	,,	,,
,,	,,	,,	,,	,,	,,	,,
Investigate repossession complaints	0	24	6.7	2.5	0.30	0.30
Punch cards for data processing system	0	1	6.8	4.5	0.22	0.22
Photograph lineup	0	3	4.6	4.7	0.14	0.14
Train/care for dogs (Canine Unit)	0	2	6.4	4.5	0.09	0.09
Conduct airborne surveillance	1	10	3.2	2.6	0.08	-0.92*
Inspect men on roll call	0	3	3.8	4.0	0.04	0.04
Prepare and present speeches	1	7	7.8	3.0	-0.02	-1.02*

Y = 1 if the task is currently taught, 0 otherwise
X_1 = percent of patrolmen performing the task
X_2 = delay tolerance (1-9 scale, '1' means must perform immediately)
X_3 = consequencies of inadequate performance (1-9 scale, '9' means consequences disastrous if the task is not done correctly)
Y' = estimate of Y by applying the regression equation
$(Y'-Y)$ = deviation of actual value of Y from its estimated value

Table 3. Data for Analysing Training Decisions for Highway Patrolmen

obtained from the staff of the academy and X_1, X_2 and X_3 were obtained from an occupational survey. Actually other factors were also used and these 14 tasks are only a small proportion of those involved in the study. On the assumption that the policies used over the years in deciding to add tasks to the course and remove tasks from it had been fairly consistent overall, the current training status (Y) was used as the criterion in a regression analysis and X_1, X_2 and X_3 (among other factors) were used as predictors in an attempt to capture these policies. The resultant equation was then applied to the data-points from which it was derived; the estimates of Y are designated Y′ and appear towards the right of Table 3. As indicated in the extreme right hand column of Table 3, the estimates of Y generally approximate quite well to the actual values, but there are three notable exceptions. If the policy used to select tasks for training and captured by the equation had been consistently applied, high-speed pursuit-driving would be included in the course (Y′ = 1.09); and airborne traffic surveillance and preparation and presentation of speeches would not be taught (Y′ = 0.08 and -0.02 respectively). The policy-capturing model has thus identified those items where the general policy, as captured, has not been applied consistently.

Policy-capturing has been used for validating personnel establishments in military organizations. The present establishment of all sub-units of a particular type (eg, orderly rooms, education sections, etc) are assumed to be about right on the average. Some will of course be over-established and others will be under-established, and in a climate of staff ceilings identification of those over-established is highly desirable. A data-point is generated for each occurrence of the sub-unit throughout the Service, or the Defence Force if the review is tri-Service. The present establishment is used as the criterion and quantifiable aspects of the work-loads of the sub-units are used as predictors. A regression equation is computed and applied to the data-points from which it was derived, and the estimates of the criterion are compared with the actual current establishments. Should the values of the criterion and the estimates of them be plotted on a two-dimensional graph like that shown in Figure 2, some points would lie above the line of best fit and others would lie beneath it. Those sub-units represented by the points significantly above the line are, *prima facie,* over-established in accordance with the policy captured by the equation; their establishments should thus be critically reviewed. The application of policy-capturing to establishments validation is known to have been applied in the U.S. Army[50] and in the Australian Department of Defence.[51]

In some circumstances the policy-capturing model has been found to be more valid than the actual decisions from which it was derived.[52,53] In a study conducted by the Oregon Research Institute, a regression equation was derived to predict the decisions made by a graduate school admissions committee on the degree of suitability of candidates for admission to graduate school.[54] Data derived from the candidates' performances during their primary degrees were used as predictors. The results subsequently obtained by those admitted were compared with the decisions of the admissions committee, and with the estimates of their decisions computed using the regression equation. The regression model actually proved to be the better indicator of success. The rationale advanced for this paradox is that the members of the committee, while indeed developing an effective policy for weighing the information available to them, did not apply their policy consistently over a period of time. This unrealibility could stem from boredom, fatigue, interruptions and bias generated by personal prejudice. The regression equation was able to capture their underlying policy, and to apply it consistently and unemotionally. The Oregon Research Institute appended the name 'bootstrapping' to this phenomenon.[55]

Regression Models Developed for Later Use as Estimators

In perhaps their most common application, regression equations are derived from specially gathered data-points for application at a later time when direct measurement of the criterion may be inconvenient or impossible. The calibration of measuring devices used in test flying is a typical example of this use of regression analysis.[56] During post-flight analysis the computer needs information such as the settings of various flight controls, and the test pilot is usually too preoccupied to record all such information during the flight. A transducer fitted to the flight control generates an electrical signal, the magnitude of which depends on the setting of the control. As the computer needs the control setting, not the magnitude of the signal, it must know how to convert the magnitude of the electrical signal into control setting. A mathematical relationship for estimating the control setting from the magnitude of the electrical signal, usually in the form of a polynomial, is derived using regression analysis. The data-points are gathered by the pilot successively selecting a series of predetermined control settings; the polynomial-fitting program in the computer is subsequently able to associate each setting with the corresponding electrical signal and compute the polynomial of best fit. Once the computer has computed the appropriate equation, it automatically computes control setting from the respective signal strength throughout subsequent processing of flight data.

In the calibration of measuring devices just discussed, values of the criterion were set and the corresponding magnitudes of the predictor were measured. Useful prediction models can be generated by recording historical combinations of the predictor and criterion values and then deriving a regression equation for predicting future values of the criterion. An example of such an application was the development of a 'general cost-estimating relation for use in estimating the construction costs of new surface ship escort types built in the United States.'[57] The sample used was the 80 such ships built between 1956 and 1963. Actual costs and values of potential predictors were available from records, and a 5-predictor equation with a multiple-R of 0.98 was derived. The five predictors were the ship's displacement, the sustained speed, and three binary predictors indicating whether or not the ship was a guided missile ship, the lead ship of its class, and built in a naval shipyard.[58] The equation was subsequently used to predict the cost of new ships. Regression analysis has also been used for costing in the Australian Department of Defence.[59]

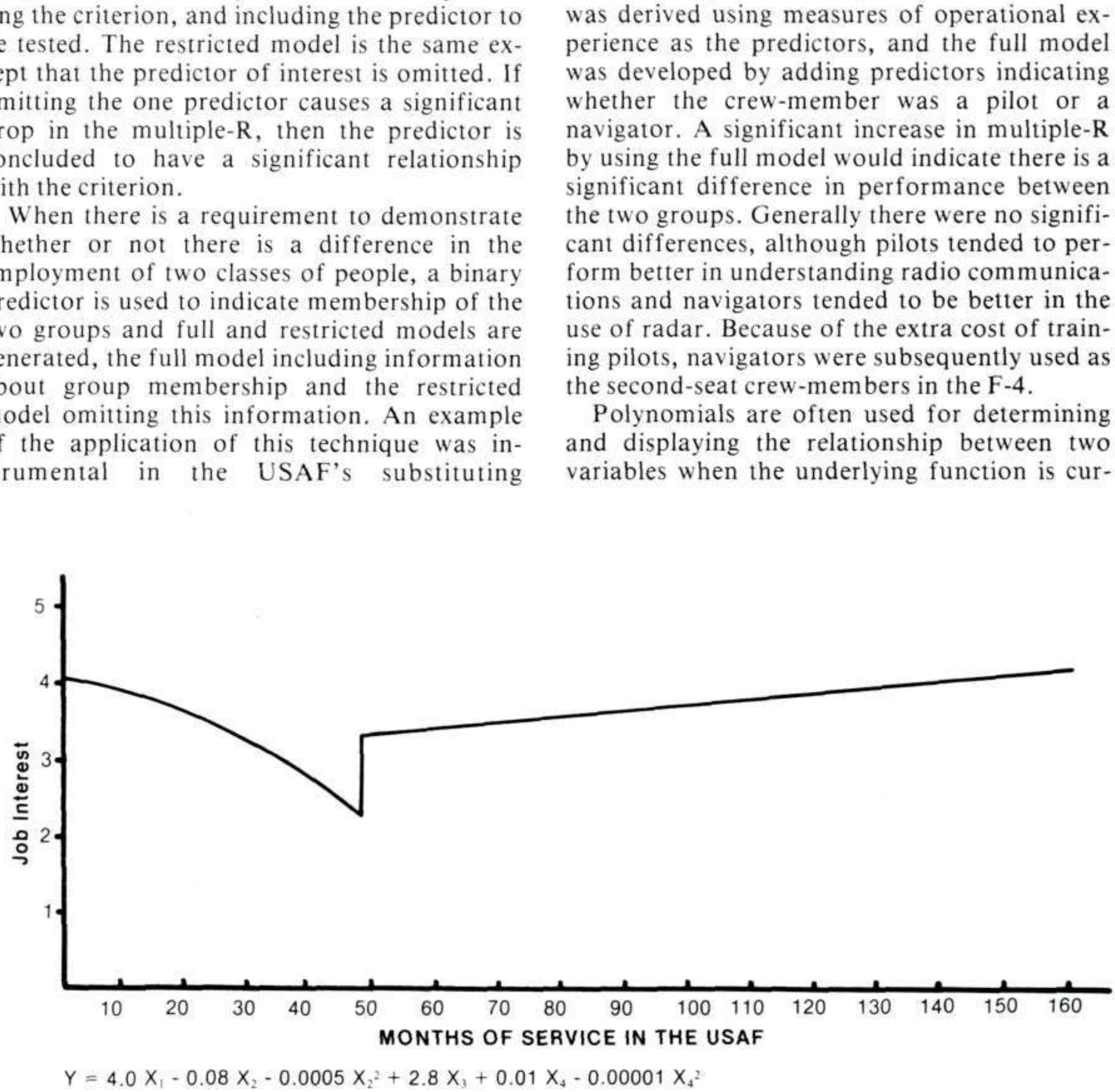
The two examples of predictive models just discussed relate to normally measurable criteria. Policy-capturing regression models can also be derived for later use in estimating the value of the criterion. An example of such an application is the USAF Officer Education Requirements Study.[60] All officers entering the USAF have at least a bachelor's degree, and USAF manuals specify educational prerequisites for the various officer specialities in terms of type of degree, major area of study, and/or specific subjects. As with a number of other military Services, these specifications are essentially 'go/no-go' gauges with a provision for an educational waiver if a candidate is exceptionally well qualified in other areas. The Officer Education Study developed a methodology for quantifying the educational demands of various officer specialities in the form of educational suitability indexes, and regression models were developed for computing these suitability indexes from quantifiable aspects of the candidates' university degrees. 120 typical university degrees were condensed into a standard format displaying the numbers of semester hours in each of 20 subject areas and other information such as the type of degree, the name of the college and the major area of study. To obtain criteria measures of the indexes of educational suitability, samples of officers serving in a number of specialities were selected randomly from throughout the USAF, and each was asked to rate each of the 120 university degrees on suitability for training for and service in his specialty, all other things being considered equal. To assist in their ratings they were provided with a 9-point scale ranging from 'extremely suitable — difficult to improve' down to 'least suitable — education of no value'.[61] The average rating on each degree within each specialty was used as the educational suitability index of that degree for that specialty. Using these indexes as criteria and quantifiable aspects of the degrees as predictors, a regression equation was computed for each of the specialties included in the study. The number of predictors ranged from seven to 12 and the multiple-Rs ranged from 0.92 to 0.98. After further development and before implementation of the results of this line of research, a regression equation would be derived to compute the educational suitability index for any university degree for training for and service in any officer specialty. This index would then be weighed against the candidate's other qualifications in allocating him to an officer speciality.

Determining and Displaying Relationships

The final class of applications of regression analysis to be discussed in this article concerns the identification and perhaps display of relationships between variables. In its simplest form, this involves the application of regression analysis to a criterion and a pool of predictors to determine which of the predictors have an effective relationship with the criterion. Stepwise regression may be used to identify the useful predictors. The significance of any one predictor is tested by computing what are referred to as the full model and the restricted model. The full model is the equation of best fit using all the predictors the analyst has chosen for predicting the criterion, and including the predictor to be tested. The restricted model is the same except that the predictor of interest is omitted. If omitting the one predictor causes a significant drop in the multiple-R, then the predictor is concluded to have a significant relationship with the criterion.

When there is a requirement to demonstrate whether or not there is a difference in the employment of two classes of people, a binary predictor is used to indicate membership of the two groups and full and restricted models are generated, the full model including information about group membership and the restricted model omitting this information. An example of the application of this technique was instrumental in the USAF's substituting navigators for pilots as the second crew-member of F-4 aircraft.[62] A control group of pilots and a group of navigators were trained for and used as the second-seat crew-members of F-4s flying a series of operational missions in South-East Asia. After each mission the crew-member was assessed on several performance criteria by the aircraft captain. For each criterion of performance, the restricted model was derived using measures of operational experience as the predictors, and the full model was developed by adding predictors indicating whether the crew-member was a pilot or a navigator. A significant increase in multiple-R by using the full model would indicate there is a significant difference in performance between the two groups. Generally there were no significant differences, although pilots tended to perform better in understanding radio communications and navigators tended to be better in the use of radar. Because of the extra cost of training pilots, navigators were subsequently used as the second-seat crew-members in the F-4.

Polynomials are often used for determining and displaying the relationship between two variables when the underlying function is cur-



$$Y = 4.0\,X_1 - 0.08\,X_2 - 0.0005\,X_2^2 + 2.8\,X_3 + 0.01\,X_4 - 0.00001\,X_4^2$$

where Y = job interest
X_1 = 1 if service less than 48 months, O otherwise
X_2 = months of service if less than 48 months, O otherwise
X_3 = 1 if service at least 48 months, O otherwise
X_4 = months of service if at least 48 months, O otherwise

Figure 4: Fitting a Linear Model to a Discontinuous Curvilinear Function

vilinear. Part of the USAF research into job satisfaction will be used to illustrate this useful technique because it involves fitting a single linear model to data where the underlying function is discontinuous as well as curvilinear.[63] The criterion used here is a measure of expressed job interest provided by airmen completing occupations surveys, a '5' indicating they find their job very interesting and a '1' indicating very dull. Graphs like the one depicted in Figure 4 were often obtained when examining the relationship between job interest and length of Service in the USAF. The discontinuity in the graph at 48 months coincides with the expiration of the first engagement for airmen. The shape of the graph suggests that those airmen who decline re-engagement tend to have found their jobs less and less interesting throughout their first engagement, this suggesting a connection between job interest and re-engagement. This example is a small part of extensive research into job satisfaction. It has been included here to demonstrate the use of a linear model to determine and display relationships between variables, even when the underlying function is curvilinear and discontinuous.

CONCLUSION

This article has sought to communicate a feeling for the capabilities of regression analysis as an analytical tool. 'Despite the relative simplicity of its ideas, it is a powerful technique for elucidating relations, and its results are easily understood and applied.'[64] It can capture and duplicate decision-making strategies, and even identify inconsistencies in the decision-maker's application of his own policy. Mathematical formulae are produced for estimating the unmeasurable by measuring the measurable, and indicators of the accuracy of estimation are included. In a sense, its major limitation lies in the imagination and competence of the analyst.

No attempt has been made to transform the reader into a trained analyst. Nor has the decision-maker been offered a substitute for his judgement; all quantitative techniques are tools, not tin gods. Hopefully, this article will help the decision-maker recognize when he should seek out an analyst familiar with regression analysis, whether his problem be formulating policy or selecting a harem.

NOTES

1. Quade, E. S. Analysis for Public Decisions. New York, 1975. p4.
2. ibid, p4-5.
3. Ward, J. H. and Jennings, E. Introduction to Linear Models. New Jersey, 1973. Preface, pxv.
4. Quade, op cit, p10.
5. ibid, p11.
6. ibid, Preface, pvii.
7. A number of examples of monograms and articles on regression analysis are included in the bibliography. Christal's 'Selecting a Harem — and Other Applications of the Policy-Capturing Model' (PRL-TR-67-1) is perhaps the easiest to read. The technical report by Bottenberg and Ward (PRL-TDR-63-6), the book by Ward and Jennings (New Jersey, 1973) and the journal article by McCornack (Psychometrika, 1970) are recommended for the more serious reader.
8. Regression analysis can be performed without the aid of a computer, but for most practical applications the computation would be prohibitive.
9. The term 'data-point' stems from the situation when there are only two variables, the criterion and one predictor, and each data-point can be plotted as a point on a two-dimensional graph.
10. The effect of the imperfect fit of the regression equation is to under-estimate the heights of tall men and over-estimate the heights of short men. For example, as not all extremely tall parents have extremely tall sons, the average height of the sons of extremely tall parents (the estimate that will be provided by the equation) will be something less than 'extremely tall'. The values of the estimates provided by the regression equation are said to regress, or fall back, towards the average. This phenomenon is, in fact, the origin of the use of the word 'regression' in this context.
11. For good mathematical reasons, the equation is computed so as to minimize the squares of these deviations rather than the actual deviations. The equation is said to be fitted by the 'method of least squares'.
12. Analysts often prefer to think in terms of the square of the correlation coefficient which they sometimes designate 'R-square'. They speak of R-square as representing the proportion of the variance captured or explained by the equation. There are good mathematical reasons for this, but the explanation is beyond the scope of this article.
13. The Concise Oxford Dictionary. Sixth edition, 1976. p859.
14. 'A colossal example of biased sampling' occurred in the conduct of a public opinion poll during the 1936 United States presidential campaign. It is reported on pp157-158 of Guilford's 'Fundamental Statistics in Psychology and Education (McGraw-Hill, 1956 — see bibliography). Several million post card ballots were sent out, but the mailing lists were drawn up from telephone directories and automobile registration lists. Further, as people could not be compelled to return the questionnaires, there was perhaps a tendency for those disgruntled with the incumbent president to register their anguish by returning the questionnaire, while some of those who supported the incumbent perhaps did not bother. The opinion poll predicted confidently that the incumbent would be defeated, but those voters who owned neither a car nor a telephone and those who did not return the questionnaire voted so differently from those who returned the questionnaires that the incumbent won with what the CBS News Almanac describes as the 'most sweeping electoral victory in modern history.'

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17. The Concise Oxford Dictionary. Sixth edition, 1976. p677.
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19. Christal, R.E. JAN: A Technique for Analysing Group Judgment. PRL-TDR-63-3. Lackland AFB, 1963. passim.
20. Goody, K. Comprehensive Occupational Data Analysis Programs (CODAP): Use of REXALL to Identify Divergent Raters. AFHRL-TR-76-82. Brooks AFB, 1976. passim.
21. Lindquist, E. G. Design and Analysis of Experiments in Psychology and Education. Boston, 1953. pp359-361.
22. In statistical terms, a judge's rankings are from a 'rectangular distribution', and the means of a number of judges' rankings tend towards a 'rectangular distribution'. Ratings and measures of size and quanitity, on the other hand, tend to be 'normally distributed'. One way of reducing this incompatibility of variable-distributions is to divide the rank-ordered items into a number of ordered categories so that the proportions in the various categories approximate to a normal distribution. Alternatively, rankings can be effectively approximated to normal scores by using a third order polynomial regression model.
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24. loc cit.
25. ibid, p316.
26. Guilford, op cit, p422.
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30. Goody, AFHRL-TR-77-44, op cit, passim.
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32. ibid, p1.
33. loc cit.
34. loc cit.
35. loc cit.
36. ibid, p4.
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41. Christal, PRL-TR-67-1, op cit, p5.
42. Christal, PRL-TR-65-15,op cit, p33.
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46. loc cit.
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51. Knowledge of the application of regression analysis to establishments validation in the Australian Department of Defence stems from the author's personal involvement in performing the regression analysis for a study conducted in 1977 with a view to rationalizing the establishment for messes across the three Services.
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53. Dawes, R. M. A Case Study of Graduate Admissions: Application of Three Principles of Human Decision Making. American Psychologist, 1971. pp180-188.
54. loc cit.
55. ibid, p182.
56. Knowledge of the use of regression analysis for calibration of flight-testing measuring devices stems from personal discussions with the staff of ARDU, RAAF Base EDINBURGH on 8 August 1979.
57. An Example of the Application of Statistical Multiple Regression Analysis for Developing a Cost Model: Ship Investment Cost-Model for Navy Surface Ship Escort Types. Student Notes issued to 1977 DSMC Courses. Original source United States DRMEC Course. passim.
58. Actually logarithmic transformations were used of the criterion (cost), the ship's displacement and the sustained speed.
59. Regression analysis has been used for costing in relation to Garden Island Dockyard and Computing Services Division. Information obtained through personal discussion with Assistant Secretary, Costing on 15 October 1979.
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THE AUSTRALIAN PEOPLE AND THE GREAT WAR by Michael McKernan, Melbourne, Nelson 1980. 224 pp., notes and index. $19.95.

Reviewed by Kevin Fewster, Monash University.

FORTY-FIVE years have passed by since the publication of volume eleven in the series *The Official History of Australia in the War of 1914-1918*. Unlike the other books in the series, volume eleven dealt not with strictly military matters but with events in Australia during the war. Its author was Ernest Scott, Professor of History at the University of Melbourne. For generations his book stood as the definitive source for anyone interested in the homefront. Only in the past decade or so, as historians have turned their attention back on to the Great War, have the book's many deficiencies and weaknesses been revealed. Much of this recent research has been in the form of university theses which either go unpublished or appear only in truncated form as articles in the specialist historical journals. It was for this reason that I eagerly awaited the release of Michael McKernan's new book. He was in the vanguard of the new researchers and already has one book *(Australian Churches at War)* published in the field. From the title of his latest work I assumed that McKernan had performed that much needed service; namely, a revision of Scott.

Alas, I was sadly mistaken. Both books are largely thematic in structure but, in the main, McKernan has concentrated on areas Scott omits. Thus, where the *Official History* deals at length with politics, recruiting, economics and trade, McKernan's chapters investigate responses of the church, schools, women, sporting bodies, the AIF in Britain, enemy aliens, and rural Australia. This need not in itself be a bad thing. An author is, after all, at liberty to write on whatever he chooses. Where McKernan's approach falls down, however, is that it presents the reader with a war without work. In his selection of themes and, more importantly, in the manner only the middle class (generally the most overtly patriotic) response is considered, the book largely removes the war from the social framework in which it occurred.

The Great War brought unprecedented economic, social and political dislocation to Australian society. The most significant manifestations of this unrest are still remembered today — the two conscription referenda, the ALP split, the great strike in 1917, and the bitter sectarianism. What students often fail to appreciate, and what McKernan largely chooses to avoid, is that these disputes grew neither out of political intrigue nor the plotting of German agents but came in response to the savage inflation and spiralling unemployment that befell Australia with the onset of war. The war also coincided with a severe drought. These factors combined to force up the prices of many staple commodities. The cost of bread in Melbourne, for example, rose by fifty per cent in the ten months after August 1914. Butter prices rose 62.5 per cent and meat 120 per cent in the same period. The story was much the same all across the nation and posed massive problems for the Federal Labor Government elected soon after the war began. As the months went by, it seemed the Government was unwilling, or unable, to defeat inflation. Instead, workers were urged to do the patriotic thing and accept wage restraint. Consequently, their purchasing power shrank drastically. Still worse off were the not inconsiderable numbers of workers who were either laid-off or put on short time because of the war-induced slump in trade. As 1915 progressed increasing numbers of ALP supporters, both in and out of Parliament, began to question if the Federal Labor Ministry was doing all that it might to ensure that the sacrifices were shared equally by all classes. The final straw came when, shortly after replacing Andrew Fisher as Prime Minister, W. M. Hughes cancelled a proposed referendum on price control. The Labor press had branded Hughes a rat long before the conscription crisis of August-October1916. McKernan devotes only a brief introductory chapter to such matters. Not only does it lack much of the necessary detail, the very fact that it stands alone entices the reader to believe that the issues it raises can in some way be isolated from the book's other themes. References to economic dislocation and social disunity are generously sprinkled throughout the book but nowhere does the author describe the war's impact on the everyday experience of the average worker. It was a surprise, for example, to find that the term 'economic conscription' does not appear anywhere in the book. Similarly, it seems a pity that his chapter on Australians in Britain concentrates exclusively on the troops and nurses when it might also have looked at the experiences of the 6000 Australians sent over as munitions workers.

McKernan has given us seven interesting vignettes of the Australian response to the war. The picture he paints, however, is highly selective and certainly falls well short of the claim implicit in the title that the book covers all groupings in society. Most chapters restrict themselves almost entirely to the middle classes — those who responded most vocally to the war and thus those easiest to identify and study. Only the two chapters dealing with sport and rural life go any way towards revealing the attitudes and responses of society as a whole. These chapters succeed largely because they bring together people with differing economic circumstances. Also, the clashes of interest tend to reveal themselves more clearly in these situations than in larger communities or organizations.

Some of the book's problems stem from the author's apparent reluctance to consult the relatively large body of recent research in the field. The research McKernan has put into this book adds considerably to our knowledge of the homefront. It thus seems curious that he then reduces the impact of his work by disregarding other readily available studies which I would think could only assist anyone trying to compose an overview. He admits, for example, that his random search of country newspapers uncovered only one which opposed conscription. A check of R. B. Walker's *The Newspaper Press in New South Wales 1803-1920* (Sydney, 1976) would reveal another six such journals in New South Wales alone. It is equally disappointing that no reference to Marilyn Lake's *A Divided Society: Tasmania During World War I* (Melbourne, 1975) appears anywhere in the book. Even if he disagrees with Ms. Lake's conclusions, some alluding to her evidence could only have broadened the scope of McKernan's survey with beneficial results.

I hope my criticisms do not give the impression the book is without merit. It is likely to find ready market, in part, because it is presented with an attractive format and many illustrations, but also because the research adds not inconsiderably to our knowledge of certain aspects of life in Australia during the war years. I am only disappointed that the author did not put his material to better effect. For the time, at least, it seems Professor Scott's volume will continue to stand unchallenged. I only hope it will not be a case of: the professor is dead, long live the professor.

CRISIS IN COMMAND: MISMANAGEMENT IN THE ARMY, New York, Hill and Wang, 1978, 242 pp., Defence Library Call No. 355.330973 GAB.

Reviewed by Lt. Col. N. A. Jans, SO1 DPP-A

SOME Americans believe that their country suffered more than just the mere failure to achieve political objectives in South Vietnam in the 60s and early 70s. The authors of this book claim that assassinations of officers, combat refusals (a euphemism for 'mutiny'), events like that of My Lai, the bestowal of unearned medals and honours, racism, inflated body counts and drug abuse were endemic in the US Army in Vietnam and were indicators of a general organization disintegration of these forces which has still to be corrected. The book describes these phenomena and discusses what the US Army must do to reform itself.

The authors are both academics (in political science) and ex-officers. Their diagnosis of the malaise which affected the US Army is based on their assertion that the officer corps lacked the will and ability to maintain unit cohesion under combat stress. They argue that the officer corps had and has lost sight of the obligation of combat leaders to adopt the 'heroic' role and has instead adopted the 'entrepreneurial' model of behaviour. That is, Army officers used their Vietnam experience to maximise their personal self-interest and, in so doing, failed to do (and to be seen to do) what the traditional requirements of the combat leader demand. The authors cite much evidence for their thesis but the aspects which they regard as most pernicious were the individual rotation scheme (versus unit rotation) used by the Army, and the propensity of officers to have shorter tours in combat units than did enlisted men, for the purposes of 'ticket punching'.

The prescription for change proposed by Gabriel and Savage include: an IG system, independent of the chain of command; an Army-wide system of 'honour boards'; greater stability in officer assignments; measures to increase soldier identification with the unit; restoration of the intrinsic value of awards; a reduction in the number and size of staff agencies; a re-emphasis, in officer training, of the details of minor tactics; and more emphasis on selection and training of combat leaders.

This book should be compulsory reading for all professional soldiers. Whether or not the US Army did suffer from discohesion in Vietnam and whether or not similar problems were experienced by Australians, the material is a case study which will repay careful consideration. For example, it calls into doubt our ready acceptance of frequent job rotation as a career development technique for officers. Paradoxically, it also serves as a tribute to the American habit of refusing to hide their dirty washing. One wishes the writers well in their crusade for reform.

C. E. W. BEAN AND G. M. LONG: AUSTRALIA'S TWO WAR HISTORIANS: TOWARDS A BIBLIOGRAPHY, by Alan Ives, Canberra, Pearce Press Processed Publications, 1978

Reviewed by Captain C. D. Coulthard-Clark, Reserve Staff Group

THE work of C. E. W. Bean and Gavin Long in connexion with the official histories of Australia in the First and Second World Wars represents a monumental achievement in recording Australia's military heritage. Their writings, however, extend beyond the volumes of these immense undertakings so that an attempt to compile a bibliography of works by these two great historians as well as writings about them is a useful aid to anyone entering the field.

The publication under review is rather a slender work; despite its large format, it is only 20 pages long and seven of these have no more than a dozen words on them. It is actually only one of 12 papers which appear in Volume 7 of *Archives in Australia: a Bibliographical Guide to Writings on Australian Archives and Manuscripts,* although it has been published separately in a limited edition of 100 copies. The price of the limited edition has not been notified to DFJ but the complete Volume 7 costs $30.

Mr Ives recognises in his subtitle that this bibliography is incomplete and certainly there are items missed which ought to have been included. He was evidently aware of the old Australian *Army Journal* as a source and included an article appearing in that publication, but there are others to be found there. A. W. Bazley's tribute "Charles Edwin Woodrow Bean" in the December 1968 issue is one example (this is different to Bazley's obituary on Bean in *Historical Studies* which Ives includes), and Gavin Long's piece, *"Sources of Contemporary Australian Military History",* which appeared in the October 1969, issue is another. Bean also contributed a short article entitled *"Who Was Our Greatest Fighter"* to the December 1923 issue of the *Journal of the Royal Military College of Australia,* and perhaps some of his newspaper writings — for example, his assessment of Lieutenant-General J. G. Legge in the *Sydney Morning Herald* of 26 September 1947 — ought to have been listed too. Little known these latter pieces may be, but arguably they deserve inclusion in a work such as this.

The idea of providing brief biographical introductions to both Bean and Long seems a useful and appropriate inclusion but those provided, it seems, are too bare-bones and incomplete to be of real value. In Bean's case, we are not even told when he died, although in Long's sketch it says Long died 'in 1968 at about the same time as his mentor and predecessor C. E. W. Bean'. A small matter certainly, but an omission which seems odd given other precise dates mentioned, especially when the information is easily obtainable.

Despite these minor shortcomings, this work is a convenient starting point for those seeking to gain an introduciton to the major writings of two of Australia's most important military historians.

THE NEGOTIATIONS ON MUTUAL AND BALANCED FORCE REDUCTIONS, The Search for Arms Control in Central Europe, by John G. Keliher, New York, Pergamon Press, 1980, pp x and 204, US$25. Available Pergamon Press (Aust) Pty Ltd, PO Box 544, Potts Point, NSW, 2011.

Reviewed by Brigadier F. W. Speed

DESPITE the European nature of this book's title, it is of importance to Australian and New Zealand planners, staff college students, and others interested in super power inter-play.

Colonel Keliher analyses in some detail and with considerable dexterity a mass of evidence relating to the negotiations that began in 1972, with formal meetings starting a year later, aimed at mutual and balanced reductions in the ground forces of the Warsaw Pact and NATO. He had four years experience at staff level in the U.S. side of MBFR followed by a period with the SALT Task Force, an organisation with somewhat different aims. He shows a marked restraint, even absence of bias, in describing the negotiations in which each side has operated from a base that is quite distinct ideologically and philosophically.

Herein lies the value of the book. It unravels Russian motives and thought processes in an effective and convincing way. Though forceful in expression, the author leaves it to the reader to decide whether or not to accept his dissections. Interestingly, he is almost as thorough in observing American attitudes and manoeuvres.

The author brings out clearly the truth that Soviet-style communism can survive in Eastern Europe only through the presence of the Russian Army. This is emphasised in Hungary, which has a military presence and, more recently, in Poland which has not. Further, he takes the point that Germany was, in Lenin's opinion, of paramount significance in Russian foreign policy, and that now, though divided into East and West, it is still of outstanding importance.

From there, it can be argued that West Germany's recent relatively moderate attitude towards Russia's incursion into Afghanistan may harden the Soviet attitude to MBFR, and indeed may embolden the next generation of Soviet leaders to reach out in other directions. In this, the leaders would doubtless receive the enthusiastic support of the expanding Russian Navy — and so a new dimension would be added to any Western attempt to effect maritime arms control.

It is immaterial whether the individual reader thinks Russia's participation in the negotiations represents a genuine desire to achieve force reductions or is just a ploy to contain the West. Negotiations continue however desultorily, and the West as recently as 1980, certainly did not seem to have any intention of disengaging.

Though it is improbably that Australia or New Zealand will, *for the present*, be involved in any form of direct military negotiation with Russia, a knowledge of Russian thought processes, as seen by the author, would be of considerable help in interpreting the volume of intelligence that flows around us. And there is also much of value to be gained about American negotiating techniques, applicable in this case to the Russians, but suggestive of the form they might take when applied to U.S. allies.

Further, the book is useful in another, quite different direction — thesis writing. Colonel Keliher wrote it while a senior research fellow at the National Defense University, Washington DC, and it serves as a worthwhile guide to the form of a thesis for a higher degree on a military subject. He marshals his data in a clear and effective way, and presents his statistics in easily assimilable form. Though there is a plentitude of Notes, they are in the main confined to citation of references, and the reader's thought flow is not unduly disturbed by having to absorb material from the Notes that should more properly be in the text. It is just unfortunate that his university apparently adheres to the use of the archiac latin abbreviations such as *'ibid'* when others prefer simply the author's surname, followed by the page number. Beyond that kind of detail, the book is well worth examination.

THE DAY THE BOMB FELL, by Clyde W. Burleson, Sphere Books, 1980, 316 pp. paperback, Australian recommended price $4.25.

Reviewed by Donald R. Jender, Department of Defence

DID you know that in 1958 a U.S. B-47 bomber dropped an atomic bomb on the town of Mars Bluff, South Carolina? This book, subtitled *"True Stories of the Nuclear Age"*, gets off to a strong start with this story (true) as Chapter One. To satisfy your curiosity, there was an explosion, but only of the bomb's high explosive component. The safety mechanism prevented a nuclear detonation.

For the benefit of the would-be reader, the seventeen chapters in the review book cover nuclear weapon accidents, a Soviet nuclear waste dump explosion, several nuclear power station incidents, extortion, secret nuclear weapon development, nuclear-related civil liberties issues, a crashed nuclear-powered Soviet satellite, evacuation plans, and nuclear audit procedures. The book does not have a contents page or index, an unfortunate omission when each chapter deals with a different event. The text is a series of dramatised accounts drawn from various documents and news reports, and might be called "docu-fiction".

Civil nuclear-related incidents provide the majority of the stories. These include the well-known cases such as the Three Mile Island nuclear power station affair, and a number of lesser incidents. This is a suitable book for those who are interested in concise, dramatic accounts of these events. However, the title of the book is somewhat misleading, since only three of seventeen chapters deal directly with nuclear weapons. Although the author may have researched the above-mentioned B-47 event with care, his treatment of other nuclear weapon incidents is superficial and at times inaccurate. For instance, he incorrectly states that a U.S. bomb was lost off the coast of Spain and never seen again. All the bombs involved in that event were in fact recovered.

The author has a simple, effective style of writing. He provides concise explanations which will assist the uninitiated in understanding technical matters, but he does not always draw correct conclusions about technical issues. He adopts an on-the-spot, narrative presentation, which gives the reader the sense of being present as events develop.

The book has a short chapter in conclusion, in which the author makes some recommendations about the civil nuclear power programme. However, the book is in essence a dramatised account of events, not an advocacy of any particular cause or policy. It is enjoyable and easy to read, but not strictly a documentary, and not written by an expert. Read it with these points in mind.

BALLISTIC MATERIALS AND PENETRATION MECHANICS Ed. R. C. Laible, Elsevier Scientific Co., Amsterdam, 1980.

Reviewed by Dr. R. Woodward

THIS book presents a history of armour development, followed by a series of chapters which specifically review 20th century contributions in testing methods, fibrous, transparent, ceramic, and metallic armour, vulnerability analysis and mechanics and computer simulation. All the authors have made outstanding scientific contributions in the field.

The historic introduction highlights the fact that vehicular armour is a modern phenomenon, following millennia of developments in personnel armour. Important 20th century contributions have hinged on the application of science, both in the collection of data upon which rational armouring decisions can be based, and in the contribution of materials technology and mechanics to the development of new materials and their optimum employment.

The quest for light weight led to the application of ceramics and new fibre materials, and transparent armour is a totally modern development. Even high quality steels, aluminium and titanium alloys have really only appeared as a result of demands and the introduction of new processes since the world war II. Compromise is always a key factor in engineering and this is illustrated by the many competing requirements that materials must meet in addition to the weight limitation.

The book is a unique collection of papers and an important scientific reference, but I believe its appeal to other readers is mixed. Some chapters give much scientific detail, for example those on fibrous armour. Other chapters are well tailored to give the engineer a suitable appreciation of the background and a good introduction to methods, eg. the chapter on vulnerability and the excellent outline of the development of testing procedures. Certainly by selectively reading aspects of all chapters and skipping some of the "heavier" detail one can obtain a good overview of most aspects of the science and technology of armour materials.

Figures 4 and 12 in the chapter by Wilkins are mixed up.