AIR TRAFFIC SERVICES PLANNING MANUAL

PART III

FACILITIES REQUIRED BY ATS

AIR TRAFFIC SERVICES PLANNING MANUAL

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SECTION 1. GROUND BASED NAVIGATION, SURVEILLANCE AND COMMUNICATIONS EQUIPMENT

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GROUND BASED NAVIGATION, SURVEILLANCE AND COMMUNICATIONS EQUIPMENT

Contents

Chapter 1
General

1.1 INTRODUCTION

1.1.1 To function properly, an air traffic control (ATC) system requires various items of equipment. Types and quantities of this equipment will vary with the properly justified demands on the particular system.

1.1.2 Equipment elements should generally be installed in stages and in proportion to the increase in demand(s) imposed on the air traffic services (ATS). Such phasing has the advantage of reducing the immediate economic burden imposed on administrations by spreading system establishment or expansion costs over a longer time. It also reduces the critical effect of time on personnel recruitment, selection and training necessary for equipment installation, maintenance and operation.

1.1.3 In addition to the pure equipment costs, there are many "hidden" costs associated with the acquisition of major items of ATC equipment. Hidden costs include personnel salary and allowance costs associated with the preparatory work and the procurement, installation, operation and maintenance of the equipment. It is therefore essential that relevant hidden costs be included in the preparation of initial budgetary estimates.

1.1.3.1 Activities, materials and other elements which are associated with hidden costs may include:

a) site survey — selection of the best site for optimum operational benefit from the equipment, commensurate with ecological considerations and consistent with budgetary limitations;
b) site acquisition — rights to the property including protection against future neighbouring encroachments (e.g. growing trees, other structures or electronic interference) which could adversely affect the performance of the equipment; rights to ensure appropriate site access throughout the predicted life of the equipment;
c) site preparation — foundations, clearing, etc., and shelter for the equipment and the maintenance personnel against the meteorological conditions common to the location; similar protection against catastrophes which could be expected to occur at that location (e.g. earthquake, landslide, flood, washout, etc.); provision of utilities including the required degree of reliability; site access improvement as needed (e.g. power lines and access roads);
d) preparation of equipment specifications — an equipment specification is prepared either as a functional specification or as a technical specification:
   1) a functional specification describes the purpose the equipment is expected to serve and the terms of desired performance, i.e. operational needs, maintainability, reliability, durability and useful life, etc. It gives the potential supplier information on how, or what equipment, he will need to produce in order to satisfy the specified functional performance requirements;
   2) a technical specification describes the detailed engineering (physical, mechanical, electronic) aspects of the components making up the equipment in question;
e) contract negotiation;
f) equipment inspection(s) before technical acceptance;
g) installation;
h) systems evaluation (operational acceptance) including flight inspection costs for aircraft and crew;
i) ancillary monitor equipment;
j) standby equipment and/or fail-safe or fail-soft provisions;
k) spare parts inventory or suitable alternative(s) such as rapid, reliable replacement from a centralized source;
l) special tools required for maintenance of that equipment;
m) training for operations and maintenance personnel;
n) manuals of the operation and maintenance of the equipment.

1.2 COST-BENEFIT CONSIDERATIONS

1.2.1 When considering the acquisition of expensive equipment, the use of cost-benefit methodology may be desirable to help in determining budget justification for new equipment. The cost-benefit method described in the following paragraphs lists some of the elements which should be considered in this respect. The method has been used successfully but the elements listed here are neither all-inclusive nor does each of them merit inclusion in the equation in every case. Pre-operation costs have, to a large measure, been listed in 1.1.3.1 above. When added to the pre-operation cost outlay, the equipment price as agreed in the contract with the supplier, plus the anticipated continuing operations and maintenance costs (personnel remuneration, utilities, etc.) give the total "cost" portion of the equation. If these estimated costs are within the budgetary limitations, then the "benefit" portion of the equation should be developed.

1.2.2 Benefits derived from additional ATC equipment may be categorized by any one of the following: increased productivity, efficiency, safety and/or environmental improvements. As is done for the costs, the benefits are normally determined for the life cycle of the equipment.

1.2.2.1 Productivity can be measured in terms of how many more operations are expected to be handled with the improvement than without it. From this, one derives how many controllers expected to be leaving the service do not need to be replaced, or how many additional controllers need not be hired to satisfy increased demands on ATS. Cost-saving or cost-avoidance is then quantified by multiplying the cost per controller times the number of controllers not replaced or not hired (due to the new equipment). Calculated for the equipment life, this is the benefit for this element.

1.2.2.2 Productivity in the control environment may also be obtained by the elimination or reduction of non-control tasks which nonetheless contribute to the system, e.g. automatic instead of manual preparation of flight progress strips. The remuneration costs for the personnel whose functions will then be eliminated or substantially reduced are then added to the benefit column of the equation.

1.2.2.3 Productivity related to replacement of maintenance personnel and/or to additional equipment is measured by its predicted maintenance time (number of scheduled and non-scheduled outages over a fixed period of time, multiplied by the average time per outage). The time so obtained is then compared with actual maintenance time as experienced with the equipment which is intended to be replaced or supplemented. Where this comparison is in favour of the new or additional equipment the differential is multiplied by the maintenance personnel remuneration cost, which results in the benefit quantification for this element.

1.2.2.4 Where an efficiency improvement is expected by the use of more direct routings, the time saved per aircraft, multiplied by the aircraft cost per unit of time, multiplied by the anticipated number of such flights over the lifetime of the equipment under consideration provides the "efficiency" benefit.

1.2.2.5 Where the additional equipment permits a reduction of ATC delays because of the following, the reductions are considered as time savings and computed as in 1.2.2.4 as an efficiency benefit:

a) the use of lower landing minima (thus avoiding holding or a diversion to an alternate aerodrome); or
b) the use of lower departure minima; or
c) the use of reduced separation and a resulting higher rate of arrivals and/or departures; or
d) the implementation of an improved ATS route structure (e.g. parallel routes).

1.2.2.6 Where the reductions in operating time obtained in accordance with the provisions in 1.2.2.4 and 1.2.2.5 above relate to commercial operators, the average number of business travellers per affected flight and the economic value of such travellers' time should be available from the operators concerned. These factors are then treated as described in 1.2.2.4. The result is added to the "benefit" column.

1.2.2.7 It is difficult to quantify "safety", since it is virtually impossible to agree on the material value of a human life. However, an approximation for the safety benefit may be obtained by assessing the probable reduction in aircraft accidents attributable to the new equipment. This is then multiplied by the probable number of fatalities (based on historical data) and this, in turn, is multiplied by a reasonable (national) assessed value for a life (insurance companies may be a logical source for such a value). This total is then extrapolated for the life cycle of the equipment in question and the end product represents the "safety" benefit value.

1.2.2.8 Environmental improvement cannot be easily quantified in economic terms; however, a reasonable broad-based assessment is possible. A review of the properties on the ground which are overflown with existing arrangements and its comparison with those overflown as a result of new routings, made possible through the new equipment, would provide a basis for such an assessment. Demographic comparisons of the two areas could then be made with special reference to numbers of people, hospitals, schools and private residences and values could be assigned to personal health, quiet enjoyment and duration of exposure. When these values are integrated with the data from the demographic comparisons, any favorable differences should then be added to the benefit column. Similarly, loss or gain values could be assigned to the two areas of real estate involved and a net favourable difference should also be added to the "benefit" side.

1.2.2.9 Replacement equipment may also be more reliable. Any benefits derived from this fact may take several forms. More reliable communications and/or radar will induce the controller to adhere more closely to minimum and thus more efficient separation standards, while, with less dependable equipment, the controller will tend to apply larger separations for reasons of safety. This benefit is, however, too indefinite to be quantified but should be referred to in narrative terms on the "benefit" side. In addition, increased reliability should reduce maintenance efforts (see 1.2.2.3 above) and may permit more dependable commercial air carrier operation which, in turn, may encourage an increasing number of passengers to elect to travel by air. This intangible fact should also be included in the narrative accompanying the benefit material.

1.2.2.10 Further to the considerations in 1.2.2.4 and 1.2.2.5, reliability may enhance air defence capability. If this is the case, it should also be mentioned in the benefit material, even though economic values cannot be assigned to such benefit.

1.2.3 Whenever the total benefit, as expressed in material terms alone or together with those benefits described in narrative form, is found to be higher than the costs, it should be considered as substantial support for a decision to proceed with the necessary steps for procurement of the equipment item in question.

1.3 TYPES OF EQUIPMENT ASSOCIATED WITH ATC SERVICES

1.3.1 Major types of equipment associated with ATC services include:

a) very high frequency omni-directional range (VOR);
b) non-directional radio beacon (NDB);
c) long-range radio navigation aids;
d) communication equipment;
e) primary and secondary radar;
f) radar presentation equipment;
g) automated systems;
h) instrument landing system (ILS);
i) very high frequency direction-finding (VDF).

1.3.1.1 The respective functional and operational requirements for the equipment listed above are discussed in the following chapters, with the exception of primary and secondary radar, radar display equipment and automated systems (e) to g) above). It was believed advantageous to deal with the functional and operational requirements of this equipment together with the use made of it because of the close interrelation which exists between these two aspects of such equipment (Part II, Section 3, Chapters 2 and 3 refer).

Chapter 2
VOR/DME and TACAN

2.1 FUNCTIONAL REQUIREMENTS

2.1.1 The VHF omnidirectional radio range (VOR) is an omnidirectional (360° of azimuth) range station which operates in the very high frequency (VHF) band of the radio spectrum between 108 to 118 MHz, sharing the band from 108 to 112 MHz with the localizer component of instrument landing systems (ILS). Since it is normally used within approximately 130 NM of the station, the VOR is considered a short-range navigation aid. VORs are used at times beyond 130 NM; however, the accuracy of navigation guidance derived from it decreases with increased range. The basic navigation guidance derived from a VOR is a radial line of position (magnetic) with respect to a known geographic point (the VOR site). The radial line is read in degrees of azimuth from magnetic North and is technically accurate to within ± 2.0°. The over-all system accuracy is ± 5.0° (see Part I, Section 2, Chapter 5, Appendix B). Bearing information may be used by aircraft to fly toward or away from the station at any azimuth selected by the pilot. The 180° ambiguity in this indication is resolved by the provision of a "to/from" (the VOR) indicator in the aircraft avionics.

2.1.2 The identification of specific VORs is provided by means of a Morse Code identifier or by voice recording. The VOR may also be provided with a voice channel for ground-to-air communications. VORs can be remotely operated by the use of telephone lines from the control facility. Where standby or dual equipment is provided, an automatic transfer between the equipment is made whenever the operating VOR is subject to malfunction. In case of malfunction of a VOR and/or in case the VOR signal received by the aircraft is not adequate to give reliable navigation guidance, a visual alert is triggered in the cockpit display, e.g. a warning flag appears on the airborne receiver indicator.

2.1.3 The VOR is subject to line-of-sight limitations; that is to say that its signals can only be received at increasingly higher altitudes as the distance of the aircraft from the station increases. The usable range of a VOR is also proportional to its power, i.e. the greater the power output, the greater the effective range. In addition, VORs are subject to co-channel or adjacent channel frequency interference problems with other VORs or ILS localizers if care is not taken in the frequency assignment planning made for these aids.

2.1.4 When overflying the VOR, aircraft will enter a "cone" of signal "softness" but its horizontal dimension at any level is relatively small and has, therefore, normally no noticeable effect on navigation. The ratio of altitude to horizontal "soft" signal distance is probably less than 1.7 to 2; for example, at 1 700 ft above the station, irresolution will exist, at most, for 2 000 ft longitudinally.

2.1.5 A Doppler VOR (DVOR) is an improved, but more expensive version of the VOR. It has the advantage of being able to overcome many electronic interference problems of a particular site. DVORs are, as a rule, also more precise than the basic VOR. The precision VOR (PVOR), a modified DVOR, is significantly more precise than a VOR or DVOR, but it is still more expensive. Its use of DVOR is clearly advantageous in all those cases where very accurate track guidance is required by aircraft. A terminal VOR (TVOR) is a low power (50 W) VOR used for terminal navigation guidance.

2.1.6 Distance measuring equipment (DME) is a useful adjunct to, and is normally collocated with a VOR. In such cases, the VOR is referred to as "VOR/DME". DME is also subject to line-of-sight limitations, but is normally usable up to 200 NM at appropriate levels. A DME provides a continuous digital readout of the slant-range distance, in nautical miles, between the aircraft and the DME site. It is a rather precise aid, the slant distance accuracy being ½ NM or 3 per cent of the distance, whichever is greater. Slant range differs from horizontal distance when projected onto a plane, the former being always larger, and the difference will be greatest when aircraft are at their highest level directly over the station. When using a VOR/DME, the tuning of the airborne receiver to the VOR will automatically couple the DME receiver to the associated DME ground station. DME operates in the ultra-high frequency (UHF) band between

962 MHz and 1 213 MHz. This band is relatively free of interference from atmospherics and precipitation static.

2.1.7 Tactical air navigation (TACAN) is a military development providing both the azimuth and distance components by equipment operating in the UHF band. Where a TACAN is collocated with a VOR, the distance measuring component of the TACAN substitutes for and fulfils any civil requirement for DME. The VOR is then referred to as "VORTAC". As with DME, tuning to the VOR will automatically interlock with the associated TACAN distance measuring element. When used by civil aircraft, the guidance derived from a VOR/DME and a VORTAC is identical.

2.2 OPERATIONAL APPLICATION

2.2.1 The VOR/DME is the basic short-range aid used to provide navigation guidance along airways, air traffic services (ATS) routes and specified tracks. Its accuracy allows ATS routes to be kept at reasonable widths and permits the application of comparatively small lateral separation criteria between routes, resulting in a more efficient use of the airspace.

2.2.1.1 The VOR/DME route structure is normally established so as to make it possible for aircraft to fly from one VOR direct to the next, or along intersecting radials of two adjacent VORs. Reporting points and/or other significant points are normally established along radials, either together with a given DME distance from an associated VOR, or by an intersection of radials from two different VORs and change-over from one VOR to another is normally made at the mid-point between the two VORs concerned.

2.2.1.2 The TVOR can serve as a landing aid at locations where no precision approach facility (ILS, precision approach radar (PAR)) is available. Where required by the local situation, it may also be provided with a collocated DME in order to provide improved guidance along the approach path.

2.2.1.3 Where standard instrument departure (SID) and standard arrival (STAR) routes have been established to facilitate the flow of departing and/or arriving air traffic these are frequently based on VOR/DMEs and TVORs (see Part I, Section 2, Chapter 4, 4.4).

Chapter 3
Non-directional Radio Beacon

3.1 FUNCTIONAL REQUIREMENTS

3.1.1 Non-directional radio beacons (NDB) transmit non-directional signals in the low and medium frequency (L/MF) bands, normally between 190 to 1 750 kHz. With appropriate airborne equipment, the pilot can determine the bearing of the station, or can "home" on the station. The specific identification of an NDB is normally broadcast in Morse Code.

3.1.2 Although NDBs are comparatively inexpensive navigation aids and relatively simple to install and maintain, they have significant drawbacks. Bearing information derived from NDBs is not very precise and lightning, precipitation static, etc., cause intermittent or unreliable signals resulting in erroneous bearing information and/or large oscillations of the radio compass needle. At night, since L/MF radio wave propagation increases, the radiation patterns of NDBs are subject to considerable but unpredictable variations which might result in interference from distant L/MF stations which can render navigation with this aid difficult. Nearly all disturbances which affect the bearing radiation output also affect the facility identification. Usually noisy identification occurs when the automatic direction-finder (ADF) needle of the radio compass in the aircraft behaves erractically; voice, music, or erroneous identifications will usually be heard and a false bearing will be displayed on the radio compass. Since ADF receivers do not have a "flag alarm" to warn the pilot when erroneous bearing information is being displayed, the pilot must continuously monitor the NDB's identification.

3.2 OPERATIONAL APPLICATION

3.2.1 NDBs continue to be used as air navigation aids despite the availability of improved aids, e.g. VHF omni-directional radio range (VOR), and the deficiencies described in 3.1.2. This appears to be mainly due to the fact that, in many cases, NDBs were installed before the VORs became available and because NDBs are, even now, so much less costly to install and maintain. Where operating, NDBs are mainly used:

a) as a non-precision instrument approach aid (by itself); or
b) in conjunction with an instrument landing system (ILS) (then designated as a "locator"); or
c) to define L/MF routes/airways, etc.

3.2.2 When NDBs are used to define L/MF routes/airways, etc., they are normally operated as short-range aid. However, the power output is raised significantly when the NDB is serving as a landfall point used to define an "off-shore" or similar route.

3.2.3 The effective range of an NDB is proportional to its power output. NDBs with a power output of less than 25 W are classified as "compass locators" and their effective range does not exceed 15 NM during day time.

Chapter 4
Long-range Radio Navigation Aids

4.1 FUNCTIONAL REQUIREMENTS

4.1.1 General

For universal application, a navigation system should provide accuracy, low cost, high availability and broad coverage. Since no single type of navigation aid meets all of these requirements, diversification has become a necessity. The very low frequency (VLF) navigation aids, (e.g. OMEGA, LORAN-C), with their more extensive coverage are better suited than very high frequency (VHF)/ultra high frequency (UHF) aids (e.g. VHF omnidirectional radio range (VOR)/distance measuring equipment (DME)) to meet current long-range navigation requirements. Although VHF/UHF facilities contribute greater navigational accuracy (at a cost of significantly less signal range) recent developments with OMEGA have shown that the accuracy requirements are now being met to a satisfactory degree.

4.1.2 OMEGA

4.1.2.1 OMEGA is a VLF (10 to 14 kHz) circular or hyperbolic navigation system whose propagation characteristics are such that eight strategically located transmitting stations will provide world-wide coverage. The eight stations now in operation are located in Norway, Liberia, Hawaii (United States), North Dakota (United States), Argentina, Japan, La Réunion (France) and Australia (see Figure 1).

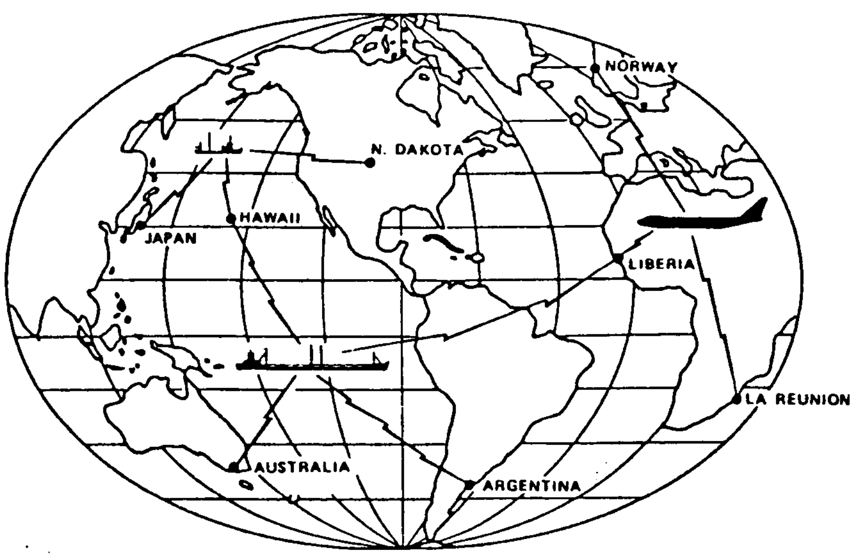

Figure 1.— OMEGA transmitter locations

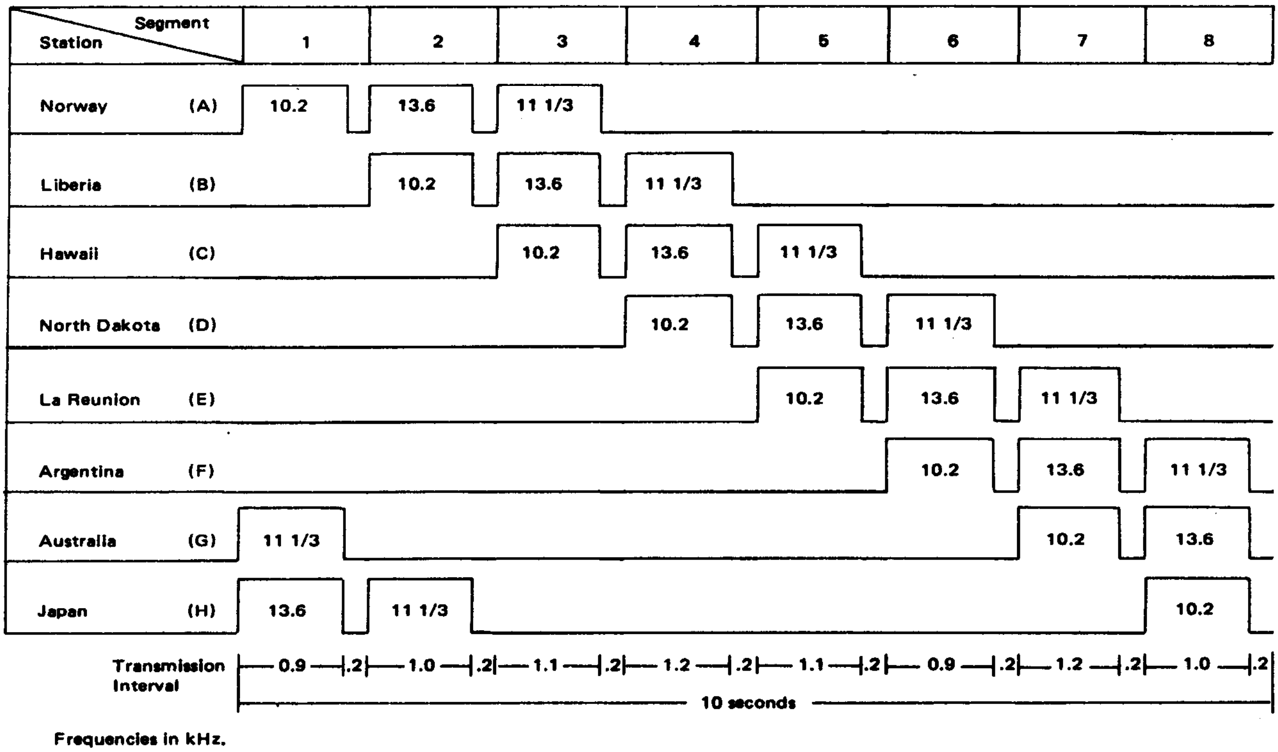

Figure 2.— OMEGA transmission pattern

4.1.2.2 The existing OMEGA navigation system provides coverage over more than 90 per cent of the earth's surface, including virtually the entire Northern Hemisphere. OMEGA stations transmit omnidirectional, continuous wave (CW), coded and precisely timed signals. Each station transmits on four specified, basic, navigation frequencies in sequenced format. This time-sequenced format prevents inter-station signal interference. The pattern is arranged so that during each transmission interval only three stations are radiating; each at one of four different basic frequencies (see Figure 2). With eight stations and a silent interval of 0.2 s between each transmission, the entire cycle is repeated once every 10 s. An OMEGA station is operating in full format when the station is transmitting on the basic frequencies plus the unique frequency.

4.1.2.3 Each OMEGA transmitter has a range of about 5 000 NM. The range will vary since it is dependent upon noise (from lightning discharge), the frequency and intensity of which change with latitude, season and time of day. Propagation over the ocean suffers the least attenuation while propagation over areas covered with ice is most affected. It is for this reason that the best coverage is obtained over oceanic areas. In addition, at night the range of individual stations is generally increased, thus improving the use of the system.

4.1.2.4 The airborne receiving equipment computes a line of position (LOP) based on the phase difference between signals received from two transmitter stations. Using a minimum of three stations, the receiver computes at least two LOPs and the intersection of these two defines the aircraft position. The current position accuracy obtained with OMEGA is 2 to 4 NM. It is expected that this accuracy can be further improved when the system is completed. Position accuracy derived from OMEGA may be better at the end of a flight than at the beginning due to more favourable propagation conditions, i.e. errors may be time-dependent since signal reception by aircraft is often a function of the time of day. Heights of specific layers in the earth's ionosphere and their degree of ionization vary (see Figure 3), a condition which affects the sky-wave corrections and consequently results in decreasing accuracy of the system. Accuracy will be improved, however, with better sky-wave correction prediction. Another limitation of OMEGA is that signals from a particular station should normally not be used within a 600 NM (about 1 000 km) radius of that station, and this radius limitation is greater at night. Such a limitation is, however, not very significant since each transmitter has a useful range of about 5 000 NM, and aircraft can generally receive signals from at least 3 stations; the consequence of possibly using long baselines considerably increases the accuracy.

4.1.2.5 In the USSR a long-range navigation system similar to OMEGA is used. The Russian system has transmitters located within its territory (contrary to OMEGA); one full transmission cycle takes, however, only 3.6 s. This rapid data transmission rate is likely to be even more valuable for aviation.

4.1.3 LORAN-C

4.1.3.1 Long-range navigation (LORAN-C) is the improved version of the LORAN navigation system. It is a pulsed, hyperbolic system operating in the frequency band from 90 kHz to 110 kHz. Three or more transmitting stations are set up in chains in which the master station and its associated slave stations can be separated by up to 800 NM.

4.1.3.2 The LORAN-C receiver computes LOPs based on time-of-arrival differences between signals from selected combinations of two transmitters of the same chain, one of which must be the master station. The aircraft position is at the point where these LOPs intersect. LORAN-C chains provide geographic coverage ranging from 900 to 2 400 NM by means of their ground-wave signals. LORAN-C does not provide world-wide coverage, although its (sky-wave) signals are used in northern latitudes by some trans-oceanic flights. The ground-wave range of the LORAN-C transmitter is generally less than 1 200 NM; the one-hop sky wave, less than 2 300 NM; the two-hop sky wave, up to 3 400 NM. Between 1 200 and 1 800 NM from the stations used, the ground wave is sometimes received, but this reception is unpredictable.

4.1.3.3 Sky waves normally provide a stronger signal to the LORAN-C receiver, but these signals should only be used when no ground wave signal is received because each LORAN line on the chart represents a difference in arrival time of two ground waves. The sky-wave correction is only an approximation, since the height of the reflecting layer varies (see Figure 3). Thus the system accuracy is 0.25 NM in published areas of ground wave coverage, whereas with the use of sky-wave signals the position error is of the order of 2 NM.

4.1.3.4 LORAN-C signals are available continuously regardless of the time of day or weather conditions, and the system has a record of very high reliability. Over the years

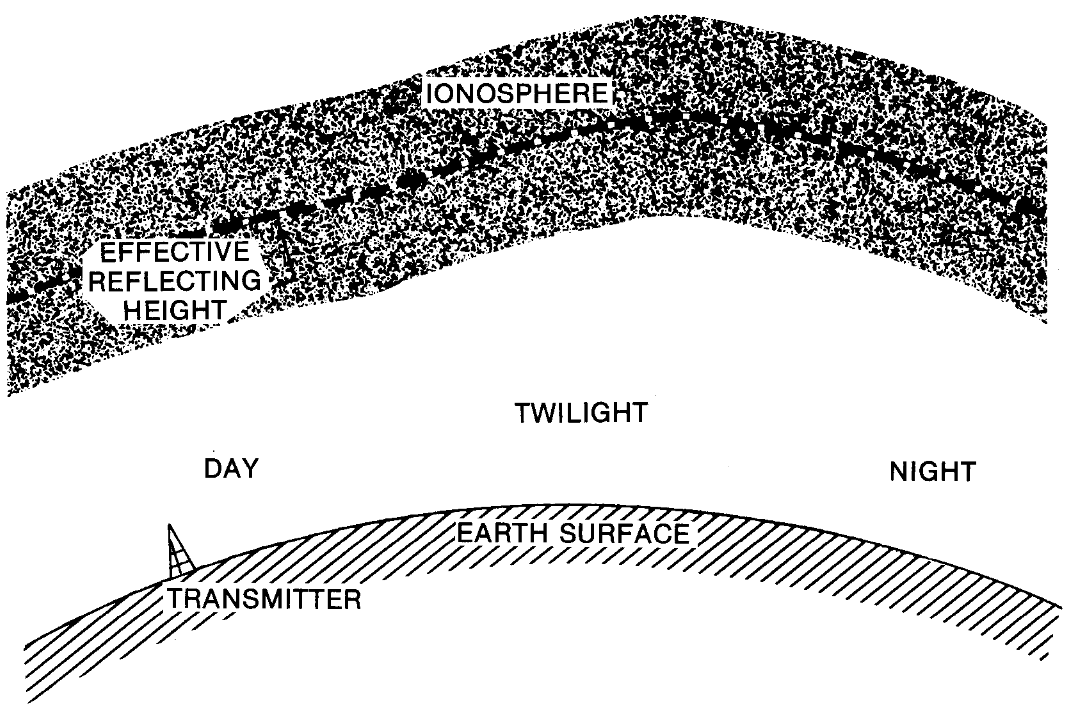

Figure 3.— Earth-ionosphere relationship

of operation of this system very few outages have occurred and these have been of very short duration.

4.2 OPERATIONAL APPLICATION

LORAN-C offers medium to high accuracy in position determination over an extended range. OMEGA offers even greater range, i.e. world-wide coverage, but with a lesser degree of accuracy. LORAN-C and OMEGA are the major, ground-based systems providing navigation coverage over wide areas. OMEGA will continue in operation, due to its international civil character, coverage and economy of user equipment. LORAN-C will continue in operation because of its predictable and repeatable accuracy within its area of coverage and due to the economy of user equipment. However, its operation will be restricted to specific areas because its extension so as to provide world-wide coverage would pose prohibitive ground equipment costs. When using both OMEGA and LORAN-C, the user has a purely passive function. He does not transmit any signal for position fixing and, because of this, the systems are never saturated and the number of users is unlimited.

Chapter 5
Landing Systems

5.1 FUNCTIONAL REQUIREMENTS

5.1.1 Instrument landing system

5.1.1.1 The instrument landing system (ILS) is the ICAO standard, non-visual aid to final approach and landing. Ground equipment consists of two highly directional transmitting systems and two marker beacons aligned along the approach. A third marker beacon may be added along the approach path if operationally desirable. The directional transmitters are known as the localizer and glide slope transmitters. The total landing system of which ILS is an integral part generally provides the pilot with:

a) guidance information regarding the approach path derived from the localizer and the glide slope;
b) range information at significant points along the approach path by marker beacon or continuous range information from distance measuring equipment (DME); and
c) visual information in the last phase of flight from approach lights, touchdown and centre line lights, runway lights.

5.1.1.2 At selected locations where the provision of marker beacons at the defined locations creates difficulties, they may be replaced by a DME which is associated with the ILS. This provision is particularly advantageous when approaches have to be made over water. At some locations a complete ILS system is provided for each landing direction of a runway, or for a number of runways. When such is the case, only one of the ILS systems is, however, put in operation at any time.

5.1.1.3 The localizer transmitter, operating on one of the 40 ILS channels within the frequency band from 108 MHz to 112 MHz, emits signals which provide the pilot with course guidance onto the runway centre line. The approach course of the localizer, which is used with other components, e.g. glide slope, marker beacons, etc., is called the front course. The localizer signal emitted from the transmitter site at the far end of the runway is confined within an angular width between 3° and 6°, depending on the distance of the localizer site from the approach threshold, so as to provide a linear signal width of approximately 210 m (700 ft) at the runway approach threshold. The course line along the extended centre line of a runway, in the opposite direction to the approach direction served by the ILS is called the back course. Back course signals should not be used for conducting an approach unless a back course approach procedure has been published for the particular runway and is authorized by ATC. The identification of an ILS is transmitted in International Morse Code and consists of a two or three-letter identifier starting with the letter I (· ·). It is transmitted on the localizer frequency. Category I and II (see Part II, Section 5, Chapter 2) localizers may provide a ground-to-air communication channel.

5.1.1.4 The localizer provides course guidance throughout the descent path to the runway threshold from a distance of 18 NM from the antenna between a height of 300 m (1 000 ft) above the highest terrain along the approach path and 1 350 m (4 500 ft) above the elevation of the antenna site. Distinct off-course indications are provided throughout the areas of the operational service volume as shown in Figure 1. These areas extend:

a) 10° either side of the course within a radius of 18 NM from the antenna;
b) 35° either side of the course within a radius of 10 NM from the antenna.

5.1.1.5 The ultra high frequency (UHF) glide slope transmitter, operating on one of the 40 ILS channels within the frequency band from 329.15 MHz to 335 MHz, radiates its signals only in the direction of the localizer front course. However, in some cases where a back course approach procedure has been established an additional glide slope transmitter has been installed to radiate signals in the direction of the localizer back course to provide vertical guidance for this approach procedure. Where this is done, the two glide slope transmitters will operate on the same channel but are interlocked so as to avoid simultaneous operation and ensure that either the front course or the back course is provided with vertical guidance but not both at the same time.

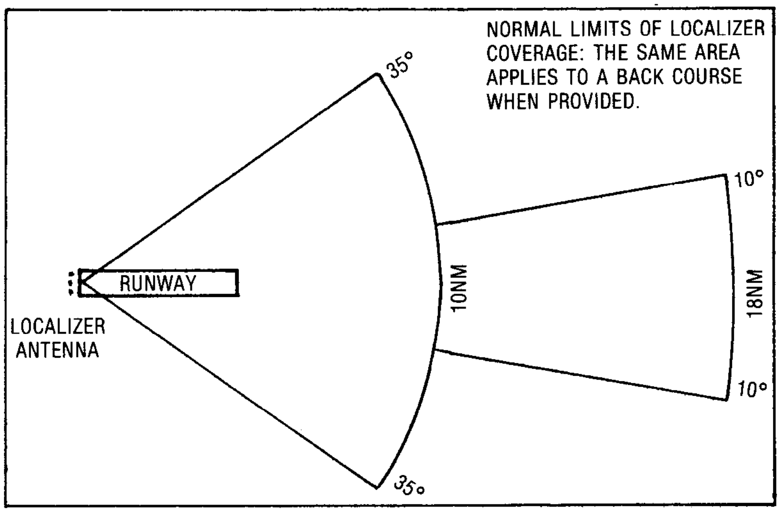

Figure 1

5.1.1.6 The glide slope transmitter is located between 230 m (750 ft) and 380 m (1 250 ft) from the approach end of the runway (down the runway) and offset between 75 m (250 ft) and 198 m (650 ft) from the runway centre line. It transmits a glide path with a beam width of 1.4° ("glide path" means that portion of the glide slope that intersects the localizer). The glide path projection angle is normally adjusted to 3° above the horizontal plane so that it passes through the middle marker at about 60 m (200 ft) and the outer marker at about 426 m (1 400 ft) above the runway elevation. The glide slope is normally usable to the distance of 10 NM. However, at some locations, use of the glide slope has been authorized beyond this range. The glide path provided by the glide slope transmitter is arranged so that it flares from 5 to 8 m (18 to 27 ft) above the runway. Therefore, it should not be expected that the glide path will provide guidance to the touchdown point on the runway.

5.1.1.7 Conventional ILS is subject to siting problems which, at certain aerodromes, can be acute. In addition, at high-density aerodromes further problems with ILS operation may be caused by overflights or by other disturbances. Glide slope and localizer signals are adversely affected by reflecting objects such as hangars, etc. At some locations, snow and tidal reflections also affect the glide path angle to a noticeable degree. In addition, the limited number of channels available for use by ILS may cause interference problems in areas where, due to the proximity of aerodromes, a large number of ILS are required.

5.1.2 Microwave landing system

5.1.2.1 The microwave landing system (MLS) is an improved version of the ILS and has been conceived so as to meet the present and future ICAO functional requirements for landing guidance systems. It is envisaged that MLS will be progressively implemented as of 1990. The transition period where both ILS and MLS will be in operation will extend to the year 2000, when it is expected that ILS will be completely replaced by MLS.

5.1.2.2 The operation of the MLS is based on time reference scanning beam (TRSB) principles. Electronic beams scan the volume of the service area to be covered in a clockwise, then counter-clockwise (to-fro) manner. The scanning generates the angular functions for azimuth, elevation, missed approach azimuth and flare guidance and information. Usable navigation information is provided within an area +40° from runway centre line, between 2° to 10° in elevation and between 20 and 40 NM in range.

5.1.2.3 The degree of sophistication of the MLS at specific locations can range from simple and inexpensive installations to complex systems. The more complex systems enable landing under zero visibility conditions. Unlike the present ILS systems, which basically provide only a single approach path, MLS, while being less subject to siting and interference problems, will cover a wider area, thus providing a number of possible approach paths. In addition, an integrated DME provides continuous distance information, thus eliminating the need for marker beacons, as with the present ILS.

5.2 OPERATIONAL APPLICATION

5.2.1 Instrument landing system

5.2.1.1 The lowest authorized ILS minima, with all required ground and airborne system components operative, are normally as follows:

a) Category I — decision height (DH) 200 ft and runway visual range (RVR) 2 600 ft.
b) Category II — DH 100 ft and RVR 1 200 ft;
c) Category IIIA — DH (optional with State) and RVR 700 ft.

Note.— Special authorization and equipment are required for category II and IIIA.

5.2.1.2 ILS localizer and glide slope course disturbances may occur when surface vehicles or aircraft are operated near the localizer and glide slope antennas. Antenna locations are such that most installations could be subject to signal interference by surface vehicles, aircraft or both, and it is for this reason that ILS critical areas are established on the surface about each localizer and glide slope antenna. Air traffic control (ATC) procedures provide for the control of vehicles or aircraft on the taxiways and runways. One of the aims of these procedures, in relation to ILS critical areas, is to prevent arriving or departing aircraft from causing interference to the ILS when the ILS is being used under weather or visibility conditions requiring such use by other arriving aircraft. Appendix A provides an example of procedures used in the United States for control of aircraft in the ILS critical area.

5.2.1.3 Where ILS systems are installed to serve parallel runways, some States authorize simultaneous ILS approaches if the served parallel runways are at least 1 310 m (4 300 ft) apart. In addition, some States also permit the use of reduced minimum separation of 2 NM between aircraft established on adjacent localizer courses, if the centre lines of the parallel runways are at least 914 m (3 000 ft) apart.

5.2.1.4 ILS localizer courses can be used to define portions of standard instrument departures (SIDs) and standard instrument arrivals (STARs), thus contributing to the expedition of the traffic flow and a reduction in air-ground communications.

5.2.1.5 When considering the establishment of an ILS, care should be taken to ensure, not only that it serves the preferential traffic flow at that aerodrome, but also to ensure minimum interference with the traffic patterns at neighbouring aerodromes. In addition, environmental (especially noise abatement) considerations are assuming an increasingly significant role in the orientation of an ILS.

5.2.2 Microwave landing system

5.2.2.1 MLS reduces siting problems since it is less critical in respect to ILS and to the adequacy of its site. MLS permits the establishment of flexible, curved, multiple and segmented approach paths in azimuth and elevation and provides improved flare guidance. Such capability increases the traffic handling capacity of ATC and/or helps avoid overflying noise sensitive areas at low altitudes. Such multiple paths also help reduce wake vortex problems, and provide more guidance for missed approaches and departures. Finally, MLS permits the interference-free installation of more facilities in a given area because there are up to 200 channels available in the frequency band in which it operates in comparison with a maximum of 40 channels for ILS.

5.2.2.2 Additional information or application and benefits for MLS and possible approaches to the introduction of the system are contained in ICAO Circular 165 — *Microwave Landing System (MLS) Advisory Circular Issue No. 1.*

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Appendix A
General Procedures used in the United States for the Control of Aircraft in ILS Critical Areas

1. When the aerodrome control tower is in operation at controlled aerodromes, and with weather conditions less than ceiling 243 m (800 ft) and/or visibility 2 miles, ATC issues control instructions to aircraft so that they do not interfere with ILS critical areas.

2. Vehicles and aircraft are not authorized in the glide slope critical area when an arriving aircraft is between the ILS final approach fix and the airport unless the aircraft has reported the airport in sight and is circling or "side stepping" to land on a runway other than the ILS runway.

3. Except for aircraft that may operate in or over the critical area when landing or leaving a runway, or for departures or missed approaches, vehicles and aircraft are not authorized in or over the localizer critical area when an arriving aircraft is between the ILS final approach fix and the aerodrome. When the ceiling is less than 200 ft and/or the RVR is 2 000 ft or less, no vehicle and/or aircraft operations are authorized in or over the localizer critical area when an arriving aircraft is inside the ILS.

4. While no specific critical area is established outward from the aerodrome to the final approach fix, an aircraft, holding below 5 000 ft above ground level and inbound toward an aerodrome between the ILS final approach fix and the aerodrome, can cause reception of unwanted localizer signal reflections by aircraft conducting an ILS approach. Accordingly, such holding is not authorized when weather or visibility conditions are less than a ceiling of 800 ft and/or a visibility of 2 miles.

5. Critical areas are not protected at aerodromes when weather or visibility conditions are above those requiring protective measures as specified above.

6. Vehicular traffic not subject to control by ATC may cause momentary deviations of the ILS course or glide slope signals.

7. Critical areas are not protected at aerodromes without an operational aerodrome control tower.

Chapter 6
VHF Direction Finder

6.1 FUNCTIONAL REQUIREMENTS

6.1.1 The VHF direction finder (VDF) is a ground based radio aid used by the operator of a ground station and consists of a directional antenna system and a VHF radio receiver. Each time the aircraft transmits on the frequency to which the VDF is tuned, its display indicates the magnetic direction of the aircraft from the station. Recent equipment presents this information as a digital readout. At a radar equipped ATS unit, the VDF indications may be superimposed on the radar display. Where DF equipment is co-located with radar, a strobe of light flashes from the centre of the radar display in the direction of the radar target representing the transmitting aircraft.

6.1.2 VDF stations may operate independently or in groups of two or more stations under the direction of a main VDF station. A VDF network can supply azimuth as well as position information. In this case, the main VDF station integrates, computes and plots the bearings from the individual VDF stations and from this derives the position of the aircraft so plotted. A single VDF station can determine only the relative bearing of the aircraft, unless this bearing is correlated with a reported, intersecting VOR radial. As VDF relies exclusively on air-ground communications, standby or back-up equipment is normally provided for VDF.

6.1.3 VDF stations are usually located on or near aerodromes, a situation that frequently poses significant problems with siting due to obstructions which reflect signals and due to electronic radiation which interferes with the signals. These disturbances will cause perceived signal errors and consequently incorrect bearing and/or position results. If no suitable site is available at the aerodrome, the VDF antenna may be located elsewhere; however, in this case, the bearing information is then given in relation to the antenna site rather than the aerodrome.

6.1.4 Equipment specifications normally require a bearing accuracy of $\pm 4°$ on the azimuth indicator. This deviation may however be greater depending on site, terrain or other factors. A small additional error is introduced when the strobe line indication is superimposed on the surveillance radar display. VDF equipment furnishes bearing information from any aircraft within communications range transmitting on the selected frequency. Any signal within range affects it. Therefore, when two or more aircraft are transmitting simultaneously on the same frequency, bearing indication is determined by the relative strength of the two signals received.

6.1.5 ICAO provisions classify estimated bearing accuracy as follows:

a) Class A — within ± 2°
b) Class B — within ± 5°
c) Class C — within ± 10°
d) Class D — > Class C

Similarly, the classification of estimated position accuracy is made in accordance with the following:

a) Class A — within 9 km (5 NM)
b) Class B — within 37 km (20 NM)
c) Class C — within 92 km (50 NM)
d) Class D — > Class C

6.2 OPERATIONAL APPLICATION

VDF is of particular value in locating lost aircraft, in helping to identify aircraft on radar and to guide aircraft to areas of good weather or to aerodromes. At aerodromes equipped with VDF, instrument approaches based on the use of VDF may be offered to aircraft in a distress or urgency condition.

AIR TRAFFIC SERVICES PLANNING MANUAL

PART III

SECTION 2. FACILITIES REQUIRED BY ATS

SECTION 2
FACILITIES REQUIRED BY ATS

Contents

Chapter 1
General

1.1 INTRODUCTION

1.1.1 In view of the fact that air traffic services (ATS) facilities form part of the public service institutions provided by governments, their level of functional suitability, convenience and comfort must correspond to that which governs public service institutions in general. It is, however, also a fact that this level varies considerably from State to State or even within States, depending not only on the specific economic situation, but also on climatological conditions, acquired habits and tradition.

1.1.2 It is therefore nearly impossible to develop standard provisions regarding the layout, installation and furnishing of ATS facilities, especially when covering the non-technical aspects which are more concerned with well-being and/or comfort than with purely operational factors. Nevertheless, under these circumstances and in order to provide some guidance in this respect, discussion of both the essential and the desirable features of ATS facilities follows. It is hoped that States, in consultation with representatives of their ATS personnel will then be able to decide which of the desirable features listed are reasonable and can be provided in addition to those required to meet essential operational requirements.

1.2 OPERATIONAL REQUIREMENTS

At all ATS units, the controller must be provided with a suitable environment and appropriate equipment. The environment should be safe and comfortable and should afford protection from the elements as well as adequate heating, ventilation and, where required by climatological conditions, air-conditioning. Operating space should be ample without being spacious. Controllers should be able to work at their positions without physical discomfort, e.g. chairs should be strong and comfortable while providing proper back support, be adjustable in height, and easily movable. The environment should be sufficiently free from noise so as to be conducive to mental concentration. Appropriate equipment includes those items which enhance the controller's ability to see and to communicate with aircraft, his colleagues, other ATS units, maintenance personnel, other aviation agencies or bodies, e.g. airlines or military authorities and supporting services such as meteorological (MET), aeronautical information service (AIS), etc. Typical items in this respect are lighting facilities, radio and telephone.

1.3 STRUCTURAL REQUIREMENTS

1.3.1 Special buildings or those parts of other buildings used by ATS should be designed specifically for the particular needs of the ATS unit concerned. The buildings should be sufficiently durable to last for the expected life of the facility they are to house and should be capable of accommodating all personnel, materials and visitors expected to occupy the structure. Additionally, each level should be strong enough to support all equipment and people expected to use that level. The structure should be fireproof.

1.3.2 The initial design should make allowance for flexibility in accommodating occasional relocations of control positions and/or radio or telephone lines. There should also be similar expansion capability in order to accommodate additional or new, operational or administrative equipment.

1.3.3 Sufficient dedicated power (and outlets) should be provided for all existent and anticipated equipment (radar, data automation, etc.), lighting, heating, ventilation, etc. Critical items of equipment, including radio and telephone equipment, should be connected to an uninterruptible power supply, a back-up power generator, and/or two independent power sources.

1.3.4 Where necessary for the exercise of control function, windows must be provided. In all cases, windows should be provided whenever feasible in order to create a normal working environment.

1.3.5 In tall structures, a dual-purpose elevator should be included to be used by personnel and for freight lifting purposes. Space allocated for each function or item of equipment should be ample with reasonable allowance for expansion.

1.3.6 There should be provisions for emergency exits from all personnel areas. In addition, buildings should be provided with lightning protection, emergency lighting, fire alarm and extinguishing systems and security systems.

1.4 ACCOMMODATIONS

Further to the space required for the operations area, buildings serving ATS units should provide for a briefing room, administrative offices, equipment repair space, locker rooms, administrative supplies storage, technical equipment storage, lounge facilities with cooking facilities, toilet facilities, running water (where possible cold and hot), cold drinking water (if the normal running water is not suitable for drinking), outside lighting and a vehicle parking area. At smaller facilities certain space can serve a number of these requirements simultaneously, but at larger facilities this may not be possible. It should, however, be noted that the arrangements for space needed for efficient operation and for the personnel should receive priority consideration in the design of an ATS structure. The requirements in space for certain special equipment are critical, whereas other space requirements, while desirable, are required for convenience only. Specific ATS accommodations are treated in more detail in Chapter 2 to Chapter 4, which follow.

1.5 SECURITY MEASURES

Note.— See also Part IV, Section 2, Chapter 1.

1.5.1 Security measures and procedures will be required to ensure effective control of entry into all areas where air traffic control (ATC) operations are conducted. They must cause a minimum of delay and inconvenience to persons who regularly need access to the secured areas. These requirements apply equally to self-contained ATS buildings as well as to an ATS operations area within a multi-tenant building. In such a building control of access only to the portion occupied by ATS may be required.

1.5.2 Security measures and procedures should take into account the following factors:

a) self-contained ATS operational buildings are usually surrounded by a security barrier with controlled access points;
b) where guards are used to control an access point, a communications capability to summon assistance in the event of an emergency will be required in addition to a structure to provide protection for the guard on duty during inclement weather conditions;
c) at some ATS facilities an additional access control point may be considered necessary. It may be combined with an information or reception desk;
d) in addition, the appropriate authority may require that specified areas be further protected by restricting access to designated personnel only. Such areas could be:
    1) the ATC operations rooms, computer rooms, and associated facilities;
    2) telecommunications areas and associated facilities; and
    3) service areas housing standby diesel generators, central heating and air-conditioning plants and like facilities;
e) emergency exits from restricted ATS buildings, areas and rooms will need to be supervised by guards or alarm devices to safeguard against unauthorized use.

1.5.3 Security measures can vary from posting security guards at access points, to the installation of closed-circuit television monitors and/or the security locks operated by special keys or coded cards.

1.5.3.1 While the use of guards is frequently recognized as the most reliable method of access control, the cost of manpower involved in such a system should be weighed against the use of mechanical or electro-mechanical access control devices which may provide an acceptable level of protection.

1.5.3.2 Systems based on the use of special keys, coded cards or a combination of both, are now in widespread use and provide an acceptable level of security. These systems can be encoded in such a manner that the individual is permitted access to all areas or is permitted access only to those areas which the individual is authorized to enter. Some coded card systems also provide for joint use, i.e. an identification card. A weakness in this system, which may be considered a major defect in specific circumstances, and which may therefore have to be taken into account before implementation, is that any person in possession of an appropriately coded card may enter the area to which access is controlled if that person knows the sequence of use and related procedures in effect.

1.5.3.3 Closed-circuit television monitors and intercom systems provide a sophisticated means of identification prior to access being granted an individual. Such systems tend to be complex and the installation and maintenance costs may prove to be excessive. In addition, ATS staff on duty may be required to monitor and operate the system to the detriment of their regular duties.

Chapter 2
Specific Requirements for an Aerodrome Control Tower

2.1 OPERATIONAL REQUIREMENTS

2.1.1 An aerodrome control tower has two major operational requirements for an air traffic controller to be able to properly control aircraft operating on and in the vicinity of the aerodrome. Those requirements are:

a) the tower must permit the controller to survey those portions of the aerodrome and its vicinity over which he exercises control;
b) the tower must be equipped so as to permit the controller rapid and reliable communications with aircraft with which he is concerned.

2.1.2 Surveillance by the aerodrome controller is normally done by visual means (eyesight) alone, mechanically through the use of binoculars to improve eyesight or electronically, through the use of radar or closed-circuit television. The controller must be able to discriminate between aircraft and between aircraft and vehicles while they are on the same or different runways and/or taxiways. The most significant factors contributing to adequate visual surveillance are the siting of the tower and the height of the control tower cab. The optimum tower site will normally be as close as possible to the centre of the manoeuvring part of the aerodrome, provided that at the intended height, the tower structure itself does not become an obstruction or hazard to flight.

2.1.3 The height of the tower should be such that, at normal eye level (about 1.5 m above the floor of the tower cab) the controller is provided with the visual surveillance previously described. The higher the tower, the more easily this optimum surveillance is attained, but at greater financial cost and with a greater likelihood of penetrating the obstacle limitation surfaces. Reflections in the cab glass and sun or lamp glare through the windows should be kept to a minimum.

2.1.4 Vertical supports for the cab roof should be kept to the smallest feasible diameter so as to minimize their obstruction of the controller's view. The supports should also be as few as possible commensurate with minimizing reflections. In this respect it should be noted that the less vertical supports, the fewer window panes are required. However, with fewer panes there will also be more reflections. The height of the window sills, which support the windows in the cab, should be as low as practicable since they affect the controller's ability to scan the surface area extending from the base of the tower. For the same reason, tower consoles should be designed so as not to exceed the height of the window sill. The depth of consoles has similar effects on sight limitations. Generally, the higher the window sill and/or the deeper the consoles the larger the surface area extending from the base of the tower which cannot be seen by the controller. Suitable minimum glare or non-glare lighting must be provided to allow the controller to read and write. It must also be arranged so that at night it does not diminish his ability to survey the aerodrome and its vicinity.

2.1.5 The tower controller must be provided with the capability to communicate rapidly, clearly and reliably with aircraft in his area of responsibility. Normally, this is accomplished through air-ground communications. It may occasionally be done by means of a light-gun from the tower using specified signals and prescribed acknowledgements from the aircraft. Since operations in and around a control tower generate a fair amount of noise (e.g. radios, aircraft engines, talking), the provision of sound-deadening features in control towers is very important. Therefore, the acoustic qualities should be taken into account in the selection of structural materials used for control tower construction. Sound-deadening materials should also be used internally, e.g. carpets or similar sound-absorbent material (dust-free and anti-static, if possible) should cover the cab floor and the walls up to the window sills.

2.1.6 The layout of working positions within the tower cab and the consequential arrangement of operating consoles will obviously be determined by the location of the tower in relation to the manoeuvring area, and more especially, the approach direction which is most frequently used at the aerodrome in question. It is also determined by the number of operating positions which are occupied simultaneously in the tower and the respective responsibilities of these positions (control of arriving and departing traffic versus that of ground movements, clearance delivery position, operation of the lighting panel, etc.). As a consequence of this, the layout is most likely to vary from aerodrome to aerodrome and also at an aerodrome as traffic changes. Flexibility and far-sightedness are therefore primary considerations in the initial installation in order to avoid major structural or installation modifications that may result in the future due to changing operational requirements.

2.1.7 It should also be noted that, because of the responsibilities, and the frequent stress involved in the provision of ATC, the provision of other than purely operational facilities contribute to no small degree to the efficiency of the service provided and, as such, deserve careful consideration. They are more fully described in 2.2 and 2.3 below.

2.1.8 In view of the above and what has been said in Part III, Section 2, Chapter 1, 1.1, it should be noted that the illustrations, shown in Appendix A, can only serve as examples of possible arrangements and that final decisions regarding specific control towers must be based on detailed local studies conducted with the active participation of their eventual users.

2.2 STRUCTURAL REQUIREMENTS

2.2.1 Ideally a control tower should be of the required height and should have ample space to ensure an optimum working environment for personnel and equipment (including expansion capabilities), be energy efficient, durable and aesthetically pleasing — all at moderate cost. In the case of control towers located atop the aerodrome terminal building, it has often been found that such a location limits the expansion capability of the facility when air traffic and consequently tower staffing and equipment increase (e.g. radar, automation, etc.). Therefore, at the more important aerodromes or at those where significant future traffic developments are expected, it is better to have a separate control tower structure which is optimally sited, specifically designed to fulfil its operational purpose and whose height is sufficient to best meet ATC needs (see 2.1.3 above). Free-standing control towers have three main components: cab, shaft and base building (see Appendix A, Figure 1). A tower need not have a base building provided its offices, etc., can be integrated into the tower shaft (see Appendix A, Figure 2).

2.2.1.1 The space reserved for the tower cab should be ample but not excessive. As its size is increased, the controller's viewing angle out the opposite side of the tower cab becomes more limited by the height of the window sill (downward) and the roof line (upward). Similarly, physical co-ordination problems between controllers increase with larger space. One State (United States) suggests polygonic cabs of the following dimensions:

Level of activity	Approximate number of personnel simultaneously present in cab	Cab area (square metres)
Low	Not more than 6	21
Intermediate	Between 6 and 12	32
Major	More than 12	50

2.2.1.2 The size of the control cab should be primarily dependent on the number, location and size of control positions and consoles (see Appendix A, Figures 3 and 4). In relation to the primary runways, the cab should be physically oriented so as to obtain the best unobstructed view of the aerodrome manoeuvring area. The orientation should also be such so as to minimize sun glare while controllers monitor the primary areas, especially at sunrise and sunset when the sun is low on the horizon. The window panes should tilt outward to eliminate reflections from the consoles and to provide shading at high sun angles. They should be double-pane, free of distortion, untreated, with the frame banded to the glass for an airtight, waterproof and vapour-proof seal. Interior wall surfaces should be painted in a dark, flat colour to avoid reflections and vertical supports should also be non-reflective and also painted in a dark colour. Minimum clear height from cab floor to ceiling should be 3 m. The ceiling may slope up at its perimeter to enhance upward visibility, especially from the opposite side of the cab. It should be sound-absorbent and painted charcoal gray or flat black to avoid reflections.

2.2.1.3 For washing windows, there should be an automatic window washer or a walkway around the exterior of the tower cab. This walkway should be as narrow as possible and as low as possible (including railing) so as not to impair the controller's close-down view. The walkway may also serve as part of an emergency escape route.

2.2.1.4 If the vertical supports between the window panes are not sufficient to support the roof alone, an additional minimum number of cab columns, with minimum diameter may be used. However, their number should be kept to a minimum commensurate with engineering standards.

These cab columns may be multi-purpose and also serve as roof drain, sanitary vent, conduits for power and antenna cables and the grounding system.

2.2.1.5 Tower cab lighting of variable intensity should generally be recessed in the ceiling and directionally adjustable. Operational lighting required to illuminate a specific working position should be placed and painted so as to minimize glare and reflections. Floor lighting and stair lighting should be recessed and shielded.

2.2.1.6 Carpeting of the tower cab floor should be wear-resistant, sound absorbant, anti-static and flame resistant.

2.2.1.7 Where airport movement radar/airport surface detection equipment (AMR/ASDE) or daylight radar repeater equipment is available, the displays should be swivel mounted, or suspended from a trolley and track in the cab, so that their orientation can be adjusted to remain in the field of vision of the controller concerned under varying conditions.

2.2.1.8 Due to its location, a control tower cab is normally very exposed to changes in atmospheric conditions and a wide variance in temperatures. Therefore, in many cases, a good air circulation is required to retain reasonable working conditions. Where provided, it should be equally distributed around the cab perimeter and operated so as to provide a stable environment. Experience has shown that air distribution from the window sill is better than roof-mounted equipment since the latter arrangement is frequently too noisy for personnel working in the cab as well as more difficult to maintain. A separate air-conditioning and heating/cooling system for the cab will prevent interior fogging or frosting of windows without overheating the cab. It will also prevent or remove the accumulation of ice on the outside of windows. In addition, the system will also serve to heat the cab alone, when it is not yet necessary to heat the rest of the structure, which in certain areas amounts to considerable cost-savings. The thermostat controlling such a system should be located away from exposure to direct sunlight or any other heat source.

2.2.2 The tower shaft has two primary functions; it supports the cab and provides access to the cab by a stairway and/or elevator and as such, it encloses and supports wires, pipes, etc. A secondary function of the tower shaft can be to provide accommodations for personnel and equipment on its different levels.

2.2.3 Where required, a building at the base of the tower shaft may be added as a single or multiple story structure. Normally, its primary function is to house an approach control unit and/or to provide accommodations for services associated with the provision of air traffic services (ATS). Such an arrangement is preferable to housing these services in the control tower shaft.

2.2.3.1 A free-standing functional shaft (without an associated base building) requires a very small area. It can be readily constructed in prefabricated sections and assembled on location in less time than a conventional building. The disadvantages of free-standing shafts are that they provide for practically no expansion in accommodations and various services are distributed at different levels which generally results in poor communication.

2.2.3.2 A base building combined with a functional shaft provides maximum utilization of space by using the vertical space in the shaft thus reducing space requirements in the base building. However, three separate air-conditioning and heating/cooling systems may be needed for the cab, shaft and base building. Another disadvantage is that the future expansion of those services accommodated in the shaft of the tower are limited.

2.2.3.3 The combination of a base building with a non-functional tower shaft limits the use of the shaft to the point where it houses only a minimal amount of mechanical and electronic equipment but no support personnel. This configuration provides great flexibility in the use of space, offers maximum expansion potential and permits separate construction of the two basic units. Additionally, a single or two-story base building lends itself to a more convenient and efficient circulation of people. The disadvantages are that a larger site is required and the associated design and construction costs are higher.

2.2.4 The material used for the structure of a control tower should be fireproof and all internal material should be fire resistant. In addition, the structure should provide for emergency exit especially from the tower cab and the upper shaft levels. Emergency exit points could be achieved by permanently affixed steel ladders to the outside of the structure or a safety cage on the inside. The structure should also be provided with a smoke detection and alarm system and an ample supply of pre-positioned fire extinguishers which are periodically checked. All stairways should include a hand rail. An elevator should be provided where the cab floor is 15 m or more above the ground. It has also been found that the provision of a central vacuum cleaning system with outlets in each room and blower units remote from normally occupied areas help appreciably in reducing noise.

2.3 ACCOMMODATIONS AND EQUIPMENT

2.3.1 The tower cab should be fitted with consoles to house equipment and provide desk space of the same height as the consoles for writing as well as space to mount monitoring equipment such as aerodrome lighting panels, instrument landing system (ILS) monitor panels, telephone and radio selector panels and brackets to hold microphones and telephone handsets. The console desks should also provide support for flight progress strip holders and should have radio/telephone connexions, including those used for monitoring. There should also be drawers for pens, pencils, paper, etc. Drink holders as well as ashtrays should be located safely away from radio and telephone selector panels and other equipment sensitive to liquid or ash spillings. A supervisor's desk(s) should be provided with necessary telephone and radio terminals and a bookcase should be available to keep appropriate reference material.

2.3.2 Where equipment is enclosed in fixed consoles which are backed to the outer walls of the tower cab, the consoles should open at the front for ease of maintenance. Modular consoles which are easily plugged in and out will similarly help in the maintenance work. If plexiglass tops are provided on consoles and other writing surfaces, regularly used essential charts and other materials may be inserted under the plexiglass. If the consoles and desks are not overlayed with some transparent material, the top surfaces should be made of stain-resistant laminate. Windows may require transparent, glare-proof shades which can be raised or lowered as needed. Where required because of local conditions, towers serving low activity aerodromes with only one or two control positions should have a convenience unit (drinking water, hot-plate or small microwave oven, small refrigerator to permit controllers to remain on the post while eating or drinking). Towers with intermediate or major activity require only the drinking water and possibly a hot-plate in the cab since the refrigerator, etc., generally caters for more persons and therefore must be larger. It can then be located more easily in the tower shaft or in the base building. Stairs leading up to the cab should be located furthest away from the cab operational areas in order to have the least impact on the cab's functional perimeter. There should be a gate at the top of these stairs to prevent accidents.

2.3.3 Where an approach control (APP) unit is located in the tower shaft or base building, provision should be made for a "drop tube" to send current flight progress strips on departures and arrivals to the APP. There should be a secured floor hatch (75 by 90 cm minimum) in the cab floor with an electric mechanical hoist which permits hoisting heavy equipment between the cab and the top elevator landing. If the highest elevator level is not on the floor level immediately below the tower cab, a hatch should also be provided on any intermediate floor.

2.3.4 For a tower performing a combined aerodrome/approach control function, where APP is equipped with radar and operated from the cab, there may be an additional requirement for special screening of the radar displays to minimize reflections and glare. This special screening may be required despite the use of daylight radar displays (see Appendix A, Figure 5).

2.3.5 In a tower with low activity, the junction level in the tower shaft is primarily reserved to house the equipment work room, control tower mechanical equipment, elevator equipment, toilet and washing facilities. The level below that usually houses the uppermost elevator landing lobby, electronic equipment room and other spaces as required. If the toilet and washroom facilities cannot be located on the level immediately below the tower cab, they must be located on the next lower level in order to keep absences from duty by controllers as short as possible. In radar-equipped towers, equipment rack space for ASDE radar and microwave links may be located on either level. In towers with non-functional shafts, the levels between the base level and the next to last level normally serve only to add height to the tower shaft and to provide access to utility and elevator shafts at the various elevations (see Appendix A, Figure 6). Space in these levels may be used for storage, and other non-operational purposes.

2.3.6 The APP operations room, administrative offices, training and conference rooms, ready or break room, locker room, radar simulator training room, communications equipment room, radar equipment room, automation equipment room, recorder equipment and playback space, telephone equipment room, mechanical and/or electrical maintenance space can all be housed in a base building where provided, or, if space permits, in a functional tower shaft. The immediate economy of accommodating all these functions into a functional tower shaft may, however, be lost if there is no room for future expansion to accommodate new or additional control devices or personnel.

2.3.6.1 The APP operations room size is largely determined by the number of operating positions and radar consoles required or planned for the room. There are two types of radar consoles in use, vertical and horizontal and both types may be used in the same level (see Appendix A, Figure 7). In either case, illumination of the controller's operating position should be such that the presentation of information on the display is not impaired or that its interpretation is rendered difficult. Arrangements should be made to allow individual controllers to exercise personal preference in this area to the degree that it does not interfere with the requirements of others. Within operational limits, the controller should have control over the intensity of any display which involves the transmission of light. Primary flight data information, i.e. information directly related to the traffic situation, should be displayed in such a way as to avoid significant refocussing of the eyes. For this reason, it is possible that large general displays of secondary information, i.e. information not concerned with the traffic situation, may not be practicable. Space and material for writing notes must be provided. The manipulations required to select specific facilities for use, whether data displays or communications, should be simple. Critical and most frequently used equipment and functions should be located closest to the controller and arranged so that their manipulation follows a logical sequence. A separate desk and adequate lighting, telephone and communications facilities should be provided in the operations room for the watch supervisor.

2.3.6.2 General lighting of operating rooms should be kept at a low ambient level consistent with good working conditions and with reflections reduced as much as possible. However, the floor area should be sufficiently illuminated to prevent accidents, etc. Door openings to lighted adjacent spaces should be screened so that light will not flood the space when doors are opened and interfere with a controller's vision. Operations rooms should be sound-proofed but the floor covering used should still permit chairs to roll easily. Consoles should be of the plug-in plug-out type and/or should be accessible from the rear for maintenance purposes. In some locations where space permits, consoles have been arranged so that they are backed into the radar repair room, thus permitting maintenance while the console remains in place.

2.3.6.3 At some selected locations a room similar to the APP operations room may be required for training controllers in the use of radar in a simulated APP environment. The radar simulator training room should be located in the training area and close to or above the radar equipment room (see Appendix A, Figure 8).

2.3.6.4 A room for training and conferences should be provided at larger facilities. When the size of the room exceeds 22 m^2 the room should be divisible by a movable type partition with low sound penetration characteristics. Controllable day-light lighting of such rooms is desirable. A chalkboard should be provided for each space. Wherever possible, a roll-up projection screen and an overhead (transparency) projector, as well as a film and slide projector should be included in the room equipment. This space may also be used as a briefing room.

2.3.6.5 The ready or break room provides space for personnel to relax during off-duty periods. Its size will be determined by the number of people likely to use the room simultaneously. Normally, allowance is made for 2.5 m^2 per occupant but starting with a minimum size of 10 m^2. In functional shaft facilities the break room should be located near the cab and in aerodrome control towers with a non-functional shaft, in the associated base building near the APP or combined aerodrome control tower/APP facilities. Lighting by controllable day-light is desirable. The layout of the room should separate the eating area from the lounge area and there should be a small counter, storage cabinets, food heating facilities and an appropriately sized refrigerator available in the break room.

2.3.6.6 Recorder equipment automatically records voice communications between controllers and pilots and telephone communications between controllers. The equipment is usually located in the communications room where access to cable ducts is facilitated. Access to recorder equipment and tapes should be restricted to only authorized personnel because of the valuable nature of recording tape in the investigation of incidents. When not installed in the chief controller's office a separate playback equipment room may be provided to permit personnel to listen to recordings for training purposes. When the playback equipment is portable it may be set up for use in other existing rooms. There should, however, be a separate tape storage room in a secure area to avoid the possibility of tapes being tampered with. The tape storage room should preferably be located away from areas which are frequented by many persons.

2.3.6.7 Whenever there is a requirement for operational equipment, there is a complementary requirement for technical equipment. Space provided for technical equipment must be ample and as close as possible to its operational counterpart(s). Therefore suitable provisions should be made for the housing of communications, radar and telephone equipment plus the required cable ducts and other utilities. Space for electronics equipment, in respect of required cable lengths is particularly critical, as are temperature, in some cases, and the cleanliness of the room.

2.3.6.8 Administrative personnel will require appropriately sized offices, furnished and decorated in accordance with their respective positions. Some functions will require a completely enclosed office while open-plan partitions (about 2 m high) will suffice for others. Clerical staff other than the unit secretary should be assigned common space. Staff establishments vary with facilities, therefore, office space may be required for some or all of the following (or counterpart) titles: Chief Controller; Deputy; Operations

Officer; Plans and Procedures Officer; Training and Evaluation Officer; Data Systems Officer; Personnel Officer; Chief Controller's secretary; and secretarial pool.

2.3.6.9 The locker room provides a space for personnel to secure their personal belongings while they are on duty, or a place to store work equipment while they are off duty. The locker room size depends on the number of personnel requiring lockers. Lockers are placed in rows, with an aisle of sufficient width (1.2 m) to allow personnel to pass. Lockers are normally provided with separate coat compartments and small upper compartments and should be provided with locks to all compartments. The locker room should be adjacent to the rest or ready room (see Appendix A, Figure 9).

2.3.6.10 Lavatories must be provided adjacent to areas occupied by personnel and, as a general rule, one toilet may be provided for occupancies of 15 persons or less. Where there is an APP operations room, the lavatories shall be located nearby; however, a lavatory should be located on the closest possible level below the cab in all towers. If a rest area is not provided elsewhere within the facility, there should be one in the women's lavatory. The arrangement and installation of the lavatories should, at least, correspond to the level normally provided in public service installations, i.e. accessories, mirrors, grab bars, soap and towel dispensers, waste receptacles, coat hooks, etc., as required.

2.3.6.11 The peak demand for parking at the facility will determine the required employee parking lot size. However, in some cases allowances need to be made for official cars and visitors. Normally, peak demand for parking will occur during shift changes. A study and evaluation of the largest concentration of personnel at the facility during this shift change (employee, visitor and official vehicle parking) will determine the capacity required.

2.3.7 Where aerodrome ground radar surveillance equipment is available, it will normally be mounted on the roof of the cab and the display(s) mounted in the cab and readily accessible to view by the ground control and the local control positions. The installation of the display should be made so that it poses the minimum obstruction to the controllers' direct view of the aerodrome traffic. Where an APP is collocated, and a repeater radar display is mounted in the cab, it should be readily accessible to view by the local controller and without creating any obstruction to view.

2.3.8 The aerodrome lighting control panel should be incorporated in a cab console or in a separate desk. The ILS monitor panel/alarm should also be mounted in the cab console but can be in a less utilized area. Radio and telephone selector panels should be installed at the control positions and should include emergency and other special use telephone equipment. Depending on their number and personal preference, radio speakers may be mounted in the consoles or a special overhead rack suspended from the ceiling. Other cab equipment includes wind direction and speed indicators, altimeter readout indicator, light-gun(s) and clock(s) and, where required, remote runway temperature readout. Where the tower personnel have been assigned the additional responsibility for making partial weather observations, cloud height and temperature indicators should be included. A link to the local meteorological station and to aeronautical information service (AIS) needs to be included and, in some cases, a connexion to the computer of the associated area control centre (ACC) so that flight plan information can be exchanged.

2.3.9 Towers with intermediate and major activity should be supplied by one commercial power source and one uninterruptible power supply; or one commercial power source and one standby power generator capable of supplying power to all critical equipment within 15 seconds of failure of normal power supply; or two independent sources of commercial power. Where the primary commercial power source is of poor quality, a power stabilizing system should be considered for installation to prevent damaging voltage surges.

2.3.10 Provision should be made for emergency lighting as follows:

a) for an aerodrome control tower without power generator, the emergency lighting should be battery supplied and provide lighting of exits, corridors and stairs, interior spaces housing critical electrical and mechanical equipment and critical areas having electronic equipment;
b) for an aerodrome control tower/APP with a power generator, the emergency lighting arrangements should cover:
   1) battery lights in the power generator and electrical rooms;
   2) reduced lighting connected to the emergency power supply for the cab, the APP operations room (spots and floor lights only), the radar and communication equipment rooms, the electrical/mechanical room, the break room and the lavatory;
   3) exit corridors and vestibules should be sufficiently lighted by the emergency system to provide illumination for emergency exiting.

2.3.11 There should also be an internal telephone system at towers with intermediate and major activity. All the operation rooms, the more important work rooms and offices and some strategic locations in the general areas (entry hall, etc.) should be provided with clocks. Where necessary, adequate security systems should be provided (see Part III, Section 2, Chapter 1, 1.5).

2.3.12 If the location of the aerodrome served by an ATS unit, in relation to nearest housing, is such that commuter distances to work are excessive and/or if housing at reasonable cost cannot be found by personnel within a reasonable distance from the aerodrome, it may be advisable to consider the development of a residential housing project in co-operation with the appropriate local public authorities.

2.4 OTHER CONSIDERATIONS

Where APP is provided for one aerodrome only, the APP will normally be accommodated within a control tower structure unless it is performed by one or more sectors within an ACC. In some rare cases where approach control for a number of closely located aerodromes is provided from one APP and where neither of the two preceding arrangements is satisfactory, a stand-alone terminal control centre (TMC) may need to be provided to perform the APP function. In this case it is most likely that it will resemble a miniaturized version of an ACC and the provisions for such a facility apply, albeit on a reduced size (see Part III, Section 2, Chapter 3 — Requirements for area control centre).

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Appendix A

Illustrations of Aerodrome Control Tower Designs and Layouts

Figure 1.— Aerodrome control tower with base building and non-functional shaft serving an intermediate activity aerodrome — outside view

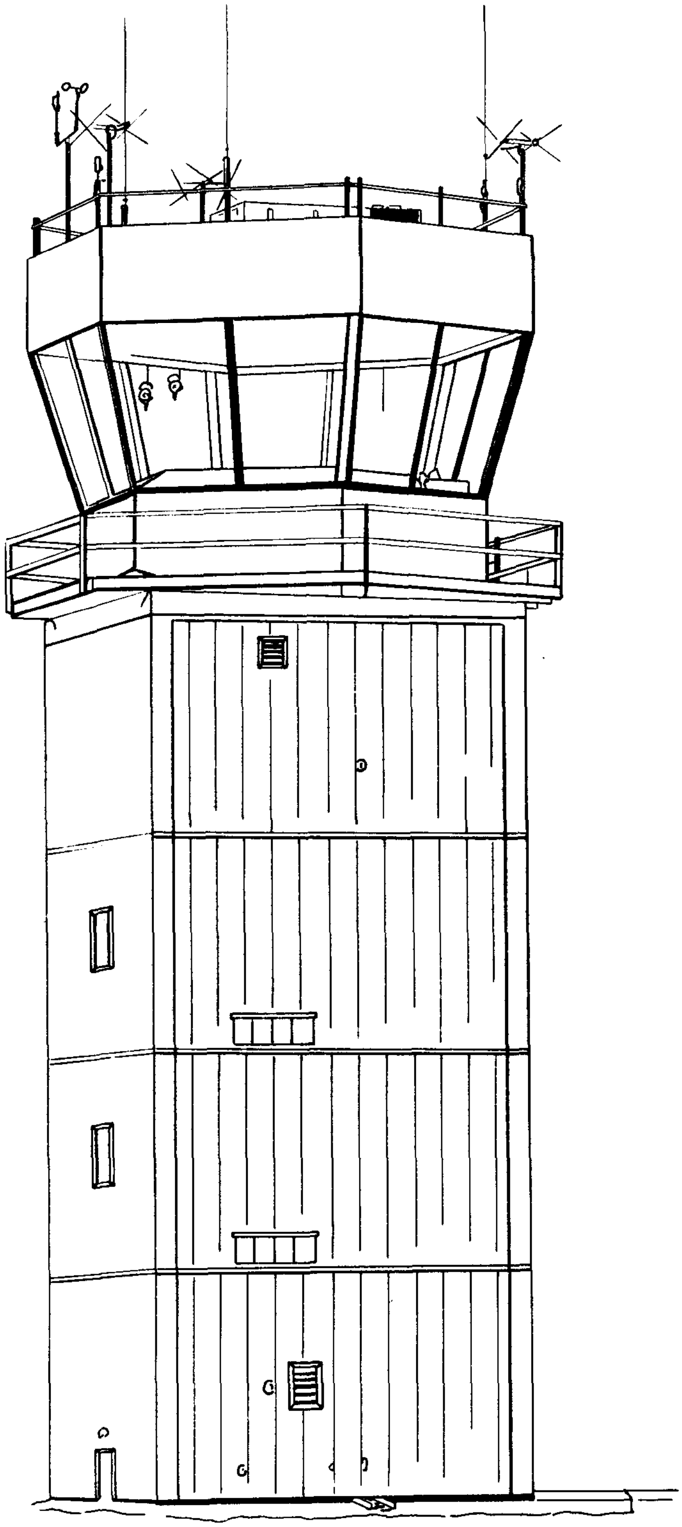
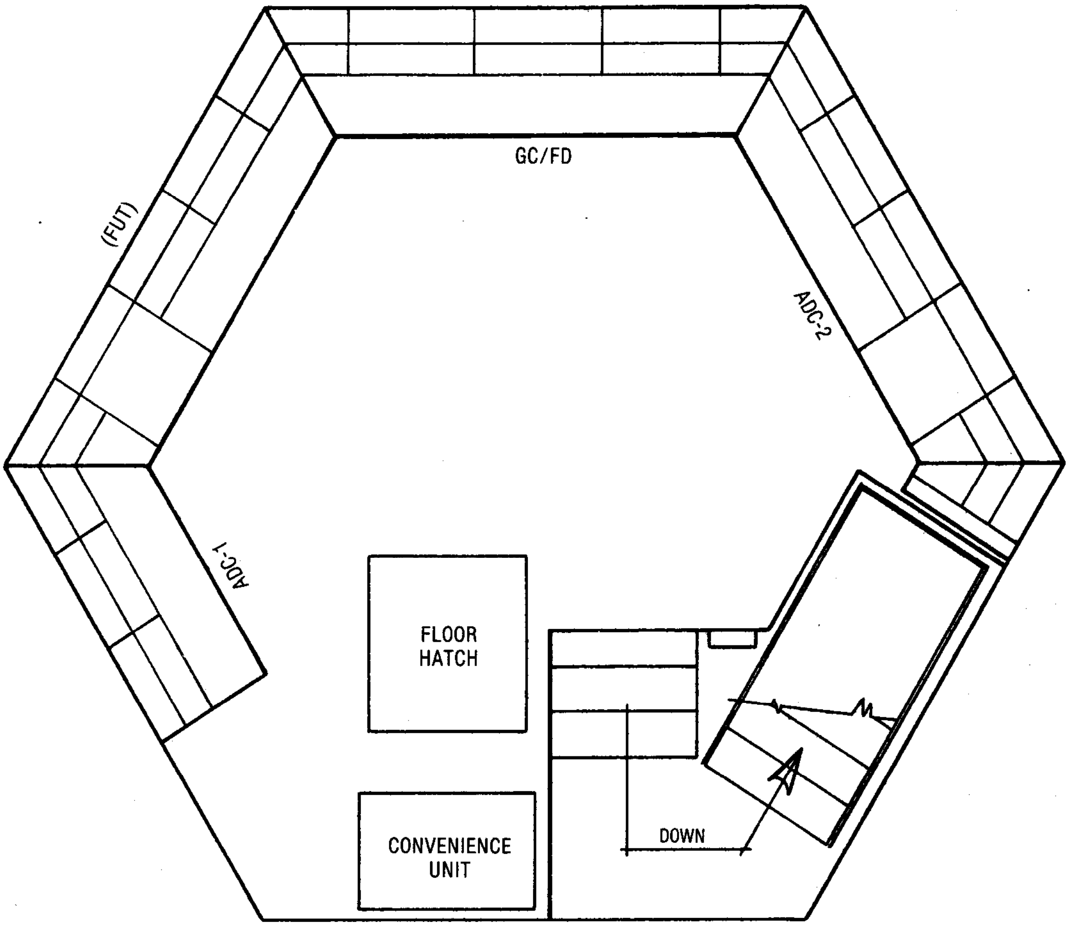


Figure 2.— Free-standing aerodrome control tower with a functional shaft serving a low activity aerodrome — outside view



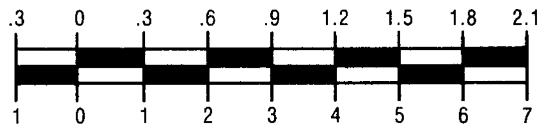
CAB FLOOR PLAN

Key to symbols

ADC = Aerodrome control
GC = Ground control
FD = Flight data
(FUT) = Future

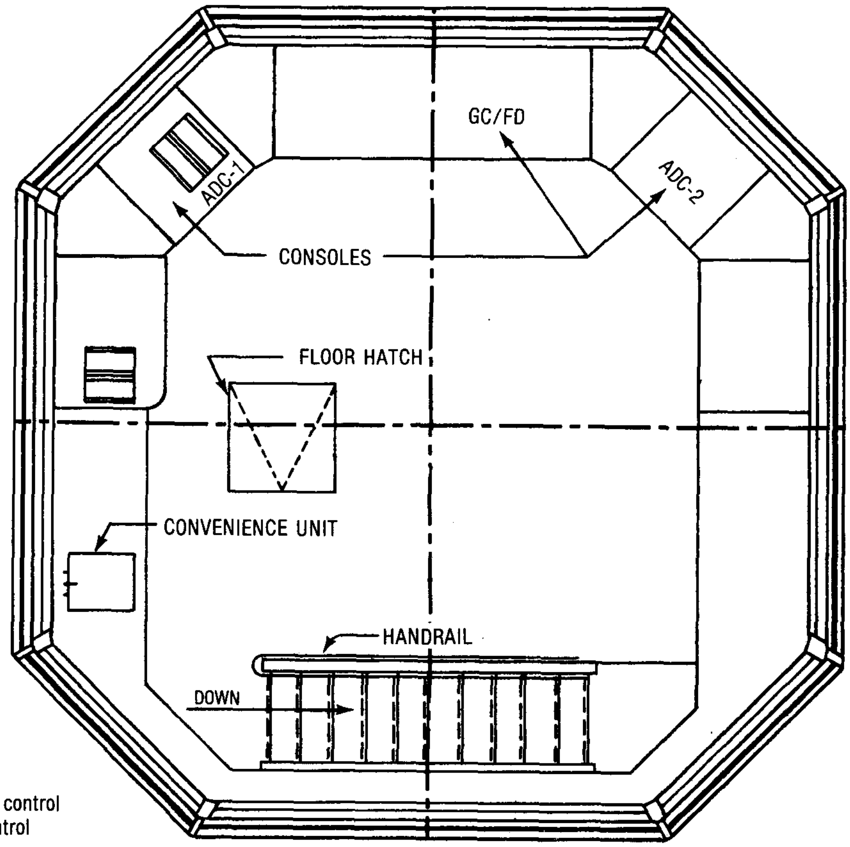
Scale

Metres



Feet

Figure 3.— Interior layout of a low activity aerodrome control tower cab



Key to symbols

ADC = Aerodrome control
GC = Ground control
FD = Flight data

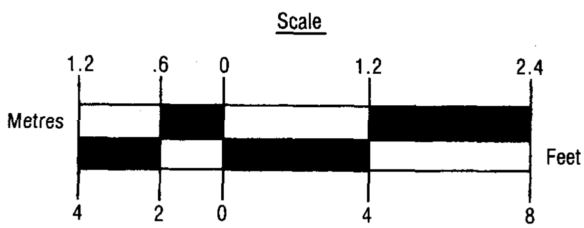


Figure 4.— Interior layout of an intermediate activity aerodrome control tower cab

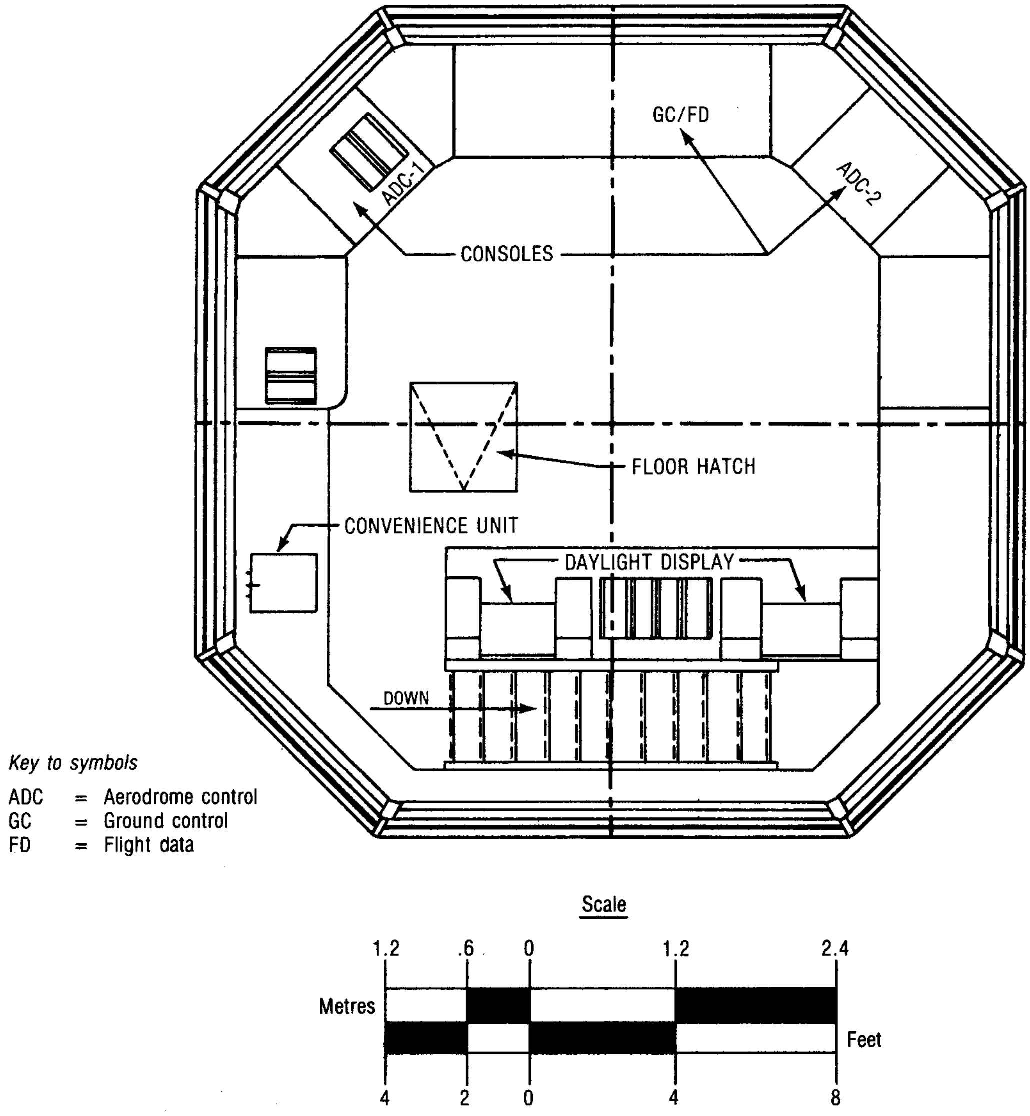


Figure 5.— Interior layout of an intermediate activity aerodrome control tower cab with radar-equipped approach control in the tower cab

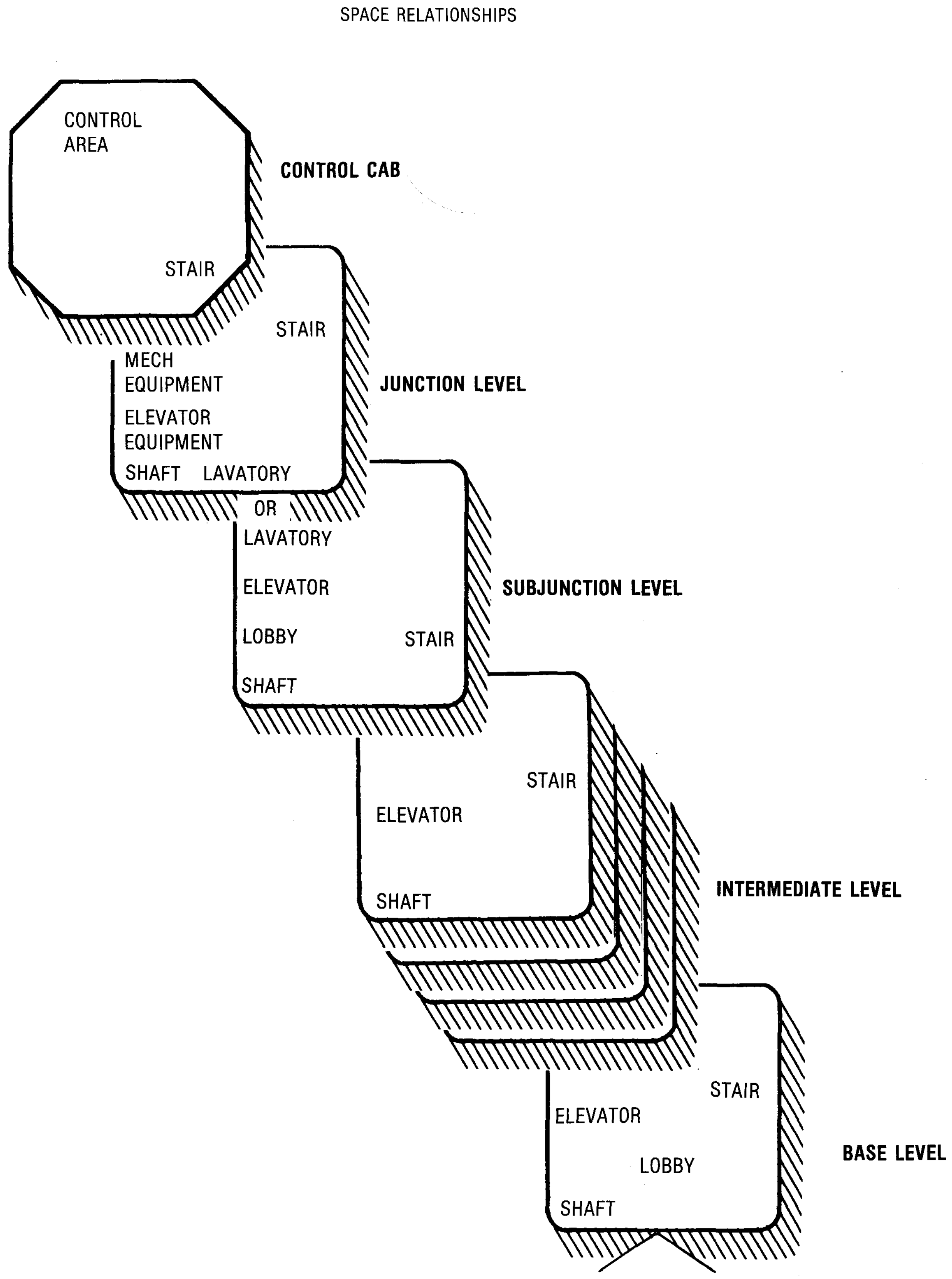
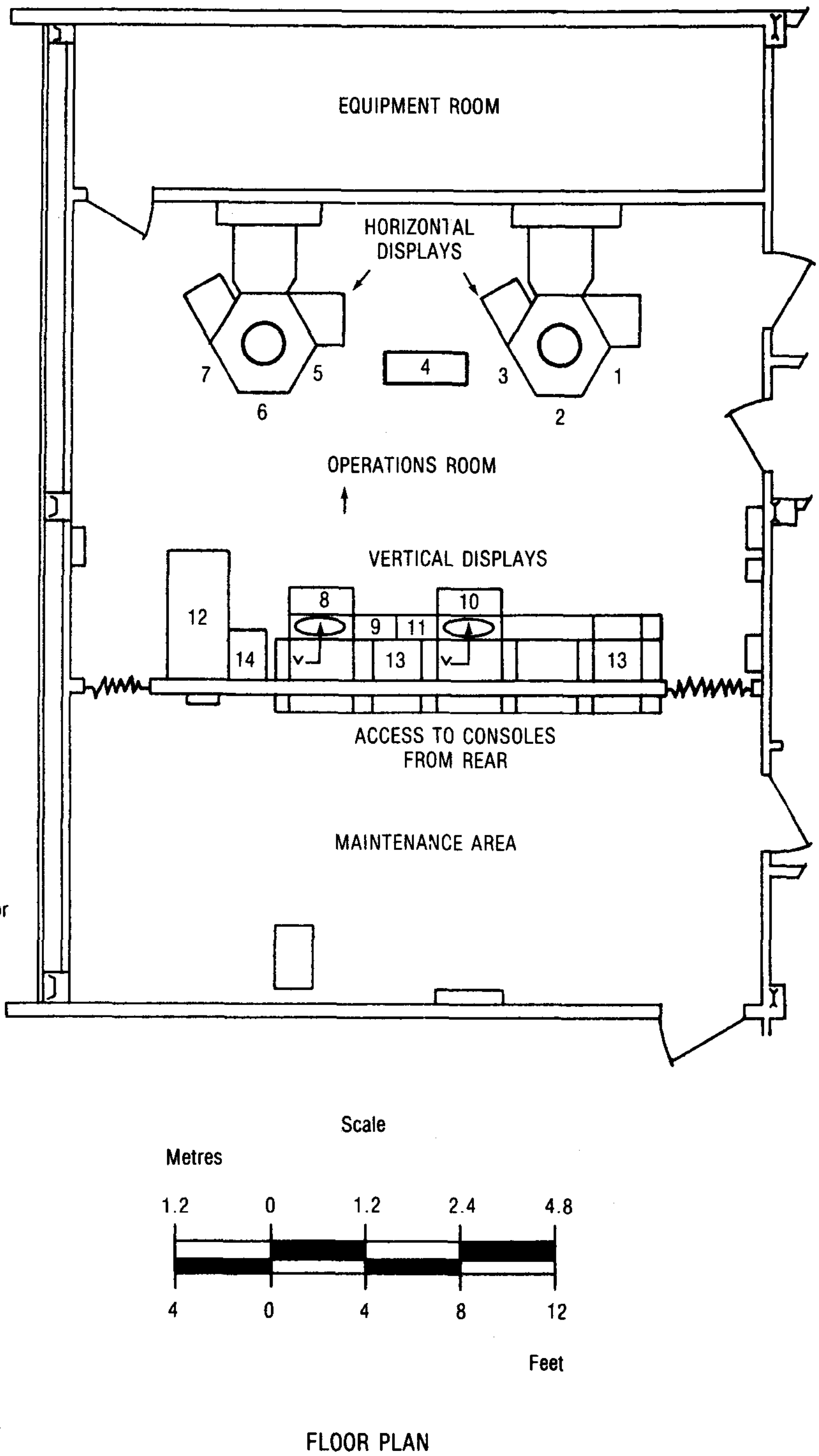


Figure 6.— Diagram of the level arrangement in the non-functional shaft of an aerodrome control tower



Key to numbered positions

1 to 3, 5 to 10 = Control positions
4 and 11 = Co-ordinator positions
12 = Assistant chief/Watch supervisor
13 = Strip printers
14 = Local weather & NOTAM circuit

Figure 7.— Layout for approach control operations room using horizontal and vertical displays

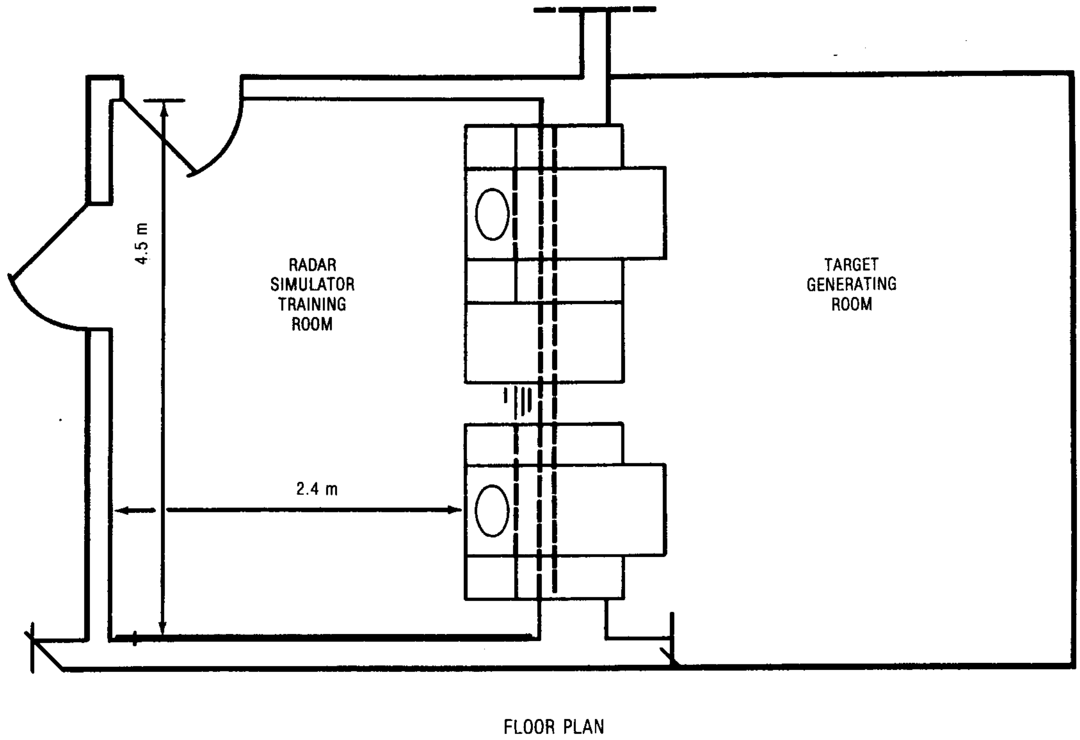


Figure 8.— Layout for radar simulator training room

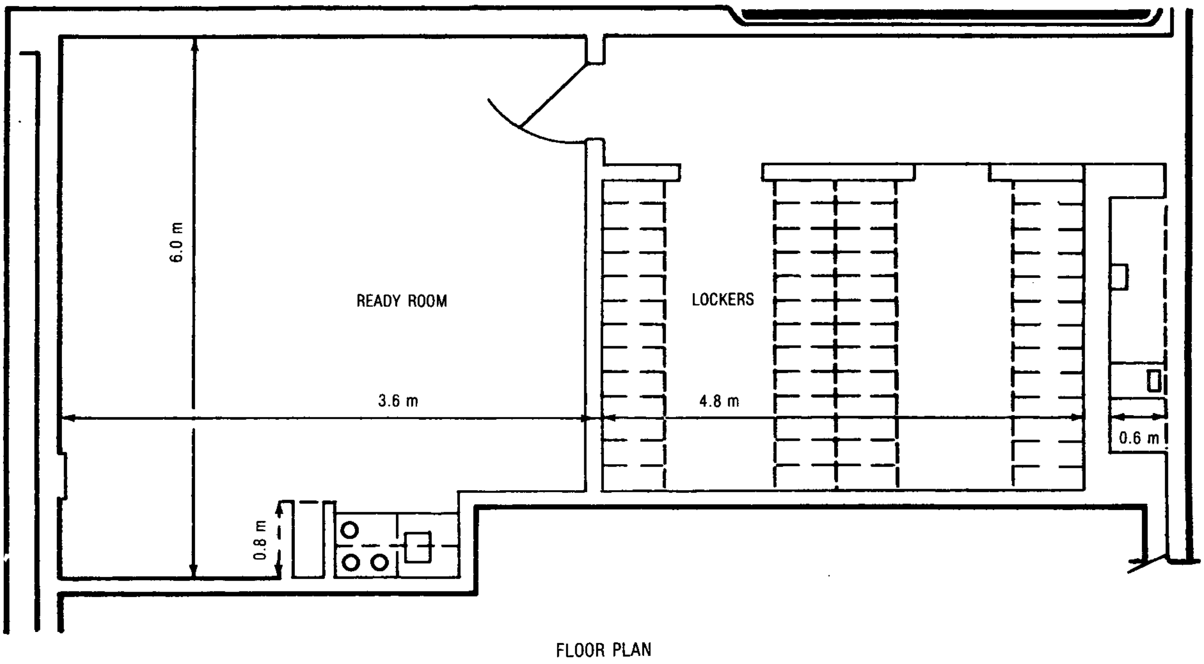


Figure 9.— Possible layout for a ready and locker room

Appendix B

CHECK-LIST

AERODROME CONTROL TOWER AND APPROACH CONTROL OPERATIONS EQUIPMENT

Item	Tower only	APP in Tower cab	Separate APP
1. Headset	x	x	x
2. Microphone	x	x	x
3. Transceiver	x	x	x
4. Speakers	x	x	x
5. Radio selector panel	x	x	x
6. Telephone selector panel/handsets	x	x	x
7. Intercom	x	x	x
8. Auto-switch headset/speaker	x	x	x
9. Recorder (radio and telephone)	x	x	x
10. Power	x	x	x
11. Back-up power	x*	x	x
12. Signal lamp and reel	x	x	
13. Wind speed and direction display	x	x	x
14. Barometric altimeter	x	x	
15. Altimeter setting indicator	x	x	x
16. Clock	x	x	x
17. Aerodrome lighting panel	x	x	
18. Navaid(s) monitor panel	x	x	x
19. Lighting, including emergency lights	x	x	x
20. Daylight radar/display consoles	x*	x	
21. Radar displays, controls, consoles			x
22. Secondary radar controls		x	x
23. Radar simulator			x
24. Flight data panel	x	x	x
25. Automation equipment		x	x
26. Clipboards/displays (NOTAM etc.)	x	x	x
27. ATIS recorder		x	x
28. Fire alarm and extinguishers	x	x	x
29. Desks/consoles/shelves	x	x	x
30. Chairs	x	x	x
31. Shades	x	x	
32. Air conditioning, heating/cooling	x	x	x
33. Convenience group (hot-plate/water, etc.)	x		
34. Lunch facility		x	x
35. Water fountain		x	x
36. Bookcases	x	x	x
37. Binoculars	x	x	
38. Sound-absorbing coverings (floor/wall)	x	x	x

* Where necessary due to particular circumstances.

Chapter 3
Requirements for an Area Control Centre

3.1 OPERATIONAL REQUIREMENTS

3.1.1 Area control centres (ACCs), broadly speaking, are divided into three levels of development. At the first and most basic level, the ACC relies on flight progress strips for its method of control. For each flight, a flight progress strip is prepared for each designated reporting point. The estimates on each strip are updated by the controllers as the flight passes through the airspace of the ACC. The control methods used at this level are generally referred to as procedural control.

3.1.2 At the second and more advanced level, the ACC relies on radar as its primary means for controlling traffic. When the radar displays, used by the ACC, are horizontal, plastic markers are moved along the surface of the display to aid the controller in maintaining the identity of individual radar targets representing aircraft under its control. For both vertical displays and horizontal displays, flight progress strips continue to serve as back-up for the information displayed by radar. At some radar-equipped ACCs, strips are prepared (including the calculation of estimates) by a strip printer and automatically distributed to the proper control sectors.

3.1.3 In the third and most advanced level of operation of an ACC, radar information is digitized and strips are computed, printed and distributed automatically. However, what is more significant, the identity and other pertinent data relating to each radar target are shown on the display together with the associated target.

3.1.4 At all three levels the controller is provided with the combined capability of being able to communicate with aircraft, to monitor their flight progress, and to determine potential conflicts between flights. However, since much of the work done by ACCs involves co-ordination with adjacent ACCs or other air traffic control (ATC) units, it is equally important, at all levels, that ACCs are provided with adequate means to permit controllers to co-ordinate their activities, both within an ACC and also with adjacent ACCs and/or other associated ATC units (aerodrome control towers, approach control units (APP)) in the area of responsibility of the ACC concerned. The primary means for this purpose are direct telephone links and, where automation is used, automatic exchanges of data generated by the computer within an ACC for sector to sector co-ordination or automatic exchanges of data between the computers of adjacent ACCs. The more sophisticated levels of development provide ACCs with an increased traffic handling capacity and higher controller productivity.

3.1.4.1 Because of the widely varying conditions under which ACCs are required to operate, there is no single, optimum solution to the problem of layout of an ACC. Each one has its advantages and disadvantages and will vary with the method of control used (procedural, radar, etc.), the number of sectors required and the available space. Layouts now in use include straight line, controllers back to back, rows of parallel consoles/displays, all oriented in the same direction, horseshoe configurations of operating positions and island configurations where assistants' consoles are arranged beside controllers' consoles, or arrangements where assistants operate from the back of the controllers' consoles (teepee-type arrangement). However, the layout selected for a specific ACC should mainly be determined by the need to facilitate intra-centre co-ordination (i.e. between sectors) to the maximum extent possible and permit a logical flow of information between operating positions as flights progress.

3.1.4.2 At individual operating positions within the ACC, the radio, intercom and telephone control panels should be located within easy reach of the controller and should be simple to operate with quick response times. Connexions for headsets and telephones should be conveniently located and should be duplicated to permit monitoring of controllers and/or trainees as necessary. Additionally, a separate desk equipped with telephone and communications channels should be provided in a convenient location in the ACC for the watch supervisor. To keep the noise level down, every controller position as well as each co-ordinator position and the watch supervisor position should be equipped with an interphone system to permit communication with and between operating positions in the ACC. Complete sound-absorbing treatment of the floor, walls and ceiling of the operations room is necessary.

3.1.4.3 The brightness control of radar displays is critical. The controller should have the ability of individually and conveniently controlling the brightness of his display. Any glare and spillover of light from adjacent positions should be shielded and reflections from other sources masked. Polarized screening of radar displays is effective in eliminating reflections, not only from the overhead map board of the particular operating position, but also from those of the opposite row of sectors where controllers work back-to-back. General lighting of the operations room above the level of the display should be kept at the lowest possible level consistent with operational needs. Illumination below the console shelf level should be that required for safety.

3.2 STRUCTURAL REQUIREMENTS

3.2.1 For an ACC, a one or two storey stand-alone building of sufficient size to accommodate all present sectors and other equipment and positions which must be installed in the operations room, plus expansion space, access to reliable utilities, parking area and within reasonable commuting distance to suitable housing of employees would be ideal. The operations room should have ample space to permit the addition of further sectors in accordance with realistic forecast requirements, sufficient space between the rows of sectors for free movement, and sufficient space at the rear of each console to permit ease of maintenance. The room should be high enough to facilitate sound-proofing and, in view of the general interest in such facilities, should be provided with adequate arrangements to permit non-technical visitors to observe the operation without distracting controllers. If other than the ground floor level(s) of the building have to house heavy items of equipment, a freight elevator will also be required.

3.2.2 A briefing room, limited to team size, should be located close to the operations room. It can be used for briefing sessions and for current pre-shift, individual, briefing. Where required, individual delivery boxes (pigeon-holes) may also be installed in the briefing room. A ready room or break room for employee relaxation, to provide relief from operational stress, fatigue and tension, should be located near the control room for convenience during brief breaks. Where possible, it should be provided with an intercom system permitting the recall of required personnel. A bulletin board area and a literature rack for reading materials are desirable. Planning should be based on a minimum of 2 m^2 per person of the expected simultaneous occupancy.

3.2.3 Training and conference rooms in excess of 25 m^2 should have arrangements for being divided by a movable type partition with low sound transmission characteristics. Controllable natural window light is desirable.

3.2.4 At selected ACCs where radar control is the primary means of control, it may be advisable to provide a radar simulator room or space to allow training of personnel for higher qualifications and/or for the conduct of proficiency checks. If provided, it should include two to four consoles, including programmable displays, to display control problems which may, but need not, include the presentation of "live" targets as they appear on displays used in the operations room. The room should be adjacent to the computer equipment room and the training room. If space is available which can be partitioned off, the area where the radar simulator training is conducted may even be located in the control room.

3.2.5 Where provided, the playback room should be used to listen to recorded communications, either for the purpose of supporting investigations into incidents and/or to improve controller performance. The area should be provided with the required equipment including a lockable tape storage unit. The room should be acoustically treated to eliminate background noise and should be located in a secure area of the facility.

3.2.6 The communications equipment room and the radar equipment room should be located as close as possible to the operations room. The telephone equipment room should be located adjacent to the communications radar equipment room or operations room. The same applies to the automation equipment room if the ACC is using automation. These equipment rooms need not, however, be located on the same level as the operations room, but would be equally well sited immediately above or below it.

3.2.7 The locker room should provide space to secure personal belongings while controllers are on duty and to store work equipment (headsets, etc.), when off duty and should be located near the operations room. The size of the room depends on the number of lockers required. All lockers should be lockable.

3.2.8 Administrative space includes offices or space for the chief controller, and, as required for the deputy chief, administrative assistant, chief's secretary, stenographic pool, operations officer, procedures and plans officer, personnel officer, data systems officer, military liaison officer, proficiency training officer, cartographer as well as appropriate offices and space for the maintenance personnel. Adequate lobby and reception space should be provided adjacent to the major administrative area.

3.2.9 Provisions should be made for on-site food preparation and storage if the facility is remote from local markets and suppliers. When a cafeteria is provided, this may only operate during those periods of the day when a large number of people are working. To supplement the cafeteria service during the hours when the cafeteria is closed, food and drink dispensers may be provided and located in the rest room or break area.

3.2.10 Lavatories should be provided adjacent to areas of personnel occupancy. The number of toilets should be in accord with local or State code requirements for number of occupants. One or more should be located near the operations room. One or more should be designated for female use only, when appropriate.

3.3 ACCOMMODATIONS AND EQUIPMENT

3.3.1 There should be access to current weather information at each control position, preferably through individual or shared displays between adjacent positions. A link to the appropriate meteorological service is necessary in the operations room.

3.3.2 In addition, in all ACCs, an input-output link will be needed to handle control messages, approval requests (mass military movements and others), etc., received and transmitted via these links. In those ACCs where flight progress strips are computer prepared and delivered, provision must be made at the appropriate number of sectors for output printers.

3.3.3 The area reserved for the watch supervisor and, where required, the supervisory maintenance man, on duty should include desk space, telephone and intercom selector panels, and, where appropriate, a selectable radar display. Storage space for reference documentation will also be required.

3.3.4 If smoking is permitted in the operations room, consoles or desks should be fitted with ashtrays. If beverages are permitted, there should be built-in holders located safely away from all selector panels and other areas where inadvertent spillage could cause damage. There should also be small built-in drawers below the writing surface for pencils, paper, etc. Every sector should have a 24-hour clock; additional clocks should be placed in all other major work areas. These clocks should be controlled by a master clock which should be checked for correct time at least once a day.

3.3.5 Control room chairs should be comfortable, with armrests and supportive backs, and be adjustable in height and back inclination. They should roll easily on the floor covering.

3.3.6 Water should be available in all lavatories and rest rooms. Where required by climatological conditions, chilled drinking water should be readily available in the operations room and other personnel areas.

3.3.7 The training and conference rooms should be equipped with chalkboards, and, if possible, a roll-up projection screen, an overhead projector and film and slide projectors. There should be a suitable number of desk-chairs as well as an instructor desk or suitable lectern.

3.3.8 Emergency lighting in the operations room should be provided by spotlights and floor lights only. Other areas requiring emergency lighting are exit corridors and vestibules, the power generator room, the electrical and other equipment rooms, the rest room and the toilets.

3.3.9 The fire alarm system should consist of heat sensing and ionization smoke detectors, manual alarm stations, fire extinguishers, and control panels. The smoke detectors should be located in areas where a fire is most likely to break out. Manual alarm stations should be provided at exits. The fire control panel should be located at the main entry with a remote annunciator at the operations room. The control panel should activate an alarm and be capable of shutting down air-conditioning equipment. The control panel should also be connected to the local fire department. There should be an ample supply of pre-positioned fire extinguishers.

3.3.10 Each ACC should be provided with a security system adequate to the likely threats to which the facility may be exposed (see also Part III, Section 2, Chapter 1).

3.3.11 A central vacuum cleaning system should be installed for ease of maintenance. However because of noise, its blower units should be remote from areas which are normally occupied during duty hours.

3.3.12 A heating, ventilation and air-conditioning system should be provided and installed so that disturbance by the noise of its operation is kept as low as possible in the control room, offices, conference and training rooms, and in the lounge and rest room.

3.3.13 Each ACC should be supplied by a commercial power source and an uninterruptible power supply, or by one commercial power source and one standby power generator capable of supplying power to all critical equipment within 15 seconds of normal power supply failure, or by two separate commercial power sources. Where the primary power source is of poor quality, a power stabilizing system should be installed to control damaging voltage surges.

3.3.14 The demand peak in parking facilities at the facility should normally determine the required size of the parking lot; the peak will occur during shift changes. Additional arrangements to accommodate visitor and official vehicles should also be considered.

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Appendix A

CHECK-LIST

AREA CONTROL CENTRE OPERATIONS EQUIPMENT

1. Headsets
2. Microphones
3. Transceivers
4. Speakers
5. Radiocommunications selector panels
6. Telephone selector panels and handsets
7. Intercom
8. Clocks
9. Recorders (radio and telephone)
10. Daylight radar displays and consoles including radar controls
11. Secondary surveillance radar controls
12. Radar simulator
13. Automation equipment including input/output devices
14. Flight progress boards
15. Teletype for weather and for aircraft movement messages
16. Weather displays including appropriate altimeter settings
17. Clipboards and wall projection devices
18. Bulletin boards for posting pertinent information
19. Desk
20. Chair
21. Lighting — including emergency lighting
22. Fire alarm and extinguishers
23. Water fountain
24. Lunch facility
25. Heating — air conditioning/cooling
26. Power
27. Back-up power

Chapter 4
Requirements for a Flight Information Centre

4.1 OPERATIONAL REQUIREMENTS

A flight information centre (FIC) is a unit established to provide flight information service (FIS) and alerting service as specified in Annex 11 (see Part I, Section 2, Chapter 2). The basic operational requirements for FICs are the capability to obtain meteorological and other aeronautical information, and the capability to communicate with aircraft, other air traffic services (ATS) units, and associated aviation offices, e.g. search and rescue units, operators by radio, telephone, teletype.

4.2 STRUCTURAL REQUIREMENTS

4.2.1 Flight information and alerting services are in many instances provided by area control centres (ACCs), approach control (APPs) or other air traffic control (ATC) units. In those cases it is sufficient to allocate an area within the operations room or the aerodrome control tower cab for the FIS equipment and the establishment of a separate structure is not required. Combinations of other aeronautical services with FIS is also possible (see Part I, Section 2, Chapter 2).

4.2.2 Where a stand-alone FIC has been established, the building should be capable of properly housing the operating personnel and the equipment listed in 4.3 below. The building can be relatively small and simple. There need not be emphasis on expansion capability since a step up would probably result in provision for an ATC unit requiring a significantly different kind and size of building.

4.2.3 Nonetheless, the stand-alone FIC should be durable, have proper heating/cooling and ventilation facilities, sufficient electric outlets, windows, good lighting, and sufficient parking area. There should be space for storage of supplies and records. The building should be fire resistant, with an adequate number of entryways. Radio antennas can be located on the roof. Space should be set aside for the unit chief's office and for other administrative and maintenance needs as required.

4.3 ACCOMMODATIONS AND EQUIPMENT

4.3.1 Whether the FIC is a stand-alone facility or its function is included within another ATC unit, its operational equipment will be identical.

4.3.2 There should be an appropriate writing area and counter space and a display area to enable FIC personnel to keep track of aircraft for which the FIC is responsible. This can best be achieved by use of flight progress boards and equipment. There should be wall space or other adequate space to display maps, charts and similar material for easy reference. Air-ground communications with microphones and speakers or headsets are needed and a selector panel is desirable. Telephones, including selector panel, connecting with adjacent ATS units may be needed to connect the FIC with appropriate aerodrome control towers, APPs, ACCs, the associated rescue co-ordination centre or equivalent office, meteorological offices, appropriate operators' offices, NOTAM office and military units. Radio and telephone positions should have dual connexions for training and monitoring purposes. Recording equipment for both air-ground and telephone communications is desirable.

4.3.3 If possible, the FIC should have a receive unit for meteorological maps. Unless provision is adequately covered by other arrangements, the FIC should be able to make use of direction-finding equipment to plot bearings to help locate lost aircraft. There should be sufficient teletype equipment to send/receive weather information, NOTAM and flight data messages. Clipboards to maintain current NOTAM are desirable. Charts showing the approach procedures at controlled aerodromes, aerodrome layouts and similar material should be available and displayed at the operations desk or counter-top. Where possible, the material may be stored in a carousel slide projector equipped with a selection device for projection onto a convenient light wall or projection screen in case of need. Clocks and bookcases for storage of reference material are needed. Suitable chairs are necessary.

4.3.4 A stand-alone FIC should also have lavatory facilities, running water and chilled drinking water where required by climatological conditions as well as fire extinguishers and a limited amount of emergency lighting. Where necessary, a security system, adequate to the likely threat to such a facility, should be provided.

4.3.5 Appendix A provides a check-list of equipment normally required in an FIC.

Appendix A

CHECK-LIST

FLIGHT INFORMATION CENTRE EQUIPMENT

1. Writing area/counter space
2. Plotting table
3. Navigation plotting equipment
4. Large-scale area map
5. Headsets
6. Microphones
7. Speakers
8. Radiocommunications, selector panels
9. Telephones and selector panels
10. Teletype
11. Access to direction-finding equipment*
12. Flight progress console and equipment*
13. Clocks
14. Typewriter and table
15. Lighting
16. Chairs
17. Storage for reference documents
18. Lavatory
19. Running water
20. Fire extinguisher
21. Emergency lighting
22. Drinking fountain
23. Heating-air conditioning/cooling
24. Power
25. Back-up power

* Where particular circumstances warrant.