SP link which the POLARIS Sales Agreement created; this would not only affect design configuration but, to the extent that the setting up of an ANC would be an experimental development, would introduce additional uncertainties about timescales and the availability of proved equipment as well. This last point was important in respect of the equipment that was needed for the RNPS as well as for the submarines.

The dispute could not be settled within the Polaris Executive; it concerned the development of a general SINS programme for other parts of the Fleet and therefore became a general issue which had to be referred to the Controller, and ultimately to the Admiralty Board. There was a direct antithesis between what CPE believed was necessary and what DGW wanted to do, and although Admiral Le Fanu would have been prepared to take specific US Navy advice, it was understandably difficult for Admiral Galantin and Admiral Smith to intervene directly. They were careful to limit their advice to statements of facts and of SP intentions as they related to the FBM programme; but the disagreement had become so intense within the Admiralty that at one stage, the Controller asked Admiral Bush, the Chief of the British Navy Staff delegation in Washington to check directly with Admiral Galantin that the advice being channelled through SPRN was of SP origin and was not being dominated by CPE's technical staff in Bath. The acrimony was in part a reflection of the smouldering resentment felt among DGW directing staff, over the loss of function which the setting up of the POLARIS technical directorate represented; and although the battle over SINS represented a high water-mark both of importance and of intensity, it was only one of a series of differences between the two organisations that occurred between 1963 and 1965. In February 1964, however, Admiral Mackenzie persuaded DGW to agree to a regular programme of liaison meetings at which differences could be discussed and progress could be reviewed. This device enabled better working relationships to develop, and some differences to be defused; in the same month the Board finally approved that the POLARIS submarine navigation sub-system should be based upon two Autonetics SINS.

The fifth boat

The government decision on the size of the POLARIS force was taken, in January 1963, at a time when neither the financial nor operational implications had been precisely established; for this reason the decision was cast in terms that provided for an option to be taken up on a fifth submarine and for a final decision to be made on the matter before the end of the year. Such a decision would clearly be of some importance. So far as CPE was concerned it would mean the lengthening and extension of the building period, with a good many additional contracts, and details to be determined; it would be logical to place the main building contract with Vickers, but it would also be necessary to order extra equipment from the United States, as well as to extend the overhead payments to SP that

became a requirement in the Sales Agreement. So far as the defence budget as a whole was concerned, it would imply additional capital and manpower costs and, in later years, an increased allowance for running costs for the POLARIS force. From the beginning the arguments surrounding the fifth boat hinged upon the balance of advantage between this extra investment in the deterrent force and the opportunity costs that would be created elsewhere; was the cost of the extra hull a sufficiently good investment to offset the effects that it would create – given the assumption that the total size of the defence budget was unlikely to be increased?

The view within CPE increasingly came to fix upon a belief that the fifth boat was necessary to make the squadron a fully cost-effective force. The fifth hull provided a degree of flexibility in operational deployment that significantly altered the Royal Navy's ability to maintain more than one submarine on station at all times; with two submarines on patrol all the time, the deterrent capability would be nearly doubled, with no significant increase in overhead costs over the life of the system. It also gave some flexibility to refit schedules, and might in due time assume considerable importance in allowing improved ship-borne sub-systems to be installed during extended refits. As an addition to the programme, it called for a full outfit of shipfitted sub-systems but it did not call, necessarily, for the purchase of a full load of sixteen additional missiles. With one hull assumed to be in refit, five submarines did not call for much more than sixty four operational missiles, plus missiles under test and reassembly at the armament depot (although the total purchase of missiles had to allow for test firings and some contingency provision). Moreover, the creation of a second construction line at Cammell Laird meant that a fifth SSBN need not necessarily extend the interruption of the SSN construction programme which had been accepted as one of the general naval consequences of Nassau. It might even be possible too to cut down on the manpower costs of the fifth boat by providing, on an analogy with the missiles, something less than a full complement of ten crews for the five boats. So far as CPE was concerned, the benefits seemed clear; Admiral Mackenzie played a leading part in the discussions about the fifth boat which began in September 1963, and the organisation as a whole came to assume that a five-boat force was not merely desirable but should be the norm.

At ministerial level, and elsewhere in Whitehall at official level, the movement of opinion tended to go the other way, and to assume that the four-boat force was the norm, and the fifth boat an addition. The practical effect of this difference was that in interdepartmental discussions the Navy Department has to assume the onus of making a positive case for the fifth boat, and of trying to obtain a decision at something like the time which had originally been suggested. It was however less important to Ministers to stick to what had been an arbitrary time-scale than it was to CPE, who had to take into account procurement schedules and the subjective effect of any delay upon his United States counterparts. The principal issue which Ministers debated was the difficulty of containing the

additional costs in the period between 1967 and 1969 without making adjustments to the conventional weapons programmes of, perhaps, all three services; the immediate extra expenditure involved was about £11m., covering two extra quarterly overhead payments to SP and the long-lead items for the hull, but the eventual extra capital cost would be at least £50m., much of it falling in the 1967–69 period. Extra expenditure, and a larger Defence Budget, would of course only be called for if all the various programmes of development in all three services proceeded according to schedule. Some officials, and some ministers, doubted if this would turn out to be the case; if it did not, the fifth boat costs would not create the 'hump' that the projections indicated; but it was hardly a case that could be advanced at that stage without provoking serious inter-departmental differences. How to contain these costs was not finally determined, but Ministers authorised the announcement of a decision to construct a fifth POLARIS submarine, and official action followed to give effect to the decision.

By the early autumn of 1964, formal agreement had been reached with SP to extend the formal concept of 'the initial building period' by six months, and to pay an extra overhead charge; the shipbuilding contract with Vickers Shipbuilding had been amended, and action was in hand to amend the procurement schedules for equipment to be purchased through SP. Long lead items for the hull and propulsion systems had been ordered. But also by the early autumn it had become clear that the fifth boat was a particularly vulnerable part of the programme which was itself an election issue.(26) Virtually the whole of 1964 constituted an election campaign; an election had, under the Quinquennial Act, to be held before November and, as the months passed by without a dissolution, speeches and pronouncements by leading political figures began to be related more and more openly to the impending election. The Conservative Party leadership frequently referred to the necessity of maintaining Britain's nuclear capability and it was in particular a favourite theme of the Prime Minister. Labour Party speakers, on the other hand, dealt with three main defence themes, although the way in which the issues were raised indicated a wide range of opinion within the party. The most generally adumbrated view was that defence spending as a whole was too great a burden on the economy; the second theme – expressed in a variety of ways – was that Britain's nuclear deterrent capability was of questionable utility, that its standing as an 'independent' deterrent was low and that even as a contribution to the Atlantic Alliance it did as much to create dissension as to enhance cohesion. The third theme was that, specifically on the naval level, expenditure on the POLARIS force inhibited the growth of other capabilities, particularly nuclear hunter-killer submarines. An inference was clearly established that, at the very least, a new Labour government would critically scrutinize the POLARIS

(26) See Pierre, *op. cit.* pp. 251–272, for a very well-informed summary of the period between the Nassau Conference and the General Election of October 1964.

programme, along with other major defence projects; and there was intermittent speculation in the press that it might be cancelled outright.

Against such a background CPE was hard put to it to maintain the momentum which the timescale of the programme required. In particular it became very difficult to get beyond the early planning stage so far as the Faslane Base was concerned. The local agencies in Scotland were, understandably, loth to commit themselves to house-building programmes for which they had no local alternative use, and the Treasury was increasingly concerned about the possible effects of authorizing contracts – principally from the Ministry of Public Buildings and Works – that might not be needed. Nevertheless progress in general was maintained.

While the election was under way, in September–October 1964, a series of briefs was prepared, embodying the most up-to-date material relating to expenditure, estimates, possible cancellation charges and, indeed, almost anything else that a new Government of whatever colouring might want to know. In this respect CPE's position was not much different from the rest of the Ministry of Defence; and shortly after the new Labour government took office, CPE, along with a number of other departmental heads, was called on to make a presentation about the state of his programme to the new Secretary of State for Defence and his departmental colleagues. From then until the end of November, a series of presentations and briefings was made, including one to virtually the whole Cabinet. It emerged fairly early on that while there was a fairly general swell of opinion within the Cabinet to trim the programme in some way, there was no urgent demand to single it out for immediate cancellation; the relatively new commitment to the fifth boat came to be seen as an enabling device which allowed the discussion to be concentrated mainly – though not exclusively – on the size rather than the existence of the programme. Sir William Cook, one of the Chief Scientific Advisers in the Ministry of Defence, prepared a report for the Secretary of State which set out the pros and cons of a force of 3, 4 or 5 submarines, and this formed the basis for most of the debate within the Ministry of Defence. The debate continued through December, and CPE was obliged to point out the difficulties that were arising, and increasing, because of the absence of an authoritative decision; two months had already gone by since the election and the programme was beginning to sag. In early January the Secretary of State formally recommended retaining a four-boat programme, but the Chancellor of the Exchequer plumped for a three-boat force, and the disagreement was taken to Cabinet Committee where the decision was taken to stick with four. A public announcement to this effect was made on 15 February.

The immediate financial effects of the cancellation of the fifth boat were small; some of the ship equipment could be diverted to other purposes, and some of the orders for US equipments and parts could be absorbed in an adjusted spares programme. The nominal saving, to the projected cost of a five-boat programme, as a whole, was between £50m. and £52m., but the actual cancellation charges came to less than a million pounds.

The more general effects of the government's decision are harder to evaluate. From one point of view the determination to retain the programme in any form strengthened CPE's position, perhaps particularly with SP; but within Whitehall the fact that the project had been scrutinized and altered was seen as an indication that political support of the programme was, at the best, equivocal. Even though departmental ministers supported CPE firmly when it was necessary to ask for their help – for example in bringing pressure to bear on contractors – it was clear that CPE was now expected to adopt a low profile: to get on with the job but to keep out of the way and especially out of the headlines.

CHAPTER FIVE

Finance and Budgeting

The management system

The financial management of the British Naval Ballistic Missile System (BNBMS: which was the formal title of the project) had to meet four major requirements. The first was a basic and general obligation to provide financial estimates for forward costings and to assemble accounts of expenditure adequate for both management and auditing purposes according to established government standards. The second was an extension of the first; to arrange for a similar system in respect of expenditure undertaken in the United States on the United Kingdom programme, in order both that dollar expenditure could be monitored and that the transmission of funds, through the Trust Fund which had been set up under the Sales Agreement, could be made in timely manner. The third was to create a reporting system that was sufficiently precise and flexible for CPE's purposes, so that both actual costs and committed expenditure in the United Kingdom and in the United States could be identified readily, and to check that expenditure and physical progress kept in step and matched forecasts given; and the fourth was to provide to CPE generally advice and support on financial planning, contracting and accounting matters.

The general responsibility for the organisation of these functions was the province of CPE's Chief Administrative Officer, an experienced Assistant Secretary with a background in financial management and in dealing with overseas governments. However, with the exception of the arrangements for CPE's office budget, the day to day responsibility for operating the procedures – as well as a great deal of the responsibility for planning them – lay with the 'allocated' staff from the Secretary's Department who had been assigned to the project. A small section of Material Finance Branch I (Mat. I), headed by a Principal, was involved, and brought with it a great deal of experience garnered from the hunter-killer nuclear submarine programme; the head of the section Mr. A. A. Pritchard, was a member of the Sales Agreement negotiating team and was instrumental in setting up both the domestic procedures and the arrangements with SP. A rather larger division of the Navy Contracts Department, under Mr. E. F. Hedger, which had also been primarily involved

with nuclear shipbuilding contracts, moved across and became closely involved with both the domestic and the Anglo-American arrangements; and a section of the Navy Accounts Department, under Mr. F. Whitehouse, became almost full-time in support.

The most immediate problem in January 1963 was to ensure that provision was made in the 1963–64 Estimates, which were about to be laid before Parliament. Nominal sums were included in the Ministry of Aviation and Ministry of Public Buildings and Works estimates through the agency of their own finance branches, but the most significant figures were in the Navy Estimates, reflecting not only staff costs, which were the principal elements in the other votes, but provision for the purchase of long-lead items for the submarines and payments to the shipbuilding yards. Cash provision was accordingly made for £6½m. The preparation of a very provisional outline programme budget had been completed by the time of the Navy Estimates debate, but the Civil Lord emphasised in the debate that a full costing had not yet been possible. The cost of equipment and services from the United States government for a force of four submarines was initially estimated by SP to be something of the order of $300m, and the capital cost overall – including the construction of the operating base – was likely to be 'rather more than £300m' in the period 1963–70. These estimates were progressively refined during 1963–64 but until a relatively late stage in the year they depended as much upon the experience and judgment of the team in Mat I about the general level of estimated costs as upon fully costed details of known requirements.

One of the most difficult areas in which to get such details was the cost of the programme of supplies from the United States. There were obvious structural differences between the two governmental systems, even extending to the timing of their financial years. The British ran from 1 April–31 March, the American from 1 July–30 June. Significantly different methods of authorisation not only meant a certain amount of text-book reading on both sides, but gave rise to quite significant problems of assimilation. The British system of annual parliamentary cash grants was, and is, quite a separate exercise from the preparation of a longer term costing which identified programme patterns of planned expenditure; the financial year was a finite phenomenon, with balances of unexpended funds to be struck at the end of each year, and with a rhythmic cycle of review which enabled political as well as administrative changes to be introduced as a matter of course as well as in a moment of crisis. The American system also had political review mechanisms, at the legislative as well as the executive level, but the attribution of funds, through the process of 'commitment' and 'obligation', did not normally require the same type of preparation of estimates and expenditure, and did not lead to anything like the 'log-jam' which was then common at the end of the British financial year. Although the system of auditing was based upon Fiscal Years, the importance of billing, and of striking a balance, in any particular year of account was not as great in the United States as in Britain. Partly as a consequence of distinctions like these, SP

had to be asked to provide expenditure forecasts for the Joint Programme which covered a longer period than they were accustomed to prepare for their own purposes, and had to be more detailed. The Trust Fund procedures called for a quarterly estimate of expenditure anticipated in the next periods for 'billing'; in ordinary United States government procedures money was obligated by function and was immediately available for any relevant bills that became due. Early difficulties in estimating arose from uncertainty about specific programme needs, but even when the United Kingdom's needs had been spelt out in some detail, shortfalls in expenditure persisted, and unnecessarily large credit balances built up in the Trust Fund. SP costs forecasts tended to be overestimated, in part because of unfamiliarity with the degree of specificity needed on the part of contractors' billing offices, in part through SP's concern to keep in funds and steer clear of any charge by the General Accounting Office that US domestic funds were being employed on United Kingdom behalf. It was not until 1966, after a number of attempts to revise procedures and when the equipment delivery programme accelerated, that this problem was reduced to proportions that both sides found tolerable.

By the end of April 1963, procedures for identifying and accounting for costs had been agreed; they had to be equally useful to CPE's sections and SP's branches, and allow attribution to functions and to formal accounting subheads.

They represented a complete innovation as far as the Admiralty's standard procedures were concerned and, for Navy Estimates, required a system of reporting that dealt with British equipment and services as well as United States equipment and services that were chargeable to the programme. Other government departments, like the MPBW, made returns to CPE about expenditures under their control so that a complete knowledge of costs, and progress, could be maintained. The activities covered by the programme were broken down into 'line items' – eventually about 280 – each of which was concerned with a discrete activity that was chargeable to one vote and subhead of account; the line item coding expressed these attributes, and identified the 'field officer' in CPE whose responsibility the activity was, in a simple six column digit pattern. Forecasts of anticipated expenditure and reports of incurred expenditure were brought up to date monthly, and every quarter there was a detailed review, in which 'field officers' participated, which revised the costings and evaluated what changes were necessary. The programme budget was also used as a basis for the standard assessments in the annual Estimates cycle and the preparation of Long Term Costings which, by 1963, had become a regular forecasting procedure in the Defence field. The line item coding was, of course, a prerequisite for the mechanised handling and preparation of the detailed material, but it was also of considerable significance in facilitating a widespread sense of financial responsibility at the field officer level; information became readily available, to managers who needed to know what was going on, not what had happened months and months before.

The system, which was discussed with the Treasury and the Exchequer

and Audit Department before it was put to the Secretary of the Admiralty for authorisation, worked well from the outset, and after one or two alterations in early 1964, remained the principal working tool for the management of the budget thereafter.

Attempts were made during 1963–64 to link the United Kingdom's purchasing needs with a new Special Projects computer-based programme, the System for Projection and Analysis, acronymically designated SPAN, which in theory would have produced both financial and material progress data.(1) The inputs necessary were however not held to justify the expense that would have been incurred, and a separate form of United Kingdom purchasing programme was devised, initially by the staff in SPRN's office, which would specify what CPE's requirements were; the programme was, in effect, a series of interlocking plans, which identified material needs in relation to timescales and to general planning criteria. Thus, the plan for logistic support began with an introductory exposition of the maintenance and stock philosophy on which the pattern of ordering would be based, and then went on to specify the goods and services in each area, including documentation and delivery, that would be required. The family of documents which together constituted the programme was called 'PEPLAN', and although the last of the major components was not put into final form until 1965/6, the PEPLAN complex represented the culminating stages of the process of learning – on both sides of the Joint Programme – what it was that the British would need to have and what the Americans would have to do to provide it.

The PEPLAN documents were, nevertheless, only general summaries. They had to be supplemented, and indeed could only be activated, by specific purchase orders which had to be sufficiently detailed to provide data on which contracts and instructions to contractors could be based. A draft order would be drawn up, and transmitted by SPRN to the appropriate technical branch in SP, who would check it against the analogous United States needs and practices, perhaps offer suggestions and fill in quantities: it would be costed and then referred back for authorisation or discussion. After authorisation by CPE it would be fed into the SP procurement organisation, and, eventually, turned into a contract. Specific time periods were laid down for the refinement process to turn a 'purchase request' into a 'purchase order': ten days was the norm, although in some instances of major importance, a longer period ensued. Particularly in the early days, when SP was pressing for purchase orders to be placed at times convenient for their own production schedules, CPE depended a good deal on SP's skill, and good faith. It was not an easy process; and it could be argued paradoxically that it was at times made difficult because of the good relations between the parties. CPE's staff was, almost without exception, enormously impressed by the scale of the FBM programme, by the record of achievement and by the evident good intentions of SP management, led by Admiral Galatin and then by Admiral Smith. After the initial and inevitable difficulties in establishing a pattern of cooperation, United Kingdom confidence in the willingness and in the capacity of Special Projects Office became so marked that a period of over-expectation ensued: the United Kingdom team tended to expect too much, and were perhaps not as rigorous as they might have been in spelling out details, difficulties and assumptions. The SP staff were guilty of this too; they were in effect being asked to explain and to share their methods of doing business, which is very difficult to articulate precisely. Even in those areas where a consciously novel pattern had been created, the procedures had become habitual and sometimes differed from Branch to Branch; where they were routine they represented years of practice rather than precisely presented regulations. As a consequence, it was sometimes difficult to identify and explain key procedures and attributes until a problem arose which required these habitual practices to be specified.

A major example of this 'confusion through goodwill' occurred in the late summer and autumn of 1963 over what SP called 'management services' and what in the Joint Programme came to be known as Contract Technical Services. This was the area of business in which SP relied upon their civilian contractors for detailed knowledge and support, not merely to back up headquarters staff but in some cases to provide what, in the United Kingdom government service, would be thought essential headquarters functions. Thus, for example, the Vitro Corporation provided the staff, the hardware and the software, to produce the documentation essential to the configuration control of the whole FBM system documentation; the Lockheed Missile and Space Corporation acted as the missile system co-ordinators and managers, and the Naval Weapons Annexe at Dahlgren acted, on an agency basis, as the centre for many of the most crucial mathematical investigations of system problems. The crux of the matter was that, in the great majority of cases, the information and data that the British needed to begin detailed work – especially to determine what their needs for procurement and training should be – were available only in contractors' plants and from contractors' personnel. In one area only this had been recognized: in the field of shipbuilding, where separate contractual arrangements had been made with the Electric Boat Company and where the distinction between 'bought-in' and Admiralty-supplied items was sufficiently familiar for CPE staff to be able to make an analogy between United Kingdom and United States practice. In other areas, the extent to which SP had decentralised its activities beyond conventional United States governmental practice was simply not hoisted in: and to SP the practice had become so standard that it was not, in the earliest days, thought necessary to explain the system in any detail. The situation first began to be identified when SP Finance Branch (SP 13) produced a provisional estimate of forecast expenditure in the light of the general statement of the United Kingdom programme, which was discussed in the margin of the first Joint Steering Task Group meeting in Washington in June 1963. The estimates of money to be spent on management services was considerably larger than the British side had expected: they anticipated that requirements on these services

(1) See Sapolsky, *op. cit.* p. 105.

would, in effect, be limited to training courses, payment for advisers on site in the United Kingdom, and the preparation of special documentation for CPE's needs. They were surprised to be told that substantial payments would be required to obtain standard and routine information. The initial reaction was that the payment made under the Polaris Sales Agreement for overhead costs ought to cover such matters, and there was some apprehension that major United States contractors were endeavouring to make themselves expensively indispensable. This not only caused concern on financial grounds; from the point of view of technical experience and the building-up of knowhow, it was highly desirable that the Royal Navy should learn as much as possible as early as possible about the intricacies of the whole system – especially since it had been accepted that they should forego the opportunity to manufacture parts in the United Kingdom. The two Project Officers agreed that the problem area should be examined in detail: the United States side to explain precisely what went on, the United Kingdom side to determine what it wanted to settle for in the light of the explanation.

The issue took several months to resolve, but acted as an important learning process on the budgetary as well as on the technical side of the United Kingdom programme. The procurement function in the SPRN office was initially covered only by a Senior Contracts Officer: a finance officer was added some months later. His initial function was to help set up a consolidated budget and shopping list, to fit United Kingdom needs, as they became clear, into SP contracts and also to learn and disseminate information about SP procedures, particularly those relating to authorisation and funding techniques. He was in the early days very heavily dependent upon the good offices and assistance of SP 13. It was difficult to comprehend easily the scope of the organisation and programme that CPE had joined up with. It turned out to be the case that, in the budgetary and contractual areas, there were few standardized procedures; practices differed between SP branches and even between different parts of the same branch. Moreover the practices of SP were being subjected to changes common to the whole of the Defense network, that were the result of Secretary McNamara's reorganisation of structures and procedures involving an extensive centralisation, and standardisation of procurement policies. Insofar as these were all directed towards greater uniformity and more evident control by the Secretary of Defense, Special Projects was one of the 'over-mighty subjects' whose effective independence of action was being scrutinized and curtailed.(2) The general effect of these changes was to lengthen the period of time between the articulation of a requirement and its validation by a formal contract with a company or firm. The requirement had to be reviewed, made as specific as possible and costed as carefully as possible before the contract was negotiated. There was by this time very little competitive or alternative source tendering in the FBM programme; only in the navigation sub-system

(2) See Sapolsky, *op. cit.*, Chapter 7, for a description in some detail of the effects which these changes had on Special Projects Office.

was there still an effective possibility of opting between two suppliers and it was in this area that a major problem arose.(3) Nevertheless procurement procedures were, by comparison with British techniques, lengthy and even ponderous.(4) There was virtually no equivalent of the simple 'letter of intent': United States government contracts were very formal documents and their negotiation reflected the relative importance of legal counsel. The function of negotiating was split between the Counsel's office, which dealt with the general terms and conditions of the contract, and the negotiating office, comprising negotiators who were principally concerned with the financial and pricing aspects. In the Admiralty, as in most other United Kingdom government offices, the Contracts Department staff were used to constructing and dealing with all the elements in a negotiation, whereas in SP even relatively minor matters were codified and institutionalized in the Armed Services Procurement Regulations (ASPR). But in 1963 and 1964 these regulations were being extensively revised to allow for the development of new and varied types of contracts including incentives to better contractual performance. In this respect, as in so many others, the United Kingdom and United States governments were making broadly similar responses to broadly similar problems of administration which they had both experienced during the 1950s, principally as a result of the rearmament programme of that period. The difficulties of estimating, and then controlling, the progress and costs of major development programmes had been highlighted by a series of cancellations or of cost overruns, and had been followed by a number of organisational changes and administrative innovations. In the United Kingdom this had been an element in stimulating the reorganisation of the Defence departments into a single entity,(5) and the analysis of the problem of controlling technologically advanced programmes in the Gibbs–Zuckerman Report was to be followed by a major reshaping of the control machinery.(6) The acceptance of a project-type organisation for the United Kingdom POLARIS programme was itself a manifestation of the same concern. In the Admiralty, as in other departments, there was a general movement towards improving the performance and sensitivity of government's contractual relationships with firms as well as in improving internal procedures (and the Ferranti and Bristol Siddeley affairs showed how necessary changes were).(7) Incentive and penalty clauses were being discussed on both sides of the Atlantic and, for the British, contact with United States thinking helped to speed up the pace of innovation. The issues involved were by no means simple. Although incen-

(3) See Chapter Four.
(4) Interview.
(5) The reorganisation took effect in April 1964; after that time the Admiralty became the Navy Department. CPE's London office moved from the Old Admiralty Building to the Main Building, on Horse Guards Avenue, to a suite of rooms snuggling behind the navel of a symbolic but unpleasing concrete deity which decorated the lintel.
(6) The most detailed description is given in the *Second Report of the Select Committee on Science and Technology, 1968–69 (Defence Research, H.C.213*, 27 March 1969).
(7) See the Lang Reports, *Cmnd. 2428 and 2581* respectively on the Ferranti and Hawker-Siddeley contracts.

tive contracts required the identification of target costs, they did not make it any easier to find out what such costs should be in R and D areas where one of the main purposes of the activity might be the exploration of uncertainty. The administrative costs inherent in new styles of contracts had to be related to effect and scale; incentives were difficult to apply in some cases, especially again in R and D work. The Ministry of Aviation had genuine difficulties here in their part of the POLARIS programme; and this perhaps was the basic reason why their procedures were neither identical nor, in one or two cases, compatible, with Admiralty practice.(8)

The business of building up detail in the United Kingdom programme budget was followed up so that by the time of the 1964–5 estimates season it was altogether a more full and reliable forecast, from the United Kingdom and from the Joint Programme standpoint. The expenditure and programme totals came to a capital cost of £345m spread over the years 1963–71, with running costs of about £95m during the same period: thus £20m was included in this total for material and services required by the Ministry of Aviation, and not covered under the provisions of the Sales Agreement.

	Total	1963/4	1964/5	1965/6	1966/7	1967/8	1968/9	1969/70	1970/1
	£m.								
Capital Cost	345	7	39	65	69	70	64	30	1
Running Cost	95	1	3	4	5	12	20	25	25
Dollar Element	$m.								
	440	8	42	69	74	82	84	55	26
	203	4	25	34	38	39	30	18	15

The functional breakdown of the capital expenditure was estimated to be as follows:–

	£m
4 SSBNs	141
Miscellaneous shipbuilding	9
Support costs	47
Missiles and torpedoes	85
R and D	52
US overhead charges	6
UK headquarters costs	5
	£345m

(Note: 'Miscellaneous shipbuilding' included capital grants to the shipyards, the construction of a new floating dock and the conversion of a Royal Fleet Auxiliary vessel to transport missiles. 'Research and Development' included ship-fitted communication equipments.)

(8) Interviews.

This total neither included provision in respect of a fifth boat in the programme nor purchase of contingency reserve equipment (£6½m) which had been decided upon as a precautionary measure.(9)

Running costs reflected the build-up of expenditure first on training, hydrographic surveys and other preparatory services and then the operational costs of the submarines themselves as they prepared for and then entered service. The continuing element of dollar expenditure was caused principally by proving trials (including the firing of test missiles) and the supply of spare parts for missile system equipments.

The addition of a fifth submarine to the programme early in 1964 called for a revision of the totals, and also for an increased payment to the United States in respect of overheads, to cover the longer building period; it was agreed by the Project Officers that two extra quarterly payments should, in due course, be made. Additional equipments and missiles would also need to be ordered. But, by the time that the fifth boat was dropped from the programme, less than a year later, no major orders relating to the ship had been made: the definition of the initial building period reverted to its previous scope, and cancellation charges on those contracts which had already been placed amounted to less than a million pounds, since some of the equipment which had been ordered as 'long lead' items was able to be used for a later fleet patrol submarine (as hunter-killer submarines had now been renamed). By January 1965, something approaching £180m of the estimated capital expenditure had been either committed or would have attracted cancellation penalties if the whole programme had been abandoned.

'Downstream definition'

During 1965 a number of factors combined to focus the attention both of CPE and SP upon the arrangements for cooperation that would be needed once the initial building phase of the United Kingdom programme had been completed. The most obvious of these factors was the decision of the new British government to continue with a four-boat programme; but almost as salient a matter within the two separate national organisations was the need to prepare financial estimates covering the post-construction period.

In Whitehall generally, the movement towards ten-year budgetary forecasts was now being extended and becoming a standard requirement; within the Ministry of Defence it was already an annual exercise, in which 'the long term costing' was based upon both approved and (towards the end of the costing period) projected plans. CPE was now both in a position to lay long-term plans and also under an obligation to specify what would be required to maintain the completed POLARIS squadron in service.

(9) The contingency reserve consisted of a virtually complete set of weapon system equipments, other than launch tubes, and was intended to be a back-up in the event of an installation mishap.

In particular it became more and more desirable to identify what the 'steady state' need for stores and spare parts would be, and what the material and manpower needs of a long refit would amount to. The first issue raised some major engineering points; would the United Kingdom system remain identical – or as near identical as possible – to the deployed United States system: or would CPE want to be able to select, and perhaps discard, future SP alterations and improvements? And, if that were to be the case, what machinery would have to be set up to make such judgments and, when they were made, to maintain an adequate – and compatible – system of configuration control? The refit problem raised even wider matters: SP themselves had relatively little experience of overhauls involving the deployed A3 system and could give, for the meantime at least, relatively little in the way of precise guidance. CPE's experience about the problems of ship sub-systems and equipment under refit would have to wait, like experience in re-fuelling the nuclear propulsion plant, upon the first refit of DREADNOUGHT. Target times and expenditures could be set but, for the time being they would have to depend upon the realism of the planning being undertaken in collaboration with the Director-General of Dockyards and Maintenance and the staff of Rosyth Dockyard. In the matter of refits, CPE and SP were more nearly parallel so far as the state-of-the-art was concerned than in any other area of the joint programme.

In Washington, SP had a somewhat similar duty to provide long term budgetary forecasts; but although in form this was a standard function, from 1965 onwards it raised problems which impinged directly on the future of the United Kingdom programme. Following the successful development and deployment of the POLARIS A3 system, SP already had approval to develop a more advanced weapon system (which sequentially was identified as B3, C3 and finally, in its eventual form, POSEIDON). Although in 1965 the parameters of the system characteristics had not been finally agreed, it was already envisaged that this development would be fitted into submarines of the earlier POLARIS classes as they became available for extended overhaul. CPE was kept informed of the progress that was being made on the new system in a number of formal presentations at successive JSTGs. One of the major consequences for the joint programme established by the Sales Agreement would be that, at some not very distant date, the A3 production lines would be closed down; and both the United States and the United Kingdom authorities might have to decide upon their gross needs for A3 equipment on a 'once for all' basis. The Department of Defense laid a requirement on SP, in the spring of 1965, to devise a plan for 'efficient missile procurement' for the A3 system; and SP in turn had to consider, in conjunction with CPE, what this would mean for them both.(10)

It was at this stage that a disparity of viewpoints began to emerge about the meaning of the POLARIS Sales Agreement as a continuing

(10) Interviews.

obligation. The staff of CPE made the assumption that the whole range of provisions in the Agreement were standard, and intended to be continuous; this would mean that not only the levels of technical assistance but also the existing levels of financial charge would be maintained. SP staff on the other hand argued that although the general provisions of the Sales Agreement had been undertaken, and acknowledged, as a continuing obligation, the financial provisions in particular – and perhaps some of the technical support too – had only been agreed as relevant to the initial building phase of the joint programme. The need would arise as a matter of course therefore not merely to reassess the technical basis of the relationship but also to review the financial terms. There was therefore a common concern at one and the same time to make sensible and responsible arrangements for a period of cooperation that neither organisation could yet discern in detail, and to manage the shift of position without losing the control that was essential to the maintenance of the status and authority which each organisation had within its own national environment.

It was first of all necessary to establish what the size of the problem was, and CPE initiated discussions in June 1965 to discover the range and extent of SP's ideas about future technical relationships as well as the procedures for arriving at longer-term budgetary forecasts. It was possible relatively quickly to arrive at a satisfactory, if temporary, arrangement on budget figures: tentative estimates were available for refit costs, at least so far as the direct POLARIS weapon system costs were concerned, and a number of major issues (like, for example, the practice to be followed on Operational Test missile firings) still had to be decided upon by the United Kingdom, so tentative expenditure forecasts were acceptable in these areas too. The United States side was less inclined to begin serious discussions straight away on technical matters; they agreed that there were likely to be problems of redefinition – indeed it was they who first put out warning noises – but they did not yet feel ready to debate them. The exact shape and timing for the POSEIDON development was not yet firm, and might substantially influence the issues, and some alterations to the A3 system configuration had to be evaluated first.(11) So each side settled down to evaluate their own positions and intentions, and came together first for formal discussions to determine 'areas of the Polaris Sales Agreement which may be limited in time or scope' during the tenth meeting of the JSTG in September 1965, in Washington.

Over the next eighteen months discussions proceeded regularly but slowly, as both sides gave priority to determining what their own national objectives in the joint discussions should be. The discussions within CPE identified four general areas of hardware support that would be

(11) The Project Definition Phase for POSEIDON had begun in January 1965, and at the same time SP formally notified CPE of the United States's intention to acquire a lofting capability in the A3 system; *JSTG 9* and *JSTG 8*, respectively.

required on a continuing basis. The first was the routine replenishment of stocks and spare parts: this might become a heavy item of expenditure as major components like missile rocket motors came to the end of their defined life. The second was the replacement of items used in practice firings; the third was the modification packages which might either arise from routine developments under the configuration control system, or might be introduced to prolong system effectiveness. The fourth area was in the nature of a contingency provision, and arose from the need to buy and support new equipment or to replace prime equipments that had become damaged. There were parallel 'software' requirements, for continuing the supply of documentation and configuration control material: for any contract technical services that might be needed: for continued participation in the AUTODIN communication links that supported the stores and spare parts provisioning system, and for assistance from POMFLANT (the Naval Weapons Annexe at Charleston, S. Carolina, where submarines stored up before practice firings). There might also, in the future, be research and development needs, for which United States support would be required – though this was much more conjectural in 1966–67. By the summer of 1967 it had been agreed to undertake a joint review of those sections of the Technical Arrangements which related to a continuing technical function, in addition to determining what the overhead rate of charge should be for United States government services and at government assisted facilities. The agreement to proceed hid a good deal of careful preparation and activity; each Project Officer obtained – on neither side without difficulty – acceptance of the principle that the discussions should take place within the ambit of the Sales Agreement and between the Project Officers; and on the United States side, SP had had to convince the United States Air Force that the undertakings in the Sales Agreement and in the existing Technical Arrangements explicitly meant that the charges for United Kingdom usage of the Air Force Eastern Test Range were to be raised on the same basis as for the United States Navy; i.e. that the Sales Agreement was a Government to Government agreement.(12)

The specific negotiations followed a predictable enough pattern; the United Kingdom side sought to establish and emphasise the essential continuity between the construction phase and the post-construction period, but they also wanted to provide for new situations that might arise. What future supply requirements might be could be worked out over a period of time; but could they include the purchase of 'common stock' equipment that was surplus to United States needs, at beneficial prices? And could such a provision be established in a way that would not overload a United States support system that would increasingly relegate A3 material to a relatively small proportion of its concerns? The United States side, on the other hand, were concerned both to retain the substance of the main obligations which the Sales Agreement represented, and

(12) Interview.

over which there was no disagreement, and also to moderate, on the basis of the experience accumulated since January 1963, the system of co-operation which was limited to an equipment configuration which no longer represented SP's prime concern. One matter was relatively easy to agree; neither side was anxious to retain the average cost adjustment formula which had been introduced to arrive at prices for United Kingdom equipment purchases during the initial construction period. It had proved in practice to be a difficult and long-drawn out series of refining approximations, which displayed no advantages over less subtle accounting procedures, except that, theoretically, the cost of items to the United Kingdom was averaged out over contracts which had not benefited from large batch orderings; in this way the Department of Defense had hoped to get a return that reflected rather more fairly the heavy 'learning curve' costs of the initial procurements for the United States Navy. But it remained the impression within CPE that what was gained on such a swing was lost in the costs of the complicated accounting roundabout that was the consequence. It was agreed that for missiles, equipment or spares delivered after January 1970, the common contract price to the United Kingdom should be either the actual cost, where that was identifiable, or the proportionate share of the total costs for a particular batch or lot.

The major issue remained whether a percentage surcharge should be levied as a contribution towards overheads and facilities in the post-building phases. Both sides were content to leave the surcharge of 5% as a contribution towards R and D costs at its current level (set out in Article XI, 1(b) of the Sales Agreement), but both sides were equally well aware that the effective levels of payment made on this account, as well as on overheads, would vary quite considerably as decisions were made about the level of equipments and services to be procured; thus, if the 1970–80 bill came to, say $300m overall, the difference between 3% on-cost (which was the initial British thought) and a 12% charge (that was discussed at one stage by the United States side) was a total of real significance to both sides. Both sides were able to produce arguments of substance, and precedents, to support their positions; but both were also aware that, as in the original Sales Agreement negotiations, a settlement had to be found. Finally, the positions were refined to a point where concessions on both sides could reasonably be made in support of a reasonable settlement, and it was agreed, and approved by ministers, that the United Kingdom would pay a surcharge of 7% on expenditure recorded after 31 December 1969, as a contribution towards the overheads and use of government facilities. Although this settlement did not remove all the outstanding financial problems likely to arise during the post-building period, it established a satisfactory basis for the continuation of financial and technical collaboration. These discussions were held on a separate basis from the complicated negotiations that developed in the same period over offsetting some of the dollar expenditures to which the Labour government had become committed with the Phantom, Hercules and F111K programmes; although it seems that, for accounting purposes, the dollar costs of POLARIS were brought into later defence

agreements about the costs of the British Indian Ocean Territories development at Diego Garcia.(13)

The total estimated costs of the POLARIS programme, from December 1962 until the end of the financial year 1973–4, were approximately £520m.(14) This total includes running costs. The report in which this estimate is published identifies the cost of the four submarines as £162m (against the early estimates of £141m), and of purchasing missiles as £53m (against what was said to be the original estimate of £92m – a figure used in 1963 and subsequently reduced).(15) The costs of the Faslane Base, including Coulport, came out to £47m, and although in recent years the running costs of the completed force have risen substantially above the early estimates of £25m per annum, the rise is more due to inflation than to any inherent change in the scale of provision for either operating costs or refits. Even on the basis of the rather generalised public statements on costs, however, what we see is an estimate, made in 1964, of a gross cost, between 1963–4 and 1970–71, of £440m, and an eventual gross cost, for the period 1963–1974 of £520m; and the difference which, on the face of things, seems to be £80m for the longer period, has to take account of some £140m on running costs (although some of the costs for 1970–71 were included in the earlier estimate). The conclusion seems to be obvious that, even given the increases in submarine costs and the decreases in missile purchases, there was, overall, a significant saving on the programme, in the sense that it eventually took less money to produce and deploy the force than had originally been envisaged.

(13) See, for example, the report in *The Guardian*, 17 October 1975, p. 2.
(14) See Appendix 1, p. 37, of *The twelfth report from the Expenditure Committee, 1972–73, Nuclear Weapon Programme, HC.399*, July 1973.
(15) *Ibid*, p. vii.

CHAPTER SIX

The Joint Steering Task Group

The Joint Steering Task Group was set up as one of the obligatory mechanisms by which the POLARIS Sales Agreement would be managed; Article II of the Agreement identified the agencies to which each government delegated functional responsibility, established national Project Officers, and required them to meet together formally and periodically.(1)

The model for the JSTG was the Steering Task Group which the Special Projects Office had established in the American national programme; that was a committee composed of senior representatives from all the major naval and industrial organisations participating in the FBM programme, and had provided specialist sub-committees or panels through which many of the actual performance goals for the FBM system had been defined. The idea of including provision for a formal group of this sort in the Sales Agreement was put forward by Special Projects Office in January 1963, when the State Department was drawing up a draft document which might be the basis for detailed negotiations; Admiral Galatin and his advisers were by no means sure at that time quite what the burdens of co-operation would be but drawing on their experience they felt that there would be advantages in providing for a formal forum. Whether it would be a decision-making body or an advisory group, or something else, could not be foreseen. Admiral Mackenzie was immediately attracted to the concept; one of his strongest initial impressions of Special Projects Office was the pressure under which they were already working, and he – equally instinctively – felt that there would be advantages to his new organisation in being able periodically to meet SP's senior management. Accordingly there was very little discussion about the JSTG during the Sales Agreement negotiations, and no very clear idea of the function that it would perform; the draft wording of Article II was accepted virtually as it had stood initially.

(1) See Appendix 1 for the text of the Agreement.

As things turned out, the JSTG meetings came quite quickly to be regarded by both CPE and SP as very important, for nearly identical reasons. The periodicity was changed in 1965 from four times a year to three times a year, but throughout the initial building phase the meetings represented an opportunity, at set periods, to supplement and review a host of other meetings and activities. From Admiral Galatin's point of view, the meetings performed at least one of the tasks that the Steering Task Groups had usefully stimulated at the national level: whereas the STGs had encouraged new insights in FBM development goals by mixing scientists and engineers together, the JSTGs stimulated co-operation and co-ordination by mixing national managers.(2) But that was perhaps a bonus; for the two national Project Officers jointly, the JSTGs provided a discipline which was instrumental in maintaining a sense of urgency, and a high standard of work and preparation. Pressure was put on individuals and sections to complete matters of business, or at the very least to clarify their ideas and establish their positions. A JSTG did not supersede a specific problem or a particular negotiation; but it did provide a framework within which the most senior management personnel in the joint programme could be kept informed, could be made aware of any special difficulties, and could collectivise any problems or devices that gave rise to concern. In this way, the JSTGs functioned, in the joint programme, in something of the same way as the 'Monday morning meeting' did within SP. The benefit was heavily concentrated on the United Kingdom side insofar as it was much to CPE's advantage to have prescribed periods during which SP management was required to give full-time attention to problems which were invariably of more concern to the British; indeed, so evident was the pressure on SP during 1964–65 from the United States national programme (3) that Admiral Mackenzie thought it a constructive gesture to propose reducing the meetings to three a year. Although this suggestion was regretted by staff members in both organisations, whose own functions were assisted by quarterly instead of four-monthly meetings, it did quite materially relieve the load on Admiral Smith (who became Director of Special Projects in February 1965) and it emphasised the role of the JSTG as a supplemental and not a transcendental management tool.

The meetings fairly quickly developed a standard pattern; the respective Liaison Officers were nominally the joint secretaries of the Group, but the *de facto* management of the Group's business was organised by the senior civilian administrative staff in each organisation. By the third JSTG, in December 1963, a routine had been established: a provisional agenda was agreed about three weeks before the meeting, usually after an exchange of teleprinter messages between Washington and London, and position papers exchanged about a week beforehand. This was an

(2) Interview.
(3) Most notably arising from the overlap of the A3 building programme and the POSEIDON development project.

ideal, which was sometimes not attained; but if it had not been possible for one side or the other to prepare a paper for discussion, the reasons why, and an outline of the probable thrust of argument, were habitually available. The JSTG was not an adversarial forum, and was not the place to spring surprises. Meetings normally took place over a three-day period; on the morning of the first day the joint secretaries and their colleagues would meet to review the agenda and supporting documentation, and each national delegation would meet separately for briefing purposes. In the early afternoon there would be a plenary session, with the 'home team' Project Officer acting as Chairman. Although the specifically accredited members of the JSTG might total no more than twelve or fifteen, attendance at plenary sessions was usually more extensive, with staff officers and assistants attending not merely to hear the discussion but also to take part in any sub-committee work that had to take place. For the most part, discussion at the first plenary session tended to be limited to establishing what the current status of agenda items was, and what the JSTG could be expected to do about them. Some items recurred at regular intervals (e.g. the preparation of the Joint Annual Report to governments that was a requirement under the terms of the Sales Agreement) and some were more or less standard items (e.g. the review of the status of the Technical Arrangements); almost by definition the JSTG did not deal with critical or immediate problems, and certainly would not deal with them as an initial step towards control or resolution. There would usually be some items about which general discussion and comment would develop, but for the most part the Project Officers would delegate to specific groups, with specific (or at least definite) terms of reference, the job of evaluating the report, or the draft, or the intransigency, and reporting back by the second plenary session. The working groups would convene at once, and would use the middle day of the meeting as well to complete their work; the second plenary session would take place on the morning of the third day, to discuss the working group reports, agree the minutes of the first plenary session, and lay down any general requirements that might have emerged. The two Project Officers would not normally take part in any of the sub-committees; they might go off together to visit a specific facility, like one of the shipyards, or they might simply take the opportunity to talk to each other.

The collectivity which the JSTGs represented was an important, if largely accidental, device in developing and sustaining the sense of unity in the joint programme. Participation in an international programme was a consolidating element in SP's national status and reputation: association with SP was an important source of strength and *morale* to CPE, and to a very real extent the JSTGs represented the physical manifestation of these attributes. They also provided a framework for the social knowledge which each group had of the other. It was, of course, not an unbroken chain of friendliness, nor did it, for the most part, extend very far down the hierarchical structures. But, where it existed, it proved to be strong and durable: and the extent of the professional trust that was engendered, as well of the personal frienships, is a phenomenon of un-

usual strength.(4) The secretaries of the JSTG very early came to an agreement that there would be no competitive hospitality; rules did not allow it and common sense indicated that it was not necessary. There were however periodic formal entertainments, when the most senior staff, for example, were entertained to lunch by the Minister for the Navy; and regular informal entertainments too, paid for entirely, and sometimes catered, by the staff themselves, not so as to invoke comparison with the lavish contractor hospitality, which was a resilient myth and an evasive reality, but to offer a welcome to a friendly and well-regarded group of colleagues.

(4) It is, of course, difficult to judge the dependability of recollections fostered by interviews: but the persistence of comments, internal evidence in the files, and experience derived from other investigations, leaves little doubt about the reality of 'the POLARIS bond' for those who experienced it.

CHAPTER SEVEN

Shipyard Progress

The choice of the Vickers Shipbuilding Group yard at Barrow-in-Furness as the lead yard was announced publicly in the Estimates Debate on 11 March 1963. Cammell Laird of Birkenhead was the only serious contender, as it turned out, for the contract to build two other POLARIS submarines. The lead yard concept was necessary for three reasons. It facilitated the close liaison that would be necessary with the United States programme; it was an economical way to provide the range of planning services that would be necessary, and which Cammell Laird themselves could not in any event provide; and it obviated any requirement to provide additional planning resources from the Admiralty. The award of contracts was announced on 8 May(1) and both shipbuilders embarked on a task which involved an expansion of facilities, an increase in staff, a change in the structure of staffing, and a profound impact on the standards of work and the nature of management operations.

By the end of May 1963 it had been decided too that CPE should assume responsibility for the progressing of the construction programme of hunter-killer submarines. Vickers were the only shipbuilders with experience of nuclear submarine work; they had constructed DREADNOUGHT, were in the process of building VALIANT, and were scheduled to produce WARSPITE. The relationship between the POLARIS programme and the hunter-killer programme was therefore substantial. This interdependence was evident not only in the shipyards. VALIANT was to be powered by the first British reactor unit, then only at the prototype stage at Dounreay, but the design was to be used in the propulsion unit for the POLARIS submarines also. The delay which would occur in the laying-down of additional hunter-killer submarines, and about which so much of the Navy's initial reservations about POLARIS were centred, was evidence of the close connexion between the programmes; but it was the only direct impact of POLARIS work on other naval construction schedules and would be reduced in its effects by a slight acceleration in the lay-down rate in later years.(2)

(1) *The Times*, 9 May 1963.
(2) See *House of Commons Debates*, Vol. 675, Cols. 1255–56, 10 April 1963.

Shipyard facilities

The expansion of shipyard facilities and increases in the skilled and semi-skilled work forces there and elsewhere were the immediate problems which pre-occupied the shipbuilders through to mid-1964 and prompted some progress chasing by CPE, involving a visit by Admiral Mackenzie to all the major contractors towards the end of 1963.(3) Skilled manpower was at a premium, and welders and draughtsmen especially were in short supply. At Vickers, recruitment figures were monitored weekly in the early period and advantage was taken of a recession on the Clyde and in Dumbarton, which released some of the necessary trades, to undertake recruiting drives.(4) Between 1963 and 1967 the size of the work force at Vickers increased by approximately 45%.(5)

In early 1962, Cammell Laird had completed the first stage of an extensive shipyard reconstruction programme,(6) but further work costing £1.6 million was necessary to equip the yard for building POLARIS submarines. Moreover almost all of this investment had to be turned into physical structures and equipments in the first eighteen months of the POLARIS project. A high level welding shop was most urgently required so that prefabrication work on the first of the Company's submarines could be begun as quickly as possible. Reconstruction of two berths and a jetty, together with associated work to the road, drainage and river wall were next in order of priority.(7) The Vickers yard at Barrow also required additional facilities, and more extensive dredging of the Walney Channel.

The nature of the task in hand, constructing nuclear powered submarines and equipping them with a POLARIS weapon system, combined with the urgency and priority accorded to the programme to generate a widespread innovatory impulse in the building yards. It was reflected not only in managerial and organisational improvements but in technical progress in, for example, the development of advanced welding techniques.(8) Urgency and the size of the undertaking were reflected at the outset, in the rapid expansion of facilities and of the labour forces. However, the various organisational and procedural innovations associated with the building of the ship, the installation of the propulsion unit and weapon system, and the testing and tuning required before the whole system was commissioned, were reflected in the establishment of new planning controls and new quality control and assurance procedures.

(3) Interview.
(4) Interviews. William Denny and Brothers, of Dumbarton, and William Hamilton and Co., Port Glasgow, closed their yards during the period. See the *Shipbuilding Inquiry Committee, 1965–1966*, Cmnd, 2937, 1966, Appendix M, P 186 (The Gesses Report).
(5) See, "The Polaris Submarine Programme", *Nuclear Energy*, Nov–Dec 1967 p. 169. The increase was from 3,100 to 4,500.
(6) See "Modernization at Cammell Laird", *Welding and Metal Fabrication*, 31st July 1963, p. 283.
(7) See W. E. Armstrong and M. J. Freazey, "Shipyard Reconstructed for Polaris Submarines", *The Dock and Harbour Authority*, Vol. XLVIII, No. 569, March 1968, pp. 359–61.
(8) J. W. Wealleans and B. Allen, "Towards automating the Tig Welding Process", *Welding and Metal Fabrication*, Vol. 34, March 1969.

New planning offices were necessary to deal with the problems of co-ordination and time schedules, and to manage new standardised progress reporting methods both within the yards and to CPE that were required under the provision of the Admiralty contracts.(9) The scale of the quality control and assurance effort that developed was perhaps the most formative and pervasive feature of the changes brought about in the shipyards, especially at Barrow.

Quality control

In principle this was not an entirely novel development. Quality control was a standard feature of most productive processes and was an extremely important and integral part of nuclear engineering work, and safety in general. Significant advances had been achieved in the DREADNOUGHT programme where the new demands and circumstances associated with employing nuclear propulsion in a submarine had already been grappled with.(10) These advances, and the experiences gained, were to be carried over into the POLARIS programme where they were applied more extensively and with a different order of intensity.

The Technical Directorate at Bath was the single most important source, within the programme, of the insistence that the shipbuilders should take over the responsibility for weapon system testing and tuning and for providing the appropriately documented assurances of the consistency and quality of their product. It was also the fact that a basic practical need existed to employ techniques which were as far as possible compatible with those employed in the United States project, and which would ensure that the United Kingdom programme achieved standards and specifications comparable to those laid down in the Special Projects Office. Beyond this, and equally important as far as CPE was concerned, was the need to operate and to be seen to operate at a level of competence which would meet and perhaps exceed SP's expectations. It was this sort of additional appreciation that was instrumental in helping to establish for the most crucial linkage in the United Kingdom programme a cordially competitive, and highly productive, relationship.

In wider organisational terms, the Admiralty too was increasingly concerned to apply the general principle that the shipbuilder should be responsible for the quality of his own and his sub-contractors' product. Production and inspection are two potentially conflicting functions. The Admiralty had provided an independent service by employing Naval Overseers in the shipyards. In effect it was a 'cheap inspection service' and quality control service for the shipbuilders.(11) There had up to that time been a measure of operational co-ordination between the various

(9) Interviews.
(10) Interview.
(11) H. J. Tabb and S. A. T. Warren, "Quality Control Applied to Nuclear Submarine Construction", *Royal Institute of Naval Architects Quarterly Transactions*, Vol. 105, July 1966.

overseers but no specific direction or cohesion existed. The link between overseers and their headquarters departments had been particularly strong, sometimes stressing professional issues above Admiralty interests as a whole. The increased burden and particular demands of the quality control function associated with nuclear submarine construction had already, with the DREADNOUGHT programme, instituted proposals for a re-organisation of the overseeing service in the shipyards; with the advent of the POLARIS tasks, these changes were implemented, giving cohesion, and the opportunity to play a more effective role, to the overseeing service.(12) It was also increasingly evident that this developing and growing task would have to be shared by the shipbuilders.

A number of factors made quality control a distinctive aspect of the construction task. The increased diving depths and higher underwater speeds attained by nuclear submarines posed two sorts of difficulties; to keep the hull weight within reasonable limits at greater depths involved the use of stronger steels, which in turn meant much closer control of fabrication and welding procedures as well as improved inspection techniques. In this way the safety of the watertight envelope could be assured. High underwater speeds increased the risks associated with errors or control system failures, and this again required higher levels of quality control in building and installation.(13)

Shipbuilding is, literally, a 'dirty' business and general standards both of cleanliness and precision were at odds with the more precise requirements of nuclear engineering. The transition to DREADNOUGHT had meant working within reduced clearances and to very close tolerances. These features were even more significant in the POLARIS submarines where precise missile tube alignment was an additional requirement. Cleanliness in the building and installation processes therefore became an even more important aspect of quality control.(14) Moreover the special deterrent role of the POLARIS submarines presented additional demands; the highest standards and assurances of operational availability and reliability were required. Precise and standardised documentary evidence was needed to establish that inspections and tests had been carried out to the quality level specified and so provide those assurances, in the ship systems, as well as in the weapon system.

Consequently the production schedule was of prime significance in determining both physical progress and quality: the risk of dislocation of a time schedule could be minimised by adherence to effective quality control and assurance procedures. Time lost through unexpected failures of a system or piece of equipment could often be totally out of proportion to the inherent significance of the defect, and experience gained in the United States had strongly suggested that efficient quality control produced higher rates of success the first time a system was tested.(15) The

(12) Interview.
(13) Tabb and Warren, *op. cit.*
(14) Interview.
(15) Tabb and Warren, *op. cit.*

substantive philosophy underpinning the quality control and assurance effort in the United Kingdom POLARIS programme was epitomised by the Technical Director:–

> "A proper programme is one that gives ample time at the end for testing, tuning and trials; ample time at the beginning for quality testing and for failures, and a few simple milestones in the middle."(16)

One-third of the total elapsed time between the order and the completion of the first POLARIS submarine was devoted to testing, tuning and trials: it was evident that if a part malfunctioned on the day before final acceptance the target date would not be met. Meeting such targets, and having it generally known and accepted that such targets must be met was an integral part of the operation and style of the programme, openly propagated and promoted by its directors. Although 'getting it right first time' was an ideal (a new device was 'bound to be wrong'), quality control was regarded as generating improvement through controlled and documented failure. Testing and inspection was a procedure for identifying troubles as early as possible; documentation of the tests established and recorded a learning process:

> "if a part failed on RESOLUTION, you might catch it out on RENOWN."(17)

The contractual obligations which the shipbuilders were required to assume gave the first public indication that the novelty of the POLARIS task would materially affect standard practices. For the first time in the United Kingdom a naval ship contract required the shipbuilders to set up quality control organisations independent of the production process and the reorganised Admiralty overseeing service was available in the yards to monitor the constructors' performance. The Principal Naval Overseer now existed to act as the focal point of contact between the shipbuilders and the Admiralty; he was supported by the Naval Constructor Overseer, the Naval Engineer Overseer, the Naval Electrical Engineer (Nuclear), the Warship Weapons Overseer, and in addition for the POLARIS programme a Naval POLARIS Weapon Overseer. These officers were technically responsible in their own fields and the Principal Naval Overseer was responsible for co-ordinating the inspection service they provided and the efficiency with which it was performed.

The POLARIS Technical Directorate was drawn in to assist in the establishment of the shipyard quality control organisations in both shipyards, and to guide the drawing up and implementation of the appropriate procedures. A quality control working party consisting of hull,

(16) Interview: see also Mr. Baker's comments in the discussion accompanying the paper given by Tabb and Warren to the R.I.N.A., *op. cit.*
(17) Interview.

mechanical and electrical engineers was set up by the Technical Director to help identify the areas and systems to which quality assurance procedures were to be applied and to establish the form of documentary evidence which was to be required. As the quality control organisations were built up, so their responsibilities were extended. Initially it was decided to employ in each yard the available and relatively limited resources to provide assurance of quality in critical areas. The first task therefore entailed a review of the submarine design to select the structures, fittings and equipments which were vital to submarine safety. The impulse to classify too many items as critical was evident and had to be resisted so that the new organisations were not overloaded. A similar impulse to set standards which were unattainable in practice was also a general problem. Careful professional judgement was required, not only to identify and specify realistic governors, but also to appreciate that a high rate of delinquency associated with unattainable standards would exacerbate the difficulties involved in introducing these innovations, undermine their utility and limit the purpose they could serve.(18)

It was not until mid-1964 that the new quality control departments began to build up at Barrow and Birkenhead. The delay was caused, in part, by the preliminary work of elucidating what was necessary, and in part, by the obligation to give priority at the beginning of the programme to the immediate difficulties associated with the yard expansion. Only later could staff be recruited into the shipyards to establish the new departments. There was some organisational inertia too in an industry not generally regarded for its innovatory character; it was perhaps the more understandable since these particular innovations were an additional cost and involved a fundamental re-organisation of the structure of work in the shipyards. Fears were expressed about future commercial viability once the impact of the changes had been accommodated and the resources demanded by them had been committed.(19) In this context the uncertain political climate which surrounded the programme in 1964 had an impact too. Nobody on the contractors' side was enthusiastic about building up particular sorts of facilities and labour force levels with which they could have been stranded, had a new government cancelled the programme or seriously limited its size and scope.(20)

Clearly it was necessary to define carefully the limits of the effort to be put into quality control. The cost of quality assurance for key products in the aerospace industry, for example, could be considerably higher than the production costs of the item. It was some time before an organisation for quality control and assurance which represented approximately 8% of

(18) Tabb and Warren, *op. cit.*
(19) See, "RESOLUTION, First Polaris Missile Submarine for the Royal Navy"; *Shipbuilding and Shipping Record*, 19 October 1967, p. 547; and the comments of shipyard management staff in the discussion accompanying the paper given by Tabb and Warren to the R.I.N.A., *op. cit.*
(20) Interview.

the direct production labour force came to be regarded as an acceptable and appropriate indicator of the effort required.(21)

This measure of initial 'diffidence' was however overcome once the future of the programme was assured. The requirement was unassailable in principle; there was evidently too some potential commercial spin-off in generally improving product quality control; and in any event the Admiralty paid for the changes as a direct production charge. More particularly, the participation of Rolls Royce and Associates materially affected the shipbuilders' development and performance in this area. Rolls Royce and Associates had been responsible to the Admiralty for the provision and assurance of quality of the major proportion of nuclear equipment on the DREADNOUGHT project. They had to be satisfied also that installation of nuclear plant and mechanical systems by the main machinery contractor was according to specification, and that the records of quality were sufficient to assure the customer. This range of responsibilities was carried over to POLARIS work. On the other hand, the shipbuilders' responsibilities in this field on DREADNOUGHT had been confined to electrical installation work and agreeing with Rolls Royce and Associates that measures taken to ensure conformance to specification of the steam raising plant were adequate.(22) Consequently although the shipbuilders' attitudes initially to a radical increase in these responsibilities was rather tentative and their experience was relatively limited, it was effectively improved by the example and willingness of Rolls Royce and Associates and the wider experience which that firm had.

In the shipyards the creation of centralised quality control departments was formed by drawing together personnel already engaged on inspection (at Vickers it was 20 people), by transferring managers within the yards, and by recruiting qualified professional staff from industry. An Admiralty requirement that the Quality Control Manager should be directly responsible to the Shipyard Director and not report to him through the production organisation elaborated the contractual requirements designed to ensure objectivity and independent control. The preference was also expressed for a functionally organised quality control department, since many of the facets of quality extended through tasks common to hull, electrical and engineering departments. Common specifications for receipt and inspection of equipment and materials as well as standard formats for reports and other control procedures were introduced as essential and integral features of the developing control organisations.(23)

These new requirements, together with the expanded planning and testing organisations associated with POLARIS work, radically altered the structure of the work forces in the shipyards. This was especially true

(21) Tabb and Warren, *op. cit.*
(22) *ibid.*
(23) Tabb and Warren, *op. cit.*; E. H. Hunter, "Quality Control for a POLARIS Submarine", *Welding and Metal Fabrication*, Vol. 35, November 1967; "The POLARIS Submarine Programme", *Nuclear Energy*.

at Barrow where the ratio of qualified to unqualified staff rose from 1:5 (which compared favourably with average for shipbuilding of 1:10), to 2.5:4.(24) That is, between 1963 and 1967 the number of staff supporting the work force rose from 800 to 2,400. The quality control department at Vickers eventually consisted of 200 people and at least half of these were new recruits. At Cammell Laird, greater recruitment problems meant that by mid-1966 only 60% of the total need for their department had been achieved. But this still meant that they were operating an organisation which consisted of approximately 90 people.(25)

At the beginning, assurance procedures were confined to critical aspects of shipyard work and to keeping defective material out of the yards. The quality control of equipment and material supplied to a shipyard is such a vast undertaking that, effectively, the yard has to rely on the manufacturers to ensure good standards. But, just as responsibility for quality had passed from the overseeing service and was monitored through the application of standardised and documented reporting procedures by the shipbuilders, so two similar sorts of innovations were introduced to monitor the quality of equipment and materials provided for POLARIS work. The first of these were manufacturers' test forms that were to be used for significant items. They required the manufacturer to submit a schedule of tests for Admiralty approval, having first agreed them with local overseers; reports were then furnished on completion of tests. In this way a form of procedural audit was carried out. Secondly, for particularly important sub-contracts, the shipbuilders and the Polaris Executive collaborated in providing field inspections and a review of purchase orders, to check that the correct design drawings and specifications were referenced and that test and inspection requirements were clearly stipulated. Experience gained, in the United States and in the United Kingdom, suggested strongly that keeping defective raw materials and finished equipment from getting into the shipyards paid good dividends in savings on costs and of time.(26)

Procedural innovations never by themselves guarantee results, and a considerable promotional effort was applied to the job of persuading the sub-contractors not only to accept, comply with and properly implement new procedures but also to produce goods on schedule. In February 1964, Admiral Mackenzie began a series of visits to sub-contractors which complemented his visits to all the main contractors conducted towards the end of 1963. In addition, direct contacts with sub-contractors were developed by the CPE organisation in London, especially when there was evident need for progress chasing.(27) This combination of measures produced good results. Sub-contractors were made aware, in a novel way, of the significance of the larger undertaking to which they were contributing and of its particular needs and demands. The shipyards reported a

(24) *The Economist*, 20 April 1968.
(25) See the discussion accompanying the paper given by Tabb and Warren to the R.I.N.A., *op. cit.*
(26) Tabb and Warren, *op. cit.*
(27) Interviews.

distinct improvement in sub-contractor reaction times and contractual performance which was instrumental in maintaining the impetus of deliveries, and of progress generally. The round of visits was not repeated, but its effect persisted and on several subsequent occasions, telephone calls were sufficient to regenerate awareness of the programme needs.(28)

By the autumn of 1965, extensive progress had been made in the application of quality assurance to crucial areas, and an extension of requirements to other areas was begun. Past experience indicated which processes, systems and equipment were persistently troublesome and which were significant although perhaps not critical to safety and performance. Controlled items and quality requirements were not immutably fixed but subject to a continuing learning process, and to the adaptive relationship between the shipyards and CPE, which mediated the developing needs of the programme.

Two features which fundamentally complemented the quality control effort were not integrated into the new quality control departments. These were the Dockside Test Organisation and the Calibration Organisation. A competent organisation for testing equipment after installation was essential for considerations of safety as well as performance. One had been established when the Admiralty purchased the nuclear equipment for DREADNOUGHT and it developed into a testing unit for the submarine as a whole as well as its sub-systems. This organisation was retained intact for the POLARIS project and became responsible for the overall administrative direction, co-ordination and documentation of the testing of all ship items prior to acceptance, and for the preparation of test forms to be approved by the POLARIS Technical Directorate. In addition, it organised, programmed and executed all the test operations: recorded and evaluated the data and certified the tests. The unit consisted of five test groups comprising representatives of the shipbuilders, Naval Overseers and appropriate contractors (see Tables 1 and 2).

Table 1 – Dockside Test Organisation

Test group	*Test and trials responsibilities*
1. REACTOR	Nuclear plant and its containment
2. SHIP	All systems not part of reactor plant, propulsion machinery, or weapon equipment
3. PROPULSION	Propulsion plant and associated equipment
4. TACTICAL WEAPONS	All weapon systems with the exception of the Ballistic Missile System
5. POLARIS WEAPON	Ballistic Missile System

Note: Compiled from Tabb and Warren, "Quality Control Applied to Nuclear Submarine Construction".

(28) Interviews.

Table 2 – Polaris Weapon System, Sub-systems and Contractors

Sub-system	*Contractors*
1. NAVIGATION SYSTEM	Elliott/Sperry
2. FIRE CONTROL SYSTEM	GEC and BAC
3. MISSILE	BAC
4. LAUNCHER TUBE CONTROL SYSTEM	Vickers launcher group
5. TEST INSTRUMENTATION SYSTEM	GEC and BAC

Note: Compiled from interviews and from Captain C. W. H. Shepherd "The UK Polaris Project", *Journal of The Royal Aeronautical Society*, Vol. 70, September 1966.

Approximately 100 test engineers were involved in work on the non-POLARIS area. The POLARIS Weapon System Test Group itself comprised 120 engineers with between 50 and 60 technical and clerical support staff. It was a composite group, which combined engineers from contractors in the United Kingdom and United States, each concerned with a separate sub-system as well as with the test procedures as a whole. Vicker's Chief Test Engineer co-ordinated the group and was responsible for the complete testing of the POLARIS weapon system (see Table 2).

Calibration

Special Projects Office took an early opportunity in discussions about construction techniques and procedures to urge that CPE should establish particular arrangements in their programme for the control of measurement and accuracy. United States experience on a number of large-scale and sophisticated technological projects had shown that such programmes frequently suffered because inaccurate and inconsistent measurements had led to wrong conclusions about the performance and behaviour of systems and equipment. Advanced mechanical, optical and electronic concepts and equipment employed in the POLARIS system required much higher levels of accuracy, and much stricter controls over test equipment than current procedures had allowed for. Accordingly, a section of the Technical Arrangements was agreed, to establish agreed standards and procedures for calibration control, and as a result, the calibration facility that was built up at Barrow between 1964–66 was designed to provide measurement of a wide range of parameters, and to establish standards of measurement and accuracy which were to be applied to the installation tests and inspections. The calibration laboratory provided a service, as part of the lead yard concept, to Cammell Laird also and in addition supported the construction and operation of the RNPS at Faslane. Senior management and technical personnel were trained in the United States to establish and operate the facility while United States

advisers assisted in the establishment and operation of the facility in Barrow.(29)

Two features associated with all of these changes need to be emphasised. The first is that the programme did not progress without any difficulty or mishap because they had been instituted. Secondly, their utility was not always, and sometimes not primarily, related simply to the control function they were intended to perform.

General progress

The measures did establish a quality control complex, but the implementation of its procedures was not always what it should have been and there were gaps in its operation.(30) Just as quality control derived in large part from the experiences on DREADNOUGHT, so its problems there were carried over into POLARIS work. This was evident in the difficulties associated with the quality of the high tensile steel used in the building process, the quality of welding and the hair-line cracks which developed in the nuclear submarines in which the steel had been used – including RESOLUTION. The presence of such cracks was acknowledged in August 1965 after they had been discovered on DREADNOUGHT.(31) British steel in use at that time included small elements of non-metallic inclusions which had not previously been thought significant but which did affect the steel's capacity to withstand the additional strain imposed on it by the rigours of nuclear submarine performance. In this instance the steel industry had produced the steel to specification (QT 35) but experience found the specification inadequate and it had to be revised.(32)

Problems were experienced both in raising the specification and in acquiring the required amounts of a better steel. Nuclear submarine steel was not generally regarded as a basis from which to develop production at a commercial rate and find additional markets, although later it was reported that some commercial benefit did result from the improvements

(29) See "The Polaris Submarine Programme", *Nuclear Energy*; and "RESOLUTION, First Polaris Missile Submarine for the Royal Navy", *Shipbuilding and Shipping Record*, 19 September 1967, p. 548.
(30) Interviews.
(31) See *The Times*, 22 August and 10 November 1965; also Interview.
(32) See *The Times*, 10 August and 23 September 1966. The problems associated with welding and steel quality appeared first in the components of the nuclear propulsion plant at Dounreay, and assistance in getting supplies of adequate stainless steel to replace specialised components was sought and obtained from Admiral Rickover's office in January 1964 and again in 1966. The steel problems relating to hull fabrication first began to be troublesome in early 1964, when emergency measures had to be taken to procure sufficient supplies of molybdenum for the steel mills. The discovery of hairline cracks in DREADNOUGHT led to rigorous surveys and tests on all the other submarine hulls, completed and building, and, naturally, to a good deal of public enquiry and concern. Reassurance was given that 'such cracks are normal in heavy welded constructions of this sort; they introduce no risk to the submarine or her crew. However, their repair does require extra heavy work at routine docking or refit periods'. (See, for example, the report in the *St. Louis POST-DISPATCH*, 25 September 1966.)

required for such work.(33) Steel made in the United States to a comparable specification (HY 80) was fairly readily available, and proved to be of good quality: sufficient quantities were bought in to complete the hull fabrication of all four POLARIS boats (and later, to build hunter-killer hulls). The decision to use United States steel was announced in August 1966, and the extra cost amounted to £1.15m by November of that year.(34)

A number of other factors combined to create delays to or threaten the progress of the programme throughout the 1964–66 period. In 1964 and 1965, the heavy demands on resources brought about by the conjunction of the hunter-killer and POLARIS submarine work were particularly evident. Construction work on the second SSN, VALIANT, was well underway in January 1963 and the commitment to a third, WARSPITE, had been made, and work had begun. Although this meant that Vickers at Barrow had accumulated a good deal of practical experience, only one nuclear submarine was yet at sea, and the new British propulsion design was not yet proved. The work load induced by running the two programmes in parallel was inevitably going to be very difficult to manage.

During 1964, the maintenance of the impetus that was necessary to complete the POLARIS submarines to time became more and more difficult as the continuation of the programme itself became – or seemed to become – a political issue. In one sense, the debate which led up to the General Election was a stimulus to action: the further ahead the programme got, the less feasible it would become for any new government to abandon it. In another sense, the mere fact that the programme was a matter of contention made it more difficult to persuade contractors to extend their liabilities.(35) One of the proposals considered was to stop work on WARSPITE and stand it over, until the POLARIS work was completed. But this proposal was resisted strongly in CPE. The idea had some attraction, but it would enormously complicate the work-loadings at Barrow, and might well have a bad effect on the POLARIS programme generally. The recovery of slippages, and successful completion of WARSPITE, without material effect on the POLARIS schedules, became an issue which provided the project organisation with an opportunity to consolidate its reputation and demonstrate its determination to maintain original commitments and targets. CPE was firm in the opinion that if WARSPITE was to go then it would in effect constitute evidence to suggest that the organisation was 'as malleable as anybody else'.(36) It was the propagation of entirely the opposite perception that was inherent in the promotional style of CPE and integral to the successful achievement of its purpose. WARSPITE stayed, was commissioned in April 1967 and was quickly followed by RESOLUTION in October, a time schedule

(33) Interview: *The Economist*, 20 April 1968.
(34) *House of Commons Debates*, Vol. 737, Col. 75, 29 November 1966.
(35) Interview.
(36) Interview.

which involved 1¾ commissioning teams being assembled at Vickers to cope with the work load.(37)

At Cammell Laird, their first SSBN was three months behind schedule when launched in February 1967, although opportunity had been taken to do extra work while the hull was still on the slip. As a company Cammell Laird had not had the experience in nuclear submarine work which Vickers had acquired and their learning phase coincided with the restricted time scale of the POLARIS submarine schedules. It was also a learning process which applied most to management, and which the lead yard concept was designed in part to facilitate. Initial difficulties were concerned with building up the facilities and shipyard equipment, a process which was not advanced by a shipwrights' strike from March to June 1964 (see Table 4). The award to Cammell Laird of a contract to build a hunter-killer submarine in August 1966 provided employment for a pool of skilled labour which could be re-assigned according to the variable work loadings of the POLARIS task. But, although the firm addressed itself 'maturely' to the problems of management and organisation their performance was consistently behind that of Vickers (between 10–13 months, see Table 3), and in January 1967 involved some high level progress chasing and 'blunt speaking' by Mr. Roy Mason, then the Minister of Defence for Equipment.(38)

It was recognised at the outset that the relationship between Vickers and Cammell Laird would be a likely source of problems. But in operation it was not a uniformly difficult one. At individual working levels, co-operation was reasonably good and appreciation of respective performances was favourable. At more senior levels, however, the formal institutional and commercial status of, and relationship between, the two shipbuilders did seem to inhibit any permanent or enthusiastic co-operation. In addition, procedures which operated well at working departmental levels tended to exacerbate institutional sensitivities at senior managerial levels. Frankness in team reporting and discussion paid dividends at one level but were a potential source of friction at the institutional level. The process of formally reporting difficulties to CPE, while providing a useful mechanism for resolving problems and questions of priority, also tended to formalise and institutionalise issue between the two yards.(39)

Labour relations at Vickers over which there had been some difficulty in 1964 deteriorated sharply in 1968, and culminated in an inter-union dispute about pipe-fitting and testing (see Table 4). By December 90% of the work force was affected. The preoccupation in CPE, following the completion of REPULSE in September and the organisation's wider remit for SSN construction, was as much related to the reliability of the yard in general for naval construction purposes as it was with ensuring the timely completion of the remaining POLARIS work. It was not until

(37) Interview.
(38) Interviews. See also *The Times*, 31 January 1967.
(39) Interviews.

February 1969 that a board of inquiry was established and the inter-union dispute resolved.(40)

Table 3 – SSBNs: Shipbuilder Work Months

SSBN	*Builder*	*To Launch*	*To Completion*	*Total*
RESOLUTION	Vickers	32	13	45
RENOWN	Cammell Laird	33	22	55
REPULSE	Vickers	33	10	43
REVENGE	Cammell Laird	35	21	56

Table 4 – Principal Stoppages at Barrow and Birkenhead for the 5 years ending 31 December 1968 (5,000 or more working days lost)

Area	*Date of Stoppage*	*Number of Workers Involved*	*Number of Working Days Lost*	*Cause or Object*
Birkenhead	16.3.64 to 5.6.64	1,260	54,000	Claim by shipwrights for a wage increase of 1s per hour.
Barrow	13.7.64 to 20.10.64	135	7,900	In support of a claim for an increase in wages.
	5.6.68 to 3.12.68	420	39,800	Protest by apprentices against the introduction of a new pay structure.
	1.7.68 to 12.7.68	920	7,200	In support of a claim for parity in repair allowances.
	3.7.68 still in progress at the end of 1968.	1,845	166,000	Inter-union demarcation dispute over allocation of certain work.
	9.9.68 still in progress at the end of 1968.	70	5,400	In support of fitters and apprentices already in dispute (see above).

SOURCE: House of Commons Debates, Vol. 778, 26 February 1969, Columns 323–324.

The managers and contractors in defence programmes had become accustomed over the years to work falling behind schedule and to revisions of programme plans that accepted delays as ineluctable. Work fell behind time in the POLARIS programme and schedules had to be

(40) See *The Times* for 4 October and 16 December 1968 and 26 February 1969.

reshaped but the original and most significant objective was adhered to and achieved – RESOLUTION and the rest of the squadron deployed operationally on time. Keel-laying, launching and other target dates were general indicators of progress but what they represented could alter substantially, depending on the installation and testing that went on between these milestones.(41) Although there was no complacency about missing any one of these target dates, given that CPE was sensitive to the impact it would have on the promotional effort required to emphasise the urgency and priority of the programme, a commitment to a recovery philosophy was instrumental in ensuring that work loss was made up and that the distinctiveness of the operation was maintained. In addition, POLARIS work at the shipyards was essentially a production task and this feature partially facilitated the problem of rescheduling the work and directing resources into lagging areas to effect recovery. For example, although RENOWN was on the slipway longer than she ought to have been, a limited amount of work was put in progress that would normally have been started once the submarine was launched. It was also at this level, and with this sort of problem, that the instrumental utility of certain managerial devices was demonstrated. PERT networks, for example, were used in this way to good effect when delays to WARSPITE's progress gave concern, in 1964/65. They were especially useful in planning the work necessary to restore progress by identifying whence to divert effort and where to apply it with best effect without disproportionately and adversely affecting general progress.(42)

Throughout the latter part of the construction phase, from 1965–66 onwards, maintaining progress in the shipyards remained a continuing and demanding task, if a less exciting one than beginning construction had been. Individual problems threatened the progress of the programme, such as labour difficulties, strikes and the accidental flooding of compartments in RENOWN while she was fitting out. These generally required the re-ordering of schedules, the adaptation of plans and redistribution of resources, so as to maintain momentum and stay within reach of the original targets.

There were in addition, however, more general sorts of difficulties associated with the shift in the construction process from hull fabrication to fitting out the submarines, installing equipment, and testing and tuning the various sub-systems. Work on these tasks presented new planning requirements and new planning problems which frequently demanded the day-to-day specification of tasks and planning of work. In this sense, therefore, the advancement of the work in the shipyards never became an automatic function. Instead it had to adapt constantly to special problems, shifting general requirements and variable rates of progress at different times in different areas. Recovery programmes of various kinds were regularly required to maintain overall progress.

(41) See the comments in *The Times*, 27 April 1966, reporting that work on RESOLUTION and RENOWN was behind schedule.
(42) Interview.

RESOLUTION was commissioned on 2 October 1967 (to be followed at intervals by the other SSBNs, see Table 5), conducted her first missile firings in a demonstration and shakedown operation (DASO) during February and March of 1968, and was on operational patrol by June of that year.(43)

Table 5 – Principal Milestones

SSBN in Order of Acceptance (anticipated 1963)	*Laid Down*	*Launched*	*Accepted*
RESOLUTION (Vickers)	22.2.64	15.9.66	2.10.67 First
RENOWN (Lairds)	25.6.64	25.2.67	15.11.68 Third
REPULSE (Vickers)	12.3.65	4.12.67	29.9.68 Second
REVENGE (Lairds)	19.6.65	15.3.68	4.12.69 Fourth

This event signalled the beginning of the end of the construction task. Although the last SSBN was not to become operational until 1970 the headquarters manpower effort had progressively to be re-deployed to support, maintenance and refit tasks. In accord with this change of emphasis the post of Chief Polaris Executive was abolished in June 1968 and replaced by a new two star appointment with the title of Assistant Controller (Polaris).(44) AC(P) was to exercise the residual functions of CPE until the SSBN construction programme was complete and he succeeded CPE as the United Kingdom's Project Officer under the terms of the Polaris Sales Agreement. He was to work under the joint superintendence of the Controller of the Navy, and the Chief of Fleet Support, whose responsibilities included the oversight of the preparations for the refit of the POLARIS submarines.

The Technical Directorate in Bath was similarly reorganised. The Technical Director (Polaris) became the Director Project Team (Submarines) and his organisation remained as a project team. His responsibilities were essentially to be concerned with the drawing up of the 'work package' for each refit. Each 'work package' was to include full design information and documentation. The refits themselves were to be conducted by an integrated refit management team at Rosyth responsible to the Admiral Superintendent there, but subject to the executive authority of the Director General Dockyards and Maintenance. By June 1970 the first cycle of construction, acceptance, trials, operational patrol and refit was completed when RESOLUTION went to Rosyth for her first refit.(45)

(43) See *The Times*, 5th March and 21st June 1968.
(44) Later changed to Deputy Controller (Polaris), in consonance with other changes in the Controller of the Navy's supporting management structure.
(45) See *The Times*, 23 June 1970.

In general shipyard progress was characterised by retrieval and recovery. Such programmes operate directly, by changing the status of a delinquent area, injecting more resources into it, and paying particular attention to the resolution of its problems. But some more general philosophy of retrieval – that is to say a predisposition to adhere to milestones and to take special action if progress falters – must provide the impulse and general support for instituting and carrying out any particular programme of recovery. And such a philosophy is directly associated with the expectations that operate in a project concerning the standards of achievement and the degree of urgency required. If the standards of achievement and the degree of urgency in practice are high, and are expected to be high, there will be less disposition to tolerate short-falls in the progress of work. Within the shipyards work did not always and automatically progress according to schedule. What was distinctive about the project, however, was the disposition to pull progress back on to schedule by diverting resources and increasing effort as situations demanded.

This condition prevailed more generally throughout the POLARIS project. The managerial and procedural innovations associated with the project had a promotional significance as well as, on occasions, a direct instrumental utility in establishing that disposition, and confirming the associated expectations by providing a record of achievement. The relative novelty of these procedures defined and demonstrated the peculiar significance of the programme at an operational level, which the formal accreditation of priority was meant to convey at an official level. Where they were implemented and where they worked (and these areas were always more limited than their formal justifications allowed), they improved performance. But it is difficult to disassociate the usefulness of this specifically instrumental feature from the more general appearance of distinctive competence to which it contributed. Neither can it receive more acclaim than the utility and importance of that sense of cohesion, style and novel purpose, which the new POLARIS language of standardised reporting procedures and detailed documentation, systematically promoted throughout the programme, gave. It was these general characteristics that provided the means, and the record of substantive achievement, required for the promotional effort that was employed to motivate the nexus of relationships between the industrial organisations and government departments which, overall, constituted the programme in the United Kingdom.

CHAPTER EIGHT

The Base and the Support Facilities

The decision that specialised support facilities would be required for the POLARIS submarine squadron was taken at the first meeting of the Admiralty POLARIS Committee in February 1963. On the basis of information that had been made available by Special Projects Office about maintenance practices, and by the operational authorities in the United States Navy about operational cycles, the Committee reviewed the principles that should be used to plan the support and operational philosophy to be applied to the British force. Given the likely size of the force, it would be even more important than the Americans had found that the maximum operational availability should be achieved; this inferred manning each submarine with two crews and setting up closely controlled maintenance and refit schedules. In turn, this objective required the provision of material and manpower resources, for British as well as for American equipment, in sufficient and readily available quantities (and quality) to ensure that the schedules could not only be met but sustained, throughout the life of the force. It was clearly going to be a major task and lent support to the argument that the Polaris Executive should include a specialist logistics component as a part of the organisation.(1)

The task divided into four major parts. The first was to identify the necessary scales of stores and spare parts, and to make provision for them; this was, classically, the function of the Admiralty Supply departments, who allocated staff to CPE for this purpose. The second was to establish the scope of the facilities that would have to be set up: workshops, store-houses, power supplies, accommodation, communications and so on. As an organisational task this was less straightforward, insofar as it required the coordination of the efforts of a number of authorities, not only in other government departments like the Ministry of Aviation and the MPBW but in local government as well. It was in this area that the Polaris Logistics Officer and his immediate staff concentrated their activities. The third component was the planning of ship refits, including nuclear refuelling of the propulsion plant. In terms of timescale this requirement was less urgent than the others, though no

(1) See Chapter Four.

less important. And the fourth component was to ensure that all of these activities marched in step with the other tasks of the Polaris Executive.

By the end of March 1963, it had been decided that the operating base should be located at Faslane, where the Third Submarine Squadron already had a forward operating base, centred around jetty facilities and the submarine depot ship, HMS MAIDSTONE. The refit yard for the submarines was to be H.M. Dockyard, Rosyth, where extensions to the yard's capacity were already underway to enable HMS DREADNOUGHT and later hunter-killer submarines to be refitted. Later H.M. Dockyard, Chatham was equipped to provide a comparable range of services for the SSNs and Rosyth was reserved to the POLARIS Squadron.(2) Faslane had a number of desirable operational and safety characteristics which caused it to be preferred to other possible sites, including the immediate availability of government-owned land for the base itself and the armament depot which would need to be located close by. But, architecturally, it was not the easiest of sites to develop; the hills and the hardness of the rock (and, during the building phase, the high rainfall) gave rise to a number of persistent difficulties.

As in other areas of the programme, the logistic planning was beset by 'chicken and egg' difficulties. The urgency of the timescale to which CPE was to work called for early decisions to be made so that lengthy processes – like designing and building a large complex of buildings, in this instance, could be put in hand straight away. But they could not begin until sufficiently firm and detailed information was available to be sure that the initial plans were unlikely to require later, time-consuming, modifications. Detailed knowledge about the POLARIS weapon system was obviously going to take time to acquire and assimilate; but it was also going to be fairly difficult to make suitable assumptions at once about the maintenance load for the ship systems. DREADNOUGHT was at sea, and provided some experience on which to draw; but there was yet no extensive knowledge about the needs of the VALIANT class, on which the POLARIS submarine hull design was based, and no clear ideas about any special problems that would arise from the mating of the main weapon system to this design. So, early planning began by dealing with general issues: the organisation of the stores and spare parts network of sites at Copenacre, Eaglescliffe and Faslane itself, the general layout of an 'ideal type' base to identify highway, sewerage and power needs and, along with the rest of CPE, the acquisition of as much information as possible from SP.(3)

(2) These decisions were announced in April 1963 (*House of Commons Debates*, Vol. 676, Cols. 219–223, 24 April 1963) and March 1965 (*House of Commons Debates*, Vol. 708, Col. 665, 11 March 1965).

(3) Representatives from the Stores and Armament Supply departments were appointed to SPRN's staff in Washington: one was based full time at the Naval Weapons Annexe, Charleston, S. C., and another spent most of his time at the Lockheed company plants in California.

Stores and spare parts

The stock inventory for the POLARIS weapon system ran to rather more than 80,000 separate items and although usage and replenishment rates were well established for the A2 system, the position in regard to the A3 system was still undetermined for a number of components and equipments. It was not therefore a simple matter, either for installation in the submarines or for building up system spares, to determine what had to be procured. A separate contract had to be arranged between the Admiralty and the Electric Boat Company to provide the details of what ship-fitted equipments should be ordered to complete the hull installations, in addition to the contract that was negotiated between the Bureau of Ships and EB to provide installation and guidance drawings. The contract provided for the supply of components, materials and spares against orders placed by the Admiralty after the scrutiny of schedules and drawings and what were called 'group lists'. These were schedules of work units, defined in terms of what work actually took place in the process of installation, identified trade by trade. The schedules effectively replaced compartment or equipment plans as the production unit on which progress was based. The 'group master schedule' identified all Government Furnished Equipment (the US Navy equivalent of Admiralty Supply Items) and provided a check on material which might also be identified as necessary in PE-PLAN 'shopping lists'. The main flow of weapon system-linked and electrical components was programmed to build up through 1965, and the staff of the Technical Directorate worked very effectively together to define the full range of requirements by the middle of 1964; but the actual supply of the material fell behind schedule, as much as five months in some cases, and remained a major cause of concern in RESOLUTION's programme throughout the autumn and winter of 1965. A recovery programme was instituted, which resolved most of the shortfalls by the early months of 1966.

The provision of weapon system equipment parts proceeded more smoothly once the 'learning curve' of assimilation flattened out. The links between the PLO's staff and their equivalents in SP and at Charleston became close and fruitful, and the difficulties that arose from time to time on provisioning seldom reached major proportions. Agreement was reached in the autumn of 1964 about the principles on which arrangements for the return and repair of equipments to the United States should be based; because CPE was not provided with design information under the terms of the Sales Agreement, there would be a limit to the scope of any repairs that could be undertaken at Faslane. Although considerations of speed and economy pointed to the need to include a specialised workshop (the Module Repair Facility) at Faslane, on the model of similar workshops in US support facilities, some types of equipment would need, as in the United States programme, to be returned to the manufacturing agencies for repair, and for this type of item a system of joint replenishment was agreed. Later on, when the testing and tuning of equipment, initially in the training school at Faslane, began, the Department of Defense agreed that Faslane should be incorporated in the teletype communication system (AUTODIN) which allowed virtually instantaneous communication with the major United States Navy stock-handling depots. Similar communication links were set up between Faslane, Rosyth, Bath and the major Royal Navy store depots throughout the United Kingdom.

Missiles and missile spare parts

Early in the programme, there was a good deal of concern, at Board and ministerial level, to define responsibilities between the Admiralty and Ministry of Aviation clearly and definitively. Relationships between the two departments historically had not been easy and the Admiralty was, collectively, determined that the prospects of completing the POLARIS programme successfully should not be put at any additional hazard by any divided responsibility, or by any divided loyalty to the general naval cause which the new programme was seen to embody. The Navy suspected that Aviation's SKYBOLT scars would be long in the healing, and they had their own SEASLUG scars to display. The crux of the matter, for CPE's staff, was that the Admiralty should be the approval authority for the missile. The approval authority, in the government service, was responsible for assessing the suitability of a weapon for service use, both in regard to safety and to its operational characteristics; it specified the conditions under which the weapon might be used and it set the inspection and maintenance standards that should be followed. The circumstances of the Nassau Agreement, in which an existing system was to be procured, made the reservation of this responsibility to the Admiralty a logical consequence, although the design and provision of a suitable British 'front end' provided the Ministry of Aviation with a crucial role to play.

This was not, however, the only organisational difficulty. The determination of appropriate safety standards was an important, and potentially sensitive, area. The attitudes of the United States Navy and the Royal Navy towards safety controls had differed over the years and it was quite conceivable that the Inspectorate of Naval Ordnance, and the Ordnance Board, might require different procedures and standards to those which had been incorporated in the POLARIS designs and layouts. If there had to be differences, this in itself would be unwelcome to CPE, whose determination was to alter nothing that did not have to be altered; but it was even more important that alterations should not in any way degrade the operational characteristics of the proved system. To find out whether any changes would have this effect might take both time and money to establish, and to make the earliest possible resolution of this difficulty, an Inspector of Naval Ordnance was appointed to act as SPRN's local staff officer in the Lockheed Missile and Space Company's offices at Sunnyvale, California, in addition to the CINO designated staff in Bath. CINO's participation in the programme proved very helpful,

both in regard to the deployed system, and in the establishment of safety procedures and controls at the RNAD, Coulport.

Coulport was some eleven miles by water and seven miles by land from Faslane; the armament depot, which would store torpedoes as well as missiles, would be the responsibility of the Director of Armament Supply. The planning of the depot had to provide for the care and maintenance of many technically complex equipments as well as for their storage, issue and replenishment; although the range of items was not nearly so great as on the Naval Stores side, their proper care was crucial and called, in addition to careful planning, for an extensive training programme in the United States for the technical staff who would be concerned in the operation of the depot.(4) Test and check-out equipment would need to be installed, and accurately regulated environmental controls would be necessary. Indeed, as time went on, it became apparent that it was the technical equipment controls and processes that presented the greatest difficulties. As in the case of the RN Polaris School there was no directly relevant American model upon which the design of the depot could be based in detail, although the new POLARIS Missile Facility, Pacific on Puget Sound, provided SP with precedents (and design experience) that were very helpful. The scale of the technical problems to be surmounted was daunting, and the difficult terrain at Coulport – steep gradients, hard rock and underground springs – was an added complication to the building of the depot.

There was however a fundamental organisational difficulty too. Although at the level of theory the dual nature of Coulport's role, combining technical as well as supply functions, was not unprecedented, the scale and the nature of the technical issues were novel to the Armament Supply Department. But DAS's management hierarchy was dominated by supply specialists and the status of the engineering staff was relatively low. Technical issues were not therefore grasped as firmly or as early as they might have been, and in spite of remedial action that was taken from time to time as the reported status of progress at Coulport dropped to an unsatisfactory level, the possibility that Coulport would not be ready in time to perform the full range of its defined duties for RESOLUTION's first patrol began to emerge as a distinct likelihood by the end of 1966. A recovery programme was instituted by the project Management Team, and additional support was arranged through the provision of Lockheed staff, as part of an augmented contract technical service programme agreed with SP, and through the provision of extra constructional and engineering resources. Much of the slippage was recovered in this way and the depot facilities were tested and checked-out in time for RESOLUTION. But the argument whether the depot should remain a DAS responsibility, or whether it should have more properly been regarded as a technical establishment – in which case it would have become

(4) The training programme was carried out between 1964–1966, principally at Charleston and Sunnyvale.

a Weapons Department responsibility – was a proper issue to raise, and had nothing to do with the skills or backgrounds of particular groups, who all worked with considerable diligence to procure a satisfactory outcome. It had to do rather more with the difficulty of fitting a novel function into a structure of defined responsibilities and organisations, and illustrated, more clearly perhaps than in any other part of the programme, that the powers of the Polaris Executive to assemble and deploy resources were as much limited by the structure of its component elements as by any financial or political guidelines.

Re-entry systems

The decision to base the BNBMS upon the A3 weapon system produced a requirement to design and provide a compatible British re-entry system. This was clearly a complex engineering task in itself, but it was also a sensitive political area, in which the exchange or provision of information was limited by agreements which pre-dated the POLARIS Sales Agreement, and which very carefully defined the procedures, as well as the scope, of any information-flow. Indeed, in almost all important particulars, the 1958 Exchange Agreement (which had been amended in 1959) rather than the Sales Agreement was the effective authority under which the Ministry of Aviation's team, under Admiral Dossor, went about their task in this area.(5) The United States authorities – which in this case were represented by a group staffed by officials of the Atomic Energy Commission under an SP chairman – were committed to provide the basic data whereby a British re-entry system could be mated to the rest of the missile, but precisely what data would be required, and whether the information could be supplemented by the provision of any hardware components, had to be worked out in careful detail, against the limits laid down by United States law as well as against the needs of the British design. A special committee, called the Joint Re-entry System Working Group, was set up to provide a forum for discussion and a channel by which information could be passed. By March 1964 a decision on the type of re-entry system to be provided was made by the United Kingdom side, and the JRSWG was reconstituted, with a slightly wider membership, to assist in the planning for the manufacture and support of the approved design. This required a defined division of responsibilities between the AEC and the Department of Defense about their respective roles, as well as the preparation of PEPLAN-type schedules of equipments and maintenance plans.

The proving of the design required a number of experimental tests, including an underground nuclear test, which was carried out at the AEC's testing ground in Nevada in November 1965, and was announced in the House of Commons on November 18. The Prime Minister told the

(5) *Agreement for Cooperation on the uses of Atomic Energy for Mutual Defence Purposes*, July 1958 (Cmmd. 537), HMSO London: Amended in 1959 (Cmnd. 859).

House that the test, which was in every way successful, "would lead to a very considerable saving in costs".(6) The design was completed in the spring of 1966, along with the definition of storage and maintenance parameters. Production was put in hand at once and, although some difficulties in maintaining progress were reported, a full set of re-entry systems was ready, as intended, for RESOLUTION's first operational patrol.

The Main Base

The design of the base facilities at Faslane was principally the responsibility of the Ministry of Public Buildings and Works, which absorbed the Directorate-General of Navy Works in April 1963. But the design had to meet the stated requirements of the user, which meant that besides the composite needs of CPE, the requirements of the Dockyard and Maintenance department, the personnel departments, and of the Flag Officer, Submarines had to be taken into account. They were all coordinated by the Polaris Logistics Officer, and this meant that his office became the clearing-house for all the plans and ideas that were thrown up, some of them in virtual ignorance in the early days of what the demands of operating the POLARIS force would entail. Although the Polaris School was contiguous to the Base, its planning was a separate activity, in which the PLO was concerned only in the bricks-and-mortar side at first, although the provision of accommodation for the staff and their families also became part of his concern. Indeed, married quarters, houses for key civilian personnel and service accommodation eventually became a major preoccupation, and links with the local authorities in the area and with the Scottish Special Housing Association became very close. The base would provide support facilities for the Third Submarine Squadron as well as the Tenth Submarine Squadron (as the POLARIS boats became) and this meant that workshop, stores and accommodation space had to be provided accordingly. A new jetty, with an extensive range of services (including, as a later modification, a heading check test facility for the submarine's navigation subsystem), had to be built: a range of workshops and test bays: emergency power sources: a separate Module Repair Facility for weapon system parts: a Calibration Laboratory: sleeping, eating, recreational and administrative accommodation: security installations: computer installations: playing fields, and so on – the variety of the components to the Base was, as the PLO reported to one Progress Meeting, "as nearly infinite as I can bear to contemplate".

(6) *House of Commons Debates*, Vol. 720, cols. 1332–3. The Prime Minister had been pressed on this matter since February 1965 by both sides of the House. See *House of Commons Debates*, Vol. 108, col. 1065, 16 March 1965; Vol. 709, cols. 1843–46; and Vol. 716, col. 1336. At a later period, other tests were carried out in order to maintain the effectiveness of the re-entry system design (see *The Guardian*, 22 October 1975 for a reference to a 1974 test and the possibility of another test in 1976, which was subsequently, and successfully, performed).

It was all rather slow to get under way. The PLO experienced the common 'chicken and egg' difficulties which have already been mentioned, but there were additional problems. The choice of Faslane imposed some of them particularly because local labour was more difficult for the contractors to come by and retain than had been expected. The attitude of contractors was not always as helpful as it could have been, although this was probably more due to the general state of the construction industry than to any particular reservations about the Faslane, or Coulport, contracts themselves. Relations with the Dumbartonshire County Council were generally good, and became good with the Helensburgh authorities, who were naturally concerned at the effects which a £47m development would have upon local affairs and amenities. In the run-up to the 1964 Election, the MPBW experienced some difficulty in obtaining Treasury authority to proceed with some contracts, and the SSHA was reluctant to commit its resources fully to a housing programme for which there was no local alternative use if the programme were to be cancelled by a new government; the result was that a great many items had not been put out to tender by October 1964,(7) and a great deal of effort had to be expended in the ensuing months towards creating a renewed sense of urgency in the programme for the Base.

There were four areas in which the plans for the Base did not work out as well as they might. The design underestimated service accommodation needs, although provision was made according to standard scales of expectation about the proportion of officers and men who would live in the Base or live with their families in the surrounding area; this led to some overcrowding of what had been intended to be above-par facilities.

Secondly, the importance of a fully developed industrial relations policy was rather under-played. There was an extensive dependence upon regular overtime, and a 'Clyde Base allowance' was allowed to grow up in a haphazard way, which created some difficulties when the Base became operational.

Thirdly, the managerial organisation of the Base proved to be unsatisfactory and had to be reshaped. The original scheme provided for over twenty senior managers to report directly to the Commodore, who quickly found the situation unbearable. Most of the department heads also had functional links to their parent organisations in the Navy Department, and it was not until an alternative scheme was devised and put into effect, embodying the devolution of much day-to-day responsibility, that the organisation settled down to work smoothly. The revised management structure has become a standard pattern for naval base organisations.(8)

The fourth problem area was the provision of automatic data processing equipment. In 1965, CPE had a run-in with the Ministry of Technology over their insistence on purchasing American-built machines for the ADP systems for the stores depots at Copenacre and Eaglescliffe, that

(7) Interview.
(8) Interview.

provided back-up spares for the submarines. Although it was Government policy to require departments to purchase British computer equipments and material wherever it was possible, no comparable British-built equipment was available in the required timescale, and those that could be made available were inadequate and, even the Treasury agreed, incompatible. The Minister of Technology, Mr. Frank Cousins, fought the issue but failed to persuade his colleagues.(9) Even though there were subsequent difficulties about mating the buildings for the computers with the hardware, CPE's proposals were undoubtedly cheaper and more efficient than the proposed alternatives could possibly have been.

But, partly because of this earlier *contretemps*, the selection of computer equipment for the Naval Stores stock control task at Faslane (which also covered pay-roll programmes) was approached with some caution. A committee, including Treasury representatives, was set up early in 1966 to review the preliminary choice of British equipments and programmes that had been made, on the basis of specifications and an element of competitive tendering. By November 1966, it became clear that some at least of the equipment would be delivered late, and thereafter the situation became increasingly unsatisfactory. Installation, and performance after installation, was beset by delays and breakdowns, and a Treasury investigation in the autumn of 1967 led to a decision to buy a standby equipment to provide a backup to a machine that seemed to be unable to have certain 'rogue' characteristics eliminated. As late as 1969, the Base staff, supported by ACP (as CPE had by then become) were complaining of the unreliability of the installed equipments and proposing measures to reduce the amount of stand-down time.

In the event, the Faslane Base, commissioned as HMS NEPTUNE, was not quite completed by the time of the first operational patrol, although all major services were functioning: the effluent disposal plant and some of the extra accommodation were not ready for use. Given the extent of the task that had been assumed, however, it was not a bad result; the essential services of the Base had been set to work sufficiently early for there to be no doubt about the ability to ensure RESOLUTION's material well-being.

(9) Interview.

CHAPTER NINE

Reflections

The processes by which technological innovation is organised appear, in practice, to display dynamic attributes which are not only inherent to the business of change which innovation represents but also require alterations in the boundaries of the divisions which have previously been established for the organisation of work; that is to say, innovation regularly alters both attitudes and institutions. One of the consequences of this phenomenon has been the emergence of designedly novel organisational structures that are intended to be more readily adaptive to innovatory circumstances, and better able to cope with the demands that they throw up. This pattern has been particularly noticeable where innovation has focussed on development and production tasks that require the combination of complex scientific, engineering and industrial components, which have frequently been organised, in traditional and hierarchically-fashioned units based upon staff functions, or technical specialisms, or phases of activity. The new demands, defined in effect by the desired innovation, have not matched either the boundaries or the established relationships between existing structures and have, as a consequence produced new, and specific, organisational patterns. These in turn are faced with problems that not only relate to the management of whatever the innovation may be but also to the new boundaries and the new relationships that now become the interface between the novel grouping and the old, or 'parent', structures.(1)

The notion of 'project management' that arises from these features is certainly not new; there are those who would claim that Noah was the first recorded 'project manager', and the title could certainly be attributed to Lloyd George for his work at the Ministry of Munitions in the First World War, as it was specifically attributed to General Leslie Groves, who managed the Manhattan Project in the Second World War. But the adoption, as a deliberate policy, of a distinctive method of management is relatively novel and has certain distinguishing characteristics. One is that project management is usually adopted as an organisational strategy against a background of compulsion; it may be a compulsion in

(1) Sapolsky identifies the policies that the Special Projects Office adopted in managing both innovation and the relationships to associated organisations: see Sapolsky, *op. cit.*, Ch. 2.

time or in money that arises from either a political or a commercial requirement to ensure success, but, underlying these positive objectives is an acceptance that they would be unlikely to be achieved by the existing organisations or procedures. So, particular attention has to be given to the other standard characteristics: new forms of administrative authority, financial discretion and management expertise; and in practice project management represents the eclipse of established technical disciplines and staff functions. Eclipse, but not necessarily supersession: because the project that is to be managed will, most commonly, represent only a partial transfer of function or responsibility. The organisational complex, in which project structures overlay existing administrative structures, and in which established functional and technical channels of responsibility co-exist with the new project responsibilities, has been termed "matrix organisation".(2)

Within a matrix complex, organisational structures may form and reform, on the basis of projects whose boundaries will be set by the technical demands of the job in hand. Hence, "since the project organisation is essentially based upon the technological systems necessary to solve the problem represented by the project, it is structured according to the definitions of the various pieces of work that must be done".(3) As the task entrusted to the project organisation is accomplished, or changes, so the structure of the project organisation will adapt, to disappear or to reform. In short, project organisations have been envisaged as specially designed tools for the accomplishment of specifically defined tasks: and an important part of the concept is that the objective is precisely delineated. Project management is therefore taken to represent an 'organic' organisational form, peculiarly capable of adapting to changing circumstances rather than a 'mechanical' structure likely to be outmoded by the course of events.(4)

But the element of compulsion or, to put it another way, the identification of a need to attribute priority to a specific task or objective, is also an instrumental factor in developing project organisations, that can be represented as a more general and perhaps even a more traditional feature of organisational development. The concern here is not with deciding which tasks *should* receive priority – that decision pre-dates the instrumental response – but with specifying the manner in which priority may best be identified and the structures or processes by which it can best be operationalised.

By 1960, and increasingly during the following decade, it was realised that priority could not effectively be attained for any particular programme – whether in government or industry – merely by designating a formal status or only by identifying the tasks which it had been decided should be dealt with more expeditiously within a general programme of work and a wider set of responsibilities. A label alone ensured nothing: it provided no substantative guarantee that the priority task would be able to compete more effectively with other tasks that also sought their share of limited resources and attention, and no range of sanctions, if the acquiescence towards the priority task that was implicit in the label was not conceded by other parts of the activity.(5) It became evident that, to achieve in any sort of real way the special status which the formal designation of priority was intended to accomplish, the chosen tasks would have to be set aside from the general context of standard organisations, procedures and responsibilities; and that to provide a greater measure of assurance that an accredited status of priority would facilitate the operation of a particular function over a prolonged period, a more demonstrative and specific structure had to be harnessed to the function.

Project styles of management and the establishment of project organisations provided the mechanism. In the later 1950s they were used in the British and United States government service selectively and sometimes in a rather tentative fashion but, as the 1960s passed, they were used more extensively, and with increasing enthusiasm, not merely to achieve priority but also to organise a range of weapon system programmes more coherently.(6)

The Polaris Executive was, therefore, an early example of the *genre*, and it stands as a good example of the success that can be achieved by such mechanisms. When it was set up it reflected primarily the requirement to endow a new task with a measure of real priority, and to give its managers a sufficient range of responsibilities to fulfil their goals. It was not therefore the type of project organisation, strictly speaking, that represented an organisational adaptation to the demands created by an emergent technology.(7) The technology, in substance, was already there; the amount of research and development was untypically low. But the transference of an unfamiliar technology imposed some, if not all, of the constraints associated with successful innovation and, arguably, the dependence upon a principal agent – in this case, Special Projects Office – introduced another untypical layer of relationships to be mastered. The definition of the duties and the scope of the Polaris Executive became, in

(2) See, for example, the work of D. R. Kingdon (*Matrix Organisation: Managing Information Technologies* (London, Tavistock, 1973)) and L. R. Sayles and M. K. Chandler (*Managing Large Systems: Organisation for the future* (New York, Harper and Row, 1971)).
(3) Kingdon, *op. cit.* page 60.
(4) The distinction between 'organic' and 'mechanical' forms was first made, and examined in some detail by T. Burns and G. Stalker in *The Management of Innovation* (London, Tavistock, 1961). It is elaborated in J. Woodward, *Industrial Organisation: Theory and Practice* (London, O.U.P., 1968) and P. R. Lawrence and J. W. Lorsch, *Organisation and Environment; Managing Differentiation and Integration* (Boston, Harvard 1967).

(5) Between 1951 and 1955 the government of the day accorded 'priority' and even 'superpriority' to a range of tasks in the defence and industrial fields caught up in the Korean war rearmament programme; but the results were extremely patchy.
(6) This development can be traced in the British government service, through the deliberations and reports of a number of investigation. See, for example: *Report of the Management Committee on the Management and Control of Research and Development* (London, HMSO, 1961) – otherwise known as the Gibb-Zuckerman report; the Ministry of Technology *Report of the Steering Group on Development Cost Estimating* (London, HMSO, 1969) – the Downey Report; the *Second Report from the Select Committee on Science and Technology, Defence Research HC213* (London, HMSO, 1969); and *Government Organisation for Defence Procurement and Civil Aerospace*, Cmmd 4641 (London, HMSO, 1971), which embodied the Rayner Report.
(7) A form discussed in Kingdom, *op. cit.*, see especially the foreword by Tvist.

a way that was not fully foreseen by Admiral Le Fanu, an outcome of the interaction between established organisational interests at three different levels: between the United Kingdom and United States governments: within the Admiralty: and between the Admiralty and other government departments, most crucially the Ministry of Aviation. And the definition also represented a compromise with the requirement for priority, that arose principally from the perceived need to protect other naval programmes from disproportionate effects. The net result, as it happened, was sufficient to the task, in the sense at least that it was made to work.

The operation of the Polaris Executive demonstrated that project organisation is not a means for consciously resolving the dilemmas associated with the setting of priorities. Attribution of a project's limits of authority should, ideally, follow after the decision to attribute priority, and may be rendered ineffective if a number of projects are set to compete against each other in similar or overlapping fields of activity. Project management reflects and enacts an ordering of priority; it is a device by which a choice once made can be adhered to, and an objective which has been identified as specially desirable can be pursued. It would be going too far to say that a multifunctional organisation such as a large government department can only successfully support one project organisation at a time; but it is equally clear that to hive off all new tasks, or large tasks, or salient tasks, within a department to a battery of projects is unlikely to be productive, and may easily become counterproductive, as the parent organisation is drained of resources and, probably, morale.

Given its status as a project, and given the absence of a dominant research and development function, the task environment of the Polaris Executive was primarily an institutional one – although it was nonetheless difficult and novel. Its operations were as much concerned with raising the performance standards and expectations of significant elements in the defence procurement process in the United Kingdom, and with fostering a consistently cooperative relationship with SP, as they were with the development of nuclear shipbuilding technology and its integration with the POLARIS weapon system. This role was reflected in the project management processes that were employed.(8)

Project organisation is ideally characterized by three basic features. First, the project itself must be sufficiently distinctive and discrete as a programme of work to require distinctive levels of competence and combinations of services over a period of time; thus, it is typically large and important, but not so demanding that it requires all the services of the parent organisation at the one time. Second, the management structure which the project is given has wider discretion, unusual limits of power and some freedom at least from prevailing procedures in the parent organisation. These exceptional limits of delegated authority must apply – though the degree of delegation may vary according to circumstances – to

(8) Institutional tasks are increasingly regarded as one of the central challenges that contemporary organisations have to meet. See, for example, Sir Geoffrey Vickers, *Making Institutions Work* (London; Associated Business Programmes, 1963) and H. A. Simon, *The Sciences of the Artificial* (Cambridge, Mass: M.I.T. Press, 1969).

the crucial functions of management, viz. budget, personnel and internal organisation. There is no optimal way to determine the best combination of discretion and authority in these areas, but discretion has to be sufficient in practice for the project organisation to claim, and for its environment consistently to accept, a distinctive competence and authority in its identified sphere of operations.(9)

The third feature of project organisation is that the life of the project is, ideally, a function of the objective that has been set. The project management may be granted exceptional powers, organisationally, to achieve the objective, conduct the associated tasks and resolve associated difficulties; but there is an implicit expectation that when all this has been accomplished, the project should disband, its functional utility having also passed away. The particular demands of new and different tasks will call for new project structures to be set up.

These attributes of project organisation are necessary, but not sufficient, conditions of project success. They have to be put to use by a management structure that is sufficiently self-aware to be willing to use them, and sufficiently capable to employ them to good effect. A successful project organisation is one that has deployed and employed its discretionary authority, distinctive competence and promotional licence to the limit afforded by its separate status: and done all this well. There is no guarantee, even as there was no guarantee in the mere declaration of priority, that a conglomeration of people and power will, of itself, ensure success. Success is self-generated by the exploitation of the opportunities that exceptional status presents, and by the de-fusing of institutional reactions that the grant of this status may create; the test is a record of substantive achievement, which has to be put alongside the exceptional status and may in the end displace it as the fundamental source of the project's real authority.

Nevertheless, exceptional status is crucial: and offers two sorts of opportunities. In the first place it creates a requirement to manage and to motivate the internal structures of the project organisation in distinctive ways. Wide discretion in the pursuit of a discrete objective can be used to generate a relatively well-defined sense of purpose and a specific innovatory impulse to improve upon – or short-circuit – established administrative processes. This is a cause as well as an effect, in the sense that the significance of the objective around which the project is formed is sufficiently urgent to transcend the utility of existing disciplines and organisations.

In the second place, these same factors can provide the project organisation with the capacity to manage its external environment successfully: to establish, and legitimise by achievement, the urgency of its task and elicit timely and appropriate responses. This is done, and arguably has to be done in order to be effective over time, without formal recourse to the sanctions implied in the stipulated authority that the project's

(9) The notion of 'distinctive competence' is examined by P. Selznick in *Leadership in Administration* (New York, Harper and Row, 1957).

remit provides to invoke compliance; the expectation must be sustained that the project organisation's unusual demands upon associated organisations are both appropriate and legitimate, and thus confer the obligation to provide a special response.

There was a direct comparability of style between the Polaris Executive and Special Projects Office in these matters of setting and structure. But, in detail, their relative status, the degrees of discretion they enjoyed, their range of responsibilities and their powers of decision were all quite different. Most notably, SP had much greater formal and informal authority; it also had a much wider task in its research and development function, and therefore, an inherently greater capacity to re-form, and technically to regenerate its task objectives. The general environment in which it operated was more benign and supportive; there was a well-espoused and unambiguous commitment to the continuous refinement of strategic nuclear weapon systems, and an increasing support for submarine-borne systems. In addition, SP fostered and employed a general political environment, based upon the Congress, to sustain a high level of support for the 'audit function'; it delivered the goods, in style and on time, and got political credit for doing so in a way that was not possible for the Polaris Executive to emulate. As a consequence, SP has been able to institutionalise itself, through a succession of technical advances, and in this way transcended the ideal-type of project organisation to become an institutionalised matrix organisation.(10)

By contrast, the Polaris Executive more nearly represents an ideal-type project in that its structure and functioning were radically changed on completion of its initial task. On the other hand, it could be argued that it did not have the full range of attributes, and power, that a completely standard project should, by definition, encompass. The budgetary and personnel authority was carefully qualified, and certainly never as wide as SP's, and the general environment was not as benign or supportive. Reservations within the Admiralty concerning the distinctiveness of the Polaris Executive at the outset specifically constrained the new organisation while the qualified commitment to strategic nuclear weapons, in the Navy no less than in the political arena, made the task, and by implication the lifespan, of the new structure contingent upon the performance of a time-constrained objective: to build and deploy a squadron of four submarines with the necessary support facilities.

Nevertheless, the performance of the Polaris Executive during this period was distinctive. The Nassau Agreement provided a radical change in circumstances for the Royal Navy's relationship to the national strategic deterrent force and for the Admiralty's procurement processes. It changed the limitations imposed by existing attitudes and established expectations; and the setting up of the Polaris Executive was a signal

(10) The study of how weapon system development gives rise to distinctive organisations and to successful bureaucratic politics has produced a number of interesting studies: e.g. T. Greenwood, *Making the MIRV* (Cambridge, Mass., Ballinger, 1975): R. E. Coulam, *Illusions of Choice* (Princeton, Princeton University Press, 1977): E. Beard, *Developing the ICBM* (New York, Columbia University Press, 1976) are three examples.

that the Admiralty was prepared to engage the challenge of these new circumstances. The operation of the Polaris Executive was a demonstration that in practice the Admiralty had the capacity and the innate talent to meet the challenge successfully.

CPE generated, and won acceptance for, a distinctive sense of competence and a novel sense of purpose which materially aided its progress. In the Special Projects Office it had an unusually cooperative partner and a distinctively successful pacesetter. It was able to exploit the initial conditions, which its creation acknowledged, and to turn them into substantive achievement.

But the work of CPE, and the effective span of life of the project organisation, cover only a part of the task which the Royal Navy assumed after the Nassau Conference. The maintenance and operation of the deployed deterrent force also call for careful organisation and the scrupulous fulfilment of defined responsibilities, involving many of the authorities which contributed to the Polaris Executive. Their roles may be somewhat different, and therefore the way in which their efforts are brought together are different; but the type of responsibility, to maintain a specialised activity having priority, is not all that different. It is, however, another story.