CHAPTER 12

Telecommunications equipment and its maintenance

12.1. In this chapter we examine the Authority's telecommunications functions. The equipment provided includes radio communications, radar and navigational aids.

Radio communications

12.2. Speech communication between aircraft and the ground is essential to the safe operation of ATC. The facilities used are VHF/UHF transmitters and receivers, either in a control tower or at remote sites to give adequate cover within the United Kingdom FIRs. Because of the close spacing of frequencies in the aeronautical radio band, the main transmitter and receiver stations are located sufficiently far apart to avoid interference.

12.3. At Heathrow, for example, ATC uses 12 radio telephone channels for the control and direction of aircraft in the air and on the ground. There are also three channels which can be used either by Heathrow or by LATCC. Two more channels, which are allocated to the automatic terminal information service, are used to transmit meteorological and other essential information continuously to arriving and departing aircraft.

12.4. Service vehicles at airports are also provided with radio links. These use a UHF R/T system, with some of the ground channels linked to VHF aircraft channels so that ATCOs can hear both vehicles and aircraft as if they were on the same frequency.

12.5. All radio signals are fed through a distribution and control system, which enables ATCOs to select any radio channel or telephone line. Standby and emergency services are incorporated in the system to maintain communications under all conditions. Each channel has a main and standby transmitter and receiver, while standby handsets are available to bypass the distribution equipment and connect ATCOs direct to the transmitter and receiver stations. In addition, emergency equipment provides VHF channels in the event of a complete breakdown of other standby services.

12.6. All speech communication on the air-to-ground radio channels is recorded in accordance with the standards laid down by ICAO. Recording tapes are retained for 30 days, to be available should any incident need investigation. The tapes are examined from time to time to check that a high standard of communications procedures and equipment is maintained; reports on sample tapes give a quality control service.

Radar

12.7. Radars provided by the Authority cover large areas of the approaches to the United Kingdom, and in conjunction with MOD radars give virtually full coverage of national airspace. There are two main types of radars, primary

and secondary, as described in paragraph 3.20. The analogue data from the radars are digitised by plot extractor equipment and transmitted over landlines to ATCCs. Computers process incoming data at ATCCs and these are combined with a video map which produces a picture showing, for example, boundaries of airways, extended centrelines of runways, reporting points and other geographical data. Various video maps are available and it is possible for the ATCO to select and enlarge any part of a map.

Navigational aids

12.8. The Authority provides a range of ground-based devices to assist en route navigation, airport approach and landing. Non-directional beacons are radio transmitters modulated with a coded identity signal. Such devices normally exist as locators of airports and are used more by general aviation, ie light aircraft, than by the more extensively equipped aircraft of the international airlines. VORs[1] are the main aid to navigation, providing a radio signal that enables a pilot to take his bearing from a particular beacon; and installed with these is usually a DME[2], by interrogating which he can compute his distance from that point.

12.9. This combination of VOR/DME is the ICAO standard short-range navigation and position fixing system. ATC instructions require pilots to fly particular courses or patterns and these are normally linked to individual VOR 'radials' or positions. Outside controlled airspace the pilot can navigate independently with reference to VOR/DME, which can also provide a reliable means of defining a predetermined approach to airports.

Instrument landing system (ILS)

12.10. When a suitably equipped aircraft has been positioned by radar on the extended centreline of an airport runway, the pilot can complete his approach by using ILS. Not all airports have such a facility, but it is increasingly required by aircraft operators.

12.11. ILS is a radio system which transmits two beams, one—the localiser—operating on VHF, the other—the glide path—operating on UHF. The localiser beam defines the centreline of the runway and extends along the approach path for up to 20 miles. The glide path beam defines the angle or glide slope on which the aircraft should fly while following the localiser course to approach the runway, safely clearing all obstacles. A pilot may also use the visual display provided by the aircraft's ILS instruments to make manual corrections to his position relative to the glide path and centreline. When this system is coupled to the flight controls of an aircraft, automatic approaches, even landings, can be made in very poor visibility.

12.12. There are three internationally recognised categories of ILS performance:

Category I For operations with a minimum cloud base of 60 metres and forward visibility down to 800 metres runway visual range (RVR).

[1] VOR—Very high frequency omnidirectional range.
[2] DME—Distance measuring equipment.

Category II For operations with a minimum cloud base of 30 metres and forward visibility down to 400 metres RVR.

Category III For guidance down to and along the runway with a cloud base at ground level. This enables an aircraft to land in fog if it is equipped with a suitable flight control system.

12.13. To obtain essential reliability in this critical phase of flight, ILS ground equipment employs duplicate electronic systems, alternative power supplies and continuous monitoring of signal accuracy and integrity. The performance and integrity of these installations are checked periodically and recalibrated by the Authority's Flying Unit, which uses aircraft equipped as flying laboratories (see paragraph 12.45).

Instrumented runway visual range (IRVR)

12.14. Aircraft landing or taking off in poor conditions need accurate measurements of the visibility along the runway they intend to use. IRVR provides this information, using an instrument which measures the loss of light from a source projected over a standard distance. Three measurements are taken on each runway—at each end and in the middle. The measurement is fed into a computer together with other data, such as runway lighting intensities, and a computed RVR within each area of the runway is displayed in the airport control room. The information is transmitted to pilots by ATC when visibility falls below 1,500 metres. IRVR is always used with Category III ILS, and almost always with Category II ILS.

Aeronautical fixed telecommunications network (AFTN)

12.15. International airline operations are supported by a world-wide point-to-point communications system (AFTN) for ATC purposes. It passes messages in a format laid down by ICAO. Most developed countries have one main switching or relay centre feeding a national network of sub-centres and terminals. The United Kingdom Civil Aviation Communications Centre (CACC) at Heathrow is connected to seven other similar centres in Europe and North America.

12.16. In the CACC all message routeing is fully automatic, using dual digital computers to identify the address codes and to switch each message according to the agreed routeing plan. An average day's throughput is 60,000 messages, which may also be transmitted automatically to addressees by telex.

Changes in technology

12.17. When the Ministry of Civil Aviation was formed in 1946, it inherited from the RAF a number of airfields and navigational aids with associated Tels equipment. This equipment was analogue in nature and based on thermionic valve technology; it was relatively simple but, because of its failure rate, required continual attendance by maintenance staff on site. During the following two decades new navigational aids were introduced. These, together with the concentration of services into ATCCs, and a progressive movement from procedural control (which determines position by verbal reports from the

aircraft) to radar control, created the need for national coverage by radar, navigational and communication systems.

12.18. These new systems continued to use analogue techniques and thermionic valves until the early 1960s, when solid state technology started to become available. Initially, this technology replaced thermionic valves and used discrete components, but later the development of computer technology resulted in gradual introduction of digital techniques and data processing systems, based upon computers.

12.19. Increasing aircraft traffic necessitated better use of available airspace by means of improved track guidance to aircraft, particularly in the landing phase, and required more sophisticated communication networks. Many types of equipment have now reached the limits of development. Although the intrinsic reliability of equipment component parts has improved over the years, demands for greater performance accuracy, together with growing system complexity, have to a large extent counter-balanced this improvement.

12.20. The introduction of computer-based systems generated a requirement for software maintenance. For field maintenance staff, this activity was mainly directed at the diagnosis and resolution of system faults and the provision of routines to expedite such diagnosis.

Maintenance policy

12.21. Maintenance policy within NATS is promulgated in a manual entitled Standing Telecommunications Instructions. These instructions seek to achieve the highest possible operational availability of Tels facilities, systems and equipment consistent with safety, efficiency and economy. This policy is set against a background of international rules and regulations relating to civil aviation and Tels, in particular those issued by ICAO and the International Telecommunication Union. United Kingdom legislation such as the Air Navigation Order, the Factories Acts, the Health and Safety at Work Acts, also has to be observed. Appendix 30 sets out what the Authority believes to be the fundamental factors affecting maintenance policy and procedures.

12.22. The Authority operates a preventive maintenance scheme, which is controlled by the Chief Telecommunications Officer (Central Services and Maintenance) (CTO (CSM)). His organisation prescribes maintenance activities to be carried out by the staff of the Director of Telecommunications (Field Services) (DTels(F)). Some activities require facilities to be withdrawn from operation for a short period. It is therefore necessary for there to be adequate liaison between ATC and DTels(F) to reconcile:

(*a*) The ATCOs' need for a facility to be continuously available; and

(*b*) the engineers' need to maintain equipment at times which give economy of effort and do not incur undue shift or overtime working.

In many cases these two needs are incompatible and the least objectionable course of action has to be determined.

12.23. Generally, loss of availability of particular equipment may reduce customer service but may not affect safety in the short term. In the case of

some facilities, in particular radar, operational ranges overlap and the failure of one for a short time need not prevent a satisfactory service being provided by another.

12.24. The way in which equipment fails is of importance in the safe operation of ATC. Equipment can fail, or not fully meet operational requirements, in one of three ways. It may:

(*a*) fail totally;

(*b*) fail partially (eg interference in, say, a 5° sector of a radar display, which does not impede use of the other 355°); or

(*c*) perform incorrectly by giving wrong signals to operators or other equipment. (In the case, for example, of ILS this could have serious safety implications.)

DTels(F) therefore has to judge the implications of faults and liaise with ATC to determine the best solution.

12.25. In most of the equipment procured by the Authority for ATC the principle of duplication and redundancy of cover is followed, allowing service to be maintained even when a fault develops. This permits equipment which may have become unreliable to give satisfactory service, since in many cases engineers can repair it whilst its duplicate is still functioning. Availability of equipment is therefore not necessarily linked to its mean time between failures (MTBF), but although availability is often not lost, there is an associated cost in the manpower and other resources that are necessary to maintain integrity and reliability of operation.

12.26. We examined the range of typical MTBFs experienced in NATS equipment over the years. The reliability to be expected from equipment depends on its complexity and the performance tolerances demanded. MTBFs of equipment listed in Appendix 31 exhibit a considerable variation: from 265 hours to over 35,000 hours (ie some runs for four years without failure, whilst other items do not manage to run for two weeks). The Authority told us that some of the disparity between these figures was the result of different technologies and differences of complexity and scale. The Appendix also gives details of MTBFs which the Authority would find acceptable. Many of the lower MTBFs are experienced despite considerable design work carried out by DTels(F) and more formal post-design studies initiated by the line directorates.

12.27. The Authority told us that all its major equipment contracts prescribe quality standards and the majority require a specified MTBF. It also told us that in cases where reliability is particularly important its contracts make specific provision for the protection of the Authority if the required MTBF is not met.

12.28. We were also told that in most cases the Authority purchased proprietary equipment. Generally, its quality was of a good commercial standard and the Authority accepted this because the high cost of development would not warrant special equipment being designed and made to a higher standard. Where specific shortfalls in performance and quality are identified with propri-

etary equipment, the Authority seeks to negotiate suitable modifications with the manufacturer during procurement.

12.29. We note the Authority's view expressed above, which suggests that contractual specifications may now be adequate; but there is still no management unit, separate from the line directorates, with prime responsibility for ensuring that quality objectives are achieved in practice.

The management of maintenance

12.30. The responsibility for day-to-day operational performance of Tels equipment is vested in DTels(F), the structure of which is shown in Appendix 32. DTels(F) controls the activities of some 1,700 staff (including some 980 ATEs, the remainder being operating and support staff) through five Chief Telecommunications Officers (CTOs), who report to him and are responsible for activities deployed upon a geographical or functional basis.

12.31. The major functional responsibilities of the CTOs are as follows:

(*a*) CTO (London Airports) is responsible for Heathrow, Gatwick and Stansted airports;

(*b*) CTO (Scottish Field Services) is responsible for the ScATCC en route facilities, airports and aerodromes in Scotland (including Highlands and Islands), and NATS and non-NATS equipment inspections in Scotland;

(*c*) CTO (Airports and Airways Systems) is responsible for the Manchester sub-centre, NATS operated airports in England, Wales and Northern Ireland, inspections of non-NATS equipment, en route navigational aids, and radio and radar stations serving LATCC;

(*d*) CTO (LATCC) is responsible for the systems in the Centre itself and has operational responsibility for those stations which serve it; and

(*e*) CTO (Central Services and Maintenance (CSM)) is responsible for maintenance policy, technical publications, provision of technical management facilities, test equipment and spares. The Radio Measuring Station, the Authority's Flying Unit, Central Stores Depot and the Central Maintenance Unit also report to him.

Maintenance systems

12.32. NATS has adopted a system of planned maintenance by which similar equipment is maintained at similar time intervals for specified activities. These intervals have recently been reviewed and a substantial reduction in the amount of preventive maintenance has been achieved. The extension of periods between routine maintenance has resulted in a 10 per cent increase in availability of equipment. We were told that no adverse effect on fault rates had been detected.

12.33. A maintenance reporting system records the elements of work carried out during either planned or unplanned maintenance. Telecommunications Reporting Instructions (TRIs) also record the actual time taken to carry out specific maintenance activities, but do not include unoccupied time eg travelling.

12.34. Each year the Authority publishes a document entitled 'Performance of Facilities' analysing overall performance of various ranges of equipment. This document is confined to equipment performance and does not record manpower effort expended.

12.35. The Authority does not have any formal 'life cycle costing' procedures to help it determine the optimum life of equipment. However, the TRI system is capable of further development to produce full data on equipment performance and manpower costs.

12.36. The headquarters Tels directorates are informed of the performance of facilities in service by DTels(F), which has responsibility for maintenance and its costs. However, although DTels(F) is often initially consulted in new equipment appraisal, this consultation is not sustained throughout the whole equipment evaluation and selection procedures in NATS.

12.37. During our visits to the stations and maintenance units we saw many examples of older equipment that required much effort to be kept in satisfactory operational condition. Some equipment is over 15 years old. It is often difficult to obtain spare parts and we were told by the Authority that support service by manufacturers declined with time.

Remotely monitored equipment

12.38. The Authority recognises the importance of monitoring equipment remotely and has taken significant steps towards the introduction of such methods (see Appendix 33).

12.39. DTels(F) has a strategy based on the provision of extensive technical management facilities at key points. Systems control offices (SCOs) are being established at each ATCC and at some major airports. The central facilities in SCOs will be connected by data links to outstations and equipment sites where they will be interfaced with small computers and micro-processors, which will, in turn, be integrated with operational equipment. If a fault occurs it will be monitored by the micro-processors and a signal sent by land line to an SCO, so that maintenance staff may take remedial action, which can include the replacement of unserviceable modules or printed circuit boards. It is envisaged that unserviceable boards and modules will be returned to the CMU (see Appendix 34) for further diagnosis and possible repair.

12.40. The above strategy, if fully implemented, will demand different skills from the workforce. Engineers will be required to undertake less detailed diagnostic work, but will also need an improved understanding of total systems to assist speedy fault finding. Some of the present training schemes are being reappraised to develop these skills.

Area maintenance units

12.41. We examined the area maintenance units at Runcorn and Glasgow which are responsible for repair and overhaul of certain equipment. MIS appeared deficient because:

(*a*) utilisation of manpower resources is not measured, so that it is impossible to judge how effective it is;

(*b*) input of work to sections is not fully measured and hence output cannot be controlled against it; and

(*c*) budgeting is based upon reviews of workload without the benefit of any work measurement.

Quality assurance (QA)

12.42. QA denotes an integrated approach to all aspects of quality, to ensure that the operational performance of a product is appropriate to the user's requirements. It includes evaluation of these requirements, verification of design, and the setting of quality standards; and necessitates management procedures to ensure the proper manufacture, installation, maintenance and use of equipment.

12.43. The Authority does not have a formal QA organisation and there is no management unit, separate from line directorates, with prime responsibility for QA. The management responsibility for quality is vested in engineering directors under DG Tels. The Authority told us that directors have within their organisations specialist knowledge of actual field performance, and the quality available from industry. Current proposals for the project definition stage did not require specified quality levels and the means by which they would be achieved, because it was assumed that responsibility for setting quality levels would continue to be vested in engineering directors.

Quality inspections

12.44. We examined the role of NATS in respect of its obligation to provide a service for the inspection of Tels facilities at non-NATS airports and we were satisfied with the way that DTels(F) fulfils this task. He also has a similar role to fulfil in his own organisation. In the Scottish region NATS facilities are inspected regularly and are the responsibility of a nominated section. We found that a high standard had been set and that the work was carried out conscientiously by Scottish Field Services. Elsewhere, however, the in-house NATS inspection post had been vacant for some time and inspections were not carried out. We were told that steps had now been taken to remedy this situation.

Civil Aviation Authority Flying Unit (CAAFU)

12.45. Flight inspection of all NATS and non-NATS facilities is carried out by CAAFU which is based at Stansted airport. Two specially equipped HS 748 aircraft are used for this service, which includes commissioning, calibration, routine and post-accident flight inspections. An HS 125 aircraft, normally used for aircrew training, is occasionally used as a target for ground radar evaluation. The Authority has in hand developments to enhance the capability of the present flight inspection equipment to verify ground facilities, by means of a completely airborne flight inspection system. It is expected that the proposed enhancement will improve aircraft utilisation, particularly in very poor visibility. The activities of CAAFU and the number of aircraft it employs have been periodically reviewed over the past few years.

NATS Radio Measuring Station (RMS)

12.46. All test equipment used within NATS is accepted, repaired and calibrated at RMS at Pailton, near Rugby. Its responsibilities include monitoring field strength and frequency of navigational aids and aircraft telecommunications, the standards for radio and electrical measurements, and the management of test equipment throughout the organisation in liaison with CTO (CSM), to whom RMS reports.

Replacement of equipment

12.47. There are two methods of deploying new facilities in a re-equipment programme when:

(*a*) all facilities in a station are replaced at the same time; or

(*b*) a single facility is replaced at several stations in a given span of time.

The first method has the advantage of manpower savings, whilst the second has the advantage of economies in procurement.

12.48. The pattern of equipment replacement at airports and other stations has rarely in the past been the product of a co-ordinated plan. Usually each type of equipment has been considered separately and, after purchase, it has been allocated to stations on the basis of pragmatic judgment rather than as a result of any formal evaluation taking account of the potential for manpower and other maintenance cost savings.

12.49. The Authority told us that the needs of the operational services are NATS' first concern in planning equipment replacement. It said that the potential for reducing the maintenance commitment was also given major consideration, but these two factors had to be balanced with NATS customers' priorities and the constraints on financial and engineering effort. Whenever possible (and this was the case at LATCC and ScATCC) replacement of equipment and systems had been co-ordinated and directed to major improvements in maintainability. Moreover, in major programmes such as the LATCC development, equipment replacement had been undertaken with specific consideration given to measures for reduction in overall maintenance and running costs. The Authority told us that the decrease of Tels staff numbers at LATCC was demonstrated by the following figures, taken from the current five-year manpower forecast for the CTO:

March 1983 Budget	*Estimates—financial year ending 31 March*				
	1984	*1985*	*1986*	*1987*	*1988*
410	377	371	365	365	360

These are all CTO staff and, the Authority asserts, show that notwithstanding the introduction of more equipment to cover new ATC functions, including the additional military control positions which replaced Watton and North Luffenham, staff numbers are expected to decline over the five-year period indicated.

12.50. At airports, it has rarely been possible to implement any comprehensive equipment replacement plan. The Authority said that, within the con-

straints mentioned, the pattern had been to plan replacement programmes for specific types of equipment at airports, to obtain the cost and logistic benefits resulting from quantity production and to achieve standardisation. We were told that decisions on priority of assignment to individual airports take into account maintenance, operational considerations and customers' requirements. It is not uncommon to find some of the newest equipment, which should give high reliability and require low maintenance, located with equipment which, although ageing, is not yet scheduled for replacement and requires high levels of manpower to service.

12.51. Since manning levels are predicated on failure rates of older equipment, it is difficult in a mixed equipment environment to achieve all the savings which newer equipment might otherwise make possible. Indeed, manning of stations in the past has often been based on historical complementing formulae which may bear no proper relation to present operating needs. The piecemeal replacement of equipment does not provide an adequate opportunity for reviewing such formulae. Savings of notional fractions of men at different places and times are difficult, in practice, to translate into savings of whole numbers. Moreover, the introduction of new equipment alongside old may lead to an increase in the range of maintenance skills required. NATS told us that this was a factor which had prevented it from deriving full benefit from the introduction of new equipment, even at such a large airport as Heathrow. The achievement of manpower savings, particularly when introducing remotely monitored equipment (see paragraph 12.38), will often involve a complete change of the shift system. Such a change is difficult to bring about, given the different maintenance needs of all the equipment at a station at any one time.

12.52. Replacement of equipment at a particular site can be proposed by DTels(F) since he is responsible for its maintenance costs, with which failure rates are associated. Technical directorates at headquarters can also propose replacement of a particular type of equipment if they believe that a new type is superior. However, although they know the failure rates of present equipment, full knowledge of total maintenance costs is not available. Wherever the suggestion originates, a final decision is taken by NMC, but this decision is not based on any calculation of the optimum life of existing equipment.

12.53. Although priorities may be set for different items of capital expenditure in the budget, they are not based on consideration of detailed plans for installation of equipment at particular sites, nor is sufficient weight given to the manpower savings that could be made.

12.54. The scale of provision of equipment throughout the United Kingdom is also a relevant consideration in decisions on replacement. Our attention was drawn by the British Civil Aviation Standing Conference (BCASC) to the existence of surplus navigational aids. The Authority told us that the provision of navigational aids was to fulfil a specific OR for each location. ORs themselves derive from agreed ICAO plans. However, it was possible in some cases to locate equipment, such as VORs, in such a way as to reduce the number required. Provision of navigational aids was currently under review with BCASC. In the case of other types of equipment for which there was a national

coverage requirement, some calculations have been made of the correct number needed for the United Kingdom: this was done for VHF equipment.

Manpower levels

12.55. At a typical airport or station the range of activities carried out by engineering staff includes:

(*a*) watchkeeping, which covers supervision of equipment to anticipate failures, liaison with ATC in order to meet planned short-term changes in operational needs and, when requested, the reallocation of equipment between services and the re-routeing of signals;

(*b*) planned maintenance, which follows guidelines laid down by CSM and can be carried out at times other than those prescribed if there is more urgent work to be done;

(*c*) breakdown repair, which may or may not be urgent depending upon the particular equipment and whether the loss of availability is of particular concern to ATC;

(*d*) off-line repair of unserviceable equipment or modules;

(*e*) assistance with commissioning new equipment on site; and

(*f*) training of staff on new equipment or to widen their range of skills.

12.56. There is a large variation in the size of the various units and in their responsibilities, equipment and type of work carried out. Most maintenance requiring attendance on site is carried out by watchkeeping teams, with assistance by specialists when required. Mobile equipment and smaller items such as communications receivers and transmitters, viewing units and computer peripherals are replaced and returned to the central workshops for maintenance. Similarly, modules from larger equipment which cannot be repaired on site are returned to the central workshops for attention.

12.57. At smaller stations, the watchkeeping staff are employed in site workshops when they are not engaged on servicing operational equipment. At larger stations (LATCC, ScATCC and Heathrow), watchkeeping staff are supplemented by staff working on day duties. At these stations, some day staff are also employed in offices and equipment rooms to assist in planning developments and making in-service improvements, including amendments to software.

Manpower utilisation

12.58. The wide range of equipment owned by NATS requires a high level of manpower and technical expertise to maintain it in satisfactory operating condition. We therefore studied how NATS deployed its manpower resources in order to achieve the objectives of its maintenance policy (see paragraph 12.21 *et seq*). As many faults occur at random, manpower numbers have to be set to meet a level of faults much above the average. The higher the provision made for peak demands, the smaller will be the proportion of time that staff are occupied.

12.59. MTBF is one indicator of the maintenance complement required for the operational needs of ATC. However, it is necessary when deploying staff,

to judge the level of quality of service desired, safety implications, manpower costs and appropriate equipment, so that a least cost way of achieving specified objectives can be determined.

12.60. The rules for determining manning at individual stations have been discussed in Chapter 10. Apart from one example of the use of queueing theory, we did not find that NATS calculated what its notional utilisation of maintenance manpower should be, nor did it have any formal quantitative method of measuring what manpower utilisation was in practice.

12.61. The control of maintenance manpower at a particular station is the responsibility of the Station Telecommunications Officer or officer in charge. He deploys his staff in accordance with the perceived workload, but the ineffective time of his staff is, again, not recorded (see paragraph 12.33). It is therefore not possible to say how well maintenance manpower is utilised, nor how it relates to the level of demand.

12.62. We have examined the factors which constrain management in the efficient deployment of manpower in the maintenance activity. The broader manpower issues have been discussed in Chapter 10, but those which concern DTels(F) are discussed below.

12.63. NATS recognises the high cost inherent in 24 hours shift working and is moving towards reducing dependence upon such continuous watchkeeping.

12.64. Shift working premia are considered by staff to be an integral part of salary. For many staff, the elimination of shift working would result in a reduction in salary of some £2,000 a year, or more, which they are reluctant to relinquish. NATS told us that the more proficient ATEs cannot be utilised to best effect on night shifts and that day working provides better use of their talents. They also told us that staff on night duty may refuse promotion to a higher grade if daytime working were involved. This situation is found especially in relation to the higher grades, where an officer may earn less than staff under his control.

12.65. Discussions between management and trade unions over reduction in shifts and revision of manning levels tend to be protracted, even over the elimination of a single post.

12.66. We have been told that the high incidence of shift working in NATS and the way in which shifts are arranged permit staff to live at some considerable distance from their workplace. An engineer living 30 miles or more away from his work is, in practice, not readily available for on-call working.

Logistic support—Stores Unit

12.67. The Stores Unit at Aston Down, near Stroud, maintains some 60,000 items on a KARDEX system. The depot is maintained by contract with MOD (Procurement Executive).

12.68. NATS recognised that the management of inventory control and stores in the past had been unsatisfactory, and had completed a feasibility study for the design of new stores systems and the means of computerised inventory control. The stores problem was highlighted in 1971 and since that time various internal and external consultants have recommended that a computer-based system should be introduced. We were also told of the difficulties experienced in obtaining approval for MIS improvements, and of the extended timescales set.

Telecommunications Engineering Establishment (TEE)

12.69. TEE provides NATS with its principal capability for the engineering of communications, radar, navigational aids and other electronic systems used to support ATC. These engineering services include the installation, commissioning, design and development, maintenance and repair of these and other associated electronic systems. TEE also provides workshop facilities for limited production of purpose-built electronic equipment and components, and of specialist furniture used at ATC centres and airports to house electronic equipment.

12.70. TEE engineering activities take place at any NATS facility in the United Kingdom. In addition, TEE carries out a small amount of similar work for organisations outside the Authority on a profit-making basis. It employs over 280 staff on site, but staff are detached to work at any Authority site for installation or repair work as required.

12.71. Each year, TEE produces a 'TEE Performance Statistics' report which is circulated to senior management in NATS. The basis of measurement in most of these statistics is the number of jobs received, outstanding or completed although some cost and utilisation information is included.

12.72. Because it depends largely on projects generated by other departments, the workload at TEE is highly variable. Although steps have been taken during the course of our inquiry to estimate the workload in man-weeks on each section, much still remains to be done to anticipate peaks in demand. Present capacity, particularly in the electronics assembly and mechanical workshops, exceeds demand. This situation is difficult for local management to rectify because past budgeting of the next year's manpower requirements had been based on the experience of the previous year, together with an assessment of future workload, rather than on any formal calculation.

12.73. TEE does not use work study and does not set any standard or target time for the tasks of individuals. It is not possible therefore for managers to compare actual performance of individual tasks with standards, either overall or in detail. However, the total hours required for, and the cost of, each TER is estimated and actual performance is measured against this estimate. Thus the labour utilisation figures produced monthly are based on the ratio of actual hours to available hours and are not a measure of effective use of labour capacity. Machine tool utilisation figures are produced, however, and the Authority told us they were used for planning purposes.

12.74. Recognising the problems of underutilisation and cost at TEE, NATS has carried out three reviews using consultants. The consultants said, among other things, that certain machine tools and large floor areas were gravely underutilised and that there was duplication of facilities at ATCEU with TEE, where manufacture of printed circuit boards and prototype furniture is also carried out.

12.75. The consultants also recommended that if sufficient work could not be found from outside sources to fill the under-used capacity with the manufacture of technical furniture, such furniture should be bought in. More generally, NATS was advised that alternative courses of action in respect of TEE were either to keep it open and use its capacity to the full, giving it authority to fill unused capacity, or to close uneconomic sections and relocate useful functions in smaller premises. The Authority told us that some of TEE's functions were difficult to have performed by contractors. This applied particularly to the installation of new equipment in the midst of other equipment which must work continuously; and to the overhaul of certain types of mechanical and electrical machinery.

12.76. We asked the Authority why it believed that equipment had to be installed by its own workforce and why it did not instead purchase equipment which was specified to be site-effective as part of the contract, as was done by other providers of ATC, and so reduce its own overheads. The Authority said that it had done so for certain types of equipment, including the latest radars. However, in certain cases, such as Category III ILS, it was not possible for a contractor to obtain the necessary operating experience of the equipment which was a pre-requisite for successful installation. Such equipment was purchased in accordance with an international specification which could not take account of the operational factors at a particular site. Moreover, the installation of certain equipment could only be checked properly by means of test flights and operational trials over a protracted period.

Findings and remedies

12.77. We found in our enquiries that QA procedures within NATS are inadequate. The Authority produced typical ranges of MTBF outturns for some of its equipment. In many cases these did not meet NATS expectations of reliability. We also examined the NATS procedures for equipment procurement from project inception through to its performance in the field. The role of QA appears not to be given sufficient consideration, nor are sufficient resources provided for this purpose.

12.78. The Authority should therefore set up a QA function which is independent of other management functions, and which is of such a status in the management organisation that it has the influence to amend and improve existing practices. Quality should be introduced as a special consideration in the proposed project definition stage for new projects. Special studies by contractors may be required to obtain a proper specification of quality before going to the tender stage. The Authority should specify a MTBF for every major item of equipment and should, whenever practicable, consider appropriate action when contractors do not meet that requirement.

12.79. The introduction of more modern equipment may require engineers to undertake less detailed diagnostic work. There is a danger that this will lead to a progressive loss of skills which will still be needed for other purposes. The reduced challenge of the work may lead to dissatisfaction. This problem should be kept under review.

12.80. NATS should take steps to measure work being loaded on individual sections of area maintenance units so that output can be measured against either a standard or a target. The utilisation of the workforce in terms of effective time should also be measured and reported upon regularly.

12.81. It is important that quality inspections are carried out after equipment has been installed and at regular intervals thereafter. These would be more effective in future if inspection of NATS and non-NATS telecommunications equipment became part of the proposed QA function. This function might also take over responsibility for the RMS and other appropriate inspection and technical regulating functions.

12.82. The Authority should review its policies and methods for equipment replacement and should introduce life cycle costing.

12.83. The involvement of DTels(F) in decisions on replacing all equipment is essential if there is to be a greater awareness by staff in Tels line directorates of potential savings in maintenance costs at individual stations. Since maintenance costs increase with time, they should be given much greater attention in considering the allocation of new equipment than they receive at present. To help achieve this, equipment to be replaced should be detailed in a draft operational plan giving timescales, locations and changes in manning levels. Following guidance from the Board, components of this plan should be contributed by chief officers at stations as well as by headquarters Tels directorates. Eventually the draft plan should be submitted for approval and issued in its final form as part of the Authority's corporate plan.

12.84. NATS should measure all ineffective time spent by maintenance engineers. Performance comparisons could then be drawn and the dissemination of best practice extended.

12.85. The introduction of new equipment which is monitored remotely should be accelerated. This would help to eliminate shift working by Tels staff. This should be spelled out in the operational plan which we have mentioned above.

12.86. Proper production control procedures should be established at TEE and estimates of future workload in man-hours prepared and loaded on sections by months ahead. Standard or target times should be assessed and utilisation of the workforce measured against them.

12.87. The Authority should reduce as far as practicable underutilisation of manpower and resources, particularly at TEE. A radical examination of facilities at TEE and ATCEU should be carried out:

(*a*) to eliminate duplication of work between them;

(*b*) to identify those activities which must be retained, either because they cannot be carried out elsewhere, or because they must remain under the control of the Authority; and

(*c*) in respect of any remaining work, to determine what volume retained at TEE would provide the best value for money option.

Conclusions drawn from this examination at TEE and ATCEU may result in closure of certain facilities, the putting out of work to sub-contractors, or the bringing in of work to support retention of essential men and machinery.

12.88. In carrying out this review, specific consideration should be given to whether more work, now carried out at TEE and at ATCEU, to make equipment site effective could not more frequently and economically be carried out by suppliers, and be incorporated in purchase contracts as a supplier responsibility.