THE OVERHAUL AND REPAIR OF UNITED STATES NAVY AIRCRAFT

BY

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An Outline of the Aircraft Repair Organization operated by the United States Navy, with particular reference to aspects of overhaul and repair which could be of interest to both our own Naval Repair Organization and others concerned with aircraft of American origin.

Introduction

This article is based on two years and four months exchange duty in the Overhaul and Repair Department of the U.S. Naval Air Station, North Island, San Diego.

The aim is twofold, firstly to provide a background for comparisons between the United States Navy and Royal Navy aircraft repair organizations, and secondly to stress the part played by the U.S.N. Overhaul and Repair Departments as technical authorities and providers of aircraft spares. The second point is a significant one for those involved in the procurement of aircraft types now in service with the U.S.N. Consequently an attempt has been made to highlight the differences related to the procurement of aircraft spares, as well as the facilities available to repair these spares.

After an initial explanation the normal U.S. abbreviations are used, both for the sake of brevity and because this is the form in which they will usually be met.

The old Bureau of Naval Weapons was absorbed by the Naval Material Command on 1st May, 1966. BUWEPS instructions are still quoted, however, as their new titles are not known.

All information and references in this article are from unclassified sources.

industry by the Ministry of Technology. Industry in this country is mainly interested in production and exporting, rather than research and development. With the present state of this country's economy this is understandable.

Universities are encouraging work by students in this field and a few of the larger firms maintain a watching brief on the general state of progress. The general result is, however, that as a nation we are making slow technological progress in this field.

Conclusions

Fluidics as a technology will come into increasing use in control systems. There is great promise of simpler and more reliable systems with no maintenance. The understanding of the techniques involved in the design of such systems involves knowledge of the phenomena of fluid flow. Increasing attention needs to be given to making all engineers aware of this new technology and its implications. This new technology is only as yet in its infancy, there will undoubtedly be more discoveries and applications as experience is gained. At present Fluidics is a challenge to all concerned with the design and applications of control systems.

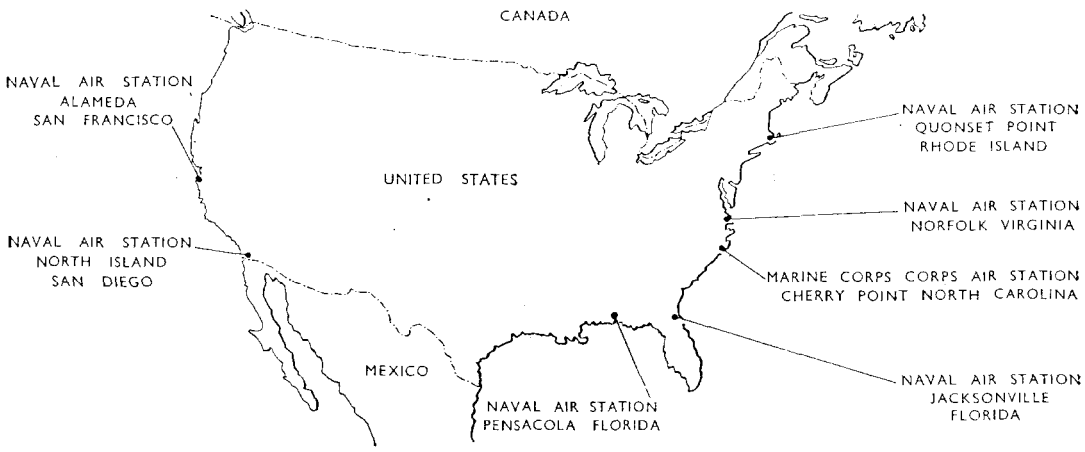


FIG. 1—LOCATION OF U.S.N. OVERHAUL AND REPAIR ESTABLISHMENTS

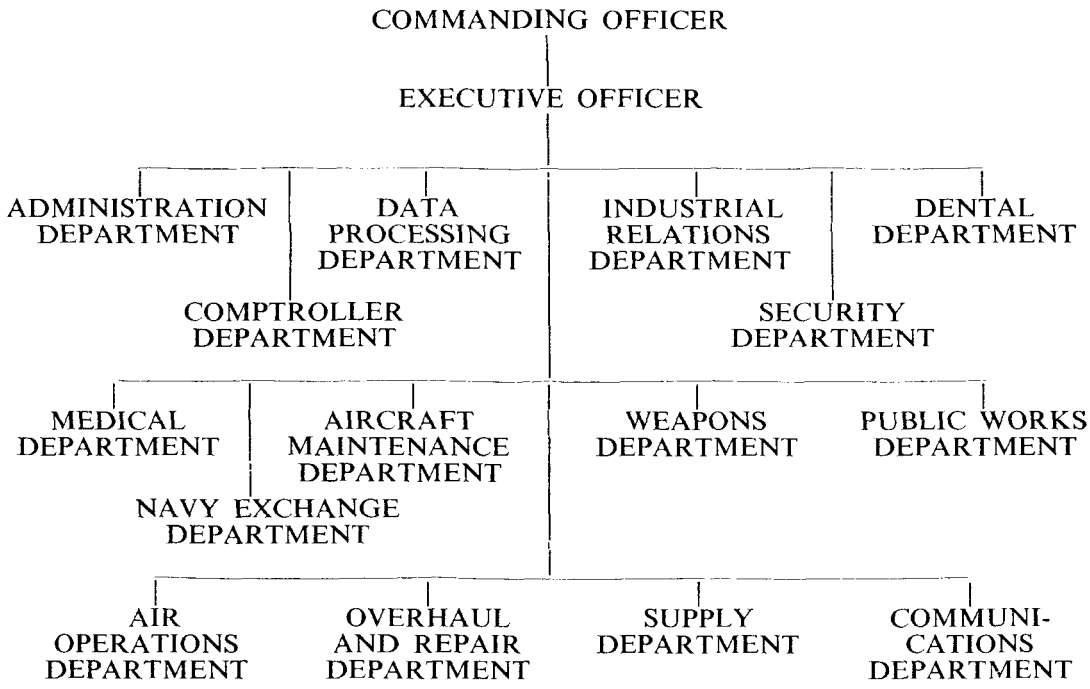


FIG. 2—ORGANIZATION STRUCTURE OF A LARGE U.S. NAVAL AIR STATION

The United States Navy Aircraft Overhaul and Repair Organization

It is the policy of the U.S.N. to be completely responsible for all levels of maintenance on its own aircraft, including associated equipment and engines. Within the Navy the levels of maintenance are separately defined as organizational, intermediate, and depot. These can be compared with squadron, workshops, and air yard levels of maintenance in the R.N. This article is concerned with a description of the depot level maintenance carried out by the seven civilian manned Overhaul and Repair Departments (O & Rs) of the U.S.N. Their location is shown in FIG. 1.

An O & R Department is a department of an air station. The departmental organization of an air station is shown in FIG. 2. The relation of an O & R Department to the overall naval command structure is shown in FIG. 3, and an example of local command structure is given in FIG. 4.

As a general rule, a single aircraft type will receive depot level support from an O & R on both the East and the West Coast. This allows Pacific and Atlantic Fleet aircraft to receive full backing in their own geographical areas. The two

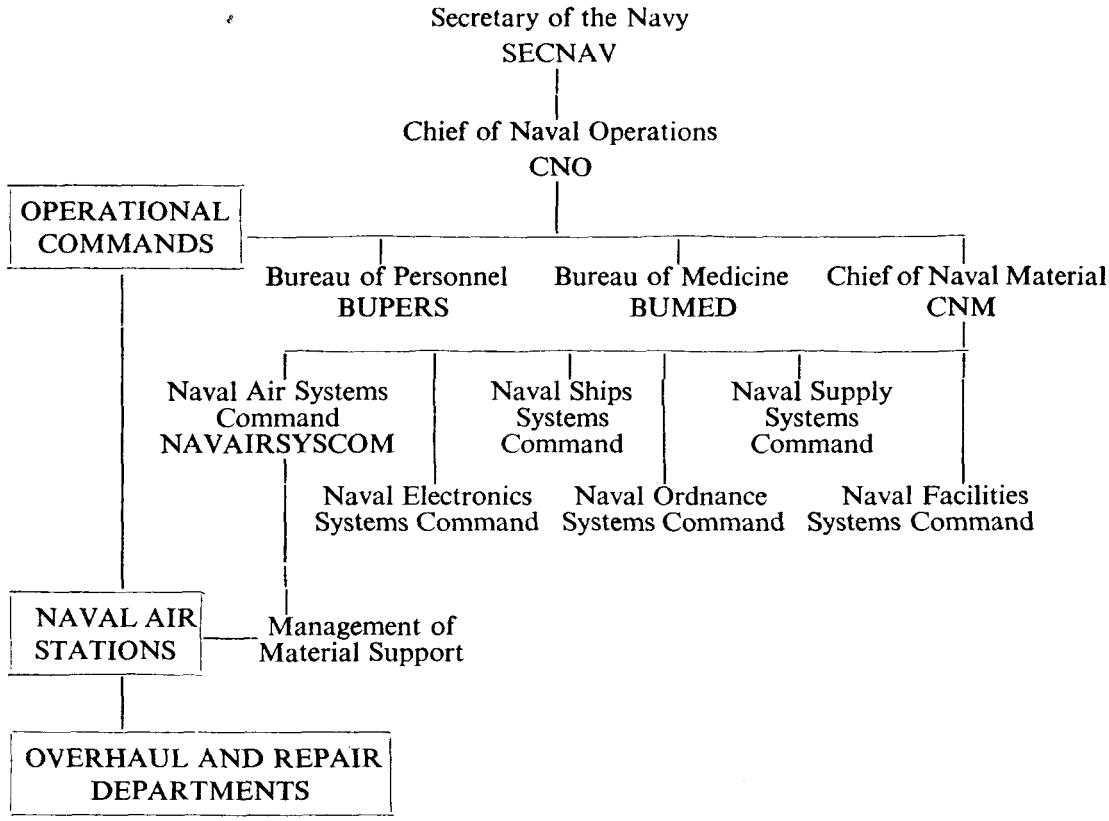


FIG. 3—OVERALL COMMAND STRUCTURE OF O AND R DEPARTMENTS

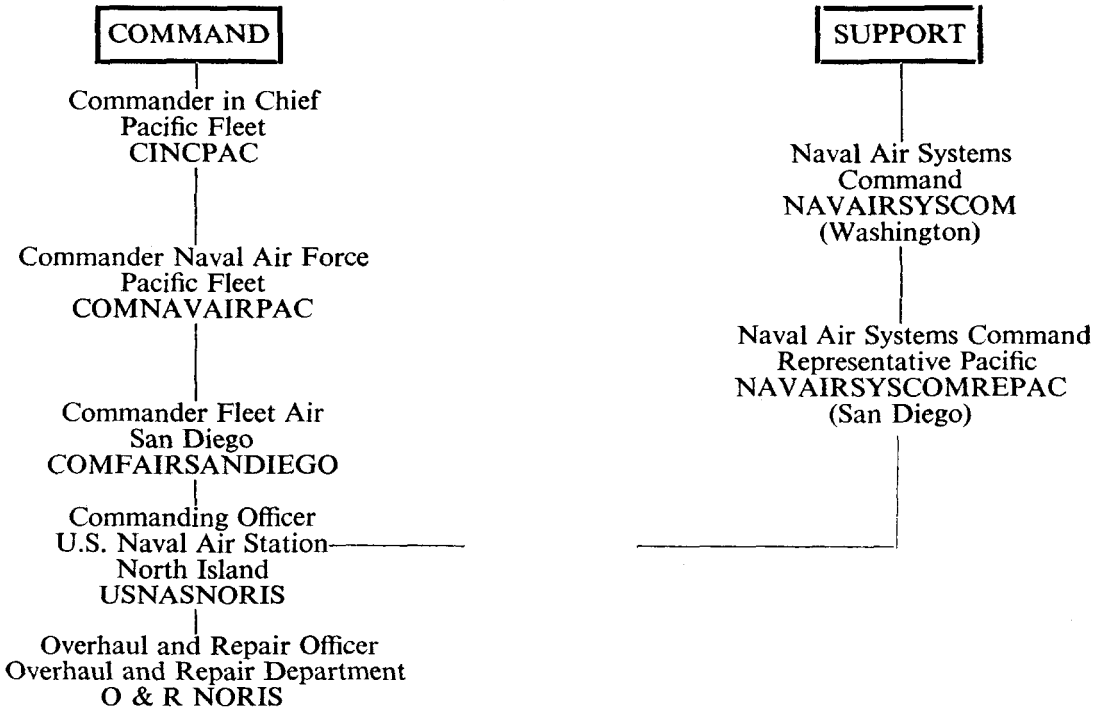


FIG. 4—LOCAL COMMAND STRUCTURE OF O AND R NORTH ISLAND

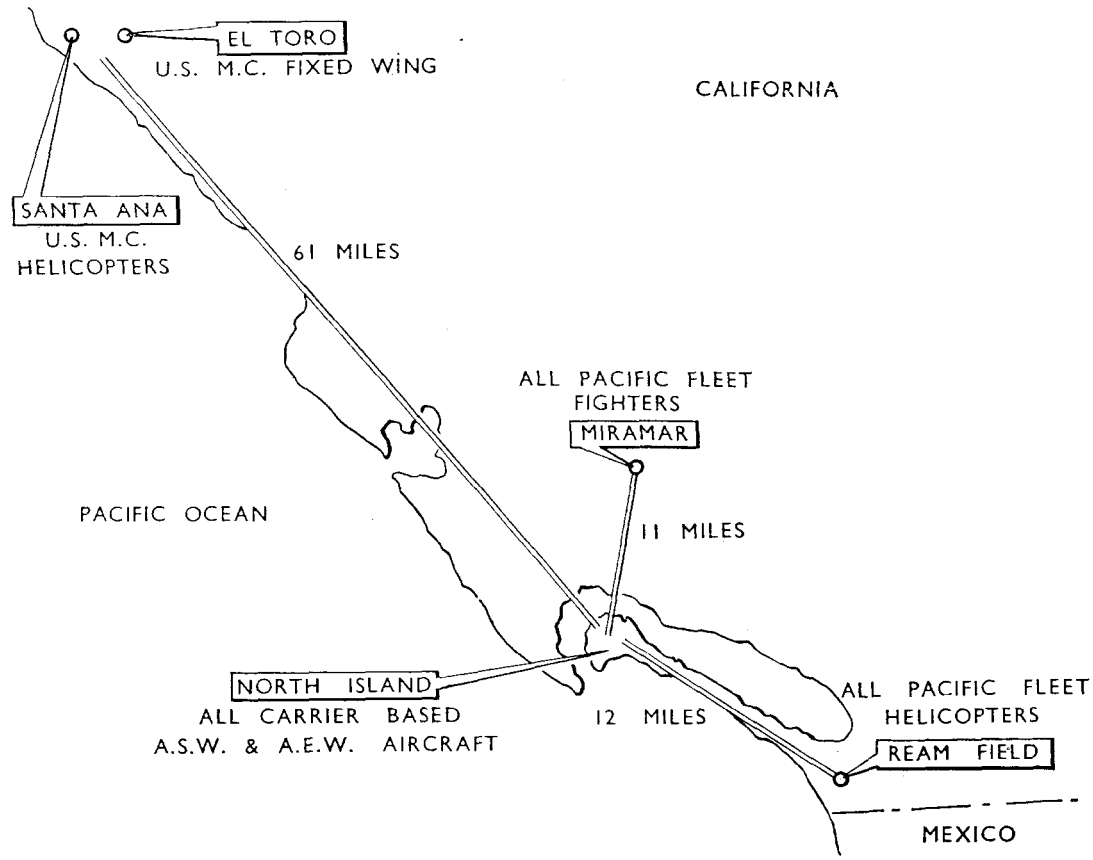


FIG. 5—BASE LOADING COMPLEX

O & Rs selected to support an aircraft type are called Designated Overhaul Points (DOP). One of these will be selected as the overhaul authority for the aircraft and will be known as the Prime DOP, with the other being known as the Secondary DOP. For example, O & R North Island is the Prime DOP for the F-4 (Phantom), the Secondary DOP being O & R Cherry Point. Normally all Pacific Fleet F-4s will be reworked at North Island and all Atlantic Fleet F-4s at Cherry Point. This does not prevent transfer of workload between DOPs in cases of overloading.

In an attempt to further rationalize depot level support, a scheme called Base Loading has been introduced. As in the Royal Navy, most operational air stations specialize in aircraft of a particular role, such as fighter, attack or helicopter, and the Air Station is located as near as conveniently possible to the O & R which is the DOP for its aircraft types. North Island is possibly the best example of this and the grouping is shown in FIG. 5. These distances are quite an achievement for a country about 2,500 miles wide and 1,500 miles long. The emphasis to locate aircraft as close as possible to the point where their components are overhauled, is one of the reasons why the O & Rs play a more direct part in daily squadron operation, compared with the air yard to squadron relationship existing in the R.N. Each O & R has a 'Customer Service' facility, which allows squadrons authorized by the administrative authority to take urgent components directly into the O & R for repair. These can then be 'walked through' the required shops and collected by the Squadron on completion, in many cases on the same day. This is a logical arrangement which relieves the pressure on a busy Supply Department.

With few exceptions, all working parties required to carry out heavy repairs and modifications in the field are supplied by an O & R. A permanent field team organization exists which can be reinforced as required by labour from the

FIG. 6—AERIAL VIEW OF NORTH ISLAND

FIG. 7—CARRIER BERTHS, NORTH ISLAND—PART OF O AND R DEPT. TOP RIGHT

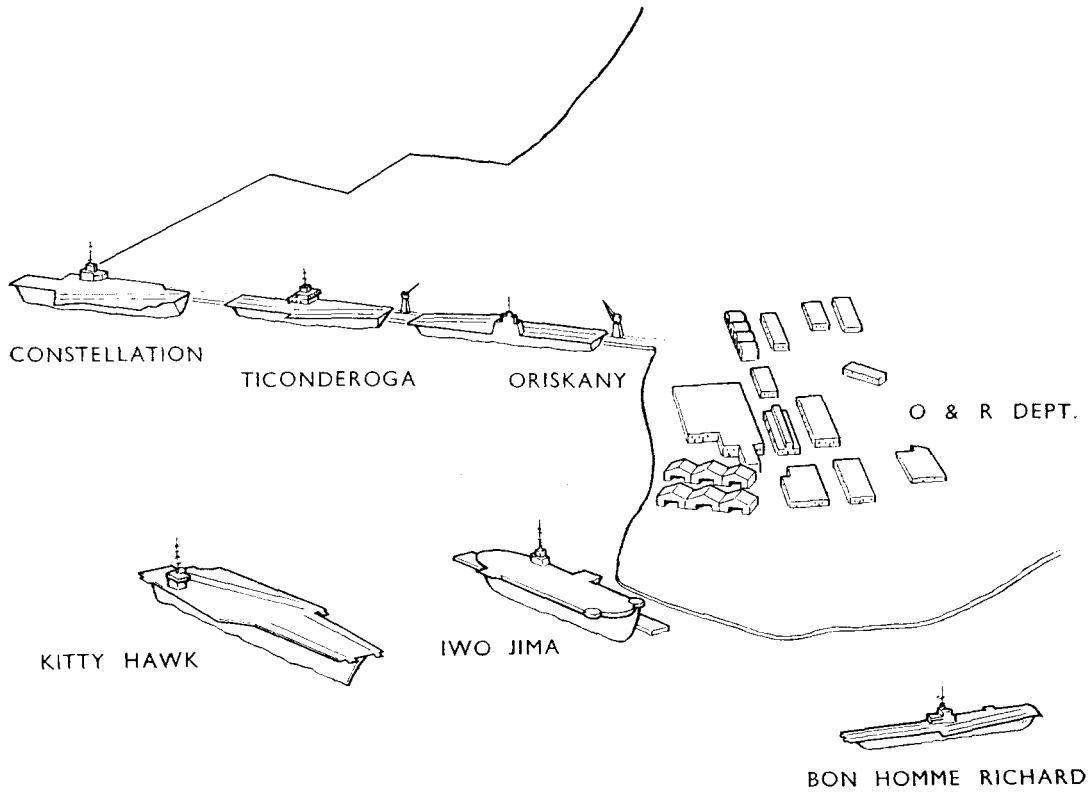


FIG. 8—NORTH ISLAND CARRIER SUPPORT

shop floor. This organization has proved its value during the South East Asia war. The system is very flexible and field teams can move out as soon as the Administrative Authority makes the decision. O & Rs also provide technical services on aircraft maintenance problems through their staff of professional engineers. These are employed to give the Department direct overhaul authority on an aircraft and its components.

The Overhaul and Repair Department, North Island

The Air Station is situated on an island in San Diego Bay, California, twelve miles North of the Mexican border. It is joined to the mainland by a peninsula stretching South. The island is about three-quarters of a mile from the city of San Diego, and the area between the island, its peninsula, and the mainland forms a fine natural harbour. The northern part is shown in FIG. 6.

North Island has very early connections with flying. Lieutenant T. G. Ellyson, U.S.N., the first Naval Aviator, received his flying training there in 1911. The Naval Air Station was commissioned in 1917 and an aviation repair facility was started in 1919. At the start of World War II, the repair facility was expanded into a very large organization capable of supporting the Pacific Fleet's aviation effort. The strategic position of North Island made it important during the Korean War and it is being emphasized again by the war in Vietnam.

By our own standards, N.A.S. North Island is very large indeed, and it is one of the largest U.S.N. air stations. On a normal working day approximately 19,000 people will be on board, including about 8,500 civilians.

Part of the Air Station has been developed into a deep water berth facility, and this is the home port for six aircraft carriers (*Constellation*, *Kitty Hawk*, *Bon Homme Richard*, *Oriskany*, *Ticonderoga* and *Iwo Jima*), see FIGS. 7 and 8. North Island is also the headquarters for the Pacific Fleet's Anti-Submarine and Airborne Early Warning Aircraft, and with other utility and ferry units, this makes it a base for about 19 squadrons. The staff of six different Flag Officers

TABLE I—*Man-hour distribution—Financial Year 1965*

Programme		*Expended*	*Percentage of total*
Direct	Aircraft . .	3,064,039	24·9
	Engines . .	783,028	6·4
	Components . .	919,510	7·5
	Other Support .	1,256,151	10·2
Total Direct . .		6,022,728	49·0
Indirect . . .		4,414,982	36·0
Leave . . .		1,845,803	15·0
Total Man-hours . .		12,283,513	100·0
Overtime (Direct) . .		119,914	—
Overtime (Indirect) . .		38,362	—

Note: Other support charges include manufacturing for supply of special Fleet orders, preservation and packaging, maintenance of storage aircraft, customer service, field teams, special modification programmes, prototype work and defect investigations.

use North Island as their permanent home, and it is also used by elements of many other organizations involved in such things as training, accounting and drafting of personnel.

The convenience of an aircraft repair facility having a carrier berth needs no stressing to anyone in the R.N. who has been involved in moving damaged aircraft from a carrier to the place of repair. A carrier berth is a feature of most of the O & Rs in the U.S.N.

The complement of the O & R Department varies slightly in relation to the workload, and the figures current in June, 1966, are used as an example. This gives a complement of 6,427 civilians and 96 military personnel, sub-divided as follows:

Civilian	Graded (White Collar)	655
	Ungraded (Blue Collar)	5,772
Military	Officers	14
	Ratings	82

Ten of the officers are employed in senior management positions and four are flight test officers. The majority of the ratings work on the flight test lines.

The composition of the O & Rs workload for the 1965 Financial Year is shown in TABLE I as a total manhour distribution. TABLE II gives the aircraft production details for the same period.

Overhaul and Repair Departments all have the same basic organization and management structure as required by Bureau of Weapons Instruction 5451.122 of 13th November, 1964. The organization of O & R North Island is shown in FIG. 9. This organization pattern was adopted in the light of commonly-accepted principles of modern management.

TABLE II—*Aircraft Production at the O & R Department, North Island, during the Financial Year 1965 (F.Y. 65 from 1st July 64 to 30th June 65)*

Programme	*Model*	*Number Completed*	*Average Direct Man-hours Expended per Aircraft*
P.A.R.	C—1 (Trader)	20	2820
	E—1 (Tracer)	23	3120
	F—4 (Phantom)	112	6630
	F—8 (Crusader)	191	3860
	H—2 (Sea Sprite)	17	4200
	H—3 (Sea King)	42	3850
	S—2 (Tracker)	139	2520
Main Spar Repair	F—4	78	1460
Par Conversion	F—8A to DF—8A	8	4220
	S—2C to US—2C	7	4100
Routine Overhaul	EF—10 (Sky Knight)	7	4350
	H—34 (Sea Horse S58)	75	4500
Crash Damage Overhaul	F—4	6	10500
	F—8	3	4060
	H—2 (recovered from sea bed)	1	16000
Overhaul/ Conversion	SH—34J to UH—34J	20	5420
Modernization	F—4	28	3250
	F—8	6	5180
Modernization/ Conversion	SH—34J to UH—34J	1	2900
	Total Throughput F.Y. 1965	785	

Note: The E2 (Hawkeye) and H.46 (Sky Knight) were not introduced into the O & R Department until F.Y. 1966.

The Overhaul and Repair Officer is a Captain, and Codes 01, 02, 03 and 04 are usually Commanders.

The O & R Officer and the Assistant O & R Officer are direct equivalents of the Superintendent and General Manager in our own Aircraft Yards. The Production Officer is responsible for production management and this includes direction of Production Planning and Production Engineering, as well as directing the main labour force of the Shops Group. The Management Services Officer is responsible for the policies of departmental management, and for providing management data and techniques to all elements of the O & R. The Engineering and Quality Officer is responsible for the technical direction of any work which is being performed to design and quality specifications.

The Project Officers are split up in the following way: Jet Aircraft, Propeller Aircraft, Helicopters, Engines, and Components. Their function is to direct their programme within the existing management structure. Reference to FIG. 9 shows that the main lines of responsibility in the O & R are vertical and that each group is organized on specialist lines. However, an aircraft passing through an O & R will sample most elements of the organization, making a requirement for a co-ordinating and horizontal line of responsibility if the aircraft is going to

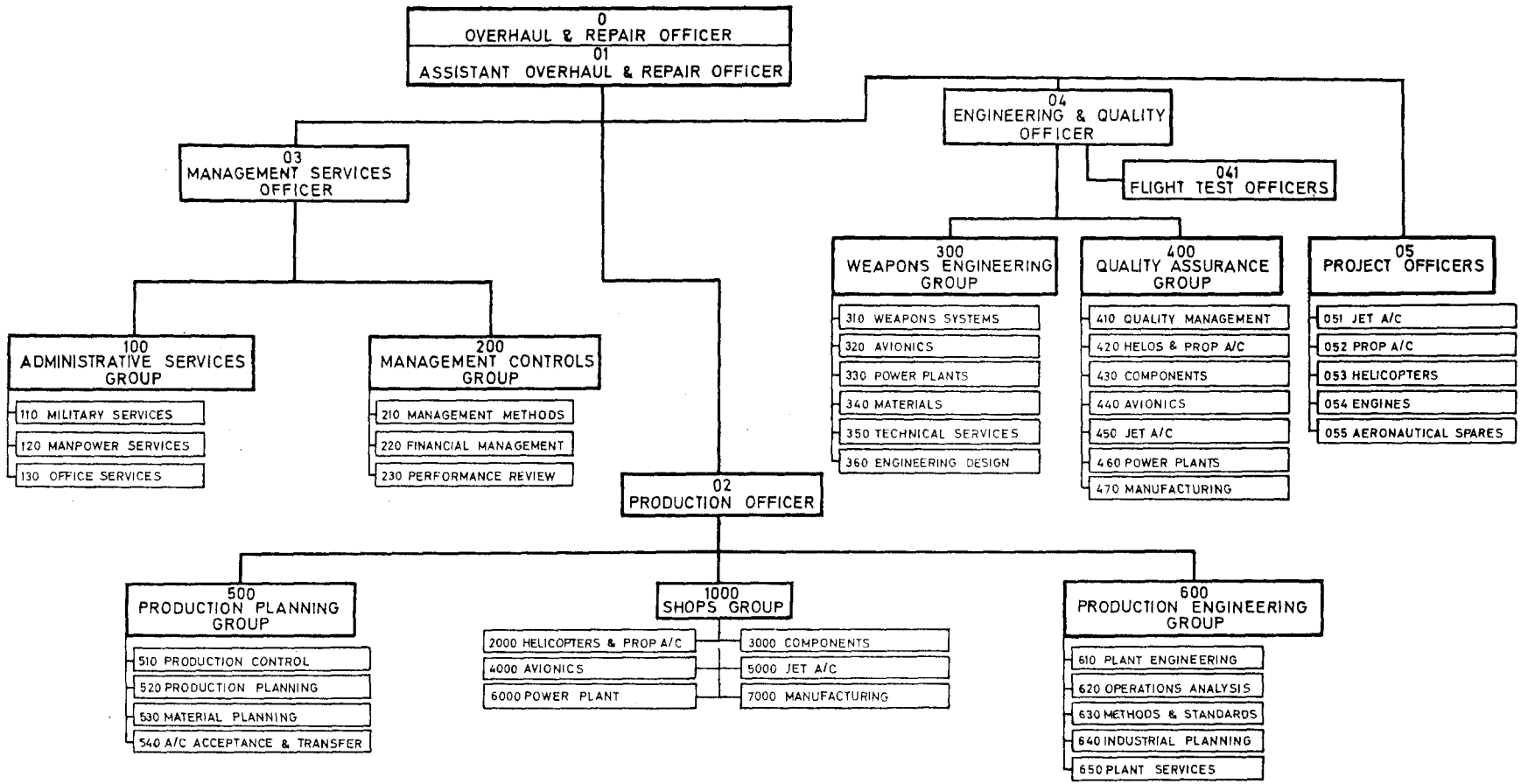


FIG. 9—O AND R DEPARTMENT, NORTH ISLAND—ORGANIZATION CHART

be produced economically, on time, and to specification. The Project Officers are usually Lieutenant-Commanders, and at North Island two of them are Exchange Officers, one is an R.N. Air Engineer Officer and the other an R.A.N. Air Electrical Officer.

The management structure of O & R North Island is described in O & R NORIS Instruction 5451.13D. This is the Organization Manual, it covers about 150 pages and presents the responsibilities of each separate element of the O & R in great detail. The intent is to provide a management tool to prevent confusion on authorized jurisdictions and authority, and to create clear-cut lines of responsibility.

The following are condensed extracts from the Organization Manual giving the 'function statements' of each Group and their manpower allocation:

100. *Administrative Services Group* To provide administrative services for the Department. Act as representative of the O & R Officer on manpower and civilian personnel services. Act as the O & R Officer's representative in relationship with organized employee groups, and external industrial, professional and government organizations.
(32 Graded, 16 Ungraded)

200. *Management Controls Group* To direct the efforts of the Management Methods Division, the Financial Management Division, and the Performance Review Division, who are responsible for the design, development and maintenance of an effective management control system for the Department.
(99 Graded, 0 Ungraded)

300. *Weapons Engineering Group* To direct the efforts of the 6 Divisions within the Group. Responsible for accomplishing engineering projects, co-ordinating weapons maintenance engineering efforts on assigned weapons systems with NAVAIRSYSCOMHQ, Fleet Commands, Contractors and other Defence activities.
(131 Graded, 0 Ungraded)

400. *Quality Assurance Group* To direct the efforts of the 7 Divisions within the Group on the operation of a Quality Assurance Programme to assure satisfactory product quality, safety and reliability.
(34 Graded, 196 Ungraded)

500. *Production Planning and Control Group* To direct the efforts of the Production Control, Production Planning, Material Planning, and the Acceptance and Transfer Divisions in the accomplishment of a production planning and control programme encompassing the total production assignments of the Department. Maintain liaison with NAVAIRSYSCOMHQ and NAVAIRSYSCOMREPAC on workload scheduling.
(119 Graded, 862 Ungraded)

600. *Production Engineering Group* To direct the efforts of the Plant Engineering, Operations Analysis, Methods and Standards, Industrial Planning, and Plant Services Divisions in providing a programme of Production Engineering Services for the Department.
(213 Graded, 406 Ungraded)

1000. *Shops Group* To direct the efforts of the 6 Divisions within the Group, in the accomplishment of the Overhaul and Repair Department's production workload.
(38 Graded, 4,292 Ungraded)

For comparative purposes with other organizations it is often difficult to define direct labour. From the previous figures it would appear that the 4,292

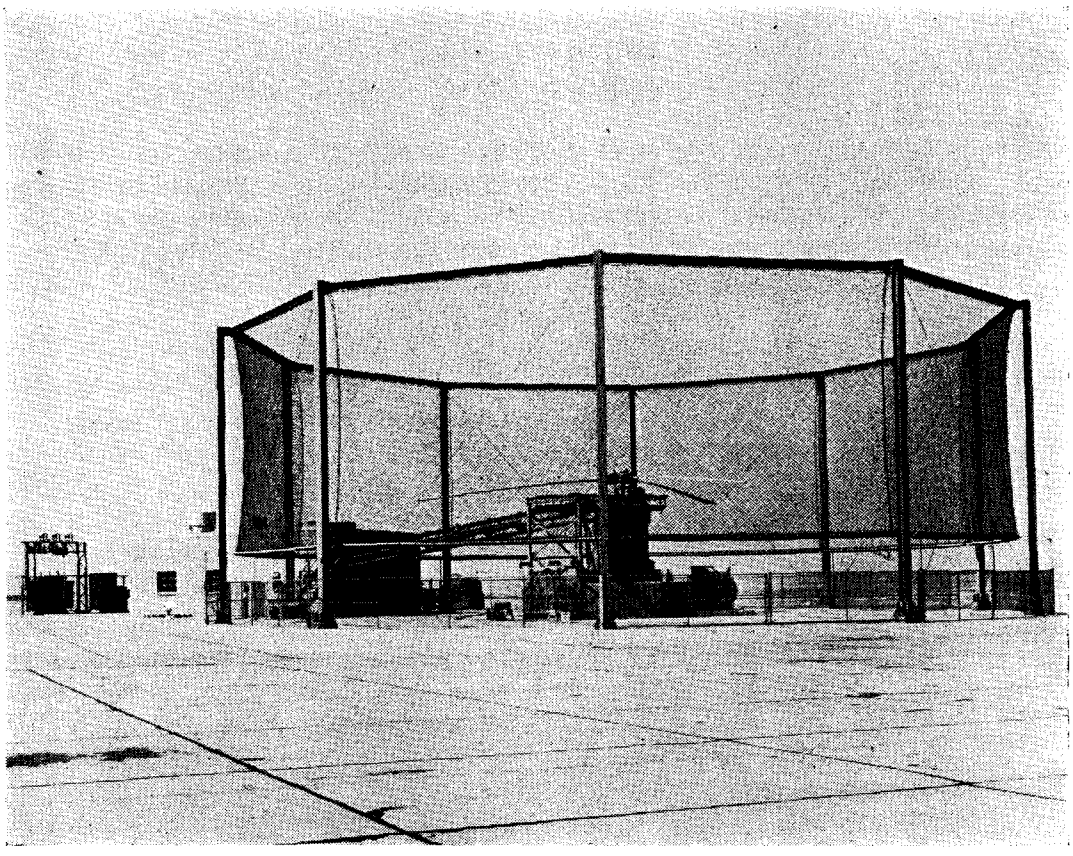


FIG. 10—HELICOPTER ROTOR BLADE TEST TOWER

ungraded personnel on the shop floor are supported by a mixture of 1,480 graded and ungraded personnel, giving a direct/indirect labour ratio of 2·9 : 1. However, a closer definition is required as many of the shops' personnel are not employed directly on the product. Machine accounting of man-hours shows that in the Financial Year 1966, 7,463,404 man-hours were used directly on the product with 4,994,722 man-hours being used in support. This gives an accurate ratio of direct to indirect labour of 1·5 : 1.

Engineering Authority and Quality Control

This section is included because it outlines fundamental differences between the R.N. and U.S.N. Naval Repair Organizations. The U.S.N. provides its own repair authority, and employs a system of Quality Control based on statistical sampling, rather than 100 per cent inspection.

An O & R will employ a fairly large professional engineering staff, who will not only design repair schemes, but also act as technical consultants for the equipment for which the O & R is responsible. The Departments will usually solve its own engineering problems, and advise when contractor design changes appear necessary. NAVAIRSYSCOM HQ use the appropriate O & R Weapons Engineering Groups for many purposes, including the investigation of defective components returned for FUR (A.21) action, preparation of some Bulletins (STIs), design of certain changes (Modifications), and for general monitoring of contractor's technical proposals. Some O & Rs are also responsible for specialist publications, for example, O & R North Island is responsible for the U.S.N. Corrosion Manual.

When a new aircraft is introduced into service, the DOPs receive a complete micro-film index of the aircraft drawings as a reference. The Weapons Engineering Group rapidly builds up experience on an aircraft or engine type due to the amount of work they do. After the equipment has been in service for some

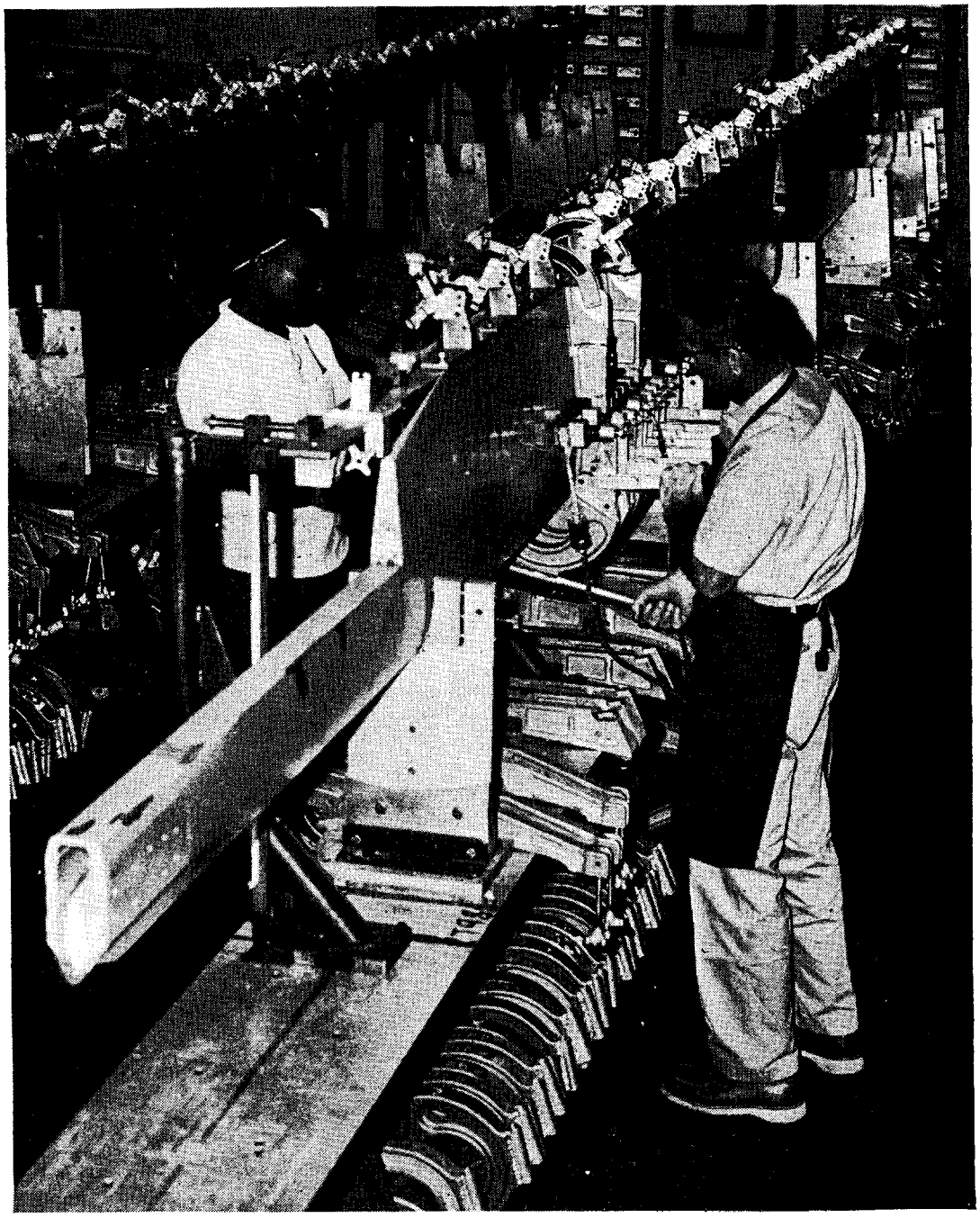


FIG. 11—HELICOPTER ROTOR BLADE REPAIR SHOP

time, a valuable amount of knowledge is concentrated in an O & R. The facilities available in the Department allow quite comprehensive projects to be undertaken. A few recent examples are the fitting of two 300-gallon drop tanks to the H-46 (Sea Knight) helicopter, the design and production of kits to put a turbojet in the tail of the P-5 (Marlin) flying boat, as well as various armour and armament schemes, the details of which are probably still secure. These projects are usually produced at a fraction of the cost and time tendered by commercial organizations, but prototype work is limited by the Department's design capacity and the never-ending demand for repair information.

The availability of special repair schemes for an individual part or component allows much greater salvage of items worn or damaged beyond the nominal limits. This is a great help in component overhaul, and in cases of extreme

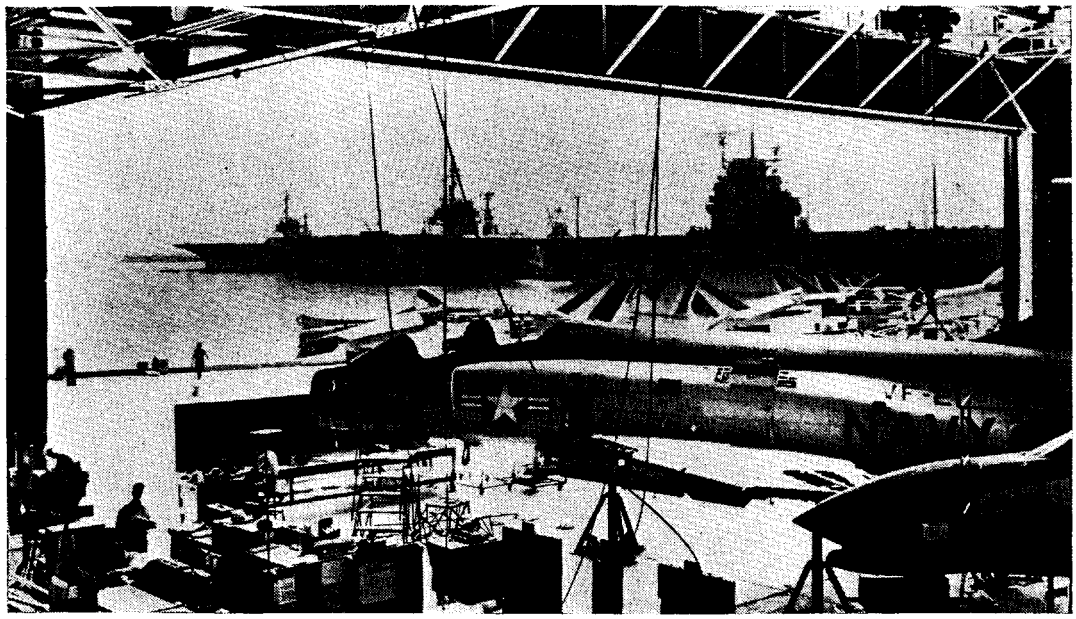


FIG. 12—VIEW OF F-4 (PHANTOM) PAR LINE

shortage, replacement parts are sometimes designed and manufactured within the O & R.

FIGS. 10 and 11 show stages in helicopter main rotor blade overhaul; this is one specific example of an overhaul and repair process controlled by the Weapons Engineering Group.

FIG. 9 shows the breakdown of the various Engineering Divisions within the Weapons Engineering Group. This group should not be confused with the Production Engineering Group. Weapons Engineering are concerned with problems related to the aircraft itself. Production Engineering are concerned with the provision of the required tooling, test equipment, machinery, and correct sequence of events to enable overhaul and repair to be carried out the most economical way (over 600 people are employed in the Production Engineering Group at O & R North Island).

The policy of 100 per cent inspection of the product has been superseded in the Naval Repair Organization by a Quality Assurance Programme, detailed in BUWEPS Instruction 4855.1, the quality assurance manual for the Overhaul and Repair Departments. The management principles are established by MIL-Q-9858A, the Department of Defence approved specification for quality programme requirements.

Quality Control in an O & R is based on the following principles:

(*a*) First line supervision is responsible for the quality of the product

(*b*) The verification that the required quality has been built into the product is the responsibility of the Quality Assurance Group.

The methods used for verification vary with the complexity of the component and its operating environment. Verification of in-process stages may be performed by Quality Assurance Inspectors, by production supervisors or by selected artisans. All selected production personnel are issued with certification stamps by the Quality Assurance Group. Only in very unusual circumstances will a mechanic actually pass his own work. All verifications are controlled by statistical sampling, random audits, and continuous monitoring conducted by inspectors of the Quality Assurance Group. The data collected from these sources is analysed and produced in routine report form, so that management at all levels is aware of quality trends, as well as the recommendations for corrective action. This all conforms with modern Quality Control practice.

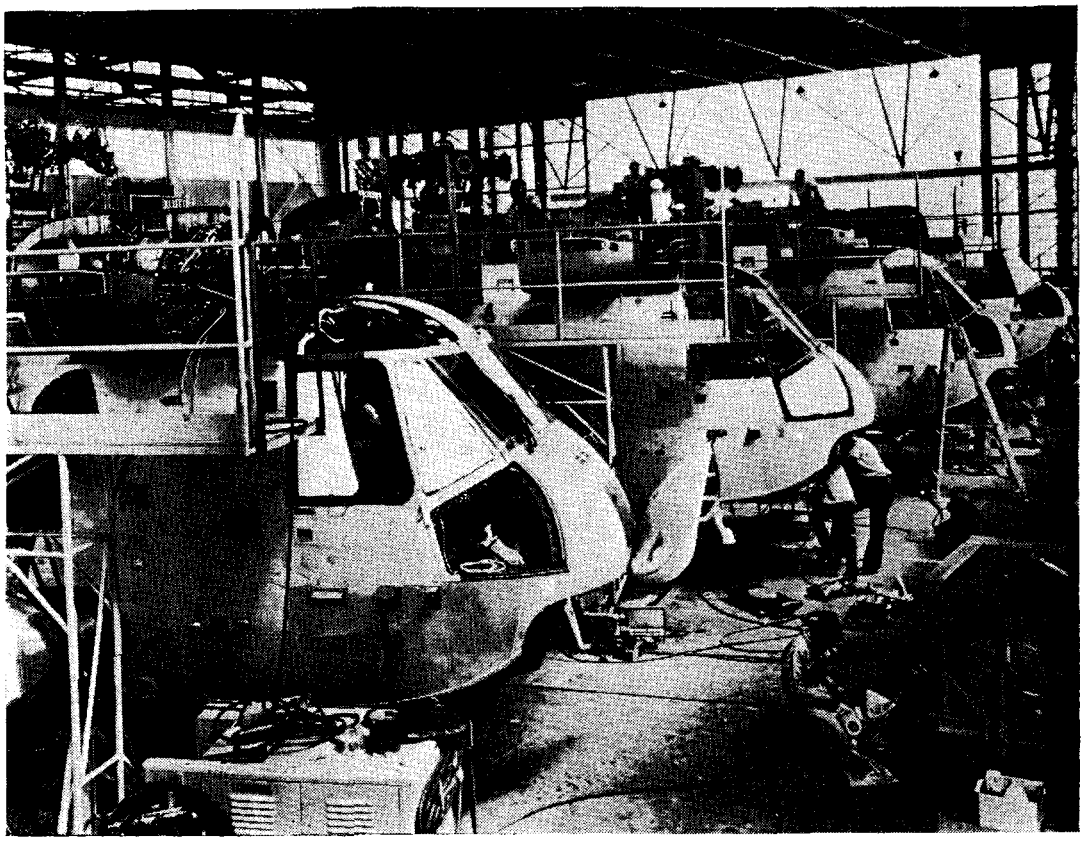


FIG. 13—VIEW OF H-3 (SEA KING) PAR LINE

The standards and specifications to which the Quality Assurance Group work are set by the Weapons Engineering Group.

Progressive Aircraft Rework

Progressive Aircraft Rework (PAR) is a major part of the work load of an O & R (see TABLE II) and it deserves some detailed explanation. PAR is the routine servicing of U.S.N. aircraft at depot level, and was developed to replace the system of relatively long periods of squadron service followed by a complete overhaul. PAR was introduced on the argument that by reworking aircraft at more frequent intervals, their condition would be maintained at a higher mean level, modernization would occur more frequently, and Fleet maintenance and total out-of-service time would be reduced. The PAR system is now an integral part of the naval aircraft maintenance programme, and it represents a significant portion of the total maintenance effort spent on an aircraft during its service life. This system must be closely controlled to make it competitive with the one it replaced, and work is confined to that which is strictly necessary. Under the more comprehensive overhaul system, the depth of rework on an aircraft in good condition would exceed the actual requirement. PAR intervals vary from 18 to 24 months, depending on the type of aircraft. FIGS. 12 and 13 show the F-4 (Phantom) and H-3 (Sea King) PAR lines.

Like most maintenance schemes, PAR is a compromise, and it is viewed with mixed feelings in the Fleet. The object of PAR is to keep an aircraft in good material condition throughout its whole life, and therefore the requirement for overhaul no longer exists. Unfortunately the cost of each successive PAR increases as the aircraft gets older. This causes pressure from the support authority to reduce work content, and pressure from the operator to do more work on his ageing aircraft, which under the present scheme remains continuously on the same squadron's charge. Examples of recent PAR costs are

TABLE III—*Average cost for Progressive Aircraft Rework (PAR) at the O & R Dept., North Island, Financial Year 1965*

Model	*Naval Industrial Fund Cost* $	*Statistical Cost* $	*Total Cost*	
			$	£
F—4	57,357	14,338	71,695	25,550
F—8	39,188	4,840	44,028	15,740
S—2	24,323	3,154	27,477	9,850
H—3	38,277	11,567	49,839	17,750
H—2	43,604	25,037	68,641	24,500
C—1 & E—1	27,879	4,289	32,168	11,450

Average cost for routine overhaul for the H—34 Helicopter (Wessex equivalent) Financial Year 1965

Model	*Naval Industrial Fund Cost* $	*Statistical Cost* $	*Total Cost*	
			$	£
H—34	45,812	7,780	53,592	19,200

Note 1: Statistical costs cover certain major components and equipment analogous to that supplied without charge to aircraft manufacturers, i.e., Government furnished equipment (G.F.E.) in U.S.N. terminology, or embodiment loan items in Ministry of Technology terminology. Statistical cost also covers the oncosts and the pay and allowances for the Military Personnel borne in the O & R Department.

Note 2: Currency conversion at the rate of $2.80 = £1.

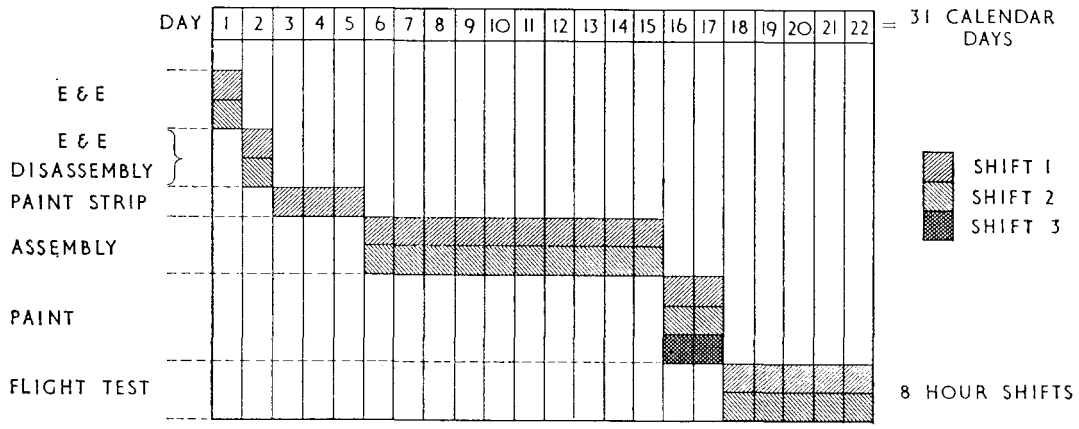


FIG. 14(*a*)—TYPICAL PAR CYCLE—SH-3A HELICOPTER

given in TABLE III. Obsolescent aircraft, such as the H-34 (Sea Horse) helicopter are remaining on the overhaul cycle until they are withdrawn from service.

The PAR concept was tailored round the existing facilities of the Naval Repair Organization, and it reflects the potential of the O & Rs. The immediate availability of spare parts and sub-assemblies is the reason why PAR works, and why a short turn-round time is possible (FIG. 14(*a*)). The policy for reworking an aircraft, its engine, and all their components in the same establishment, gives the concentration of parts required to produce an aircraft with little delay. Delays not acceptable for PAR can usually be absorbed by the components being overhauled for the Supply System. Complete rework capability means a substantial investment in test gear, but not only is this cost recovered quickly, it makes the supply of spares an almost exclusively naval problem. This is important for PAR, because if a spare is not available the aircraft cannot be produced, as the contract must be complete before the aircraft can be returned to its parent squadron. A naval problem means a naval solution,

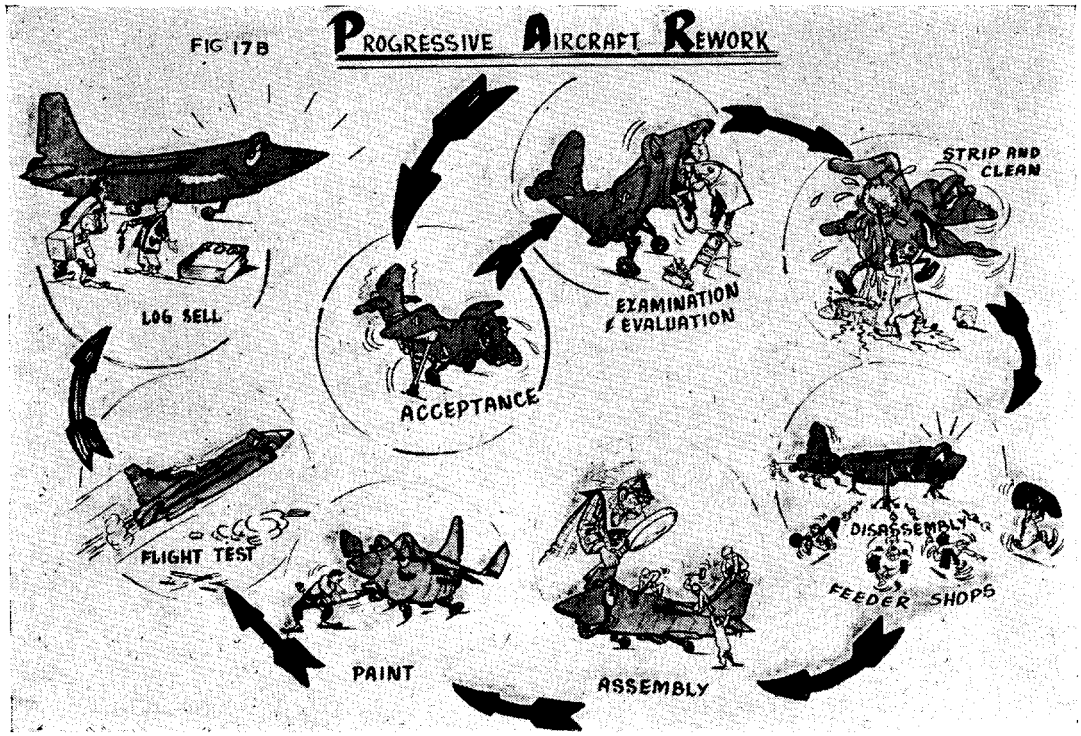


FIG. 14(*b*)—PROGRESSIVE AIRCRAFT REWORK

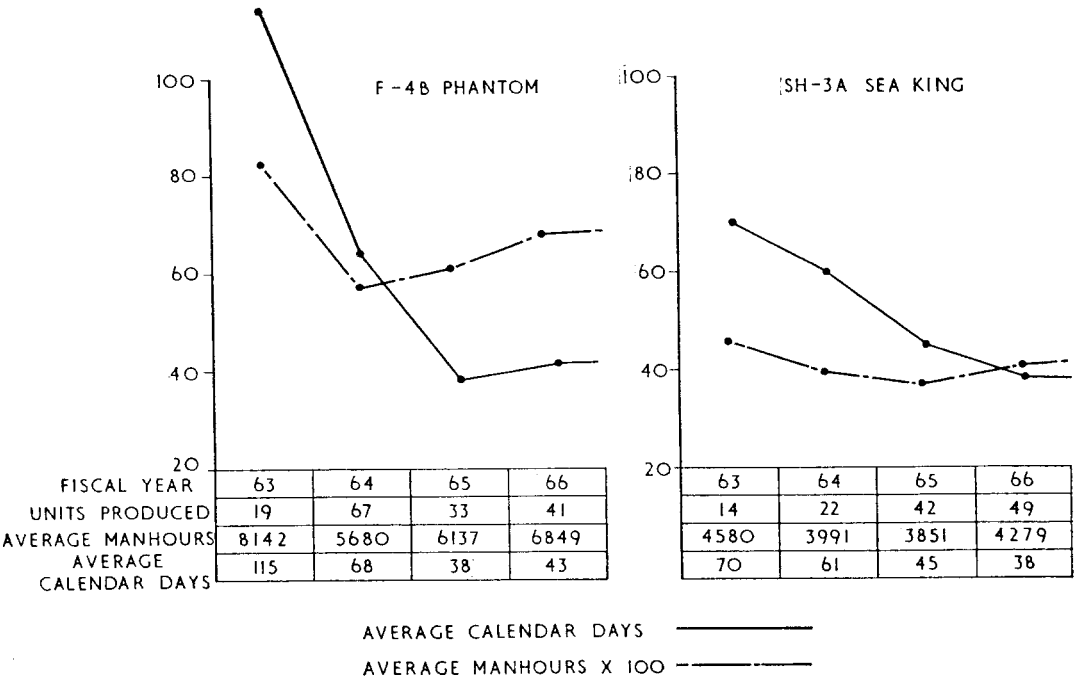
and this is usually easier to achieve. This point is made because if previous R.N. depot level servicing schemes have failed due to lack of spares support, it is hard to see why the present R.N. Partial Aircraft Rework (also called PAR but not so comprehensive as U.S.N. PAR) should have any more success with an unchanged spares backing. There also appears to be a danger that a system of PAR based on spares availability rather than on specific work content, could eventually cause deterioration of aircraft condition to a point where PAR could not restore it. It is U.S.N. philosophy that PAR was introduced to reduce the workload of embarked squadrons, a useful yardstick to remember.

The basis policy directive for U.S.N. PAR is given in BUWEPS Instruction 4710.1. This gives the guidelines for the three main parts of PAR:

(*a*) Structural examination and rework
(*b*) System and component maintenance
(*c*) Configuration updating.

Each aircraft type has its own PAR Specification which details the work to be carried out. The PAR Specifications for the older aircraft were prepared by the O & R selected as Prime DOP. With newer aircraft, the PAR Specification is prepared by the Contractor. In either case the specification will be within the policy of BUWEPS Instruction 4710.1. Once a year there is a conference by aircraft type to review the results of PAR. It is attended by representatives from NAVAIRSYSCOM, COMFAIRS, squadrons operating the type and each DOP. The operators have the opportunity to complain about any aspect of PAR they do not like, and the conference can recommend changes to the PAR Specification. The NAVAIRSYSCOM representative usually has to use a fairly severe financial brake to counteract the extra work demanded by the squadrons and COMFAIRS.

PAR is one of the main tasks for an O & R, and precision scheduling of aircraft is essential to prevent overloading or underloading shop capacity. Squadrons must deliver aircraft by 1200 on the day before PAR is due to start, and this is strictly enforced. Aircraft must be flown in, and this maintains a certain



FISCAL YEAR	63	64	65	66
UNITS PRODUCED	19	67	33	41
AVERAGE MANHOURS	8142	5680	6137	6849
AVERAGE CALENDAR DAYS	115	68	38	43

63	64	65	66
14	22	42	49
4580	3991	3851	4279
70	61	45	38

FIG. 15—PAR PERFORMANCE—MANHOURS AND TURN-ROUND TIME

minimum standard for induction to PAR. Work starts on the first shift on the planned day of induction, and an average condition aircraft should be completed with a few days of the planned 'sell date'. The importance of a rapid turn-round time was made clear by a BUWEPS directive issued in January 1963. This instructed all O & Rs to compress in-process time of aircraft undergoing PAR, with the object of reducing the aircraft inventory of the Naval Repair Organization. This eventually became known as the 'Compression Programme'. The trend is shown in FIG. 15. It has been calculated that O & R North Island now requires an inventory of 12 less aircraft to accomplish the same workload than it would have done in 1963. With the other six O & Rs achieving similar results, it can be seen that the U.S.N. has effectively increased its front line aircraft strength without having to buy additional aircraft. Within the O & Rs, the compression programme stimulated minute examination of all methods and procedures concerned with turn around time for PAR. As the results of these studies were introduced, it was interesting to note a corresponding fall in man-hours for the same work content. Although the aim of compression was a reduction in production time, it also gave a bonus in production cost. Competition is stimulated by the knowledge that another O & R is working the same aircraft types and its performance will be available for comparison by NAVAIRSYSCOM HQ.

A breakdown of PAR into its separate phases is shown in FIG. 14(*a*). A more informal version is shown in FIG. 14(*b*).

PAR starts with the Examination and Evaluation (E & E) phase. This constitutes a complete survey, and as a result of this inspection of the aircraft and its log books, the standard machine-produced production control documents are modified to reflect the condition in which the aircraft was received. The Aircraft Examiners work for the Workload Division of Production Planning (FIG. 9).

The first day covers systems operation, functional checks, engine running, superficial examination and confirmation of the modification standard. The second day is shared with the disassembly team, and examination continues as the aircraft is stripped down to a basic fuselage. At the end of the second day all

components and sub-assemblies will have been sent to the appropriate component (feeder) shops and all material demands will have been raised. The E & E phase is a very important part of PAR, and an O & R relies on a very high standard of skill from its E & E personnel. The Examiners, being employed by the Division responsible for the total O & R workload, are sensitive to the amount of work which can actually be carried out during PAR, and their work sheets reflect this. They are also responsible for interpretation of the PAR Specification and they will seek guidance on this point from the Weapons Engineering Group if required. This means that the final working documents for PAR are under the control of the Workload Division; Quality Control are only responsible for seeing that the work called up in these documents is carried out to the required standard. Every defect found on the aircraft is listed, but with the exception of safety-of-flight items, only those which are truly depot level responsibility are rectified. The others will be noted on the aircraft's records to be rectified by the squadron. This is one of the advantages of returning an aircraft to its original unit. There is good liaison between Production Planning and the Resident COMFAIR representative, and in special cases, such as imminent squadron embarkation, rectification of all defects can be negotiated.

The remainder of PAR is a fairly straightforward repair and reassembly operation, the critical part is ensuring that the original components return from their feeder shops at the correct time in the rebuild sequence of the aircraft. The extent of this problem can be judged from the fact that between 30 to 40 per cent of all direct PAR man-hours are spent in the feeder shops. The first components to go back on the aircraft will be required within 4 days of their removal. This emphasizes the basic PAR production problem, the supply of serviceable components.

Financial Control—The Naval Industrial Fund

In 1962, the Department of Defence encouraged all their industrial activities to adopt a new accounting system with the intention of promoting some of the practices and incentives prevalent in private industry. This was to replace the old appropriated fund financing and accounting system with all its well-known faults.

The Naval Industrial Fund (NIF) provides each industrial unit with a working capital fund against which most of the unit's operating costs can initially be charged.

The Overhaul and Repair Department, North Island, has $10,000,000 (£3,570,000) as its working capital. On completion of the work, the customer reimburses the industrial fund from his own appropriated funds. The use of a working capital fund in this manner is designed to concentrate management attention on costs and to allow introduction of accounting methods similar to those used in private industry. These include double-entry book-keeping, accrual accounting, and industrial cost accounting systems. The scheme also allows the use of internal operating budgets for control of man-hours and costs at shop level.

The objective of NIF is to operate in such a manner that repayments equal costs, showing neither profit nor loss at the end of each accounting period. Small gains or losses are permissible, however, and may be carried forward to the next accounting period provided action is taken to reverse the trend. Periodic accounting reports are produced under NIF similar in format and content to those of a private industrial concern. These statements are intended to provide information on which immediate management action can be taken.

NIF practice emphasizes the use of fixed price orders for specific services as the means of initiating work, and providing appropriated funds to repay the working capital fund. These orders are issued by the requiring agency to the

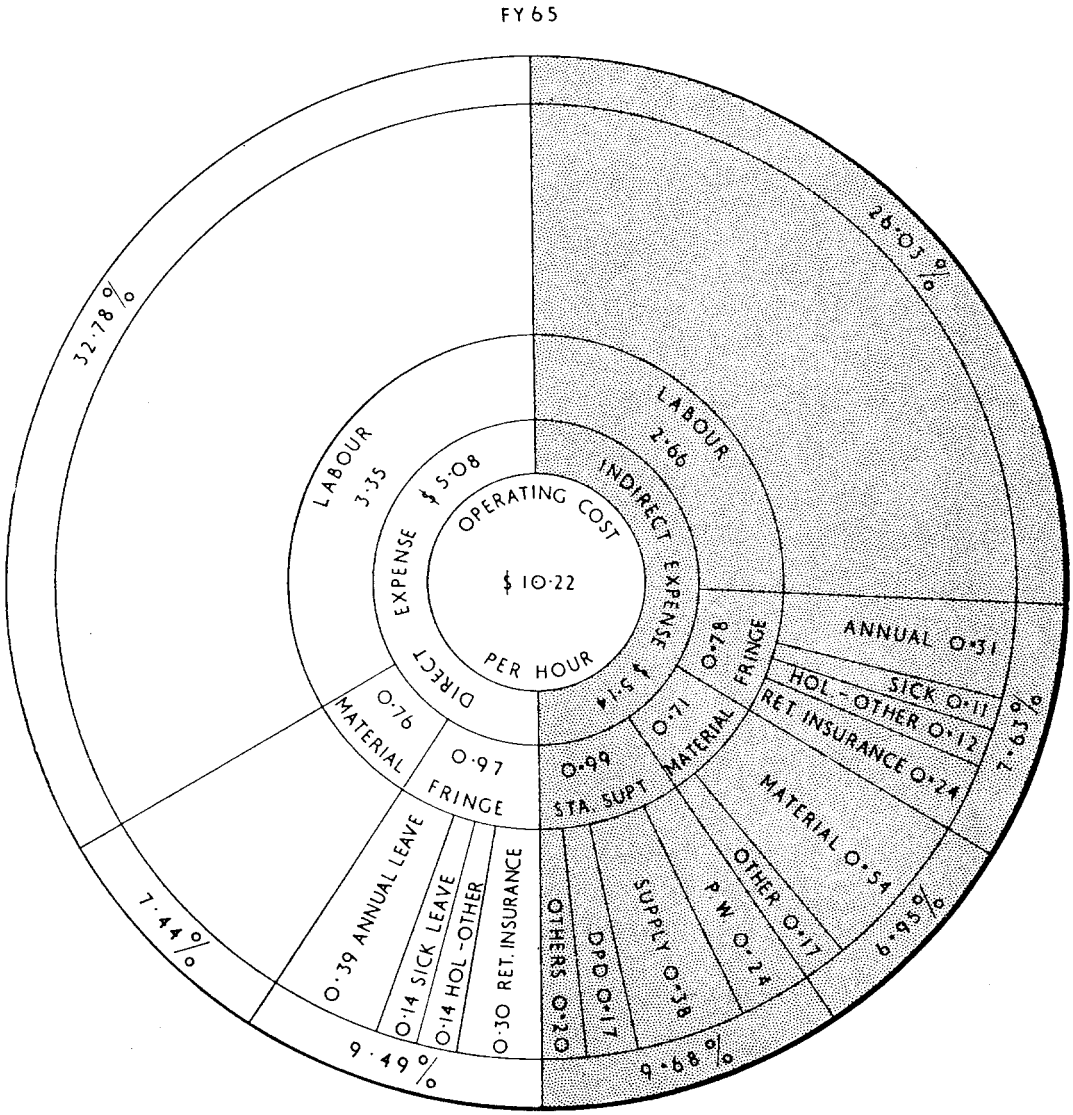


FIG. 16—OPERATING COSTS PER HOUR

industrial fund activity in much the same way as a purchase order is placed with a commercial firm. Project orders, rather than allotments are now given to O & Rs. The project order contains sufficient funds to accept bills for the completed work, regardless of the time period involved, even though completion may be due in the next fiscal year. This is the basic difference from the old funding pattern based on allotments sufficient to maintain a given level of effort for a fixed time period. NIF is designed to focus the attention of both the requiring agency and the industrial activity on the unit costs of work ordered, accepted and completed.

NIF pays for civilian labour, most of the material used, and for all indirect or oncosts of an O & R. The fund is re-imbursed by charging the direct and indirect costs for products and services billed. FIG. 16 shows that for fiscal year 1965, the break-even cost for running the Overhaul and Repair Department at North Island was $10.22 (73/-) per direct man-hour. It is interesting to note that this figure was achieved even with an average direct wage of $3.35 (24/-) per hour. TABLE IV gives a breakdown of station support costs. The procurement costs of plant equipment and machinery are separately financed by designated appropriated funds, although their upkeep belongs to NIF.

TABLE IV—*Breakdown of costs incurred for direct support given by various other Air Station Departments*

Station support costs $ 0·99 (7/1) per direct O & R man-hour, broken down as follows:

Administration—$ 0·02
Receipt and distribution of mail. Messenger and guardmail service.

Comptroller—$ 0·05
Timekeeping, accounting, payroll and disbursing.

Communications—$ 0·01
Repair and maintenance of communication equipment. Telephone and teletype service.

Public Works—$ 0·24
Maintenance of buildings, transport, utilities, civil engineering projects.

Supply—$ 0·38
General material support and operation of issue centres.

Data Processing—$ 0·17
EAM services, machine rental, supplies and personnel.

Medical—$ 0·02
Medical care, treatment and physical examinations, sanitation inspections and industrial hygiene.

Security—$ 0·05
Civil guard protection, Fire Department.

Industrial Relations—$ 0·05
Personnel matters, hiring and firing, safety engineering.

To sum up, NIF established a single revolving fund which authorizes the O & R to buy material and labour needed in the rework of aircraft, engines, and rendering of other services. The customer requests the work, the O & R draws from its NIF and does the work, and the customer pays the fund on completion. A buyer-seller relationship tends to be established between the O & R and its customers. Under this relationship, the O & R has a special responsibility for accurately forecasting its workload and planning its budget, as repayment will not be made until the job is delivered, and the revolving fund must be solvent at all times.

The NIF scheme not only provides increased management control of government industrial operations, but it provides a useful reserve in times of national emergency. If properly authorized, the fund can be run down to give immediate increased support to Fleet operations, and then re-imbursed by a special appropriation in the next budget.

Introduction of New Aircraft Types

When a new aircraft type is ordered, part of the contract is concerned with the maintainability and the logistic support arrangements. By the time it enters service the aircraft must have been proved reasonably easy to maintain, training facilities and technical information must exist, spares must be available and the Navy must be in a position to overhaul and repair the complete aircraft and its components. The means for obtaining this end are generalized in a manual called Weapons Requirement 30 (WR30), and the Contractor is obligated to provide the information and services to make this possible. (The U.S.N. is acting as our purchasing agent for the RN F-4K, and the RAF F-4M, and these aircraft are being procured under WR30, and Addendum 8A to WR30).

The governing body to ensure that the provisions of WR30 are being met is the Integrated Maintenance Management Team (IMM Team). The team consists of members from the Contractor and from all interested sections within the Navy. It is their duty to use WR30 to develop a plan, tailored to meet the specific problems of introducing a fully supported aircraft into service on time. WR30 is the IMM Team's charter and it is a very powerful management tool. This document provides for:

(*a*) The establishment of management controls between the Government and Contractor sufficient to achieve the aim.

(*b*) The establishment of an IMM team.

(*c*) The production by the Contractor of reports at regular intervals, showing the development of the plan.

(*d*) The establishment by the Contractor of a maintainability programme. This will use analytical techniques to identify factual maintenance requirements in terms of maintenance man-hours per flight hour. If the ratio is too high the maintainability design must be reconsidered.

(*e*) An evaluation plan to test and demonstrate the degree to which maintainability requirements have been met. This includes verification of the maintenance resources required.

(*f*) The preparation of Maintenance Engineering Analysis Records (MEARs) by the Contractor. This will document for each system and component routine inspection requirements, maintenance resources, level of skill and training requirements, and provide the basis for technical manuals, test equipment requirements, as well as providing a guide for provisioning of spares.

(*g*) The design, approval, and ordering of support and test equipment, including the related repair instructions.

(*h*) The selection and furnishing of spares and repair parts to be procured under the contract. This will be done by consulting the aircraft drawings and the MEARs.

The Designated Overhaul Points selected for the new aircraft will be represented on the IMM team from its formation. Their contribution is mainly concerned with, but not restricted to, paragraphs (*g*) and (*h*), thus emphasizing the basic relationship between provisioning and overhaul of components. The DOPs representatives are drawn from the Pilot Overhaul Branch in the O & R, this being the equivalent to the Forward Planning Section in our Aircraft Yards. The access of shop floor experience to an aircraft up to three years before its introduction to service, gives many advantages, such as the refusal to accept over-exotic and over-expensive test equipment sponsored by the Contractor. Quite often Pilot Overhaul representatives have returned from IMM Team Meetings to consult their Plant Engineering Division to see if alternate designs can be proposed and manufactured within the O & R. Two examples of this are the main gear box test rigs for the SH-3A/D and CH-53A helicopters designed and made at O & R North Island. These will realize a saving of nearly one million dollars.

As stated previously it is the policy of the U.S.N. to overhaul all components that are within the capacity of its O & R departments. This means that the O & R IMM team members must study each component and unit forming the complete aircraft, and decide if a repair requirement exists. The list of repairables can then be divided into:

(*a*) Those items which can be repaired using existing skills and equipment in the O & R

(*b*) Those items which because of their need for unique tooling, test equipment, and overhaul data, will need special introduction before the O & R gain repair capability.

To cover the last requirement, WR30 specifies the Component Pilot Rework Package (CPR Package). For the more complicated items selected by the O & R, the Contractor is obligated to provide a specimen of the component, all tooling and test equipment, a repair kit, and the repair instructions all by a certain date.

The CPR Package is used by the O & R for training and setting up the required repair capability. Once this has been achieved, the supply system will divert all items for repair to the O & R. In most cases, the aim is to achieve repair capability before the aircraft enters full service.

The O & R IMM team representative will also be concerned with provisioning of spares, as the potential of his organization must be considered before spares are ordered. Each aircraft drawing is examined, in conjunction with the MEAR if one exists, and the part is then given the appropriate 'Source Code'. Source codes are used to indicate to maintenance and supply personnel how the particular item is to be acquired. A 'Maintenance Code' is also given at this stage, and this indicates to maintenance and supply personnel the maintenance level at which the item will be repaired. The policy for allocation of source and maintenance codes is given in Naval Supply Systems Command Instruction 4423.14.

Source codes are broken down under the following main headings, the series themselves are further broken down, but this is not shown here:

P Series —Items to be procured and stocked by the supply system.

M Series —Items to be manufactured within the Navy and not procured or stocked by the supply system. Complicated items will be coded MD indicating manufacture by an O & R, simple items will be coded MF, MH, MO indicating its particular level of manufacture within the Fleet.

A Series —Items to be assembled from smaller items, not procured and stocked as an assembled item.

N Series —Items to be locally purchased and not stocked in the supply system.

X Series —Items not to be procured and not practical for stockage, maintenance or manufacture.

U Series —Drawings and specifications not stocked in the supply system.

Maintenance codes are broken under the following main headings:

O—Organizational—Repair at Squadron level
F—Intermediate —Repair at ship's workshop level
H—Intermediate —Repair at station workshop level
D—Depot —Repair at O & R level
C—Contract —Repair by commercial organization (may be modified to D when O & R capability is developed)
Z—Non-repairable—No repair authorized.

The difference between a P or M source code will depend on the potential of the O & R system. This will make it impossible for the R.N. to provision the Phantom on the same relative scale as the U.S.N., as the capacity and policies of our Naval Repair Organizations are not the same. Many of the items source coded M in the U.S.N. and not stocked, will have to be purchased separately for the British version.

A similar argument applies to ground equipment and repair equipment; any of these items source coded M are liable to be modified and altered as the Navy thinks fit, and as this is a purely U.S.N. matter the aircraft manufacturer sometimes loses touch with the actual equipment being used to maintain and repair his aircraft. It follows, therefore, that if another organization buys an aircraft being operated by the U.S.N., every effort should be made to obtain information about the aircraft support equipment directly from the U.S.N. As the technical authorities, the O & Rs have most of this information.

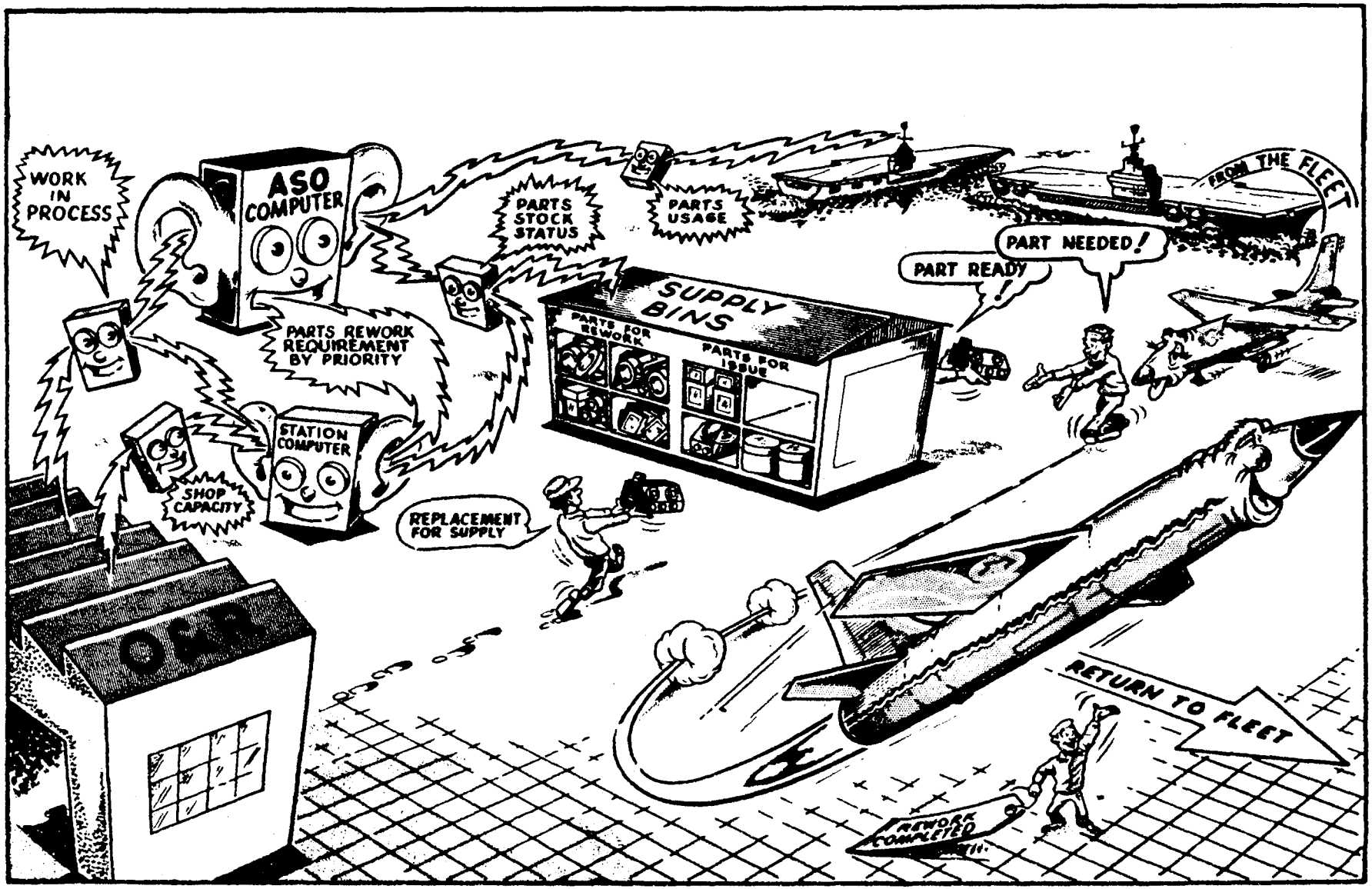


FIG. 17—COMPUTERIZED COMPONENT SCHEDULING SYSTEM

Overhaul of Aircraft Components

A modern naval aircraft costs about £750,000 and lasts about eight years. This gives a depreciation rate of approximately £280 per day. Too often a squadron 'christmas tree' will exist for three or four months awaiting spares, completely wasting about £20,000 extracted from the taxpayer for the purpose of defence.

The supply of spares is a common problem to any organization operating aircraft, particularly those which demand a high availability from their equipment. In general conversation within the Fleet Air Arm, one often hears two comments relevant to this article. The first is 'ninety-eight per cent of all stores demands are met within the required period', and the other is 'our problems are not the same as the Americans, they buy their way out of trouble'. To the first comment one must equate the modern aircraft's healthy appetite for spare parts. Taking the Buccaneer as an example, a 12-aircraft squadron generates about 15 stores demands per day. With a 98 per cent chance of success the probability is that every 3 days, one demand will not be met on time, and this could ground one aircraft and create a permanent 'christmas tree'. In short, 98 per cent is not good enough. On the second point, it would be true to say that the U.S.N. gets better spares support than the R.N., but this is not because they buy larger quantities of spare parts; the proportion of spares to aircraft is probably smaller. However, the spares utilization rate is much higher, because once an unserviceable component is removed from an aircraft, a system of management exists to repair it in time to prevent the serviceable shelf stocks from falling too low. This requires quick response from both the Supply and Repair Organizations. Obviously this is also the aim of the R.N., the difference being that whereas we have to look for our solutions inside management structures and establishments we have inherited, the U.S.N. felt the problem was important enough to create something new. It has already been mentioned in a previous section how the setting up of component repair facilities is considered right from the moment the decision is made to buy an aircraft type, and the rest of this section will describe how these repair facilities are utilized.

The control of all aeronautical spares requiring overhaul or repair, comes under the Navy Integrated Comprehensive Item Scheduling Programme, written and pronounced NICRISP (FIG. 17). This is a computerized system for loading the various component repair shops at all seven O & Rs under the direction of the Aviation Supply Office (ASO) in Philadelphia. The elements of this system were developed and put forward by some of the Production Planning Staff at North Island.

Before work of this kind can be scheduled for repair, the following conditions must be known:

(*a*) Which components are most urgently required by the Fleet?

(*b*) Which O & R has the rework capability?

(*c*) How many component carcasses are available for induction to work?

(*d*) What spare parts are required for the components?

(*e*) What is the shop man-hour capacity and what are the shop limiters?

The ASO knows what the Fleet is demanding, and knows the current stock position at the main supply points by normal machine reporting methods. The ASO is therefore in a position to direct the order of priority in which components must be worked. By examination of their master capability asset file, ASO can also find if and where repair capability has been established. On rare occasions where capability does not exist, an exception report will be generated, and the Designated Overhaul Point for the basic aircraft will start planning to gain capability.

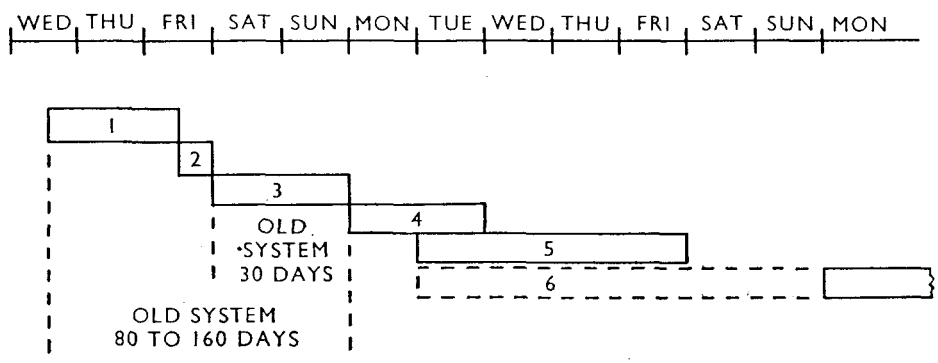


FIG. 18—TIME PHASE PLAN FOR COMPONENT SCHEDULING

Notes:
1. ASO develops naval supply system requirements in priority order and produces data in card format.
2. ASO transmits card data via transceivers to DOP where card is produced.
3. ASO card data is merged with local supplementary data such as (*i*) carcass availability, (*ii*) workload standard, (*iii*) shop instructions, etc., and printed out in priority order on a schedule requirement listing.
4. O and R scheduler determines following week's shop schedule and induction documents prepared. Essential spares for components requisitioned.
5. Carcasses, essential spares and work documents pre-positioned in shop areas.
6. Scheduled work commences.

The number of component carcasses available for induction will not always be accurately known by ASO due to items in the return pipeline. However, the recorded figure can be adjusted by the DOP, as unserviceable items are sent there directly by the user units and arrive continuously at the air station warehouse. An incidental advantage of centralized repair is that it is easy to know exactly where to send unserviceable components. For example, an F-4 (Phantom) operator in the Pacific Fleet will return all unserviceable items to North Island, and the Atlantic Fleet F-4 operator will always send them to Cherry Point. An A-5 (Vigilante) operator would return to either Alameda or Jacksonville, and so on for all other types.

The problem of ensuring sufficient spare parts for the repair of components is a difficult one. However, certain items will require 100 per cent replacement every time a component passes through a shop, and those parts which cannot be manufactured or procured locally will have a stock number and the local stock status will also be available to ASO. As experience is gained with a component, a 'usage factor' for each component spare not replaced 100 per cent is mechanically compiled, and this is introduced into ASO's records, who will now know both its local stock position and how essential it is for overhaul.

The introduction of NICRISP completely altered the system of shop loading. Under the old quarterly system of stating repair requirements, ASO determined its needs approximately six months before the start of the production quarter. To meet this need, the O & R would normally induct about three months' work at a time. With this repair cycle the result was an in-process inventory of about eight months. The time between the point of determining need and the point of actually starting work on the item was too long.

FIG. 18 shows how NICRISP has reduced this period to less than one week from the point of determination. Requirements are transmitted from ASO each Friday evening, and a schedule is ready for O & R action by Monday morning. In ASO's weekly transmission to each O & R, components are listed in their order of priority, based on the Fleet's demands and the stock situation in the current week. If the O & R by-passes an item for any reason regardless of whether it is due to lack of capability, lack of carcasses, or lack of an essential piece, the computer generates an exception report.

The NICRISP technique was first applied in five shops at North Island. It was then discovered that each shop already had about two months' work and there-

fore nothing could be inducted. A survey was made of the items causing the blockage, and it was found that some already had a two-year serviceable stock level, and enough material had been inducted to build another two years stock, even though some of the items only had a twenty-month shelf life. These shops had been meeting their standards and were very efficient. They were efficient but not effective, and as a result ten people were withdrawn from just one of the shops and sent to a more critical area. Further investigation showed that although all shops were working to capacity, some could not meet their obligations and others were building up a large stock level in the supply system. Shop manning was then reappraised on the basis of stock position and shop capacity was eventually balanced in terms of man-hours. With the full introduction of NICRISP shop capacity is now related to Fleet usage, and shop loading reflects the overall stock position after the Fleet's demands of the previous few weeks have been taken into account.

By this method of weekly scheduling, an attempt is made to keep a minimum stock level of air stores on the shelf at all times, and to concentrate labour on those items actually needed. As with all machine-controlled systems, a touch of the manual over-ride is occasionally needed, but this is well within the capacity of Production Planning Staff of an O & R.

Mechanical Production Control

The sequence and arrangement of all work carried out on aircraft or components is the responsibility of the Operations Analysis Division. This is achieved by the production of a Master Data Record (MDR) for each assembly, sub-assembly, or component part which will require a flow pattern through the shops. Source information for the preparation of MDRs is obtained from blueprints, manufacturers' data, MEARs, technical directions, experience with CPR packages and other research during the pilot overhaul period of an aircraft or its components. These requirements are related to individual shop potential and a sequence is developed which will send the item to the correct shop as each specific operation is required. The MDRs are used to transmit this engineering data to the central computer. When required, the computer can print a production control document for any individual assembly, sub-assembly or component, giving an appropriate selection of the following data:

(*a*) Amendment State of the MDR
(*b*) Reference Number and Part Numbers
(*c*) Shop routing details
(*d*) The specific operation to be carried out in each shop
(*e*) Related PAR aircraft or if for supply system
(*f*) Required production date
(*g*) Standard time allowed
(*h*) Trade skills involved (This information can be reprocessed and presented to the manpower allocation branch of Production Planning)
(*i*) Material required for repair (This information can be reprocessed and used to forecast, order, and position material for each shop)
(*j*) Specific technical information
(*k*) Job order number
(*l*) Inspection stages.

In the case of an aircraft inducted for PAR, various control documents will be printed the day before it arrives. The most important one is the operations sheet. This will give all operations required for PAR on a maximum possibility basis, listed in the order that the Operations Analysis Division has decided that

they shall be done. This will be related to a specific type, mark, and serial number grouping of aircraft. Modifications, special orders, local instructions can be filed into the machine as they are established and will be printed on all subsequent operations sheets. The Aircraft Examiners will tailor the operations sheets after inspection of the aircraft and its log books, and will also add additional work found by their inspection. The original operation sheet is used to check off work carried out and to certify inspection. At the same time as the operations sheet is printed, the machine will also provide a route card for every assembly or component which has to be removed from the aircraft for routing through the feeder shops. As the machine knows the day PAR was started, it will print the date each item will be required back on the aircraft. This route card will accompany the item at all times and will also be used for inspection certification. If the component does not arrive back in the finished parts store room on the correct day, a system is in operation which will cause the computer to print the details on a shortage list so that immediate action can be taken by production control.

Most of the shops at O & R North Island are now connected to the control computer by a transactor recording facility. When the machine prints route cards for any unit requiring rework, it will also produce a job card in punch card form. The following is some of the information it contains:

(*a*) The job order number

(*b*) Numerical description

(*c*) Standard hours

(*d*) Date required

(*e*) Programme.

When the shop supervisor allocates the item for work he will put the job card into the transactor and press the start button. On completion of the operation he will replace the job card in the transactor and press the stop button. The job order has now been charged with an exact amount of direct labour in that particular shop. Aircraft assembly operations will not, of course, require route cards, but there will still be a job card for every separate assembly operation, for example, rigging of main rotor controls or installation of engine. The machine therefore stores accurate performance data which can be processed and expressed in many parameters, and the historical data available for each particular operation can be used as a measure for current shop or section efficiency. This system gives management accurate and early cost data which is essential to the Naval Industrial Fund concept.

This has only been a brief description of a rather complex subject, but the main contribution of mechanical production control may be summed up as follows:

(*a*) Production control personnel are released from routine and repetitive work to concentrate on weak areas of production

(*b*) Management has a means of getting up to date and accurate information on current operating costs and production performance.

The Labour Force and Industrial Relations

The United States Government employs over 2,500,000 people, and about 350,000 of these work for the Navy Department. Employment in the naval service is divided into four groups:

Group II Semi-skilled workers, labourers, and helpers in the crafts and trades

Group III Skilled mechanics and craftsmen

TABLE V—*Typical hourly rates of pay for ungraded (blue collar) Federal employees in the San Diego area current in January 1966*

Workforce	*Dollars*	*Sterling*
Labourer	2·70	19/4
Helper	2·89	20/7
Semi-skilled	3·20	22/9
Journeyman	3·57	25/6
Highest skill (toolmaker, etc.)	3·84	27/5
Supervisors		
Head Mechanic	3·93	28/-
Leadingman	4·39	31/4
Quarterman	4·91	35/-
Chief Quarterman	5·44	38/9
Foreman	5·93	42/2
Shop Master	6·98	49/9

Note: There are additional step increases for length of service in each pay level. For annual rate, multiply hourly rate by 2080.

Group IVa Supervisors over Groups II and III (shopmasters, foremen, quartermen, etc.)

Group IVb Office workers, administrative personnel, scientists, draughtsmen, etc.

Groups II, III and IVa are blue collar workers and Group IVb are white collar workers.

The pay of the blue collar positions is based on wage surveys carried out near each government activity. An area Wage Survey Committee periodically visits private industrial firms, and samples wages of trades similar to those in local government employment. The Committee's findings keep wages in line with private industry in the same area. An example of wage scales in the San Diego area is given in TABLE V.

The pay of all Government white collar workers is subject to the Classification Act which requires that they be placed in grades established by that act. It also provides a pay scale called the General Schedule (GS) which is standard throughout the U.S.A. Positions are graded by number according to the difficulty of the work, starting with grade GS1 and ending with grade GS18. Each grade consists of many classes, for example, each of the following is a separate class: Clerk GS–3; Stock Control Clerk GS–3; Quality Control Specialist GS–9; Chemist GS–9; Aerospace Engineer GS–12; Mechanical Engineer GS–12. As a further example, a chemist could receive a GS rating from GS–6 to GS–17, depending on his qualifications and the responsibility of the job involved. The senior civilians at an O & R such as Group Superintendents, are usually graded about the GS–14 level. TABLE VI gives some typical salary rates for graded employees current in July 1966.

The standard Government work week is 40 hours, 5 days a week, for both blue and white collar workers. Overtime is paid at the rate of time and a half.

There is no incentive bonus scheme in operation at any of the O & Rs. Discussion of this revealed a unanimous opinion that any advantages of incentive bonus would be quickly cancelled out by time and the overheads required to run the scheme. It was considered relevant to products requiring simple repetitive operations but not to aircraft maintenance. The view was also expressed that in many cases incentive bonus schemes are introduced as a substitute for proper supervision at lower levels, and this could be taken as a reflection on management control.

As a means of improving government operation, Congress recently passed the 'Government Employees Incentive Awards Act', introducing incentive awards into the government service. The awards are given for useful suggestions,

TABLE VI—*Annual salary rates for graded employees July 1966*

Grade	$	£
GS.2 . . .	4457	1590
GS.4 . . .	5416	1920
GS.6 . . .	6659	2370
GS.8 . . .	8008	2990
GS.10 . . .	9573	3400
GS.12 . . .	12,443	4,450
GS.14 . . .	17,198	6,120
GS.16 . . .	23,000	8,200
GS.18 . . .	26,100	9,310

Only 9 of 18 grades shown. There are additional step increases for length of service in each grade.

sustained superior achievement, and other special acts of value to the Government. This scheme singles out for reward both the man who contributes genuine cost reduction ideas and the man who works exceptionally hard. For beneficial suggestions, about 4½ per cent of the calculated savings to the Government over a 12-month period are awarded to the originator. For sustained superior performance, sums from $100 to $300 are awarded.

In Financial Year 1965, 1,260 beneficial suggestions were put forward at O & R North Island and 405 of these were adopted. Calculated savings to the Navy amounted to $467,354 (£167,000) and $21,350 (£7,000) were paid out in awards. Some of the ideas received were extremely valuable and were passed on to other O & Rs.

A sustained superior performance is defined as the performance of assigned duties for a period exceeding 6 months in a manner that deserves special recognition. This award can be made to groups or individuals and it does occur often enough to be a genuine incentive. This award is not only effective because it is selective, but it is also valuable because it is designed to be recommended by first line supervision. The importance of this is supported by a quotation from the Supervisors' Guide, issued by the Naval Office of Industrial Relations:

> 'In motivation of employees, no one plays a more important part than the first line supervisor. He gives orders, directs the work, maintains discipline, and hands out rewards and punishment. To employees the supervisor is management. Thus, the attitudes and feelings that employees have about their work and about management in general, are often the same as those they have for their supervisor'.

Federal employees earn annual leave according to the number of years they have been in Federal service, including military service. They earn it at the rate of 13 days a year for the first 3 years and 20 days a year for the next 12 years. After 15 years they earn 26 days of annual leave each year.

Employees are only paid during sickness for a limited period. Paid sick leave is earned at the rate of 13 days a year and it is used for illnesses, and for appointments with a doctor, dentist or optician. Sick leave that is not used can be accumulated and forms a good form of insurance to older long-service employees in extended periods of illness. Illness is costly in the U.S.A., but major medical protection insurance is available to Federal employees, with the Government contributing part of the premium and the employee paying the balance through pay deductions. Six and a half per cent of a permanent employee's pay goes into a retirement fund. This money is withheld as the employee's share of the cost of providing him with a pension. This money is returned if employment is terminated before retirement. As an example of the Government retirement system, a man who has worked for the Government for 30 years, with an average salary during any 5 consecutive years of $8,000, can retire with a pension of $4,500 (£1,600).

In January 1962, the late President Kennedy signed Executive Order 10988, introducing a significant policy change of the Government towards Federal employees. This order allowed Trade Unions in Government establishments, and specified three types of recognition: exclusive, formal and informal.

Exclusive recognition gives an organization the right to enter collective negotiation with management. Any agreements must not conflict with Federal laws, regulations or personnel policies. Formal recognition gives an organization the right to be consulted on matters of interest to its members. Informal recognition gives an organization the right to be heard on matters of interest to its members.

Federal employees do not have the right to strike against the Government or to join an organization which claims this right.

Trade Union influence at O & R North Island was not obvious and membership was low. In some cases the organizations which received recognition were supervisors' associations with aims much the same as management. By 1966, 3 exclusive, 2 formal and 11 informal recognitions had been granted.

The prevailing industrial harmony was probably a mixture of the independent outlook of the new Californian, adequate pay, and the professional service provided by the Industrial Relations Department of the Air Station.

Conclusions

This writer has little experience of the R.N. aircraft repair organization, and is therefore not qualified to draw conclusions by direct comparison. It would be a mistake, however, to conclude that the results achieved by the U.S.N. are merely the consequence of unlimited expenditure of government funds. This is a popular fallacy, and it is hoped that this article contains enough factual information to dispel the idea. The O & R system has survived and prospered in the face of some of the keenest private enterprise in the world. The Department of Defence will neither justify nor support uneconomic enterprises in its own organization, but it does make certain that its industrial activities have access to all the management methods and techniques required to keep them competititve.

In many ways it is a stimulating experience to work in one of these civilian organizations, the personnel expect to work hard and to be paid well, but in addition they have a particular loyalty to their own organization and their interest in its future is expressed by an impressive cost consciousness at all levels. Any obvious and many not so obvious inefficiencies are reported to management from the shop floor. This interest is probably stimulated by Mr. MacNamara's ruthless policy of closing down any Government establishment proved to be inefficient. When discussing incentives, this may be the greatest incentive of all.

Looking at the O & R system from the position of an aircraft maintainer, two points stand out from all the others: the logical approach to repairing spares, and the technical independence of the repair organizations. Both are related, and the results are realized at squadron level. Ask any squadron AEO what he considers to be the greatest single obstacle in providing serviceable aircraft, and the answer will not be lack of training, manpower, organization, or directives; it will simply be lack of spares. This is an obvious point, perhaps it is so obvious that it is accepted as an unfortunate but unavoidable fact of life.

Attempts to increase aircraft availability appear to be concentrated at front line operating level, and as an example have taken the form of work study, followed by an upheaval, followed by no increase in aircraft availability. A vital supply of spares continues to come from that-one-in-the-corner-which-never-flies and which is never officially acknowledged.

In the opinion of the writer, the fundamental problem of aircraft availability should be recognized as one of spares support, and our efforts at improving our