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MANUAL OF SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS (SMGCS)

FIRST EDITION — 1986

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INTERNATIONAL CIVIL AVIATION ORGANIZATION

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AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly *Supplement to the Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
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CORRIGENDA		
No.	Date	Entered by

Foreword

Discussions of requirements for surface movement guidance and control (SMGC) extend far back in ICAO's history. However, an over-all review of the subject, using a systems approach, was undertaken after the Eighth Air Navigation Conference (Montreal, 1974) which established a set of operational requirements to be satisfied by SMGC systems. In this study, ICAO was assisted by a study group composed of experts nominated by Australia, France, the United Kingdom, the United States, the Airport Associations Coordinating Council, the International Air Transport Association, the International Federation of Air Line Pilots' Associations, and the International Federation of Air Traffic Controllers' Associations.

As a first step in assisting States in implementing SMGC systems, ICAO published in 1979 guidance on the design and operation of such systems in Circular 148 entitled *Surface Movement Guidance and Control Systems*. Subsequently, a detailed review of the SMGC specifications in the various Annexes and the *Procedures for Air Navigation Services — Rules of the Air and Air Traffic Services (PANS-RAC)* (Doc 4444) was undertaken and proposals for improving them were developed. These draft proposals and the guidance on the design and operation of SMGC systems in Circular 148 were documented for review at a world-wide meeting convened in Montreal (AGA Divisional Meeting (1981)). After an in-depth review, that meeting formulated proposals for improving the specifications and identified issues that needed further study. Furthermore, the meeting recommended that the material in Circular 148 be updated so as to reflect the conclusions reached at the meeting and to provide better guidance on the selection of system components for specific aerodrome conditions. It also recommended that the updated material should be published as a manual in view of its importance (Doc 9342, Recommendation 8/19).

Accordingly, this manual has been developed to facilitate the implementation of the specifications related to SMGC systems in the various Annexes and the PANS-RAC. The manual represents a considerable advance over Circular 148 in that it:

a) incorporates less complex tables and offers improved guidance on the selection of system components (Chapter 2);
b) deals with issues not previously addressed, such as high traffic volume operations (Chapter 6), runway protection measures (Chapter 7) and apron management service (Chapter 8); and
c) includes descriptions of low visibility procedures and apron management services established at a few aerodromes so as to provide a better depiction of the issues involved.

Future editions of the manual will reflect improvements based on studies currently in progress in ICAO and on comments and suggestions received from its users. Readers are invited to express their views, and offer comments and suggestions on this edition. These should be directed to the Secretary General of ICAO.

Table of Contents

Chapter 1
Introduction

1.1 WHAT IS MEANT BY A SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEM?

1.1.1 In its broadest sense, a surface movement guidance and control (SMGC) system consists of the provision of guidance to, and control or regulation of, all aircraft, ground vehicles and personnel on the movement area of an aerodrome. "Guidance" relates to facilities, information and advice necessary to enable the pilots of aircraft or the drivers of ground vehicles to find their way on the aerodrome and to keep the aircraft or vehicles on the surfaces or within the areas intended for their use. "Control or regulation" means the measures necessary to prevent collisions and to ensure that the traffic flows smoothly and freely.

1.1.2 An SMGC system provides guidance to, and control or regulation of, an aircraft from the landing runway to the parking position on the apron and back again to the take-off runway, as well as other movement on the aerodrome surface such as from a maintenance area to an apron, or from apron to apron. In other words, the SMGC system extends over both the "manoeuvring" and "apron" areas. These two areas are collectively referred to as the "movement area". Normally the responsibility for regulating the activities and the movement of aircraft and vehicles on the manoeuvring area rests with the air traffic control service. In the case of the apron, such responsibility rests with the apron management service which is the subject of Chapter 8 of this manual. The system also provides guidance to, and control or regulation of all ground vehicles on the movement area. In addition, the system provides guidance to, and control or regulation of the personnel authorized to be on the movement area of an aerodrome. Obviously, the provision of such a system plays an important part in guarding against inadvertent or unauthorized entry onto operational runways.

1.1.3 Although this manual was mainly written with controlled aerodromes in mind, it is nevertheless true that many of the procedures, aids and functions in the manual are applicable to all aerodromes whether controlled or uncontrolled.

1.2 WHAT DOES A SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEM COMPRISE?

1.2.1 In this manual the term "surface movement guidance and control system" is applied to the system of aids, facilities, procedures and regulations designed to meet the particular requirements for guidance to, and control or regulation of, surface traffic consistent with the particular operational needs at an aerodrome.

1.2.2 An SMGC system comprises an appropriate combination of visual aids, non-visual aids, procedures, control, regulation, management and information facilities. Systems range from the very simple at small aerodromes, with light traffic operating in good visibility conditions, to the complex systems necessary at large aerodromes with heavy traffic operating in low visibility conditions. The system selected for an aerodrome will be appropriate to the operational environment in which that aerodrome will operate.

1.3 WHOM DOES A SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEM INVOLVE?

1.3.1 Because of the multi-disciplinary interests in an SMGC system, there is a need to co-ordinate fully all current and planned use of an SMGC system to ensure compatibility with aerodrome engineering, operations, communications, aerodrome air traffic control service, operators and pilot requirements. Additionally, there is a requirement to maintain compatibility of practices between States. At aerodromes which are jointly used for civil and military operations, co-ordination with the military is necessary.

1.3.2 The aerodrome authority should ensure that there is appropriate consultation and co-ordination during planning of the SMGC system with the appropriate branches of the administration of the State concerned, including aerodrome engineering, the air traffic control unit, communications and operations specialists, operators, pilots and, where appropriate, the military, to ascertain and confirm the requirements of the surface movement guidance and control system.

1.4 OPERATIONAL CONDITIONS

1.4.1 The SMGC system to be provided at an aerodrome depends primarily upon two operational conditions. They are:

a) the visibility conditions under which the aerodrome authority plans to maintain operations; and
b) the traffic density.

Each of these conditions has been further defined in Chapter 2, Table 2-1 for the purpose of selecting the appropriate combination of aids and procedures from Tables 2-2 and 2-3.

1.4.2 Although a visibility of less than 400 m is one of the criteria used, requirements for taxiing of aircraft at or near zero visibility are not addressed in this manual. Operational experience suggests that these conditions are not commonly experienced and the cost of the electronic equipment necessary to make such operations possible does not justify their consideration at this time.

1.5 OPERATIONAL REQUIREMENTS

1.5.1 The operational requirements to be met by an SMGC system have been discussed for many years. The current operational requirements are shown in Table 1-1. The requirements in the table are those appropriate to the movement area. It is recognized that a requirement exists for guidance and control of emergency vehicles outside the movement area, but this is considered to be beyond the area of applicability of the surface movement guidance and control system.

1.6 REASONS FOR PROVIDING AN SMGC SYSTEM

1.6.1 The main reason for providing an SMGC system is to enable an aerodrome to operate safely in the intended conditions. The system should be designed to prevent collisions between aircraft, between aircraft and ground vehicles, between aircraft and obstacles, between vehicles and obstacles, and between vehicles. In the simplest case, i.e. in good visibility and in light traffic conditions, this objective may be achieved by a system of visual signs and a set of aerodrome traffic rules requiring pilots and vehicle drivers to watch out and give way in accordance with specified procedures. In more complex and/or heavy traffic, a more elaborate system will be required.

1.6.2 An essential safety function of an SMGC system is to safeguard against unauthorized or inadvertent entry onto operational runways. All the different components of the system aid in accomplishing this aim. However, under poor visibility conditions this may require a means of electronic surveillance to assure air traffic control personnel that an operational runway is indeed clear.

1.6.3 Another important safety function of an SMGC system is to provide assistance to rescue and fire fighting vehicles in locating and proceeding to the site of an accident on the movement area.

1.6.4 It should be emphasized that an SMGC system should be designed so as to maintain regularity of movement under varying operational conditions. Regularity of operations suffers under heavy traffic conditions and when visibility conditions are reduced. The objective is to have a system which is compatible with the landing and take-off capacity of the runways and with the demands placed on the aerodrome. To this end, the requirements of both landing and take-off operations should be taken into account when designing an SMGC system. At some airports it may be that take-off operations occur in lower visibilities than landing operations.

Table 1-1. Operational Requirements of Surface Movement Guidance and Control Systems

The system should be appropriate to the visibility and traffic density and should provide:

1. Requirements of a general nature

   a) communication capability between the appropriate control unit(s), between the appropriate control unit(s) and aircraft and between the appropriate control unit(s) and ground vehicles;
   b) acceptable work-loads on the users of the SMGC system;
   c) optimum use of aids and procedures already specified in ICAO regulatory documents;
   d) compatibility between individual elements of the guidance and control systems; and
   e) current and forecast meteorological conditions.

2. Requirements of pilots

   a) orientation, guidance and control beginning at the end of landing roll-out on arrival, to the parking position, and from the parking position up to alignment for take-off on departure;
   b) information on the route to be followed;
   c) information on position along the route being followed;
   d) guidance along the route being followed and parking guidance;
   e) warning of:

      1) changes in direction;
      2) stops and other speed adjustments;

   f) identification of areas to be avoided;
   g) information to prevent collision with other aircraft, ground vehicles or obstacles; and
   h) information on system failures affecting safety.

3. Requirements of appropriate control units

   a) information on the identity, position and progress of aircraft including aircraft under tow;
   b) information on the identity, position and progress of ground vehicles whose movements might conflict with aircraft movements;
   c) information on the presence of temporary obstacles or other hazards;
   d) information on the operational status of elements of the system; and
   e) facilities appropriate to the control to be exercised.

4. Requirements of ground vehicles on the movement area

   a) emergency vehicles

      1) information on the route to be followed;
      2) guidance along the route being followed;
      3) capability to locate the site of an emergency;
      4) information to prevent collision with aircraft and ground vehicles; and

   b) other ground vehicles

      1) information on the route to be followed;
      2) guidance along the route being followed;
      3) information to prevent collision with aircraft and ground vehicles.

1.7 FUTURE CONSIDERATIONS

1.7.1 All aerodromes require an SMGC system. However, each system must be related to the operational conditions under which it is intended that the aerodrome shall operate. Failure to provide a system appropriate to the demands placed on an aerodrome will lead to a restricted movement rate. Complex systems are not required and are uneconomic at aerodromes where visibility and traffic density will not present a problem for the ground movement of aircraft and vehicles. Surface movement guidance and control systems should be developed with a modular concept in mind so that components can be added when traffic requirements justify such expansion. Financial considerations play an important part in the selection of a system: it should, however, be borne in mind that the selection of components in a system and their siting, in the light of planned future development, while initially more expensive can, in the long term, lead to the more advantageous use of financial resources. An example would be the provision for taxiway centre line lights during the construction of a taxiway when it is known that at a later date it is intended to upgrade the associated runway to category II or III. It should further be borne in mind that technical research will continue in this field and new components will be developed which may either complement or replace existing SMGC system components.

Chapter 2

Designing an SMGC System for an Aerodrome

2.1 VISIBILITY AND TRAFFIC CONDITIONS

2.1.1 The visibility conditions under which the aerodrome authority plans to maintain operations and the traffic density are the two most important factors to be considered when selecting components for a surface movement guidance and control (SMGC) system for an airport. For the purpose of discussing SMGC systems, visibility and traffic conditions have been subdivided and defined according to the terms indicated in Table 2-1. Whenever these terms are used in this manual they have the meanings given to them in Table 2-1.

Table 2-1. Visibility and traffic conditions associated with SMGC systems — Explanation of terms

	VISIBILITY CONDITIONS
1	Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, and for personnel of control units to exercise control over all traffic on the basis of visual surveillance;
2	Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, but insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance; and
3	Visibility less than 400 m RVR (low visibility operations).
	TRAFFIC DENSITY (in the mean busy hour as determined by the individual State)
Light	Not greater than 15 movements per runway or typically less than 20 total aerodrome movements;
Medium	Of the order of 16 to 25 movements per runway or typically between 20 to 35 total aerodrome movements; and
Heavy	Of the order of 26 or more movements per runway or typically more than 35 total aerodrome movements.

2.2 BASIC EQUIPMENT REQUIREMENTS

2.2.1 The equipment required at a particular aerodrome for provision of an SMGC system will depend both on the density of traffic and the visibility conditions in which the operations should take place. For guidance on this, see 2.4. However, the following equipment is fundamental to any SMGC system and should therefore be provided at all aerodromes:

Markings:

— runway centre line
— taxiway centre line
— taxi-holding position
— taxiway intersection
— apron
— restricted use areas

Lighting:

— runway edge
— taxiway edge
— obstacle lights
— restricted use areas

Signs:

— mandatory signs, e.g. taxi-holding position, NO ENTRY, STOP
— information signs, e.g. location and destination

Other:

— aerodrome chart
— aerodrome control service
— signalling lamp
— radiotelephony equipment.

2.3 BASIC PROCEDURAL/ ADMINISTRATION REQUIREMENTS

2.3.1 Procedures are an important and integral part of an SMGC system and they are implemented partly by the aerodrome authority, partly by the air traffic control unit, and partly by the pilot. As in the case of SMGC aids, the procedures to be employed at a particular aerodrome will be dictated by both traffic density and visibility conditions. For guidance on this, ›e 2.5. However, the following procedures are ındamental to any SMGC system and should therefore e implemented at all aerodromes:

Aerodrome authority

— designation of taxiways
— movement area inspections
— regulation of ground staff conduct on the movement area
— regulation of ground staff radiotelephony procedures
— periodic electrical monitoring of SMGC aids
— initiation of amendment of aerodrome chart as necessary
— apron management

Air traffic services

— provision of air traffic control services
— use of radiotelephony procedures and phraseology
— use of signalling lamp
— monitoring of SMGC aids

Pilot

— adherence to ground movement traffic rules and regulations
— use of radiotelephony procedures and phraseology.

2.4 MATCHING AIDS TO AERODROME CONDITIONS

2.4.1 Table 2-2 lists the aids considered appropriate for each of the nine possible combinations of traffic and visibility conditions. It will be observed that the table includes not only the basic aids detailed in 2.2.1 but also the additional aids needed to ensure safe and expeditious movement of aircraft under different traffic and density conditions.

2.4.2 The table lists the visual docking guidance system as an essential aid for a few combinations of traffic and visibility conditions. A visual docking guidance system may be useful in other situations as well. In evaluating the need for a visual docking guidance system the following factors merit consideration:

Table 2-2. Guidance on selecting SMGC system aids

Aid — Traffic condition / Visibility condition	Light 1	Light 2	Light 3	Medium 1	Medium 2	Medium 3	Heavy 1	Heavy 2	Heavy 3	ICAO DOCUMENT REFERENCE*
Apron markings	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5; *Aerodrome Design Manual*, Part 4, Chapter 2
Runway centre line marking	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5
Taxiway centre line marking	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5
Taxi-holding position marking	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5
Visual aids for denoting restricted use areas	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 7
Runway edge lights	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5; *Aerodrome Design Manual*, Part 5, Chapter 3
Taxiway edge lights	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5; *Aerodrome Design Manual*, Part 5, Chapter 3
Obstacle lighting	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 6; *Aerodrome Design Manual*, Part 4, Chapter 14
Signs	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5; *Aerodrome Design Manual*, Part 4, Chapter 11
Taxiway intersection marking	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5
Charts (aerodrome, movement, apron)	×	×	×	×	×	×	×	×	×	Annex 4, Chapters 13, 14 and 15
Aerodrome control service	×	×	×	×	×	×	×	×	×	Annex 11, PANS-RAC
Signalling lamp	×	×	×	×	×	×	×	×	×	Annex 14, Chapter 5
Radiotelephony equipment	×	×	×	×	×	×	×	×	×	Annex 11, Chapter 6
Taxi-holding position lights			×		×	×	×	×	×	Annex 14, Chapter 5
Clearance bars			×		×	×		×	×	Annex 14, Chapter 5
Electrical monitoring system for lights		×	×		×	×	×	×	×	Annex 14, Chapter 8; *Aerodrome Design Manual*, Part 5, Chapter 3
Taxiway centre line lights			×			×			×	Annex 14, Chapter 5; *Aerodrome Design Manual*, Part 5, Chapter 3
Stop bars			×		×	×		×	×	Annex 14, Chapter 5; *Aerodrome Design Manual*, Part 5, Chapter 3
Selective switching capability for taxiway centre line lights						×			×	*Aerodrome Design Manual*, Part 4, Chapter 10 and Part 5, Chapter 3
Selective switching capability for apron taxiway centre line lights						×			×	*Aerodrome Design Manual*, Part 4, Chapter 10 and Part 5, Chapter 3
Surface movement radar (SMR)						×		×	×	*Air Traffic Services Planning Manual*
Aircraft stand manoeuvring guidance lights			×			×			×	Annex 14, Chapter 5
Runway clearance aid			×			×		×	×	Annex 14, Chapter 5
Secondary power supply			×		×	×		×	×	Annex 14, Chapter 8; *Aerodrome Design Manual*, Part 5, Chapter 2
Visual docking guidance system						×		×	×	Annex 14, Chapter 5; *Aerodrome Design Manual*, Part 4, Chapter 12

* See Appendix A for further information on visual aids

Table 2-3. Guidance on selecting SMGC system procedures

	Traffic condition —	Light			Medium			Heavy			
Procedure	Visibility condition —	1	2	3	1	2	3	1	2	3	ICAO DOCUMENT REFERENCE*
Aerodrome authority											
Periodic electrical monitoring of SMGC aids		×	×	×	×	×	×	×	×	×	Annex 14, Chapter 8 and Chapter 3 of this manual
Designation of taxiways		×	×	×	×	×	×	×	×	×	See Chapter 3 of this manual
Movement area inspections and reporting		×	×	×	×	×	×	×	×	×	Annex 14, Chapter 2 and Chapter 3 of this manual
Regulation of ground staff conduct on the movement area		×	×	×	×	×	×	×	×	×	See Chapter 3 of this manual
Initiation of amendment of aerodrome charts as necessary		×	×	×	×	×	×	×	×	×	See Chapter 6 of this manual
Regulation of ground staff radiotelephony procedures		×	×	×	×	×	×	×	×	×	Annex 10, PANS-RAC
Establishment of standard taxi routes				×		×	×	×	×	×	See Chapters 3 and 6 of this manual
Low visibility movement area protection measures				×			×			×	See Chapter 5 of this manual
Continual electrical monitoring of SMGC aids				×			×			×	Annex 14, Chapter 8 and Chapter 3 of this manual
ATS											
Visual monitoring of SMGC aids		×	×	×	×	×	×	×	×	×	Annex 11, Chapter 7 and Chapter 3 of this manual
Use of radiotelephony procedures and phraseology		×	×	×	×	×	×	×	×	×	Annex 10, PANS-RAC, Part 9 and the *Manual of Radiotelephony*
Use of signalling lamp		×	×	×	×	×	×	×	×	×	Annex 2, Appendix A
Control of other than aircraft traffic on the manoeuvring area		×	×	×	×	×	×	×	×	×	PANS-RAC, Part 5
Operation of lighting aids		×	×	×	×	×	×	×	×	×	PANS-RAC, Part 5
Determination of the taxiway route to be followed				×		×	×	×	×	×	PANS-RAC, Part 5 and Chapter 3 of this manual
Application of sequencing procedure				×	×	×	×	×	×	×	See Chapter 4 of this manual
Initiation and termination of low visibility procedures				×			×			×	PANS-RAC, Part 5 and Chapter 5 of this manual
Application of separation criteria				×			×			×	PANS-RAC, Part 5, and Chapter 4 of this manual
Continual electrical monitoring of SMGC aids				×			×			×	Annex 11, Chapter 7 and Chapter 3 of this manual
Monitoring of surface movement on SMR							×		×	×	See Chapter 4 of this manual
Selective switching of taxiway centre line lights							×			×	*Aerodrome Design Manual*, Part 4 and PANS-RAC, Part 5
Selective switching of stop bars				×		×	×		×	×	*Aerodrome Design Manual*, Part 4 and PANS-RAC, Part 5

* See Appendix A for further information on visual aids

Table 2-3. Guidance on selecting SMGC system procedures *(cont.)*

	Traffic condition —	Light			Medium			Heavy			
Procedure	Visibility condition —	1	2	3	1	2	3	1	2	3	ICAO DOCUMENT REFERENCE*
Adherence to ground movement traffic rules and regulations		×	×	×	×	×	×	×	×	×	Annex 2, PANS-RAC
Use of radiotelephony procedures and phraseology		×	×	×	×	×	×	×	×	×	Annex 10, PANS-RAC and the *Manual of Radiotelephony*
Apron management											
Apron regulations and procedures		×	×	×	×	×	×	×	×	×	Annex 14, Chapter 9 and Chapter 8 of this manual
Emergency procedures		×	×	×	×	×	×	×	×	×	Chapters 5 and 8 of this manual
Communication procedures with ATS		×	×	×	×	×	×	×	×	×	Chapters 4 and 8 of this manual
Stand allocation and information		×	×	×	×	×	×	×	×	×	Chapter 8 of this manual
Apron security procedures		×	×	×	×	×	×	×	×	×	Chapter 8 of this manual
Operation of lighting and docking aids				×			×			×	Chapter 8 of this manual
Provision of discrete RTF channel							×	×	×	×	Chapter 8 of this manual
Low visibility procedures				×			×			×	Chapter 5 of this manual

* See Appendix A for further information on visual aids

— the number of aircraft using the aircraft stand
— weather conditions
— space available on the apron
— precision required at the parking position
— availability and cost of alternative means.

2.4.3 Signs are a basic aid. They serve an important function in informing a pilot and reducing RTF communications. The number and quality of signs provided at an aerodrome is a variable which is not reflected in the table. As traffic increases or visibility decreases improvements in the signs provided as well as the lighting and electronic aids used for guidance and control are required.

2.4.4 Charts are another aid which cannot be precisely specified. Until recently only an aerodrome chart was defined in Annex 4. This is now recognized as insufficient, as more information about the aerodrome is often required than can be shown on the aerodrome chart. Accordingly, a ground movement chart is specified and when this too is incapable of showing all information an apron parking/docking chart is required. As the provision of these charts is related to the complexity of the aerodrome and not visibility or traffic conditions only one entry, "Charts", is included in Table 2-2. The aerodrome authority should assess the number of charts required in accordance with the amount of information required to be shown.

2.5 MATCHING PROCEDURES TO AERODROME CONDITIONS

2.5.1 Table 2-3 lists the procedures considered appropriate for each of the nine possible combinations of traffic density and visibility conditions. It will be observed that the table includes not only the basic procedures detailed in 2.3.1 but also the additional procedures needed to ensure safe and expeditious movement of aircraft under different traffic and visibility conditions.

2.5.2 It is to be noted that a separate section of Table 2-3 has been devoted to apron management procedures. This has been done to conveniently isolate applicable procedures for the case where it is intended to establish a self-contained apron management unit. If no separate apron management unit is established, responsibility for these procedures will rest, in part, with the ATS unit and, in part, with the aerodrome authority.

2.6 REVIEW OF SYSTEM AND IMPROVEMENT

2.6.1 Regular reviews of the SMGC system should be carried out to ensure that the system is fulfilling its intended task, and to assist the aerodrome authority in planning ahead for the orderly introduction of a more advanced system and the necessary supporting facilities, as and when warranted. Ideally, a master plan will have been prepared for the aerodrome in the early stages of its development, in which case a review of the system at regular intervals will serve to monitor the development of the aerodrome in relation to the time frame employed in the master plan.

2.6.2 In all cases, the SMGC system will need to be reviewed under one or more of the following circumstances:

a) the volume of traffic increases significantly;
b) operations in lower visibility conditions are planned; and
c) the aerodrome layout is changed, i.e. new runways, taxiways, or aprons are brought into operation.

It is also conceivable that ATS restructuring of the airspace surrounding the aerodrome, or other external circumstances, may affect the flow of traffic to and from the aerodrome, and consequently the pattern of movements on the runways, thereby influencing the SMGC system requirements.

2.6.3 Apart from traffic movement counts, the extent to which increased traffic volume is causing a deterioriation of the effectiveness of the SMGC system may be determined by the appearance of the following symptoms:

a) a marked need for increased vigilance in the visual surveillance of surface traffic movements, generated by the number of movements occurring simultaneously throughout the aerodrome complex;
b) a marked increase in the loading on the communications channels used for SMGC;
c) an increase in the number of problems occurring at crossing points and runway/taxiway intersections, requiring intervention by the controller and thereby contributing to the increase in radio communications; and
d) the occurrence of bottlenecks, congestion and delays in surface traffic movements.

Chapter 3

Functions and Responsibilities

3.1 GENERAL

3.1.1 In the surface movement guidance and control (SMGC) system, as in any other system, one needs to identify who is responsible for what and when, why and how. Accordingly, this chapter discusses certain important functions and responsibilities of those most involved with surface movement guidance and control, namely:

— air traffic services
— apron management service
— pilots
— aerodrome authority
— ground vehicle drivers.

The chapter clearly details the division of responsibilities, provides a brief outline of control functions and emphasizes the need to avoid overcontrol. In addition, some functions such as the use of ground vehicle control, monitoring and maintenance of visual aids are addressed.

3.1.2 The area most commonly overlooked in many systems is training. For an SMGC system to function correctly, all personnel responsible for implementing part or all of the system must be trained, monitored and practised in the performance of assigned duties. Training as it applies to SMGC systems is covered in this chapter.

3.2 DIVISION OF RESPONSIBILITIES AND THEIR TRANSFER

Air traffic services

3.2.1 Use of radiotelephony procedures and phraseology. Radiotelephony will be the primary method of communication between ATS and aircraft, surface vehicles and rescue and fire fighting vehicles operating on the manoeuvring area. It is important that radiotelephony (RTF) communications be conducted in the standard manner with regard to phraseology, procedures and language. At busy aerodromes the work-load on the controller can be extremely high and SMGC systems should be designed with a view to minimizing the need for RTF communication.

3.2.2 When aircraft and vehicles operate outside the manoeuvring area but under the guidance of an ATS unit it is preferable that detailed written procedures governing their operation be employed.

3.2.3 Issue of taxi clearance to facilitate SMGC. The appropriate air traffic service unit will be responsible for the release of departing aircraft in a sequence which will expedite the traffic flow, and for the expeditious routing of arriving aircraft. In good visibility, sequencing can be done by visual observation and radiotelephony. In reduced visibility or where traffic density warrants, more advanced means need to be provided since ATC becomes progressively more involved in guidance and control.

3.2.4 Determination of taxi routes to be followed. ATS and the aerodrome authority should determine jointly the routings to be taken by aircraft and vehicles. The aim should be to achieve the most expeditious and orderly traffic flow possible. ATC will advise the pilot or vehicle driver as to the particular route to be followed and will, where necessary, resolve conflicts at intersections.

3.2.5 Monitoring of SMGC system aids. As the bodies responsible for operating the SMGC system, the appropriate ATS unit and the aerodrome authority should be aware of the need to monitor the system and to have any failures rectified as soon as is practicable. This monitoring may take the form of visual surveillance of lights, taking into account reports from pilots, and of electrical monitoring of electrical and electronic components of the system.

3.2.6 Control of traffic other than aircraft on the manoeuvering area. While the principal task of an air traffic controller is the control of aircraft, he is also responsible for controlling vehicles. When visibility reduces, it shall be at the discretion of the air traffic controller to restrict movements of vehicles as necessary. The amount of control over the movement of ground vehicles exercised by the aerodrome control service will increase as visibility reduces (see 5.2 and 5.3). With the exception of rescue and fire fighting vehicles responding to an emergency, the controllers should ensure that aircraft receive priority and are not hindered by the movement of vehicles. It is important that the aerodrome authority and the appropriate air traffic control unit be empowered to carry out this task effectively.

3.2.7 Operation of visual guidance and control aids. The appropriate aerodrome control service will be responsible for operating the visual components of the control system, including stop bars, taxiway centre line lights and routing designators. That unit will also need to ensure that the lights are illuminated at the appropriate time. With regard to lighting systems installed on the apron, i.e. apron taxiway centre line lights, aircraft stand manoeuvring guidance lights and parking and docking guidance systems, it will be essential at each aerodrome to determine which body will be responsible for their operation.

3.2.8 Division of responsibility between controller and pilot. Prevention of collision is a joint pilot/ATS responsibility with the controller always responsible for the resolution of intersection conflicts. In the lower visibilities, the over-all responsibility for the avoidance of collision becomes increasingly that of the ATS unit.

3.2.9 Initiation and termination of low visibility procedures. It will be the responsibility of the air traffic control unit to initiate procedures appropriate to low visibility operations. To assist in this, advice will be needed from the meteorological office so that advance preparations can be made for low visibility procedures. These preparations may take some time, and should therefore be started in time to complete them before reducing visibility requires other actions such as the application of greater aircraft separation. When the visibility improves, the cancellation of these procedures will take place at the discretion of the air traffic control unit. (See 5.3 concerning initiation and termination of low visibility operations.)

Apron management service

3.2.10 At some aerodromes, management of traffic on the apron is not the responsibility of the air traffic control unit. At these aerodromes there should be an apron management service responsible for ensuring the safe movement of aircraft on the apron. All rules and regulations applicable to aircraft movements on the apron should be consistent with the rules and regulations applicable to the manoeuvring area and close liaison between the apron management service and ATS unit is essential.

Pilots

3.2.11 The pilot will respond to the instructions given by the apron management service and the air traffic control unit and follow the designated taxiway route. The pilot's responsibilities with respect to collision avoidance are discussed in 4.3.

Aerodrome authority

3.2.12 Movement area inspections. The aerodrome authority will be responsible for conducting frequent inspections of the movement area to ensure that the areas intended for aircraft movement are kept unobstructed and in good repair. It is particularly important that an inspection be completed before the initiation of low visibility procedures as these procedures will, in themselves, prevent such an inspection. (See 3.7 for discussion on monitoring of SMGC system aids.)

3.2.13 Ground staff. The aerodrome authority and ATS will be responsible for the regulation and control, respectively, of ground staff on the movement area. The aerodrome authority will be responsible for ensuring that ground staff are properly trained particularly in RTF and monitored in its use. During low visibility operations, it will be particularly important to restrict the movement of ground staff on the movement area to a minimum. (See 5.3 for details of procedures for low visibility operations.)

3.2.14 Servicing of SMGC aids. The aerodrome authority will normally be responsible for ensuring that all visual components of the SMGC system are kept serviceable. This will require frequent physical inspections of these visual components.

3.2.15 Designation of taxiways and standard taxi routes. In conjunction with the ATS, the aerodrome authority will be responsible for the designation of taxiways and for the establishment of standard taxi routes applicable to the types of operations expected to take place at the aerodrome. The designation and promulgation of standard routes for taxiing aircraft become particularly important for intended operations at busy aerodromes in low visibility conditions.

3.2.16 Low visibility movement area protection measures. It will be the responsibility of the aerodrome authority or other competent authority to ensure that the number of persons and vehicles authorized to operate on the movement area during periods of low visibility is kept to a minimum.

Ground vehicle drivers

3.2.17 Drivers of ground vehicles must comply with aerodrome regulations and ATC instructions. Notwithstanding this, drivers are responsible for exercising due care and attention so as to avoid collisions between their vehicles and aircraft, and between their vehicles and other vehicles.

3.3 AVOIDANCE OF OVERCONTROL

3.3.1 The surface movement guidance and control system should provide a degree of control which is adequate to meet the needs of pilots and controllers.

3.3.2 It is important to ensure that the efficiency of the over-all system is not impaired by the imposition of unnecessary controls and restrictions on pilots and controllers. Pilots and controllers should be allowed to exercise their specific responsibilities when circumstances so permit. When circumstances do not allow this, additional restraints are progressively required to ensure safety of ground movement. It is particularly important that these restraints be removed promptly as conditions improve.

3.3.3 With contemporary SMGC systems the traffic capacity may be reduced by the need, in certain circumstances such as during low visibility operations, to exercise high levels of control. Future advances in automated systems may permit a higher degree of control without adverse effect on capacity.

3.3.4 Major considerations of ground movement control in low visibility operations should be to:

a) avoid traffic conflicts between taxiing aircraft and between an aircraft and a ground vehicle;
b) ensure that aircraft or ground vehicles do not enter the ILS critical or sensitive areas at an improper time;
c) ensure that the runway in use is clear when an aircraft is landing or taking off;
d) facilitate taxiing to and from the runway; and
e) maintain the maximum safe capacity of the airport.

3.3.5 All aircraft and other vehicles operated on the manoeuvring area of a controlled aerodrome must be subject to aerodrome control, and controlled by radio communications, or as otherwise authorized by prior arrangement. Control may include accompaniment by an appropriate escort who is in direct radio communication with aerodrome control.

3.3.6 Control of ground movement of aircraft and vehicles during periods of low visibility should be based on maximum use of procedures and aids which are common for operations in good visibility. It has been found that, to a certain extent, procedures and aids which facilitate movement on a busy aerodrome will also satisfy the requirements for low visibility operations, and vice versa.

3.3.7 In order for ground movement of aircraft and vehicles to take place with efficiency and safety in low visibility, aids must be provided to substitute for the visual information normally available to pilots and controllers for surveillance and guidance information.

3.3.8 The primary means of control over ground traffic in low visibility can be procedural, using radio voice communications between aerodrome control and the pilot or vehicle operator, supplemented by visual information in the form of lights, surface markings and signs. Although visual aids and procedures may be adequate for ground movement in low visibility, such operations must be conducted with extra caution. As traffic demand increases, ATC work-load can be minimized by the provision of additional aids.

3.4 GROUND MOVEMENT COMMUNICATIONS

3.4.1 The communication aspects of an aerodrome control service fall into three main categories:

a) control of air traffic in the circuit and in the approach, landing and departure phases of flight;

b) control of taxiing aircraft and vehicles on the manoeuvring area; and
c) acquisition and passing of airways clearances, weather information and other flight data.

At an aerodrome with light traffic one controller may be responsible for all of these duties, using one RTF channel for all purposes. At a large aerodrome with heavy traffic, the aerodrome control service may be shared between a number of controllers and assistants. The increase in traffic demand may also carry an increase in total RTF loading which demands the use of separate channels.

3.4.2 In a developing aerodrome or traffic situation the point at which additional control positions need to be introduced may hinge solely upon RTF channel loading, or the decision may be prompted by other factors such as controller work-load generated by the particular mix of traffic, complexity of aerodrome layout or the need to provide a control position which offers a better view of the manoeuvring area. Whether or not the duplication of positions is due to RTF loading, each position should have its own discrete frequency.

3.4.3 A typical usage of two RTF channels is to have the service described in 3.4.1 a) on one frequency and 3.4.1 b) and c) on the other; b) and c) subsequently become divided when work-load develops to the point at which another channel is required. In some instances it may become necessary to open an additional frequency or frequencies, during the busy hours of the day and then revert to a more limited communication channel usage in the less busy periods.

3.4.4 It is customary for non-aeronautical radio frequencies to be used for communication between ground vehicles and various aerodrome agencies such as contractors, customs, police, airline companies, etc., but it must be ensured that when operating on the movement area use of the non-aeronautical frequency does not preclude maintenance of a listening watch on the ground movement control frequency.

3.4.5 A spare frequency for use if a normal channel is jammed/overloaded is a highly desirable facility which can, on occasion, save a great deal of trouble and delay.

3.4.6 At many aerodromes provision is made for a discrete RTF contact between emergency services vehicles and an aircraft which has landed after declaring an emergency, or in any emergency when the aircraft is on the ground and capable of being manoeuvered. This is of particular significance with large aircraft where it is important for the crews of the emergency vehicles to be aware of the pilot's intentions so that risk to aircraft occupants and to personnel on the emergency vehicles may be minimized. For such a discrete frequency to be of value it is obviously necessary that the users of radiotelephony equipment in these circumstances be able to communicate in a common language. For situations where a common language does not exist, communication between the pilot and the fire service will have to be relayed by ATC.

3.5 ESTABLISHMENT OF STANDARD TAXI ROUTES FOR AIRCRAFT

3.5.1 On an aerodrome the movement of taxiing aircraft generally falls into a distinctive pattern in which the major traffic flows are between:

— runways and aprons
— aprons and maintenance areas
— maintenance areas and runways.

Where possible, standard taxi routes which are direct, simple and capable of being used in both good and bad visibility (see Chapter 5 for low visibility operations) and which offer minimum conflict with the routes of other aircraft or vehicles should be arranged between these locations. One-way systems should be introduced where this can be done without greatly extending taxiing distances as, among other things, long taxi distances result in higher temperatures for brakes and tires.

3.5.2 Care should be taken to ensure that the routes are adequate for the largest aircraft likely to use them, and that aircraft using them do not offer problems of:

a) interference with navigation aids;
b) penetration of the obstacle free zone and, where possible, penetration of other obstacle limitation surfaces;
c) obstruction of radar transmissions;
d) physical obstruction (e.g. inadequate clearance from aircraft holding for take-off from an intermediate point); or
e) jet blast.

3.5.3 Routes will vary according to the runways in use for landing and take-off. A route plan must allow for an orderly transition from one operational mode to another, e.g. following a runway change, and also the aircraft which, after taxiing for take-off, needs to return to the apron.

3.5.4 For aerodromes where standard taxi routes are provided, details of such routes should be published in the appropriate aeronautical information publication and shown on aerodrome charts. Routes should normally be identified by designators. The designators of taxi routes should be distinctively different from those of the runways, taxiways and instrument departure routes. Where a route includes taxiing between areas under control of ATS and the apron management service, the transition points should be indicated on either the aerodrome chart or ground movement chart.

3.5.5 An established standard taxi route system offers advantages over a random system, in that it increases safety, expedites movement, provides for more confident operation in reduced visibility and decreases the RTF work-load.

3.6 CONTROL OF GROUND VEHICLES

3.6.1 The servicing and maintenance of aircraft and of aerodrome installations inevitably demands the presence of vehicles on the movement area. Annexes 11 and 14 and the PANS-RAC require that the movement of persons and vehicles on the movement area shall be controlled or regulated as necessary to avoid hazards to them or to aircraft. The *Aerodrome Design Manual* (Doc 9157), Part 2, Chapter 4 stresses the importance of planning aerodrome facilities for the maximum segregation of aircraft and vehicular traffic, with airside road systems so designed that critical sections of the movement area for traffic congestion can be by-passed.

3.6.2 The *Aerodrome Design Manual*, Part 2, also points out the value of airside roads to eliminate, or lessen, the use of runways and taxiways by ground vehicles which need access to the movement area. For example, aerodrome perimeter service roads may provide access to navigation aids, or from one service area to another. An airside road may connect one terminal with another for airline vehicles, baggage trains, etc. Every effort should be made to avoid airside roads crossing runways and taxiways, or affecting the function of navigation aids. If it is necessary for an access road to cross beyond the end of a runway, stopway or clearway, the road should be so located that vehicles travelling on it do not become obstacles to aircraft operations.

3.6.3 On an apron, interaction between aircraft and vehicles is unavoidable, and guidance for drivers is necessary if safe and efficient use is to be made of the available space. Apron safety lines should be provided on a paved apron to define the limits of areas established for use by ground vehicles and other aircraft servicing equipment. These lines should be of a conspicuous colour and should contrast with apron markings for aircraft, i.e. aircraft stand markings. Vehicle crossings from terminal area or airside road to an aircraft stand, and from aircraft stand to aircraft stand, should be delineated by conspicuous painted lines.

3.6.4 Airside route systems for vehicle movement fall into five broad categories:

a) roads which are completely segregated from aircraft movements;
b) roads which cross taxiways in maintenance areas but which are segregated from operational aircraft movement;
c) routes which cross operational runways, stopways, clearways or taxiways;
d) apron routes; and
e) vehicle movement along operational taxiways and runways.

The manoeuvring area should be protected from inadvertent entry by persons and vehicles from air side road, e.g. by signs or traffic lights on access roads. The movement of persons on foot should not be allowed on runways or taxiways unless absolutely necessary.

3.6.5 Where construction or other activity calls for localized free moving traffic, the boundaries of a temporarily closed area should be marked as described in Annex 14, and any movement outside the area should comply with normal aerodrome regulations. (Annex 14, Chapter 2 stipulates the requirements for promulgating information on the condition of the movement area.)

3.6.6 Detailed written procedures particularly for apron activities based on methods other than RTF, should be developed for low visibility operations by the appropriate authority to ensure safety while maintaining capacity.

3.7 MONITORING

3.7.1 *Lighting aids*

3.7.1.1 Surface movement guidance and control relies heavily upon lights for safe operations in reduced visibility and at night, and it is of vital importance that ATC should be aware of any discrepancies between the lighting selected on the lighting control panel in the control tower and the lights which actually show on the aerodrome surface. Normally in good conditions at night, it is not difficult to see whether the switches operated bring on the appropriate surface lights; the problems arise in reduced visibility when the lights are not visible to the controller.

3.7.1.2 Ideally all lights should be operative but as a guide for maintenance it is considered that not more than 20 per cent of taxiway centre line lights should be inoperative, and two consecutive taxiway centre line lights should not be inoperative. Because of the normally high reliability of aerodrome lighting systems, an electrical monitoring system may not be required, but visual inspection should be carried out with sufficient frequency to ensure adequacy of the taxiway lighting system.

3.7.1.3 In conditions when direct visual appraisal of aerodrome surface lights is not possible, monitoring is usually carried out by:

a) observation of "mimic" or "tell-tale" lights on the lighting control panel; and
b) checking of power supply and circuit state indicators.

It is important that lighting display panels are so engineered that they constitute effective monitors of surface lighting. Many lighting control panels provide a tell-tale indication only of the lighting selected and do not indicate whether the lights are actually lit. A feedback mimic may indicate whether a particular group of lights is on or not, but may not reflect individual light failures which could be significant for movement in low visibility. Power supply and circuit state indications can provide information on the percentage of light outage without showing the specific nature of the failures. Problems can arise from failure of lamps to extinguish, as well as from failure to light, on selection. Safe and efficient ground movement in low visibility demands a monitoring system so designed that the controller is quickly aware, and continuously reminded, of any lighting failure which could affect safety or cause taxiing difficulties in the area for which he has responsibility.

3.7.1.4 Information is available in the *Aerodrome Design Manual*, Part 5, *Electrical Systems*, concerning the type of electrical monitoring system which should be installed to verify instantly that all lighting equipment is in good working order. Sample monitor signals to indicate the operational status of an installation are:

a) installation out of order: tell-tale light off;
b) installation in order: tell-tale light on and steady; and
c) installation faulty when switched on: tell-tale light blinking.

Different blinking frequencies can indicate different degrees of fault and a failure warning is accompanied by a sound alarm.

3.7.1.5 The extent and detail of monitoring that can be done in the control tower will depend upon the size and complexity of the lighting system. For an elementary layout full system monitoring might be acceptable in the tower. At a large aerodrome, well equipped for low visibility operations, lighting control and monitoring might need to be concentrated in a technical control room. The panel in the control tower would indicate a fault, the more sophisticated engineer's panel would indicate the precise nature of the fault and this information would be immediately relayed to the appropriate ATS unit.

3.7.1.6 To ensure the integrity of monitoring systems it is desirable that their power supply should be obtained from a separate source. (See also Annex 14, Chapter 8 for specifications regarding the application and characteristics of a secondary power supply.)

3.7.2 *Non-visual aids*

3.7.2.1 With the introduction of non-visual aids to SMGC the dependence of ATC upon the correct functioning of the non-visual aids will be such that, as with aerodrome lighting, a monitor system must be provided to indicate any malfunction.

3.8 AERODROME SURFACE INSPECTIONS

3.8.1 *Frequency of inspection*

3.8.1.1 Inspections of the movement area should be regular and frequent. Guidance on inspections is provided in the *Airport Services Manual* (Doc 9137), Part 8. It recommends that the minimum frequency should be:

a) Runways — Four inspections daily as described below:

   Dawn inspection — A detailed surface inspection covering the full width of all runways should be undertaken. This should take approximately 15 minutes for each runway (two runs).

   Morning inspection — All runways, between aircraft movements when necessary, concentrating on the area between the runway edge lights.

   Afternoon inspection — Same as the morning inspection.

   Dusk inspection — This should cover all runways. It is designed to bridge the gap in runway inspections when the lighting inspection is not required until late in the evening, and should cover the whole runway surface.

b) Taxiways — Daily for those in normal regular use.

c) Aprons — Daily.

d) Grass areas — Those areas that may be required to sustain aircraft should be inspected as frequently as the adjacent paved areas. Other grass areas should be inspected at intervals suitable to observe any deterioration of the surface.

3.9 MAINTENANCE

3.9.1 *Maintenance — general*

3.9.1.1 The various visual aids of the SMGC system comprising route guidance are listed in Table 2-2. All these components require routine inspection, cleaning, servicing and maintenance in common with other elements of aviation lighting. Guidance on the preventive maintenance of lighting systems is contained in Annex 14, Chapter 9, and in the *Airport Services Manual*, Part 9.

3.9.1.2 The integrity and reliability of the SMGC system should match the other visual and non-visual navigation aids. Routine re-painting programmes should ensure that those components of the system comprising runway and taxiway markings, taxi-holding position markings and signs are adequate for the conditions of visibility for which they are intended. The integrity of the SMGC lighting components will depend both upon the design of the internal aerodrome circuits and the external power supply. The reliability of the system will depend upon the degree of inspection carried out and the programme of preventive maintenance employed. While unserviceable lights are undesirable, their presence within the visual guidance and control system will depend upon their spacing and the visibility limits within which the system is designed to provide guidance.

3.9.1.3 Special checks. Where visual aids are provided for operations in low visibility, special inspections should be carried out whenever possible before the low visibility operations are initiated. These inspections should ensure that serviceability is sufficient to provide continuous guidance and that no two consecutive taxiway centre line lights or more than one stop bar light on each side of the taxiway centre line have failed.

3.9.1.4 Where high intensity taxiway centre line and stop bar lighting is provided for low visibility operations, particular attention should be paid to cleanliness of taxiway centre line and stop bar lights, and to the conspicuity of taxiway centre line and apron markings.

3.9.1.5 Special inspections should be carried out before a section of a taxiway is returned to operational use if it had been closed for maintenance, snow clearance or other reasons.

3.9.1.6 Routine maintenance. The extent to which routine maintenance can be combined with routine inspection will depend upon local arrangements. Where personnel carrying out routine inspection and light cleaning are skilled electricians, maintenance as necessary should be included in the daily checks. If the inspection is carried out by operational staff who are not qualified in maintenance, close liaison will be necessary with the appropriate aerodrome maintenance personnel to ensure that follow-up action is taken as necessary.

3.9.1.7 Daily maintenance at busy aerodromes with high sustained movement rates is difficult to arrange and work within the movement area may have to be carried out at night, i.e. when the traffic volume is generally low. Work schedules should be prepared for replacement of failed lamps or rectification of circuit faults, as revealed by the daily checks. At aerodromes with a large and complex taxiway system, it may be necessary to have more than one maintenance team operating on fault rectification within the movement area during periods when the traffic volume is low.

3.9.2 *Special fault rectification*

3.9.2.1 In addition to the routine maintenance, it will be necessary at busy and complex aerodromes to have personnel available for special fault rectification when failures occur which affect the ability of the system to meet the operational requirement. This will be essential where a centralized control system has been provided and operations are being carried out in restricted visibilities.

3.9.2.2 Special fault rectification will be necessary where consecutive lamp failures have occurred within the taxiway centre line lights or stop bars, where taxi-holding position lights have failed or where lamp failure has occurred affecting mandatory instruction signs, e.g. STOP, CAT II, etc.

3.9.2.3 When a fault occurs during low visibility operations, it will be necessary to consider whether the system can continue to give safe guidance and control without immediate fault rectification or whether operations have to be restricted while the fault is being rectified. When it is decided that a fault does need to be rectified, then a ground vehicle or vehicles must be permitted on the manoeuvring area and must be provided necessary separation/protection from other traffic.

3.10 TRAINING

3.10.1 The training requirements of licensed personnel, e.g. air traffic controllers and pilots, is the responsibility of the State but the training of other personnel authorized to operate on the movement area or involved in the provision of the SMGC system, is the responsibility of the appropriate authority. Training falls into two main categories: initial and recurrent or proficiency training.

3.10.2 Initial training is provided by the appropriate authority to all new employees and newcomers to a specific unit. It normally covers but is not limited to:

- — RTF procedures
- — aerodrome layout
- — aerodrome procedures
- — aerodrome emergency procedures
- — aerodrome low visibility procedures
- — aerodrome special procedures
- — aircraft recognition
- — vehicle operating procedures.

3.10.3 Recurrent or proficiency training should not be overlooked. When dealing with low visibility operations, this training may be critical since the exposure to low visibility procedures is limited due to one or both of the following:

a) the infrequent occurrence and short duration of low visibility conditions; and
b) individual shift rotation or extended absence from duty for whatever reason.

3.10.4 It is suggested that appropriate recurrent training be given at least every six months. Such training can take different forms depending on the degree of involvement of the staff member. It should be designed keeping in mind the safety of aircraft and the effect of misapplication of an aerodrome procedure.

Chapter 4
Procedures

4.1 INTRODUCTION

4.1.1 The basis for all operations on the manoeuvring area of an aerodrome is contained in Annexes 2, 11 and 14 and the PANS-RAC. These documents prescribe rules and requirements for the operation of aircraft and vehicles on the manoeuvring area which, if meticulously observed, would ensure the safety of operation on the manoeuvring area.

4.1.2 Nevertheless, as traffic demand on an aerodrome increases, the rate of traffic flow may suffer because of the prevailing rules. With increase in the traffic density the development of more positive surface movement guidance and control is essential to maintain capacity.

4.1.3 Surface movement control requires aircraft and vehicles to obtain air traffic control clearances and authorization respectively as prerequisites to operating on the manoeuvring area (PANS-RAC), and this, in turn, gives air traffic control the authority to allocate, for example, taxiing routes and priorities to ensure the smooth flow of traffic. The result is a very practical system of surface movement control, which depends heavily on a sharing of responsibilities between pilots, vehicle drivers and air traffic controllers for collision avoidance.

4.2 TRAFFIC FLOW

General

4.2.1 Except for the resolution of taxiway conflicts, the majority of requirements to vary the flow of air traffic on the manoeuvring area spring from other sources, e.g. departure or en-route flight limitations or surface congestion. It is the surface movement control system which must act as the buffer between the runway and the parking stand to absorb externally imposed delays or priorities. This task can be accomplished in two ways: firstly, in the case of departing aircraft, air traffic control may temporarily withhold clearances to start engines, push back or taxi as a broad regulatory strategy; and, secondly, air traffic control may, as a more tactical measure, sequence aircraft which have already been given clearance to taxi.

Clearance withholding (gate holding procedure)

4.2.2 When planned departures may be subject to significant delay due to factors such as:

a) en-route or terminal clearance limitations; or
b) weather conditions below pilot's operating limits,

there are advantages in delaying engine start-up and absorbing the delay on the apron. This technique saves fuel and engine running time, and reduces the probability of the restricted aircraft blocking the route of other aircraft which are not subject to delay.

4.2.3 A method of dealing with 4.2.2 a) is for the ATS to operate a "request engine start" procedure with aircraft about to depart, and to maintain a close liaison with the air traffic control centre on the length of delay applicable on the routes served by the aerodrome. On receipt of the "request engine start" transmission the controller will consider the required departure time in relation to likely taxiing time and delay at the holding point, and will issue an engine start-up time calculated to absorb most of the residual time with engines off. For example:

Request engine start	10.10
Designated take-off time	10.42
Average taxiing time to holding point including contingencies ...	10 minutes
Time from "engine start" to "ready to taxi"	4 minutes

Instruction given "Start engines at 10.28".

4.2.4 With 4.2.2 b), since a pilot's operating limits are normally not known to the ATS, the onus is placed on the pilot to defer his call for engine start until conditions are within his limits or, possibly, one increment below such limits in improving conditions. In this way, aircraft are more likely to arrive at the holding point in the order of their ability to depart.

Traffic sequencing procedures

4.2.5 Traffic sequencing is the arrangement of taxiing aircraft into the most operationally effective order. For departures this means the order which offers the best departure rate and least over-all delay. For arrivals it entails arranging a sequence which is convenient for apron entry and subsequent parking, and causes minimum disruption to departures.

4.2.6 At many aerodromes, while the broad strategy of departure order is controlled by gate holding procedures (see 4.2.2), the sequencing of departing aircraft while taxiing is a means of adjusting to late changes in the order. Sequencing methods will vary according to aerodrome layout, type and volume of traffic and weather conditions, particularly visibility. Sequencing methods include:

a) allocating taxi routes of different length;
b) allocating priority at intersections;
c) by-passing at the holding point;
d) temporary holding during taxiing; and
e) delaying exit from apron.

4.2.7 At most aerodromes the necessary interval between landings provides adequate spacing between arrivals at the apron. When there is a requirement to control the timing or the order of traffic taxiing to the apron, the methods employed will be as in 4.2.6 a), b) or e). The application of a) may be by ATC direction after leaving the runway, or by suggesting that an aircraft take a particular runway turn-off after completion of the landing role.

4.3 EFFECTS OF VISIBILITY ON SMGC PROCEDURES

Good visibility

4.3.1 In visibility condition 1, which is when the controller can view the whole of the manoeuvring area for which he is responsible, the joint responsibility of pilot and vehicle driver for collision avoidance (in accordance with the rules prescribed in Annexes 2, 11 and 14) and with overriding controller instructions (designed to aid the smooth flow of traffic) works well. This is because good visibility allows the controller to see the aerodrome surface traffic situation and thus be able to anticipate conflicts which may occur and take early control measures to avoid them.

Reduced visibility

4.3.2 As visibility progressively deteriorates, the level of assistance which visual surveillance can give to the controller will also diminish and as the controller progressively loses sight of the aerodrome it becomes necessary for the methods of control to be adjusted to maintain a safe capacity for the prevailing operational conditions. As visibility reduces below condition 1, it may be expected that the visibility will be sufficient for the pilot to taxi and avoid collision with other traffic on taxiways and at intersections by visual reference, but insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance. The larger the aerodrome, the more likely it is that this condition will occur. Under such visibility conditions, normal air traffic demand could be expected but there may be a need for restrictions on vehicular traffic on the manoeuvring area. Some constraint on capacity and increase in pilot and controller work-load could be expected due to the inability of the controller to see all of the manoeuvring area and to the need to acquire information by RTF which, in good visibility conditions, would have been available from observation.

4.3.3 At the lower level of visibility associated with visibility condition 2, visual surveillance from the control tower can contribute in only a minor way to safe movement on the manoeuvring area, the chief visual contribution to collision avoidance being the pilot's ability to separate himself from a preceding aircraft on the same taxiway. Since the pilot's visual capability in this condition does not extend to crossing traffic, then each active crossing needs to be protected. The ATC work-load generated and the capacity of the SMGC system will depend upon the number of active crossings to be negotiated.

4.3.4 In visibility condition 3, neither the ATC unit nor the pilot can prevent collision by action based solely on visual observation of traffic. It follows, therefore, that for movement in these conditions the ATC unit must undertake the responsibility for providing both lateral separation and safe longitudinal spacing. The techniques used for longitudinal spacing and increased SMGC system capacity will depend upon the provision of SMGC components (see Table 2-2) and especially upon the number of segments, identifiable to both pilot and controller, into which a given route can be divided. For example, if a direct route from apron to runway represents 20 minutes taxiing time and there is no means of division, the effective departure capacity is three movements an hour. If the route can be divided into segments and the pilot's occupancy of each segment in sequence can be confirmed, then the capacity of the route can be substantially increased.

4.4 MODES OF OPERATION

4.4.1 As recognized above, collision avoidance by visual reference can continue after the controller has lost sight of the manoeuvring area and can continue for in-line following traffic at lower visibilities than for traffic on joining or crossing routes. No one mode of surface movement control is applicable to all weather conditions and the factor which dictates the choice should be taxiway visibility. Since taxiways are not instrumented for visibility measurement, RVRs are normally used as a guide to what is likely to be experienced en route to and from the runway. Over the surface of an aerodrome, however, there can be considerable variation in visibility conditions, thus reports from pilots and local knowledge of weather peculiarities can be of value.

4.4.2 The problem facing the controller is to maintain an efficient traffic flow in reduced visibility conditions. Although traffic sequencing procedures (see 4.2.5) will continue to be necessary, the tendency will be for the controller to restrict the number of taxiing routes made available to avoid the number of conflicts at taxiway intersections. This can be achieved by requiring aircraft to taxi via a route published on the aerodrome chart or by the use of selectively switchable taxiway centre line lighting. As visibility conditions deteriorate the necessity for en-route taxi sequencing can be reduced by introducing gate holding procedures (see 4.2.4).

4.4.3 Notwithstanding simplification of routing to the extent which the configuration of taxiways makes possible, taxiway intersection conflicts are unlikely to be completely avoided except where the aerodrome layout is extremely simple. Consequently, four main modes of control, taking visibility conditions into account, may be defined. These modes are:

a) pilot collision avoidance by visual reference along taxiways and at intersections. ATC intervenes at intersections by establishing priority only when necessary to maintain traffic flow;
b) pilot collision avoidance by visual reference along taxiways and at intersections. ATC intervenes by nominating specific routings and by establishing priorities at intersections when necessary to maintain traffic flow;
c) pilot collision avoidance by visual reference along taxiways. ATC responsible for nominating specific routings and establishing priority and providing lateral separation at intersections;
d) ATC responsible for nominating specific routings, providing safe longitudinal spacing along taxiways and establishing priority and providing lateral separation at intersections.

4.4.4 These modes of operation and their relation to visibility conditions imply a progressive increase in ATC responsibility as visibility deteriorates and the pilot becomes less capable of providing his own collision avoidance, firstly at taxiway intersections and secondly, along taxiways.

4.5 SEPARATION AT INTERSECTIONS AND LONGITUDINAL SPACING*

General

4.5.1 There is no technique of ATC applied separation or spacing between taxiing aircraft which approaches the efficiency of that which can be applied by pilots in good visibility. It follows that, allowing for ATC action on priorities and such other assistance and control that circumstances may dictate, the interests of both ATC and pilots are best served by leaving responsibility for collision avoidance with the pilots while conditions are such that they can safely fulfil the function. At most aerodromes this will be for more than 95 per cent of the time.

* Within this chapter the term lateral separation is used to describe the lateral distance between aircraft because values and aids are specified for maintaining the desired clearances. The term longitudinal spacing is used to describe the longitudinal distance between aircraft because no values or means for providing effective longitudinal separation have yet been developed.

Separation at intersections (lateral separation)

4.5.2 "Give-way" intersection control and "visual ATC directed priority" are commonly used methods which do not necessarily demand markings or lights at intersections. However, control of traffic at intersections in the visibility conditions at or below which pilots cannot provide their own lateral separation, demand that:

a) surface traffic is able to recognize the intersection and stop, when signalled or instructed to do so, allowing adequate clearance for crossing movement; and
b) ATC is able to maintain a sequential record of traffic movement, and clear or hold aircraft and vehicles to maintain the maximum flow rate.

4.5.3 It follows that markings and/or lights must protect each approach to an intersection used in these conditions, and that:

a) pilots and vehicle drivers must obtain crossing clearance at every intersection; or
b) the system, under the control of ATC, must indicate without ambiguity who is to hold and who is to cross.

The restriction and ATC work-load per movement implied by a) confines the method to aerodromes with light traffic and/or few intersections. If medium or heavy demand is to be catered for at aerodromes with a complex layout, complex control such as controlled taxiway centre line lighting linked to stop bars may be needed. When routes are set up on such a system, automatic activation of stop bars on crossing routes is essential.

Spacing along taxiways (longitudinal spacing)

4.5.4 In the absence of non-visual guidance for taxiing, the lower limit of aircraft surface operation must be the visibility below which the pilot is unable to taxi by visual reference. Clearly, this will depend upon a number of factors including surface markings, the type and spacing of taxiway centre line lights and lamp technology and performance generally. Some aircraft flight decks offer a better view for taxiing than others, the taxiing performance of aircraft varies, cockpit work-loads differ, lack of familiarity with an aerodrome layout demands higher pilot concentration in poor visibility and complex or confusing taxiway layouts require a higher level of pilot alertness to avoid mistakes. It can be seen, therefore, that a combination of these factors applying to a particular situation may well be quite different from those applying to another pilot in different circumstances, with the consequence that one pilot may achieve safe taxiing relatively easily, whereas another may encounter great difficulty.

4.5.5 As indicated in 4.5.1 there is no technique of ATC applied longitudinal spacing which approaches the efficiency of that which can be applied by pilots in good visibility; nevertheless, as visibility reduces, the pilot encounters increasing problems in maintaining a safe spacing between himself and a preceding aircraft. Firstly, the pilot must be able to recognize the aircraft ahead as an obstruction and secondly, he must take action to maintain a safe spacing with this aircraft. A knowledge of the preceding aircraft type is essential for the pilot and he must be able to assess the closing speed and the need to slow his own aircraft, or even bring it to a halt, to maintain safe spacing.

4.5.6 In low visibility the pilot will be concentrating to a great extent on visual cues necessary for the taxiing guidance of his aircraft (see 4.5.1) and his eyes are likely to be focused near the taxiway centre line. Recognition of preceding traffic at the earliest possible moment (to allow effective corrective action) is thus difficult to achieve. As visibility reduces to the lower limits, a stage will be reached when the pilot cannot cope with both the guidance of his aircraft and the maintenance of longitudinal spacing. It is at this stage that ATC must assume the responsibility for providing longitudinal spacing along the taxiway.

4.5.7 The visibility limit at which it becomes necessary to introduce ATC applied spacing can be effectively reduced by the provision of a precise, directed traffic advisory and alerting service including type, distance and relative position of preceding traffic and advice of closing speed. It is to assist ATC to provide such a service that Table 2-2 proposes the installation of SMR when it is intended to conduct aircraft operations in low visibilities at aerodromes when traffic demand is medium or heavy.

4.5.8 It is obvious that with all the variable factors it is not possible to prescribe a general fixed visibility at which ATC should assume longitudinal spacing responsibilities. Each aerodrome operational authority which intends to conduct low visibility operations will need to assess all factors in relation to the particular aerodrome and the operational circumstances to determine at which visibility the local ATC should take over longitudinal spacing responsibilities.

4.5.9 However, having determined this visibility, three further considerations are necessary. Firstly, it must be ensured that aerodrome and ATC facilities and established procedures are adequate for the proposed level of low visibility operations and ATC applied spacing (see Tables 2-1, 2-2 and 2-3). Secondly, because of the time involved in changing responsibilities in deteriorating visibilities (again a local circumstance) it will be necessary to set ATC longitudinal spacing procedures in effect before the basic visibility limit is actually reached. Thirdly, although RVR readings are the best available indications of runway conditions, visibilities on the remainder of the movement area may vary considerably and assessment of local meteorological anomalies and experience could require variation of the basic visibility. The net effect of these considerations is likely to be that the actual visibility figure at which ATC should start to apply longitudinal taxiway spacing is somewhat higher than the first determined figure. In this context, it must be emphasized that such determinations cannot be the prerogative of the aerodrome operational authority alone. Full consultations with other interested parties such as aerodrome users must be undertaken to ensure success in the practical application of low visibility longitudinal spacing procedures.

4.5.10 In so far as the practical application of ATC applied longitudinal spacing is concerned it must be remembered that aircraft movements on taxiways are discontinuous, that is, subject to starts and stops; one safe way to effect ATC longitudinal spacing is to divide taxiways into blocks or segments and, when controlling aircraft, to ensure that a "one-block" buffer is preserved between the blocks or segments occupied by succeeding aircraft. The manner in which control, using the block system, can be achieved varies from the very simple issue of RTF clearances to stop at, or proceed to, designated, well-defined clearance limits on a specified route to the very complex issue of providing a computer switched taxiway centre line lighting and stop bar system with automatic maintenance of aircraft identity using sensor detection as a basis for the system logic.

4.5.11 Clearly the very simple method generates such a high level of controller work-load and frequency congestion that it can be used only with a very low traffic level. At the other extreme, the provision of a fully computerized system for a complete aerodrome may be virtually ruled out on the grounds of excessive complexity and, therefore, cost. A practical compromise system of visual guidance and control, offered by current technology, is the selectively switchable taxiway centre line light system with integrated stop bars.

4.5.12 When an aerodrome is equipped with selectively switchable taxiway centre line lights and integrated stop bars, safe spacing can be achieved by providing taxiing aircraft with a continuous centre line of lights to its clearance limit which is defined by a red stop bar. The clearance limit, in every instance, will be based upon the known position of the previously cleared aircraft and will comply with the requirements of 4.5.14 a), b) and c). A "known position" may be a positive location identification by a pilot, a radar derived position check or, preferably, an aircraft position report confirmed by radar. Onward clearance must be sequential and consist of RTF clearance to the next (defined) point, confirmed by the suppression of the stop bar and illumination of the taxiway centre line lights up to the next stop bar. The system demands a separation minimum of one block between aircraft or vehicles under control.

4.5.13 As discussed in 4.3.4, the capacity of a stop bar defined block control system is related to the number of blocks into which a given route can be divided, but the ATC work-load involved in switching lights, RTF communication and problems of maintaining aircraft identity also act as a constraint on the amount of traffic which can safely be controlled. The ability of a pilot to identify his position by reference to illuminated location boards is a help, but unless maintained identification and automated block control is also provided, the capacity of a block control system cannot be expected to approach that of normal good visibility operations. On the other hand, at some aerodromes a compensatory reduction in demand may occur as a result of the more stringent operating requirements associated with low visibilities.

4.5.14 In addition to the variable factors and considerations mentioned before, the actual longitudinal spacing which can be provided by ATC will be directly related to the actual control facilities installed at each specific aerodrome. This scale of facilities and the procedures for their use is the final consideration in determining the longitudinal spacing which is to be applied by ATC to ensure that:

a) a following aircraft does not collide with the preceding aircraft;
b) a following aircraft does not affect the manoeuvring requirements of the preceding aircraft; and
c) a following aircraft is not affected by the blast of the preceding aircraft.

4.5.15 The minimum block length should never be less than the minimum safe longitudinal spacing which

ATC (taking all local factors into account) may be expected to apply. This does not mean that each block needs to be this same minimum length. The actual length of each block will be largely dependent upon aerodrome layout, the SMGC system facilities which may be economically provided and the demand and related ATC work-load. If, for instance, the aerodrome layout lends itself to the diverse, laterally separated routing of taxiing aircraft, then the necessity for ATC applied longitudinal spacing may be much reduced and it would make sense to provide block definition points primarily at taxiway intersections. In this way the block definition points would serve the application of both lateral separation and longitudinal spacing, and it may then be necessary to divide only the lengthier unbroken sections of taxiway into blocks. Thus, block length (subject to "minimum" requirements) will vary for each aerodrome and, possibly, for each taxiway at that airport. In this circumstance, the prerequisite for any introduction of a "block" system will be a thorough study of aircraft movement, demand and ATC work-load patterns to determine which practical SMGC design compromises may have to be made before detailed design and installation work is started.

4.5.16 Notwithstanding the general requirement for a minimum buffer of one block between traffic moving along a taxiway, pilots could (in visibility conditions assessed by the pilot to be adequate) be authorized, when approaching the runway holding point, to close up to a preceding holding aircraft. This procedure ensures optimum runway use. It can only be implemented if precise and timely traffic information, made possible by an SMR (surface movement radar) displayed directly to the controller, is available.

4.5.17 Research on, and experience in, operations at the lower visibility limits has not to date been widespread. Nevertheless, data made available by some aerodrome authorities which have extensive experience in low visibility surface operations are presented at Appendix B as guidance to the problems and requirements which must be considered if ATC longitudinal spacing on taxiways is to be applied.

4.5.18 Because procedures entailing the ATC application of longitudinal spacing are used in very critical low visibility conditions, States contemplating the initial introduction of such procedures should seek the advice of other States which are known to have considerable practical experience in this field of operations before they commence related planning, consultation and facility design work.

4.6 THE ROLE OF SURFACE MOVEMENT RADAR (SMR)

4.6.1 There is currently no facility, or combination of facilities, which compensates fully for a controller's loss of visual contact with the aerodrome surface and the traffic on it. Information derived by other methods such as RTF communication or SMR is rarely as comprehensive or informative, and is far less economic in terms of the work-load expended in its acquisition. In a manual system the ATC work-load per movement increases as visibility decreases and the traffic handling capacity of the aerodrome control service declines. On other than simple route systems, the capacity can fall sharply in visibility condition 2 when separation at intersections becomes the responsibility of the controller. It drops even more steeply when the pilot can no longer provide his own longitudinal separation.

4.6.2 Nevertheless, given that an aerodrome is adequately equipped with visual aids, the provision of an aerodrome surface movement radar can make a valuable contribution to the safety and efficiency of ground movement control in reduced visibility and at night; optimum capacity for the conditions is unlikely to be achieved without it. Surface movement radar permits a continuous check on runway occupancy and taxiway usage, allows rapid appreciation of lighting control requirements and facilitates clearances for aircraft and vehicles. In emergencies it can play a part in the expeditious movement of emergency vehicles and the safe disposition of other traffic, but it too has its limitations.

4.6.3 The accuracy of manoeuvre required on taxiways, which can satisfactorily be accomplished by following lights and markings, is far more precise than could be provided by ATC instructions using SMR direction. Although SMR can provide positional information to the controller, it is a very difficult task for the controller to position an aircraft precisely using such radar. It is necessary for the pilot to be able to comply with instructions given by the controller without the radar being used to provide directional guidance, or to afford any ultimate prescribed separation. However, the more precise traffic and positional information that the controller is able to give by using radar is of major assistance to pilots providing their own collision avoidance.

4.6.4 At a major aerodrome, a large part of the manoeuvring area can be obscured from the control tower while visibility is still within the limits at which traffic can be expected to operate at the normal level of demand, i.e. in visibility condition 2. In these conditions, while the usefulness of SMR could scarcely be exaggerated, it is not possible to monitor in detail all traffic likely to be present on the manoeuvring area. There are two main problems:

a) the work-load and concentration involved in detailed monitoring is very high and restricts ATC capacity; and
b) there is a limit to the amount of traffic information which a controller, using an SMR display, can identify and retain for an extended period.

4.6.5 In summary, therefore, SMR can make a valuable contribution to the safety and efficiency of surface movement control in low visibility and at night, but it is an adjunct and not an alternative to provision of visual guidance and control facilities and manoeuvring area protection measures. Certainly taking SMR limitations and control capacities into account, ATC cannot be charged with the administrative responsibility of aerodrome safety, although ATC could be expected to take appropriate measures to protect traffic under control if and when intrusions are detected using SMR. Also, if other facilities are not provided, e.g. holding position markings and lights, then ATC cannot confirm pilot compliance with control instructions unless guidance with respect to SMR positional tolerances are known. A set of performance objectives for SMR is included in Appendix F.

4.7 EMERGENCY PROCEDURES

4.7.1 Annex 14, Chapter 9 requires the establishment of an aerodrome emergency plan in which ATC is one of the agencies involved. An aerodrome emergency plan is intended to ensure proper and immediate co-ordination of aerodrome services with other appropriate agencies which could be of assistance in responding to emergencies occurring on or in the vicinity of an aerodrome. Emergency situations envisaged include:

a) aircraft emergencies;
b) acts of unlawful interference with civil aviation;
c) occurrences involving dangerous goods; and
d) structural building fires.

ATC is of necessity involved in any such plan, through its communications and control functions, together with many other departments, services and agencies.

4.7.2 In the event of an emergency situation on the movement area occurring in good visibility conditions, it may be assumed that the controller will either observe the incident, or be among the first to know of it, and that he will initiate emergency action. If an aircraft is involved the ATC service will supply the rescue and fire fighting services with the location and type, take action to safeguard other traffic on the movement area, restrict further entry into the area and maintain contact with the emergency command post when it is established.

4.7.3 If an emergency occurs on the movement area in poor visibility and at visibilities below the limit of ATC visual surveillance, the pattern of events and ATC action are likely to be:

a) realization that an incident has occurred which may result from:
   1) RTF messages from aircraft involved;
   2) RTF messages from other aircraft;
   3) information from vehicles, security guards or other persons;
   4) visual indications (e.g. a glow through fog);
   5) SMR indications;
   6) aural indications; and
   7) failure of aircraft to respond to RTF transmission;
b) initiation of emergency action;
c) discovery of the location of the incident or accident. This will usually to some extent become evident from information gained from a) above;
d) assistance to rescue and fire fighting vehicles, which may include:
   1) RTF advice as to the location of the incident;
   2) switching of taxiway lights to provide guidance for emergency vehicles; and
   3) use of SMR to assist emergency vehicles;
e) safeguarding of traffic in the movement area, which will include:
   1) stopping the movement of all surface traffic;
   2) consideration of suspension of flight operations; and
   3) restriction of entry to the movement area of other traffic;
f) liaison with the emergency command post;
g) the resumption of restricted surface movement when the situation has been accurately determined:
   1) by the re-routing of other traffic clear of the occurrence area; and
   2) by the re-arrangement of route system to permit continuation of aerodrome operations;
h) assessment, and indication to those concerned, of the surface movement capacity in the new conditions;

i) facilitation of traffic movement concerned with the removal of damaged aircraft or vehicles; and
j) arrangement for the inspection of the occurrence area and assessment of damage to aerodrome surface, lights and other facilities.

4.8 RTF PROCEDURES AND PHRASEOLOGY

4.8.1 The importance of correct use of language and phraseology and of adherence to associated procedures cannot be overemphasized. The safety and efficiency of ground movement depends upon the clarity of understanding between the controller and each of the pilots or vehicle operators in contact with him. Such co-operation requires an understanding of the over-all situation which, in whole or in part, is gained by monitoring RTF transmissions.

4.8.2 Annex 10, the PANS-RAC and the *Manual of Radiotelephony* (Doc 9432) contain the recognized RTF procedures and phraseology.

4.9 CO-ORDINATION

4.9.1 Each aerodrome authority must, together with its associated ATS authority, establish the facilities and procedures necessary to allow co-ordination to be performed over the full range of surface movement activities. This involves not only the establishment of direct speech circuits between controllers and operators responsible for actual aircraft movement (e.g. the control tower, the apron management service and airport safety officers) but also the administrative directives to enable the efficient application of, for example, low visibility and emergency procedures.

4.9.2 The establishment and regular meeting of a committee of which representatives of major aerodrome interests are members is a good way to resolve any problems in co-ordination which may occur.

4.9.3 A particularly important aspect of such administrative co-ordination is the need to establish sound procedures for the rapid rectification of facility faults where these adversely affect the operational safety and efficiency of the surface movement guidance and control system.

4.10 LOW VISIBILITY PROCEDURES

4.10.1 The special procedures related to low visibility conditions are fully described in Chapter 5.

Chapter 5
Low Visibility Operations

5.1 INTRODUCTION

5.1.1 The increasing demand for operations in visibilities of less than 400 m RVR (visibility condition 3) has led to an increasing number of aerodromes at which low visibility operations are conducted. Because of this, there is a need to develop an effective surface movement guidance and control (SGMC) system to cover the inherent problems associated with such operations and provide a safe ground environment for aircraft and vehicles operating in low visibility on the movement area.

5.1.2 The purpose of this chapter is to briefly outline the preparation necessary for aerodrome operating agencies to provide for low visibility operations. Guidance on the selection of particular SMGC system components for visibility condition 3 is contained in Chapter 2, Table 2-3 with appropriate reference to specific ICAO Annex documentation. Further detailed information and advice is also provided in the *Aerodrome Design Manual*, Part 4 and the *Manual of All-Weather Operations* (Doc 9365).

5.1.3 Although this chapter relates more to Category III type operations, it is important to note that many aerodromes not equipped for landing in low visibility often conduct take-off operations in low visibility and thus many of the points discussed are equally pertinent to this form of operation.

5.2 PREPARATION FOR LOW VISIBILITY OPERATIONS

5.2.1 The introduction of low visibility operations is considerably more complex than a simple adjustment of existing procedures and restrictions. Ground operations below an RVR of 400 m create additional problems due to the reduced ability of controllers, pilots, drivers and other relevant personnel to control and operate on an aerodrome in reduced visibility without risk of collision with others and infringement of an active runway. It is therefore essential that no agency be allowed to operate independently from another and, before embarking on such operations, the aerodrome operator or appropriate authority must administer and control the various organizations and provide specific low visibility procedures and regulations.

Working group

5.2.2 No two aerodromes will be exactly alike and thus during the preparation period, it is essential that all aspects of an aerodrome operation which might affect the introduction of low visibility procedures should be examined. The administrative process will vary from State to State but the most effective method is to form a working group composed of representatives of all parties involved in such operations. The working group will need to identify many general factors pertinent to operation below 400 m RVR. These include:

a) the need for additional and more reliable ground equipment and aircraft systems;
b) the special requirements for the training and qualification of flight crew and ground personnel;
c) the stringent criteria required for obstacle clearance;
d) the aerodrome layout and the nature of the surrounding terrain;
e) the stringent criteria required for the protection of the ILS signal;
f) the adequacy of runways and taxiways; approach, runway and taxiway lighting and marking for such operations;
g) the need for a more comprehensive control of ground movement traffic; and
h) the deployment of rescue and fire fighting services.

It will be necessary for the working group to establish a work programme, based on a time schedule, in which these subjects and many others are examined.

Operational assessment

5.2.3 Low visibility operations demand higher specifications in the form of equipment and training which are costly to provide. Study will be necessary in the initial planning stage to decide whether such operations are justified. This study will need to consider such factors as the incidence of low visibility, present and forecast traffic volumes, the proximity of suitable diversion aerodromes and the potential for improvement in regularity of operations and safety standards.

5.2.4 In addition to the introduction and revision of low visibility procedures, the working group will also have to decide on the visual and non-visual components of the SMGC system and the control methods to be employed. Chapter 2 provides detailed guidance on the selection of appropriate equipment and visual aids, and Chapter 4 discusses the effect of deteriorating visibility on the capacity of the SMGC system and the control methods and procedures that can be adopted.

Safety assessment and procedures

5.2.5 The working group will also need to make a comprehensive safety assessment of the aerodrome. Guidance on this assessment is given in the ICAO *Manual of All-Weather Operations*, Chapter 5 and should take account of the lowest RVR at which the aerodrome intends to remain operational and the expected volume of aerodrome traffic movements.

5.2.6 In particular, the assessment should take account of the increased operating risk due to the lack of visual control that can be exercised by ATC as visibility decreases. One method is to use the same figure that is often quoted in the development of aircraft operating minima, i.e. "risk not in excess of the probability of one fatal accident per 10^7 operations". Although this figure is used for higher aircraft movement speeds than would be expected when taxiing in low visibility, it does include the probability of runway intrusion at the time of aircraft landing or taking off and, as such, is pertinent to the over-all ground movement scenario. As an aircraft is at its most vulnerable when landing or taking off and is virtually incapable of taking any avoiding action, the attention of the working group should be focused specifically on the probability of runway intrusion by taxiing aircraft and/or vehicles. In this respect the following action should be taken:

a) examination of the movement area design with specific attention being given to aircraft routings between apron areas and runways, ground traffic control points and movement area entrances;
b) examination of the existing ATS instructions, operations orders and company rules that are relevant to the general ground movement scenario;
c) examination of meteorological records and movement statistics for aircraft and other vehicles;
d) examination of any past records of runway intrusion. If no records are available, it may be necessary to establish an incident rate by discussion with controllers, inspecting authorities, etc. or refer to general international experience;
e) examination of existing airport security procedures (see also Chapter 7 — Runway Protection Measures). The possibility of runway intrusion as an aggressive act is not large in comparison with the possibility of an inadvertent intrusion but the use of general security procedures can have a significant effect upon the over-all intrusion probability; and
f) a comprehensive inspection of the total movement area accompanied by the relevant experts and responsible authorities during which the findings from a) to e) should be verified.

5.2.7 This safety assessment should be considered by the working group as part of a complete SMGC system and should be completed in the early stages of the preparation process. Those areas of operation which are considered to have a high level of risk will require extra protection measures and associated procedures.

5.3 LOW VISIBILITY PROCEDURES

5.3.1 The procedures required for low visibility operations vary with each aerodrome. The low visibility procedures developed for an aerodrome must take into account local conditions; however, the basic factors that follow will need to be considered.

a) All drivers and other personnel authorized to operate on the movement area are adequately trained in these procedures and are aware of the additional responsibilities placed upon them in low visibility. It follows that the point at which low visibility procedures come into operation must be well defined.

b) A record is maintained by the ATS of persons and vehicles on the manoeuvring area (ref. PANS-RAC, Part V).
c) All non-essential vehicles and personnel, e.g. works contractors and maintenance parties must be withdrawn from the manoeuvring area.
d) Essential vehicles permitted to enter the manoeuvring area are kept to a minimum and must be in RTF communication with ATC.
e) Where the possibility of inadvertent entry onto the manoeuvring area exists and where physical closure is not practical, e.g. between aircraft maintenance areas and manoeuvring areas, entry points should be manned. If an opening is too wide for visual surveillance then it should be fitted with intruder detection equipment, and those areas with intensive vehicular movement adjacent to the manoeuvring area and with no traffic control should be regularly patrolled.
f) All unguarded gates/entrances to the movement area are kept locked and inspected at frequent intervals.
g) There is adequate provision for alerting airlines and other organizations with movement area access of the introduction of low visibility procedures. This is particularly important where companies exercise control over their own apron areas and maintenance facilities adjacent to the manoeuvring area.
h) All personnel whose presence on the movement area is not essential to the operation should be withdrawn.
i) Appropriate emergency procedures must be developed (see 5.4).

5.3.2 Consideration should also be given to the closure of runway access taxiways that are not essential for entrance to or exit from the particular runway. This can be achieved by taxi-holding position lights, traffic control lights, red stop bars or by physical closure using the unserviceability markers specified in Annex 14, Chapter 7. Also, where possible, there should be a limitation on the number of routes for taxiing to and from the runway in low visibility and these should be identified, marked and published for the use of aircraft operators.

5.3.3 This manual defines visibility condition 3 as "visibility less than 400 m RVR"; however, it will be necessary for the appropriate authority to provide specific procedures at a much higher RVR value dependent on the type of aerodrome operation. The figure of 400 m RVR has the advantage of being easily identified with the top limit of Category III but has the disadvantage in prompting the quite unwarranted belief that low visibility procedures and equipment are only necessary at aerodromes capable of sustaining Category III landings. At aerodromes not equipped for landing in such conditions aircraft may be able to take off in visibility less than 400 m RVR. As pointed out in 5.1.3 above it will be necessary to introduce specific safeguards and procedures at such aerodromes as well.

5.3.4 The point at which low visibility procedures should be implemented will vary from aerodrome to aerodrome depending on local conditions. This point may initially be related to a specific RVR/cloud base measurement (e.g. 800 m/200 ft) in a worsening weather situation and will be dependent on the rate of weather deterioration and the amount of lead time necessary to implement the extra measures.

5.3.5 When the low visibility procedures are implemented, it will be necessary for the appropriate authority to continuously review the effectiveness of the procedures and, when necessary, to amend or update the procedures.

5.3.6 The above is intended as a guideline in establishing low visibility procedures. The actual procedures developed for a particular aerodrome will need to take account of local conditions. Examples of low visibility procedures in use at several airports experienced in such operations are shown in Appendix B.

5.4 EMERGENCY PROCEDURES

5.4.1 An essential factor that must be addressed prior to the introduction of low visibility operations is the ability of the rescue and fire fighting service (RFF) to respond quickly to an emergency situation. Annex 14, Chapter 9 gives the specifications for the provision of RFF facilities and the requirement for an established aerodrome emergency plan in which ATC are involved. In good visibility it can be assumed that ATC will either observe an incident or be among the first to know of it, and that they will initiate emergency action, provide the RFF service with the accident location and aircraft type, take action to safeguard other traffic and maintain contact with the emergency command post.

5.4.2 Section 4.7 — Emergency procedures, in Chapter 4 of this manual, outlines in general terms the action to be taken by ATC, but in low visibility conditions and at visibilities below the limits of ATC visual surveillance, ATC may not be immediately aware that an incident/accident has occurred. For instance, a brake fire, unless detected on board the aircraft, is not likely to be noticed by ATC and a report, if any, will come from some other source. It is important therefore that those personnel permitted to operate on the movement area be aware of their responsibilities in reporting such incidents quickly and accurately and are well versed in the correct method of notification to ATC and/or the RFF service.

5.4.3 Sometimes the information received may be limited or confused and ATC may need to verify that an incident has occurred and also its location. There is no simple clearly defined operational procedure to suit every situation. It would be wrong if the crash alarm was initiated on every occasion when doubt arose but, on the other hand the time saved in the real event could be imperative. Responsibility for the final decision must rest with the controller on the spot and there should be no operational or commercial pressure that might prompt him to "wait and see" and equally no criticism if, in the final analysis, there was a degree of "over reaction". There should be no reluctance to call for RFF support.

5.4.4 Once emergency action is initiated, a number of other problems arise as a result of reduced visibility. The primary need is to get the RFF services to the scene of an incident/accident as quickly as possible without creating additional safety hazards. The factors that affect this response time are:

a) the location of the RFF vehicles;
b) the aerodrome layout;
c) the nature of the terrain adjacent to the paved areas and in the immediate vicinity of the aerodrome;
d) the RFF vehicle capabilities (e.g. cross-country); and
e) vehicle speed.

5.4.5 All the above are pertinent to normal RFF operation but in low visibility the speed and route to an incident/accident can become critical. It is not expected that vehicle speed will be significantly reduced until the visibility falls below 200 m when the need to reduce speed to avoid collisions may affect the RFF response time. Since the location of an incident/accident is random and as many aerodromes have only one RFF station, the response time in low visibility may prove to be excessive. A method of overcoming this is to re-deploy the RFF vehicles at two or more dispersal points about the aerodrome to ensure that no incident occurs at more than an acceptable distance from RFF support. The reduction in distance will compensate for any speed loss and is particularly important in the case of fire where rapid intervention may prevent a minor incident escalating to something more serious. In the event of a major accident the over-all loss of a concentration of RFF vehicles as a result of redeployment is probably offset in the early stages by the more rapid intervention of a smaller RFF force.

5.4.6 The selection of the shortest route will be dependent upon the geography of the aerodrome and the deployment of RFF vehicles. It is obviously important that RFF personnel must be very familiar with the aerodrome layout, signs, markings and easily identifiable landmarks together with the associated terrain. It is also important that they are kept fully informed of temporary obstructions such as works and maintenance that may affect the choice of route to an incident. ATC may be able to assist by switching taxiway lights to provide a clearly defined route, or by re-routing other traffic clear of the occurrence area and, where available, by the use of surface movement radar (SMR).

5.4.7 The use of SMR simplifies the solution to the many problems associated with the location of an incident and the subsequent guidance and control of RFF vehicles and other traffic. The scattering of debris in a major accident provides a most positive response on modern high definition radars and the ability to display all activity on the aerodrome surface enables controllers to identify the precise location of surface traffic and provide the best route for the RFF services. It is important that, where this facility is available, the RFF and ATC services carry out regular training exercises in order that they are both proficient in this use of the equipment.

5.4.8 When SMR and/or sophisticated lighting systems are not available for vehicle guidance, it may be necessary to consider the provision of extra navigation equipment on board the RFF vehicles. This equipment could vary from a relatively simple beacon homing device through to more complicated thermal image intensifiers or area navigation systems recently developed for vehicles. But whatever the standard of equipment, it is essential that RFF personnel are fully trained in all the problems associated with operating in low visibility and are given opportunities to carry out realistic exercises when these conditions prevail.

5.5 SUMMARY

5.5.1 Before embarking on low visibility operations, the aerodrome authority in association with the user operators will need to ascertain the:

a) incidence of low visibility conditions;
b) volume of traffic expected to operate in such conditions;
c) assessment of current needs and equipment; and
d) justification for such operations.

5.5.2 If the decision is made to proceed the appropriate authority will need to:

a) establish the lowest RVR at which the aerodrome intends to operate;
b) complete a comprehensive safety and security assessment of the total aerodrome movement area and its operations;
c) provide any additional and/or more reliable ground aids and equipment;
e) provide for more comprehensive control of ground traffic;
f) provide specific low visibility procedures and regulations with an appropriate implementation point;
g) assess the RFF deployment and response time; and
h) provide appropriate training and qualification of relevant personnel.

Chapter 6
High Traffic Volume Operations

6.1 GENERAL

6.1.1 High traffic volume operations are a fact of life at many aerodromes, and can be expected to become so at many others. They place significant demands on the surface movement guidance and control (SMGC) system and require facilities and procedures to meet the following major objectives:

a) protection of active runways from incursions by aircraft, vehicular and pedestrian traffic;
b) maintenance of efficient traffic flows, principally between terminal buildings and runways, but also between other areas, e.g. aprons and maintenance facilities; and
c) reduce conflicts between the aircraft, vehicular and pedestrian traffic.

6.1.2 While the facilities and procedures required for a high traffic volume operation call for a significant level of investment, the majority of them are also essential to a surface movement guidance and control system designed for low visibility operations. Detailed information on those common-purpose items is given elsewhere in this manual, and in the present chapter they are merely noted, with cross-references where appropriate. More complete information is provided on facilities and procedures considered unique to high traffic volume operations and attention is drawn to Chapter 2, Table 2-2, which gives guidance on selecting SMGC system aids for operations under heavy traffic conditions.

6.2 PLANNING AND SIMULATION

6.2.1 Chapter 2 of this manual, Section 2.6, gives guidance on the evaluation and improvement of an existing SMGC system, and on the designing of a new one. High traffic volume operations emphasize the importance of the associated planning process, often involving an in-depth analysis of the real time traffic situation. A representative list of items requiring consideration could include:

a) alternative runway configurations;
b) taxiway system design and/or improvements;
c) alternative runway assignment procedures;
d) ATC procedures and separation requirements;
e) automation aids available to the various components of the SMGC system;
f) terminal layout and gate/stand allocation;
g) gate/stand holding provisions and procedures; and
h) contingency provisions and procedures (accidents, aerodrome maintenance, snow removal, etc.).

6.2.2 Guidance material on a simulation model and techniques for such an analysis is given in Chapter 3 and in Appendix D. In the specific context of planning an SMGC system for high traffic volume operations, simulation can make a valuable contribution, and is recommended. Its objectives should clearly include the design of optimum aerodrome layout, facilities and procedures to alleviate or prevent traffic flow impediments.

6.2.3 Planning objectives for high traffic volume operations should also include:

a) provision of taxi-routes with the minimum number of intersections (i.e. crossing points between aircraft, or aircraft and vehicular and/or pedestrian traffic) consistent with projected traffic needs;
b) maximum use of one way taxiways and circular routes, particularly in connexion with the standard taxi-routes discussed in Section 6.4 below;
c) provision, so far as practical, of separate service roads for vehicular traffic which has no need to use the manoeuvring area (including some of the traffic to/from maintenance, cargo and catering areas); and
d) provision of adequate RTF facilities.

6.3 RUNWAY PROTECTION

6.3.1 Guidance material on the critically important matter of runway protection measures is given in Chapter 7 of this manual, and stress is laid on the fact that in very significant measure protection depends on:

a) provision of sufficient visual information (signs, surface markings and lights) to pilots and vehicle drivers, all of whom must be conversant with that information and with the associated procedures; and
b) particular attention to the clear and unambiguous marking of operational runways at all points of access (see especially Chapter 7, Section 7.4).

6.3.2 High traffic volume operations add no specific requirements to those enumerated in Chapter 7. They do, however, increase the probability of runway incursions that are known to result from accidental entry, mistaken routes and misunderstood clearances, and for that reason add emphasis to the recommendations in Chapter 7 and the comments on aerodrome surface markings, signs, lighting and procedures in the following sections of this chapter.

6.4 STANDARD TAXI-ROUTES AND CHARTS

6.4.1 The over-all objective of establishment and promulgation of standard taxi-routes is to enable traffic to be as self-regulating as possible, thus minimizing the amount of control intervention and the consequent volume of RTF communications.

6.4.2 Information on the establishment of standard taxi-routes for aircraft is given in Annex 11, Chapter 2 and in Chapter 3 of this manual. Supplementing that information, matters of particular importance to an SMGC system for high traffic volume operations can be summarized as:

a) a positive requirement for standard taxi-routes as surface movement volume increases, as indicated in Chapter 2, Table 2-3;
b) such routes to be well identified and lighted in accordance with Annex 14, Chapter 5 specifications for taxiway marking and lighting;
c) signs to reflect the provisions of Annex 14, Chapter 5, and the additional material given in Appendix A to this manual, and specifically:
   1) to be uniform throughout the aerodrome;
   2) to be self-evident (unambiguous) and simple, clearly identifying the standard taxi-route to be followed, and permitting pilots to receive taxiing clearance expressed in terms of a route designator and to proceed to the limit of that clearance without further RTF communications;
   3) to be located with due regard to the speed of taxiing aircraft, the height of the cockpit above ground, and the need to give information to pilots in sufficient time for it to be correlated when necessary with that on the aerodrome chart; and
   4) to ensure adequate protection against the possibility of an aircraft entering a one-way route in the wrong direction.

6.4.3 The ICAO Standards and Recommended Practices covering the provision and content of the aerodrome chart and the ground movement chart are given in Annex 4, Chapters 13 and 14. An aerodrome chart — ICAO will need to be made available for all aerodromes used by international commercial air transport. Where the complexity of the movement area, aids and terminal facilities make the aerodrome chart inadequate then a ground movement chart is also required. In the present context of high traffic volume operations and standard taxi-routes, charts meeting the requirements of Annex 4 are essential. As indicated in Chapter 2, Table 2-3, the aerodrome authority should also initiate amendments of the charts as necessary.

6.5 GROUND CONTROL ORGANIZATION AND RTF FREQUENCIES

6.5.1 The high traffic volume operations being addressed in this chapter will in all probability require use of more than one RTF frequency. It is recommended that consideration be given to the assignment of such frequencies on an "area basis", rather than between arriving and departing aircraft. Assignment on an area basis will in most cases ensure that potentially conflicting aircraft are guarding a common frequency, thereby both increasing the safety factor and minimizing the need for controller intervention.

6.5.2 Experience gained in the co-ordination of airborne traffic has demonstrated that safety is enhanced when the co-ordinating controllers are located in close physical proximity to each other. When several controllers are involved in surface traffic movements the same requirement for close physical proximity should be addressed, particularly in high traffic volume operations where safety is dependent on rapid co-ordination.

6.6 AIRCRAFT STAND ALLOCATION AND HOLDING

6.6.1 In the context of highest traffic volume operations two measures are particularly recommended to assist traffic flow between manoeuvring and apron areas:

a) provision of information to pilots at the earliest appropriate time on the aircraft stand that has been assigned to their aircraft;

b) provision of suitably located holding bays as specified in Annex 14, Chapter 3. Such bays can help to avoid or reduce congestion when delays in aircraft arrivals or departures occur.

6.7 SPECIAL EQUIPMENT

6.7.1 Guidance material on the role of aerodrome surface movement radar (SMR) is given in Chapter 4. Its requirement in high traffic volume operations is here confirmed, as also indicated in Chapter 2, Table 2-2. SMR can be particularly useful when darkness, atmospheric conditions, buildings or the size of the area involved make it impossible for controllers to monitor parts of the taxiway complex by visual means.

Chapter 7

Runway Protection Measures

7.1 INTRODUCTION

7.1.1 The protection of a runway from unauthorized entry by persons, vehicles or aircraft is a fundamental part of a surface movement guidance and control (SMGC) system and is essential to the safe and efficient operation of an aerodrome. Although this fact is recognized in Annex 11, Annex 14, the PANS-RAC and the *Aerodrome Design Manual*, Part 4, *Visual Aids*, the subject is not fully addressed in any of these documents. Runway protection involves many disciplines and its importance is such that separate consideration to this subject is given in this manual.

7.1.2 This chapter outlines the operational problem and gives some protection methods and equipment that can be used by the appropriate aerodrome and air traffic control (ATC) agencies to check and, if necessary, enhance their operating procedures. It is important to note that for operations in low visibility, ICAO guidance and regulation are predominantly for the landing phase of flight and take less account of take-off. Certain incidents have emphasized the need for aviation authorities to review their runway protection procedures regardless of specific visibility constraints.

7.2 THE OPERATIONAL PROBLEM

7.2.1 The function of a runway is to provide for the transition of aircraft from flight to surface movement and from surface movement to flight. This entails movement at high speed on, and in close proximity to, the runway surface and demands that the runway is free from any obstacle during landing and take-off. It is in these stages of flight that an aircraft is at its most vulnerable and is virtually incapable of taking any avoiding action and is certain of destruction if a high speed collision occurs with any obstacle of significant size.

7.2.2 The average runway occupancy time is the ultimate determinant of the capacity of an aerodrome. Consequently in busy periods there is pressure to maintain a high traffic flow rate. This and the need for safety requires the following basic philosophy of operation:

a) so far as possible the runway must be reserved for the exclusive use of landing and departing aircraft; and
b) landing and departing aircraft must occupy the runway for the minimum amount of time.

7.2.3 In practice, it is not possible to reserve a runway solely for the operation of aircraft. Maintenance and service vehicles will need access to the runway and at most aerodromes certain vehicles and taxiing or towing aircraft will need to cross. Access to the runway and its environs must be under the control of the ATC service and be subject to timing and other considerations which, in periods of high demand, can be critical. But there can be no physical barrier to the runway or manoeuvring area and safety depends upon every pilot and driver operating on the area being familiar with the aerodrome layout and complying with aerodrome procedures, signs, signals and ATC instructions. It follows that the essential basis of runway protection is the exclusion from the manoeuvring area of all vehicles that have no right or need to be there, and a requirement for adequate knowledge, competence and discipline on the part of those duly authorized to operate on the area.

7.3 PROTECTION MEASURES

7.3.1 Apart from deliberate intrusion on to a runway for unlawful purposes, which falls outside the scope of this document, there are three types of encroachment:

a) Accidental entry to the runway by a vehicle whose driver has lost his way and somehow entered the manoeuvring area;
b) Mistaken entry resulting in an unauthorized entry to the runway by an aircraft or vehicle cleared to move on the manoeuvring area; and
c) Misunderstood clearance resulting in an entry to the runway by an aircraft or vehicle whose operator believes, mistakenly, that the necessary clearance has been received.

Each of the above may be considered separately.

Accidental entry

7.3.2 The movement area must be fenced or otherwise protected against unauthorized entry, and should be provided with controlled entry points. Although such a fence protects far more than the runway itself, it is the first and most important method of runway protection since it will keep out the driver to whom movement area signs and signals would be meaningless. Complete protection can be expensive and sometimes difficult to achieve, particularly where taxiway extensions to maintenance areas cross main traffic routes for aerodrome employees, tradesmen, aerodrome contractors, etc. but the cost has to be measured against the high probability that if it is feasible for an external vehicle to gain access to the movement area, then sooner or later one will appear on the runway.

7.3.3 Another aspect of the same problem is when a vehicle, which is authorized to enter the movement area, e.g the apron, mistakenly strays onto the manoeuvring area for which it has no clearance. To preclude accidental entry, a thorough briefing of all persons in charge of vehicles authorized to enter the movement area is necessary and they should be familiar with all surface markings, signs and lights. Mistakes may occur but the provision of positive ground movement rules and regulations should reduce the chances of mistakes occurring to a minimum. Guidance on the application of such rules is given in Appendix E.

Mistaken route

7.3.4 An aerodrome can be a very confusing place, even to those who are familiar with its operation and topography. Changes in visibility or light intensity, the disappearance of familiar landmarks, use of a rarely employed taxiway or runway, even a change of aircraft type or vehicle, i.e. a different viewing aspect from cockpit or driving seat, can all contribute to mistakes being made in location identification and direction of movement. Obviously, the better the taxiway system is marked, the less likely that a mistake will be made, but at many large aerodromes errors of this kind can and do occur.

7.3.5 A mis-routing confined to taxiways can cause disruption, delays and considerable frustration but rarely causes a major incident; the danger comes with an unauthorized movement on to an operational runway. It must be recognized that in restricted visibility or at night this can happen without the ATC controller being immediately aware that an unauthorized entry to a runway has taken place. Even with surface movement radar (SMR) it is not feasible to monitor continuously every authorized movement on a busy aerodrome. Protection from this type of encroachment must rest solely on an operational runway being clearly and unmistakably marked as such from any point of access. Permanent marking as a runway may not be sufficient because non-operational runways can be used as a taxi route and entered without special clearance. Therefore, there must be some other positive method of indicating that a runway is active and taxi-holding position lights fulfil this function. Stop bars also protect a runway, and it is a Standard for these to be provided in conjunction with a precision approach runway Category III and consideration is now being given to extending the applicability to precision approach runways Category II. At aerodromes without Category II or III approach aids, aircraft are still able to depart in reduced visibility conditions and therefore the aerodrome authority must give special attention to their signs, lights and markings to ensure that the operational runway is adequately marked.

Misunderstood clearance

7.3.6 This is probably the most common cause of unauthorized entry to an operational runway and is also the most difficult to prevent. If a pilot or driver believes that he has clearance to enter a runway then, unless there is some obvious danger, he will proceed. The problem is compounded by the radiotelephone (RTF) broadcast system where all those on the frequency can hear the instructions that are passed. The fact that the controller, driver and pilot may be using a language which is not necessarily their mother tongue together with the pressures associated with a busy environment, are all factors which result in a misinterpretation of what is said. The similarity of many call signs does nothing to help what is already a possibly confused situation.

7.3.7 Until the development of discrete data transfer between the controller and individual aircraft/vehicles on the aerodrome surface, the possibility of misunderstanding or misinterpretation will remain. It follows that in the interests of runway protection, communication methods must be such to reduce the likelihood of misunderstanding and the procedures used should be such that they will not result in an aircraft or vehicle entering an operational runway without clearance.

7.3.8 For many years the value of standard RTF phraseology has been recognized and special attention should be given to the *Manual of Radiotelephony* to ensure that the phraseologies and terms used conform to those that have been agreed on an international basis. Other faults in RTF communication that can lead to unauthorized entry of a runway are:

a) careless use of a qualified clearance, e.g. "cross after the B727" to a driver whose facility for aircraft recognition may be less than the controller assumes;
b) talking too quickly;
c) superfluous remarks, particularly of protest or criticism, which do not make a positive contribution to a situation; and
d) use of abbreviations, especially call signs, which could apply to more than one aircraft or vehicle.

It would add significantly to safety if no driver or pilot would move on a clearance without being quite sure that such a clearance applied to him, and in the event of any uncertainty to check with ATC regardless of how busy the situation may appear to be.

7.3.9 The most effective way of reducing the possibility of a misunderstood clearance which may result in an encroachment on to an operational runway is for verbal instructions to be associated with an appropriate visual signal such as the switching off of a stop bar and the switching on and off of taxiway centre line lights, beyond the stop bar.

7.4 RUNWAY PROTECTION METHODS AND EQUIPMENT

7.4.1 The basic philosophy of runway protection must be the use of proven and safe procedures with all traffic conforming to recognized rules. All personnel must be fully conversant with these rules and the appropriate authorities should establish a monitoring system that maintains the highest standards possible. There is no equipment that can be a substitute for this basic philosophy.

7.4.2 The primary method of protection must be the provision of sufficient visual information to pilots and drivers that they are approaching an active runway in order that they can conform with the recognized procedures. This visual information in the form of signs, surface markings and lighting equipment can be supported by more sophisticated non-visual electronic detection equipment where traffic density and airfield complexity increase the risk of a possible infringement of the runway.

Surface markings, signs and lighting

7.4.3 Chapter 2 identifies the visual aids that are available for surface movement guidance and control. The following are for use as runway protection aids:

— taxi-holding position markings
— stop bars
— taxi-holding position lights

signs:

— holding position
— taxiway/runway intersection
— STOP
— NO ENTRY

Details on the characteristics and installation of these aids is given in Annex 14, Chapter 5. It must be recognized that the application requirements given in Annex 14 are a minimum and that some facilities only required when a runway has Category II or III precision approach status are useful in other conditions.

7.4.4 Annex 14 recommends the provision of taxi-holding position lights (sometimes referred to as runway protection lights) which consist of two alternate flashing yellow lights. At present, these lights are only recommended for a precision approach runway Category III, but consideration is being given to recommending their provision at precision approach Category II runways. Nevertheless, the installation of these lights at all taxi holding positions regardless of the runway type should be seriously considered as they are a very effective and reasonably inexpensive method of delineating an active runway in all visibility conditions.

A further method of safeguarding a runway is the installation of switchable stop bars as described in Annex 14, Chapter 5, which are also a standard requirement for precision approach runways, Category III.

Non-visual electronic protection equipment

7.4.5 The problem of continuing aerodrome operation at an acceptable level of safety and capacity in reduced visibility has led to the development of many techniques for non-visual surveillance. Many of these systems have been designed to monitor the whole of the movement area but can be scaled down to cover just the runway and its immediate environs where a more complex SMGC system cannot be justified. These techniques offer three basic forms of non-visual surveillance:

a) the use of radar sensors which produce a facsimile display of the runway and the immediate taxiways together with the operating traffic;
b) the use of linear sensors to monitor the entry and exit of traffic on defined divisions or blocks close to the runway, this being displayed on a suitable indicator; and
c) the use of small area sensors to indicate the occupancy of sectors close to a runway.

7.4.6 *Radar sensors.* The most widely used and, to date, the most successful method of non-visual surveillance is surface movement radar (SMR) which has been in operation since the early 1960s. Ideally, this presents the controller with a radar-derived plan of the aerodrome surface with the runways and taxiways clearly discernible, with the traffic, whether moving or stationary, shown as blips. This allows the controller, by monitoring a suitable display, to determine runway occupancy, taxiway movement, progress of vehicular traffic, etc.

7.4.7 The latest developments of this equipment have overcome the weather and attenuation problems which limited the effectiveness of earlier models and as a result of advances in electronics and display techniques are significantly cheaper than their predecessors. In addition, advances in computer technology, which have the capability of greatly enhancing basic radar information, allow for runway protection programmes to be designed that produce an audio alarm when the protected area of an active runway is intruded.

7.4.8 Recent developments in millimetre and FM CW (frequency modulated continuous wave) radars may offer a cheaper alternative to SMR especially where a system is required only for runway protection. Portable L-Band FM CW radars are already available for intruder detection and these could be developed for specific use on an aerodrome, but many of these systems will only detect moving targets and will therefore require a certain amount of computer assistance to display continuous data to the controller.

7.4.9 *Linear sensors*

a) *Magnetic (Inductive) Loop Detectors* — Inductive loop detectors have been used for road traffic detection and control for many years and such a system can be adapted for use as a runway protection aid. Inductive loops strategically placed along a taxiway access to a runway will detect traffic movement and this information can be displayed to the controller. The limiting factor of such a system is the cost, especially when fitted retrospectively to a large aerodrome where the data transmission and display system could be complicated. An aerodrome lighting system incorporating inductive loops, which are used for runway protection and the automatic switching of stop bars and taxiway lights, has been installed at Frankfurt Airport and is an integral part of the SMGC system.
b) *Electro-magnetic beams* — Electronic fencing using microwave techniques is feasible as a runway protection aid but indications are that to cover an area the size of a runway could prove to be expensive in basic and data distribution equipment.

7.4.10 *Small area sensors and television.* These can be used to survey a particular area such as a runway holding point. Methods available include small television cameras, specialized radars, magnetometers, ultrasonics, infra-red, lasers and seismic sensors. A combination of the above methods could provide an effective runway protection aid but may prove to be complex and expensive.

7.5 SUMMARY

7.5.1 In order to achieve a high degree of runway safety, aerodrome operators and responsible authorities must ensure that:

a) the movement area is fenced or otherwise protected against unauthorized entry;
b) all entry points to the movement area are controlled;

c) there is an adequate level of knowledge, competence and discipline among those in charge of authorized traffic on the movement area;
d) all taxiways and road systems are adequately and appropriately signposted, marked and lighted;
e) an active runway is clearly and unmistakably marked as such to surface traffic;
f) all manoeuvring area traffic conforms to recognized RTF procedures;
g) where possible, a verbal clearance to enter a runway is confirmed by a visual signal, e.g. suppression of the stop bar and illumination of taxiway centre line lights; and
h) where visibility, aerodrome complexity and traffic density demand, provision is made for non-visual electronic protection equipment such as surface movement radar (SMR).

Chapter 8

Apron Management Service

8.1 GENERAL

8.1.1 The air traffic control service at an aerodrome extends throughout the manoeuvring area, but no specific instructions relating to such a service cover the apron. Therefore apron management is required to regulate the activities and movement of aircraft, vehicles and personnel on the apron (Annex 14, Chapter 9).

8.1.2 There are a variety of different approaches to apron management which have been developed and which can, depending on the particular condition, accommodate the requirements of the aerodrome.

8.1.3 Apron management is an essential task at any aerodrome. However, the need to establish a dedicated apron management service is dependent upon three main operational factors. They are:

a) the traffic density;
b) the complexity of the apron layout; and
c) the visibility conditions under which the aerodrome authority plans to maintain operations.

8.1.4 Generally, it is not practicable to exercise total control over all traffic on the movement area. However, in very poor visibility conditions it may be necessary to exercise such a control at the expense of capacity. Within the field of reasonable constraint which varies according to conditions, safety and expedition depend upon aircraft and vehicles conforming to standard ground movement rules and regulations. The apron management must establish rules related to the operation of aircraft and ground vehicles on the aprons. These rules should be compatible with those for the manoeuvring area.

8.2 WHEN SHOULD AN APRON MANAGEMENT SERVICE BE ESTABLISHED?

8.2.1 Annex 14, Chapter 9, recommends that an apron management service be provided when warranted by the volume of traffic and operating conditions. Guidance on apron management and safety is given in the *Airport Services Manual*, Part 8, Chapter 10.

8.2.2 It is not possible to define at what levels of traffic volume and under what operating conditions an apron management service should be established. Generally speaking the more complex the apron layout the more comprehensive an apron management service needs to be, particularly when taxiways are included in the apron area.

8.2.3 The decision whether or not to provide an apron management service at a particular airport must rest with the aerodrome authority. If firm guidelines were given here on the conditions under which such a service should be provided it would remove the flexibility needed by individual States to design an apron management service more suitable to their particular needs.

8.2.4 Most aerodromes will already have some form of apron management. This may simply be an area set aside for the parking of aircraft, with painted lines to guide pilots to self-manoeuvring aircraft stands. At the other end of the scale the apron area may be a large part of the movement area with numerous nose-in stands, several terminals and complex taxiways forming part of the layout. A complex apron area such as this will need a comprehensive apron management service including radio communication facilities.

8.2.5 Aerodrome authorities must therefore consider what scope of management is needed for the activity on their apron areas to ensure the safe and efficient operation of aircraft and vehicles in close proximity. This is particularly important where low visibility operations are contemplated.

8.2.6 When considering what scope of management may be needed on an apron area, the following points should be considered:

a) Is the apron area sufficiently large, complex or busy to merit a separate staff to manage it?
b) What RTF facilities do the staff need to exercise control over their own vehicles, airline vehicles and, if necessary, over aircraft using apron taxiways?
c) If apron management staff are required to exercise control over aircraft and vehicles on the apron area to ensure safe separation, then such staff should be properly trained and licensed and their legal authority clearly established.
d) Will the apron management service issue its own instructions such as start up, push back, taxi clearances, and stand allocation or will these be given by the ATS unit as an element of the apron management service?
e) How will the various airline service vehicles be regulated on the apron as well as on airside roads serving aircraft stands? Is there a need for roads, controlled or uncontrolled, crossing apron taxiways?
f) Who will be responsible for inspection, maintenance and cleanliness of the aprons?
g) What size marshalling service, including leader van service (follow-me vehicles), is required to meet aircraft parking needs?
h) Are low visibility operations contemplated at the aerodrome? If so what procedures need to be developed to ensure safety on the apron area?
i) Are there procedures to cater for contingencies such as accidents, emergencies, snow clearance, diversion aircraft, flow control when the stands are nearly all occupied, maintenance work, stand cleaning and security?

8.3 WHO OPERATES THE APRON MANAGEMENT SERVICE?

8.3.1 Apron management services may be provided by the air traffic service unit, by a unit set up by the aerodrome authority, by the operator in the case of a company terminal, or by co-ordinated control between ATS and the aerodrome authority or operating company.

8.3.2 Some States have found that a preferred system of operating aprons has been to set up a traffic management control procedure in which a single unit takes over the responsibility for aircraft and vehicles at a pre-determined handover point between the apron and the manoeuvring area. Generally, the edge of the manoeuvring area represents the handover point. In any event, the handover point should be clearly indicated on the ground and on appropriate charts, for example the aerodrome chart, for the benefit of aircraft/vehicle operators. The apron management unit will then assume responsibilities for managing and co-ordinating all aircraft traffic on the apron, issuing verbal instructions on an agreed radio frequency, and managing all apron vehicle traffic and other apron activities in order to advise aircraft of potential hazards within the apron area. By arrangement with the aerodrome ATS unit, start-up and taxi clearance to the handover point will be given to departing aircraft where the ATS unit assumes responsibility.

8.3.3 One form of the co-ordinated apron management service is where radio communication with aircraft requiring start-up or push-back clearance on the apron is vested in the air traffic service unit, and the control of vehicles is the responsibility of the aerodrome authority or the operator. At these aerodromes, ATS instructions to aircraft are given on the understanding that safe separation between the aircraft and vehicles not under radio control is not included in the instruction.

8.3.4 The apron management service maintains close communication with the aerodrome control service and is responsible for aircraft stand allocation, dissemination of movement information to aircraft operators by monitoring ATC frequencies, and by updating basic information continuously on aircraft arrival times, landings and take-offs. The apron management service should ensure that the apron area is kept clean by airport maintenance and that established aircraft clearance distances are available at the aircraft stand. A marshalling service and a leader van (follow-me vehicle) service may also be provided.

8.4 RESPONSIBILITIES AND FUNCTIONS

8.4.1 Whichever method of operating an apron management service is provided, the need for close liaison between the aerodrome authority, aircraft operator and ATS is paramount. The operational efficiency and safety of the system depends very largely on this close co-operation. The following items are of importance to both ATS and the aerodrome authority:

a) Aircraft stand allocation

Over-all responsibility for aircraft stand allocation is normally retained by the aerodrome operator although for operational convenience and efficiency a system of preferred user stands may be established. Instructions should clearly state which stands may be used by which aircraft or groups of aircraft. Where considered desirable, a preferred order of use of stands should be laid down. Apron management staff should be given clear guidance on the stand occupancy times to be permitted and the steps to be taken to achieve compliance with the rules. The responsibility for stand allocation may be delegated to an airline where that airline has a dedicated terminal or apron area.

b) Aircraft arrival/departure times

Foreknowledge of arrival and departure times scheduled, estimated and actual is required by ATS, apron management, terminal management and the operators. A system should be established to ensure that this information is passed between all interested parties as quickly and efficiently as possible.

c) Start-up clearances

Normally these are given by the ATC unit. Where an apron management service operates its own radio communication on the apron area procedures will need to be established between the apron management service and the ATC unit to ensure the efficient co-ordination and delivery of such clearances.

d) Dissemination of information to operators

A system should be established to ensure the efficient distribution of relevant information between apron management, ATS and operators. Such information could include notification of work in progress, non-availability of facilities, snow clearance plans and low visibility procedures.

e) Security arrangements

In addition to normal security arrangements there are security requirements which are of interest to many parties who operate on the apron. These would include contingency plans for such eventualities as baggage identification on the stand, bomb warnings and hijack threats.

f) Availability of safety services

The rescue and fire fighting services (RFF) are normally alerted to an incident on the movement area by ATS. However, at aerodromes where aircraft on the apron area are controlled by the apron management service, a communication system needs to be established to alert the RFF when an incident occurs in the apron area of responsibility.

g) Apron discipline

The apron management service will be responsible for ensuring compliance by all parties with regulations relating to the apron.

8.4.2 *Aircraft parking/docking guidance system*

8.4.2.1 The apron guidance system provided will depend upon the accuracy of parking required and the types of aircraft operating on the apron. The simplest form of stand guidance, where precise accuracy is not required, will comprise stand identification and centre line paint markings. Guidance on apron markings is given in the *Aerodrome Design Manual*, Part 4. The apron management service should monitor all paint markings to ensure that they are maintained in a clean condition to retain maximum visibility. Where more accurate parking/docking is required then one of the guidance systems conforming to the specifications in Annex 14, Chapter 5 must be installed. Details of these systems are given in the *Aerodrome Design Manual*, Part 4, Chapter 12. The apron management service should monitor these systems and associated guidance lights to ensure that they are inspected at least weekly to maintain high standards of serviceability.

8.4.3 *Marshalling service*

8.4.3.1 An aerodrome marshalling service should be provided where parking or docking guidance systems do not exist or are unserviceable or where guidance to aircraft parking is required to avoid a safety hazard and to make the most efficient use of available parking space. Proper training arrangements should exist for marshallers and only those who have demonstrated satisfactory competence should be permitted to marshal aircraft. Where aerodrome marshalling is provided, comprehensive instructions should be written for marshallers including:

a) the absolute necessity for using only authorized signals (copies of these should be displayed at suitable points);
b) the need to ensure that prior to using the authorized signals the marshaller shall ascertain that the area within which an aircraft is to be guided is clear of objects which the aircraft, in complying with his signals, might otherwise strike;
c) the circumstances in which one marshaller may be used and the occasions when wing walkers are necessary;
d) the action to be taken in the event of an emergency or incident involving an aircraft and/or vehicle occurring during marshalling, e.g. collision, fire, fuel spillage;
e) the need to wear a distinctive jacket at all times. This jacket can be of the waistcoat variety coloured day-glow red, reflective orange, or reflective yellow; and
f) the action to be taken when re-positioning of aircraft is to be carried out by tractor and signalling is necessary to close down engines.

8.5 SPECIAL PROCEDURES FOR LOW VISIBILITY CONDITIONS

8.5.1 The special procedures related to low visibility conditions are described in Chapter 5.

8.6 TRAINING

8.6.1 The functions of the apron management service require that its staff be appropriately trained and authorized to carry out their respective responsibilities. This applies particularly to those responsible for the operation of an apron management centre or tower, to marshallers and to leader van (follow-me vehicle) operators.

8.6.2 Staff operating an apron management centre or tower have the responsibility for managing and, at some aerodromes, controlling aircraft movement within their area of responsibility. To a considerable extent their function is similar to that of ATC control on the manoeuvring area and similar training of staff is required. Among the issues addressed by a training programme will be:

a) ATS unit/apron management co-ordination;
b) start-up procedures;
c) push-back procedures;
d) gate holding procedures;
e) taxi clearances; and
f) en-route clearances.

8.6.3 To satisfy training requirements for apron management operating staff, some States utilize programmes developed for ATS staff. Further, some States require that apron management staff hold ATC or other licences or have as part of their training, experience in aerodrome control.

8.6.4 Aircraft marshallers require training to ensure that they are properly qualified to direct aircraft movements. Their training should focus on:

a) signalling;
b) aircraft characteristics, both physical and operating, that relate to manoeuvring of aircraft within the confines of the apron; and
c) personal safety around aircraft and particularly engines.

8.6.5 At aerodromes where leader vans ("follow me" vehicles) are in use, local regulations should ensure that drivers are suitably qualified in RTF procedures, know visual signals and have a suitable knowledge of taxiing speeds and correct aircraft/vehicle spacings. A thorough knowledge of the aerodrome layout with an ability to find one's way in low visibility is important.

Appendix A

Further Information on Visual Aids*

1. MARKING AIDS

1.1 *Taxiway centre line marking* — This marking consists of a continuous yellow line extending from the runway to the aircraft stand. Although termed centre line, the marking really denotes the path over which the cockpit of the aircraft should pass in order for the aircraft landing gear to remain on a paved surface.

1.2 *Taxi holding position marking* — The purpose of this marking is to identify the point at which an aircraft should hold at a taxiway/runway intersection so as not to be an obstacle to aircraft operating on the runway or to interfere with the operation of the ILS. When operations on the runway are conducted in different visibility conditions, more than one hold line may be required at each intersection of a taxiway with the runway.

1.3 *Taxiway intersection marking* — The purpose of this marking is to identify the point at which an aircraft must hold at a taxiway/taxiway intersection in order to be clear of other aircraft passing in front of the holding aircraft on a crossing taxiway.

1.4 *Aircraft stand markings* — This term is used to refer to a number of different markings used to provide guidance to a pilot manoeuvring his aircraft on an aircraft stand. They provide alignment guidance onto the stand, indicate the stopping position and alignment guidance from the stand.

1.5 *Apron safety lines* — This term is used to refer to those markings on an apron that are intended to provide guidance to vehicles other than aircraft; for example, wing tip clearance lines, service roads and parking areas for ground vehicles. Their purpose is to control where ground equipment and vehicles go in order to prevent them being obstacles to aircraft.

* Visual aids for navigation are specified in Annex 14, Chapter 5

2. LIGHTING AIDS

2.1 *Taxiway centre line lights* — These green lights are located along the taxiway centre line marking. Consideration is now being given to coding exit taxiway centre line lights to indicate to a pilot when he is clear of the runway. Alternate lights are intended to be coded green and yellow from the beginning of the exit taxiway lighting near the runway centre line up to the edge of the ILS critical sensitive area or the lower edge of the inner transitional surface. Taxiway centre line lights are a particular requirement for low visibility operations when taxiway edge lights provide inadequate guidance because they cannot be so readily seen from the cockpit. These lights are available in different intensities for use in different visibility conditions. Taxiway centre line lights may be selectively switched on or off to identify the route a pilot should take to reach his destination on the ground.

2.2 *Taxiway edge lights* — These lights are installed along the edges of taxiways and aprons. Their purpose is to identify the lateral limits of the paved areas and thereby prevent aircraft from taxiing off the pavement.

2.3 *Taxi-holding position lights* — This aid consists of two alternately illuminated yellow lights. A pair of such lights is located at each side of a taxi-holding position. They are operated only when a runway is being used for landing or take-off and are intended to provide a distinctive warning to anyone approaching the taxi-holding position that they are about to encroach upon an active runway.

2.4 *Stop bars* — A stop bar consists of a series of red lights perpendicular to the taxiway centre line at the point where it is desired that an aircraft stop. In general its location coincides with that of the taxiway holding position marking. The lights are operated by air traffic control to indicate when an aircraft should stop and when it should proceed. This is particularly useful when used in conjunction with selectively switchable taxiway centre line lights.

2.5 *Clearance bars* — This bar is similar to a stop bar but the lights are yellow and they are not switched on or off to indicate when traffic should stop or proceed. They are primarily intended for use at taxiway/taxiway intersections in conjunction with taxiway intersection markings.

2.6 *Visual docking guidance systems* — These systems are intended to provide precise alignment and stopping information to an aircraft entering an aircraft stand.

2.7 *Runway clearance aid* — At present the only aid under consideration to provide runway clearance information is colour coded taxiway centre line lights; see taxiway centre line lights above.

3. SIGNS

3.1 Signs are of two basic types: mandatory instruction signs and information signs.

3.1.1 *Mandatory instruction signs* — Red signs with white inscriptions used to convey an instruction which is to be carried out unless advised otherwise by ATS. Examples include:

Stop sign
No entry sign
Holding position (Categories I, II or III) sign

3.1.2 *Information signs* — Either black signs with yellow inscriptions or yellow signs with black inscriptions used to indicate a specific location or destination or to provide other information.

3.1.3 In general, signs should meet the requirements in Annex 14, Chapter 5 and the *Aerodrome Design Manual,* Part 4, Chapter 11. More importantly, signs should be uniform throughout an aerodrome, self-evident (unambiguous) and simple, and located with due regard to the speed and characteristics of taxiing aircraft (e.g. height of the cockpit, location and height of jet pods) and the need to give information to pilots in sufficient time for it to be correlated when necessary with that on the aerodrome chart. A few examples of signs meeting these requirements are illustrated in Figures A-1 to A-8.

Figure A-1. A stop sign

(Note that at the bottom of the stop sign an information sign is installed to indicate that at this holding position of runway 27, the runway length available for take-off is 3 250 m. Both signs are internally illuminated.)

Figure A-2. A Category I holding position sign and an information sign located side by side

(Note that the standard inscription for a Category I holding position sign is CAT I and the use of the word HOLD is optional. The inscription 28R on the holding position sign denotes that the holding position is related to runway 28 right. The information sign on the right indicates that surface block 40 is to the left and surface block 27 is to the right. All of the signs are externally illuminated.)

Figure A-3. A Category II/III holding position sign

(Note that the standard inscription for a Category II holding position is CAT II and that for a Category III holding position it is CAT III. Thus if a holding position is common for operations in both Category II and III conditions the inscription should be CAT II/III. The use of the word "HOLD" is optional. The inscription 28R on the sign denotes that the holding position is related to runway 28 right. The sign is externally illuminated.)

Figure A-4. A Category III taxi-holding position and a stop sign installed side by side

(Note that as in Figure A-1, at the bottom of the stop sign an information sign is provided to indicate that at this holding position of runway 27, the runway length available for take-off is 3 600 m. All of the signs are internally illuminated.)

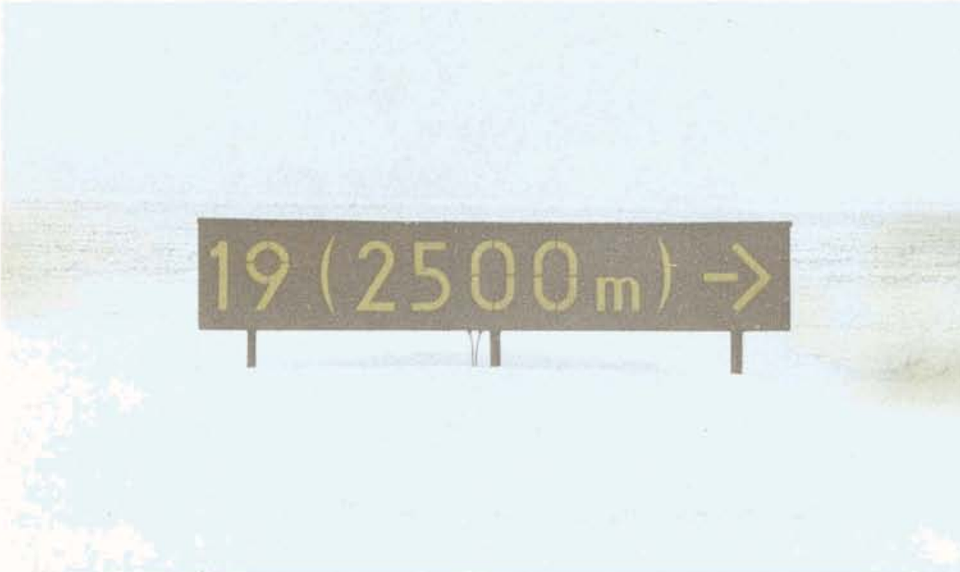


Figure A-5. An information sign

(The inscriptions on the sign indicate that runway 19 is to the right and 2 500 m of the runway length is available for take-off. The sign is internally illuminated, its background is black and the inscriptions are in yellow.)

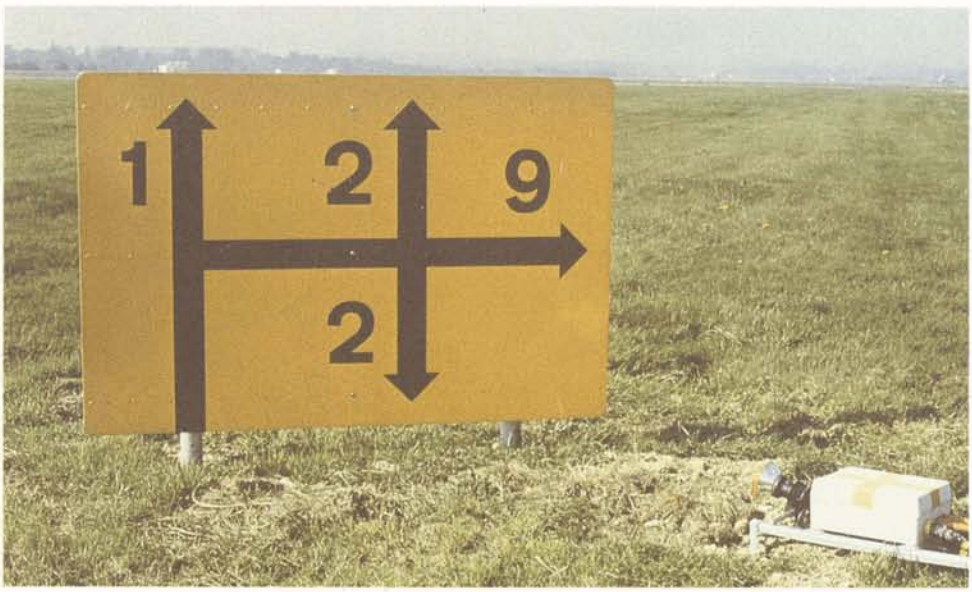


Figure A-6. A destination sign

(The sign, which is externally illuminated, indicates how to proceed to taxiways 1, 2 and 9.)

Figure A-7. An information sign

(The sign, which is externally illuminated, serves both as a destination and a location sign. It indicates that runway 10 and the cargo area are straight ahead and that entry to the taxiway on the right is prohibited. The inscription K3 at the bottom indicates the designation of the surface block.)

Figure A-8. A destination sign

(The sign, which is internally illuminated, indicates the direction to runway 10 as well as to the cargo area.)

Appendix B

Examples of Low Visibility Procedures

1. HEATHROW AIRPORT, LONDON, UNITED KINGDOM

1.1 *Introduction**

1.1.1 The procedures have been devised to simplify the differing requirements of Category II and Category III operations. To achieve this, during the relevant weather conditions (see 1.2 below), the localizer sensitive area (LSA) is to be safeguarded. This ensures the protection of the localizer signal and at the same time effectively meets the obstacle free zone (OFZ) requirements.

1.2 *General*

1.2.1 Runways 28L/10R and 28R/10L (see Figure B-1) are equipped for Category II/III operations (low visibility operations).

1.2.2 Air traffic control (ATC) low visibility procedures become effective when:

a) the instrumented runway visual range (IRVR) (or meteorological visibility if the IRVR system is unserviceable) is less than 600 m. The IRVR to be used to determine the commencement of these procedures is to be the touchdown reading but if this position is unserviceable the midpoint reading is to be used;
b) the cloud ceiling is 200 ft or less, irrespective of the serviceability state of the ILS, lighting, standby power, etc.

1.2.3 Pilots are entitled to expect ILS localizer and glide path signals to be fully protected from interference during the final stages of the approach from the time that the procedures are notified as in operation until the time that they are notified as cancelled. Controllers are reminded that they have a responsibility to notify pilots of cancellation of low visibility procedures, individually if necessary, and that localizer and glide path considerations must also be applied when operating the low visibility procedures as a result of a 200 ft cloud ceiling associated with better than 600 m visibility. The distance between successive landing aircraft is critical; experience indicates that a minimum of 6 NM is necessary to achieve the objectives.

1.2.4 Localizer sensitive area (LSA) (see Figure B-2). Effectively, for ATC purposes, the LSA is a rectangular area contained within parallel lines 137 m each side of the runway centre line and between the localizer aerial and the beginning of the runway in use. In the case of departing aircraft the LSA exists only between the departing aircraft and the localizer aerial.

1.2.5 *Protection of the LSA*

1) *Arriving aircraft.* No vehicle or aircraft is permitted to infringe the LSA ahead of the arriving aircraft from the time the aircraft is 1 NM from touchdown until it has completed its landing run. Landing clearance must not be issued if the LSA is known to be infringed.
2) *Departing aircraft.* No vehicle or aircraft is permitted to infringe the LSA ahead of the departing aircraft from the time when it has commenced its take-off run until it is airborne. Take-off clearance must not be issued if the LSA ahead of the departing aircraft is known to be infringed.

1.3 *Responsibilities*

1.3.1 It is the responsibility of:

ATC — to advise telecommunication engineers (TELS) and the airport authority when low visibility procedures are to commence.

* The procedures described below are an updated (1984) version of the procedures originally developed in 1971.

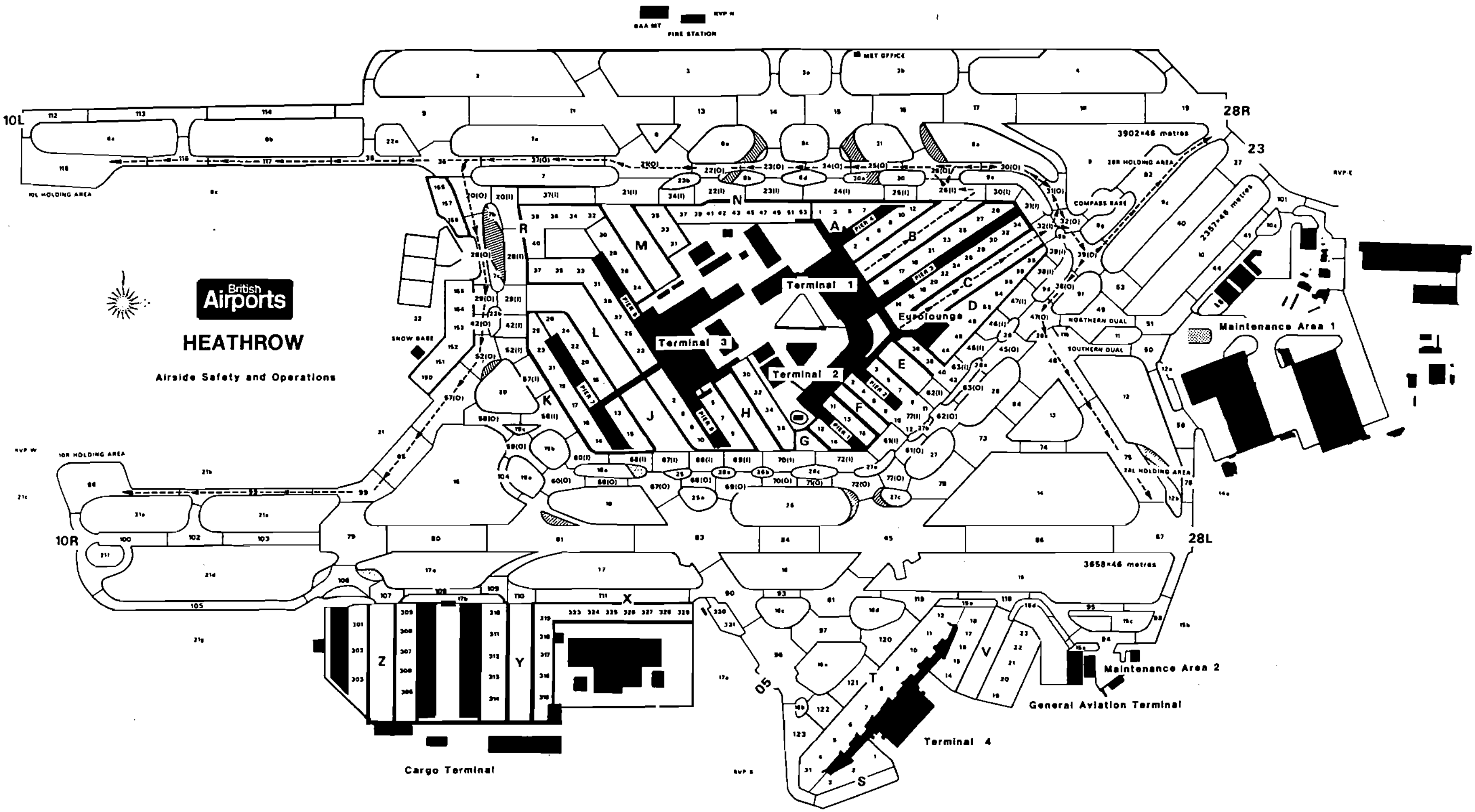


Figure B-1. Heathrow Airport London

TELS — to immediately notify ATC whenever the ILS category differs from that promulgated. TELS will take the appropriate NOTAM action.

Aerodrome authority — to immediately advise ATC of any significant unserviceability in the aerodrome lighting and/or standby power supplies, and to ensure that all necessary ground safeguarding action is taken and advise ATC accordingly. The aerodrome authority will take the appropriate NOTAM action.

Information relative to the above is to be recorded in the watch log.

1.4 *Approach control (APC) procedures*

1.4.1 *Action by APC supervisor.* In order for the necessary arrangements to be in force in sufficient time the following action is to be taken when the touchdown — IRVR or cloud ceiling is decreasing, and is expected to fall below 600 m/200 ft:

a) notify TELS and confirm the status of ILS;
b) notify the London Air Traffic Control Centre (LATCC) supervisor.

1.4.2 The APC supervisor is responsible for notifying the above agencies when low visibility operations cease.

1.4.3 The APC supervisor is also to ensure that:

a) the following message is broadcast on the automatic terminal information service (ATIS) or passed to arriving aircraft by RTF, as appropriate: "ATC low visibility procedures in operation";
b) all relevant information concerning the status of the ILS, lighting unserviceabilities, etc. is passed to the appropriate controllers (including the ADC supervisor) for onward transmission to aircraft; this notification to pilots is to indicate any lower status of the facility whether or not it has already been promulgated by NOTAM;
c) details of any unserviceabilities of equipment relevant to Category II/III operations are included in the ATIS message.

1.4.4 *Information to pilots.* In addition to the information normally transmitted by approach control, the following information must be passed by the appropriate controller to the pilot of every arriving aircraft:

a) the current IRVR readings for the landing runway (or the reported meteorological visibility if the IRVR system is unserviceable);
b) unserviceability of any component parts of the Category II/III facilities not previously broadcast on the arrival ATIS.

1.4.5 *Separation on final approach.* The No. 2 Final Approach Radar Director (DIR) will decide on a suitable final approach spacing in co-ordination with the tower controller, taking account of the prevailing weather conditions. The aim should be to ensure that arriving aircraft can be given a landing clearance at 2 NM from touchdown. Controllers should be aware that during low visibility operations aircraft may require considerable time to clear the runway. In low visibility conditions aircraft must establish on the localizer at an early stage. Therefore, whenever ATC low visibility procedures are in operation aircraft must be vectored to intercept the localizer at not less than 10 NM from touchdown.

1.4.6 *Continuous descent approach (CDA).* During low visibility operations the range information and intermediate approach speed associated with CDAs are to be given whenever practicable. However, controllers should be aware that pilots may wish to use final approach speeds which do not conform to those specified in the CDA.

1.5 *Aerodrome control (ADC) procedures*

1.5.1 *Action by aerodrome supervisor.* On being notified by the approach supervisor that low visibility procedures are to commence the ADC supervisor will inform:

— British Airports Authority (BAA) controller engineer
— aerodrome fire service (AFS)
— movement area safety unit (MASU), to institute their ground safeguarding procedures and obtain confirmation that the runway has been safeguarded

The ADC supervisor is also responsible for notifying the above agencies when low visibility operations cease.

Note.— Every effort should be made to notify MASU in sufficient time to enable ground safeguarding procedures to be completed before low visibility operations commence. However, the start of low visibility operations is not to be delayed awaiting the receipt of confirmation from MASU.

1.5.2 If the IRVR falls to 350 m or less, or cloud ceiling 100 ft or less before confirmation is obtained from MASU, supervisors are to ensure that any pilot wishing to make an approach, or take off, is notified that ground safeguarding procedures have not been completed.

1.5.3 *Action by tower controller*

a) Landing clearance should be given no later than 2 NM from touchdown. If this is not possible then the pilot must be warned to "expect late landing clearance". A landing clearance or overshoot instruction must be issued before the aircraft reaches 1 NM from touchdown.
b) A landed aircraft, or traffic which has crossed the runway, should be given an unimpeded route to allow it to clear the LSA towards, or onto the outer taxiway. Surface movement radar should be used to monitor the progress of aircraft and crossing traffic and no ATC instruction is to be issued which could prejudice this routing.

   Note 1.— If surface movement radar is not available then landing aircraft and crossing traffic must clear the runway at those exits where white flashing lights are provided. In the event landing aircraft or crossing traffic leave the runway at an exit where there are no white flashing lights then pilot/driver reports must be obtained to ascertain that the LSA has been cleared, and this may entail the use of an appropriate stop bar if block number reports are not available.

   Note 2.— If distance from touchdown indicator (DFTI) performance does not allow satisfactory assessment of the 1 NM point, the aircraft must be given landing clearance or overshoot instructions at 2 NM from touchdown.
c) During single runway operations, the approach spacing should be arranged so as to ensure that a departing aircraft passes overhead the localizer before the next landing aircraft reaches 2 NM from touchdown. Experience has shown that the departing aircraft must commence its take-off roll before the inbound aircraft reaches 6 NM from touchdown in order to achieve this.

1.5.4 *White flashing lights.* These are provided at certain runway exits and mark the lateral boundaries of the LSA. Pilots clearing at these exits will delay their "runway clear" reports until passing these lights.

Note.— It is anticipated that this facility will be replaced by yellow/green coded taxiway centre line lights to the limit of the LSA.

1.5.5 *Action by lighting operator.* The ground movement control (GMC) lighting assistant is to monitor, in liaison with the BAA Airport duty engineer, the fault indicator lights for the lighting services, establish the nature and expected duration of any faults and inform the aerodrome control supervisor immediately any fault indications appear.

1.5.6 *Information to departing aircraft.* When low visibility procedures are in force the following is to be added to the departure ATIS or passed to aircraft on RTF as appropriate:

"ATC low visibility procedures in operation: use Category III holding points"

1.5.7 *Holding points.* To comply with the safeguarding requirements, aircraft awaiting take-off must hold at the Category III holding positions which are well defined by illuminated notice boards and taxiway markings. The notified Category III holding points are as follows:

28L — Block 75, Block 94 and 95
28R — Block 92
10L — Block 115
10R — Block 98

With particular reference to runway 28L/10R, as there is no Category III notified holding point north of Block 79, aircraft wishing to depart from Block 79 on 10R are to be held at the 65-89 stop bar. This restriction applies equally to crossing traffic.

1.5.8 *Runway crossing routes.* It should be clearly understood that in low visibility operations appropriate notified holding points should be used not only for departing aircraft but also for aircraft, vehicles, etc. wishing to cross a runway, or enter for purposes other than departure.

1.5.9 If aircraft vehicles, etc. wish to cross or enter at a position where a notified holding point is not available, they must be held at a stop bar which is outside the LSA as shown in Figure B-2.

1.5.10 *Taxiway route restrictions.* The following route restrictions are to be applied during low visibility operations:

a) Landings on runway 10R. No aircraft, taxiing or towing, to route via Blocks 85-72(O)-77(O).

   Note.— This routing restriction is applicable in the direction stated, and applies equally to landing aircraft.

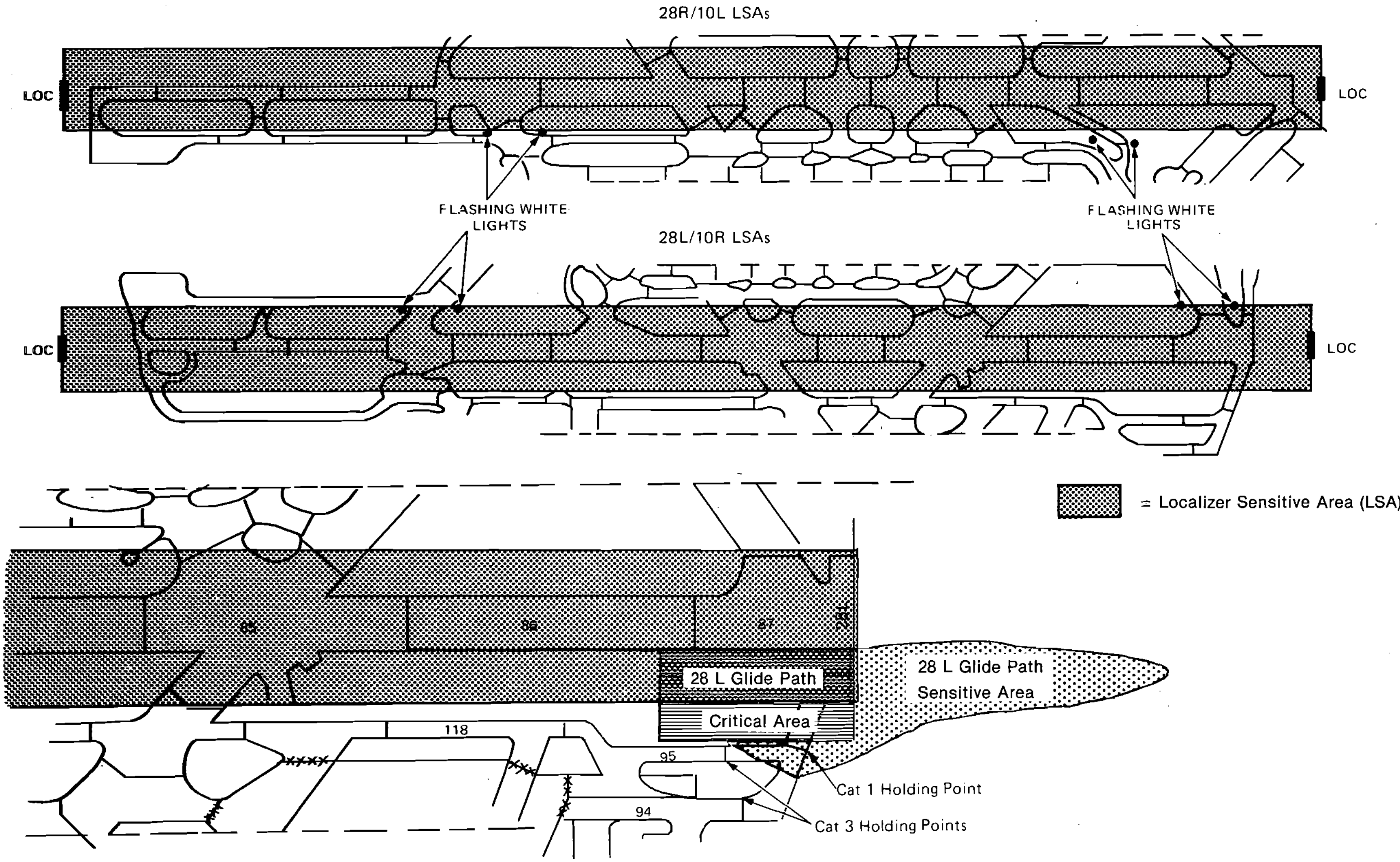


Figure B-2. Localizer and glide path sensitive areas

b) Landings on runway 28R. No aircraft, taxiing or towing, to route via Blocks 101-27-40. It is permitted to hold at the 40/27 stop bar in a north-easterly direction awaiting clearance to enter runway 28R.
c) 10L — No B747SP aircraft are to proceed westward beyond the 35/36 stop bar while approaches are being carried out to 10L.
d) 10R — No B747SP aircraft are to proceed westward beyond the 107/106 stop bar while approaches are being carried out to 10R.
e) No aircraft is permitted to route Block 94-87-75 or vice versa when the 28L glide path is being used by arriving aircraft.
f) Routes. Most routes on the airfield are fitted with high intensity taxiway centre line lighting. Special paint markings have been provided in some locations on the taxiway to warn of the proximity and direction of the curves.

1.5.11 During low visibility operations the GMC/air departure controller is to pass to aircraft approaching the holding point essential traffic information in respect of aircraft already holding.

1.5.12 British Airways' aircraft, some of which are equipped with a ground roll monitor (GRM) may request specific preferred routes to the holding points. These preferred routes are shown in Figure B-1. During the taxiing phase from the stand, ATC may be requested to illuminate the stop bar at the exit from the cul-de-sac, or at 24(I)-24(O) as appropriate, before bringing up the green route to the runway holding point. This is to provide a zero reference point for the GRM.

1.6 *Manoeuvring area safety unit (MASU) — Adverse weather conditions*

1.6.1 *Runway categories*

1.6.1.1 Runways 10L, 10R, 28L and 28R are equipped to accept aircraft operations down to ICAO Category III limits.

1.6.1.2 Special procedures have been developed for aircraft operations in low visibility conditions and are promulgated in the United Kingdom Air Pilot AGA Section.

1.6.2 *Localizer sensitive area (LSA) lights and holding points*

1.6.2.1 The following special facilities are provided for use in low visibility conditions:

a) *LSA lights.* These are positioned 137 m from the runway centre line each side of the taxiway at the nominated Category III turn-offs. The lights are omnidirectional, high intensity flashing white. They are switched on in low visibility conditions only and provide an indication to the pilot of an arriving aircraft turning off the runway that the aircraft is clear of the ILS localizer sensitive area (see the Note below).
b) *Category III holding points.* These are positioned in taxiway Blocks 75, 92, 98, 94, 95 and 115 to keep aircraft awaiting take-off clear of the ILS sensitive areas. They are marked with standard ICAO Category II/III taxiway point marks, additional runway guard lights switched on in low visibility conditions only, and illuminated Category II/III notice boards.

Note.— It is anticipated that this facility will be replaced by yellow/green coded taxiway centre line lights to the limit of the LSA.

1.6.2.2 The above facilities are inspected once a week by the MASU and immediate rectification action taken whenever necessary.

1.6.3 *Additional safety precautions — low visibility checklists*

1.6.3.1 The following additional precautions are taken to safeguard operations in low visibility.

1.6.3.2 *Low visibility Checklist 1.* Implement when the IRVR is 1 000 m and the forecast shows that the visibility will fall to below 600 m, or when requested by ATC or the operations duty manager or ADC.

a) The MASU control room will telephone the following and advise them:
"Preliminary warning — low visibility procedures are expected to be in force shortly."
   1) aerodrome fire service watchroom
   2) access control duty officer (close controlled crossings)
   3) control Post 12
   4) operations duty manager (ODM)
   5) apron safety unit
   6) police
b) Check all the perimeter fencing and access gates including Wessex Road and Viscount Way.
c) Warn and remove maintenance and works contractors as necessary.
d) Check that the "shingals" (Category III approach lighting) for the available runways are on and serviceable.

e) Check that the green/yellow runway turn-off lights are serviceable.
f) Ensure that warning signs and markers are available for Block 27/101 and No. 2 maintenance area.

1.6.3.3 *Low visibility Checklist 2.* Implement when advised by ADC that low visibility procedures are commencing (touchdown IRVR 600 m — cloud base 200 ft or less), or when requested by the ODM.

a) The MASU control room will telephone the following and advise them that:
"Low visibility procedures are now in force"
1) aerodrome fire service watchroom
2) access control duty officer (close controlled crossings)
3) control Post 12
4) operations duty manager
5) apron safety unit
6) police
b) Switch on all LSA lights at blocks 89, 36, 17 and 75.
c) Switch on all low visibility runway guard lights (taxi-holding position lights) and Category II/III board lights at Blocks 98, 115, 92, 75, 94 and 95.
d) Mark off Block 101/27 stop bar and erect "no entry" sign. (Advise ADC that route 101-27 is not available.)
e) Check that all controlled crossings are closed.
f) Erect "no entry" signs at entrances to Pan Am, GA apron and fields apron.
g) Advise ADC that low visibility safeguarding has been completed.

1.6.3.4 *Low visibility Checklist 3.* Implement when advised by ADC that low visibility procedures are cancelled, or at the request of the ODM.

a) The MASU control room will telephone the following and advise them that:
"Low visibility procedures are cancelled."
1) aerodrome fire service watchroom
2) access control duty officer
3) operations duty manager
4) apron safety unit
5) control Post 12
6) police.
b) Remove "no entry" signs at Pan Am, GA apron, Block 101 and advise ADC that route 101-27 is available.
c) Switch off all LSA lights.
d) Switch off all low visibility Category II/III board lights.
e) Advise maintenance and works contractors that they may resume operations.

2. FRANKFURT AIRPORT, FRANKFURT, FEDERAL REPUBLIC OF GERMANY

2.1 *Introduction**

2.1.1 In 1982 Frankfurt Airport introduced all-weather operations down to Category III limits of an RVR of 125 m. At the request of the Federal Ministry of Transport, procedures and measures for Category II/III low visibility operations have been introduced and in the interests of safety, all departments, authorities and companies are required to instruct their employees to comply with these procedures which are contained in Part II, Chapter 1.1 of the Airport Regulations.

2.2 *Category II operations*

2.2.1 *Definition*

2.2.1.1 Operations with a high probability of successful approach and landing from a 200 ft (60 m) decision height and an RVR of 800 m down to a 100 ft (30 m) decision height and an RVR of 400 m.

2.2.2 *Operational requirements for Category II*

2.2.2.1 Category II operations may only take place if Air Traffic Control (ATC) has taken the measures stated in 2.4 and the following systems and installations are in a "fail-safe" operation:

a) Instrument landing system (ILS)
— localizer
— glide path
Note.— In the event of a failure of the outer marker and/or the middle marker, no downgrading to a lower approach category shall take place. The failure shall be reported to the pilot who then is solely responsible for determining his operating minima.

b) Visual aids for landing
— approach lighting system
— runway threshold lights
— runway touchdown zone lights
— runway centre line lights
Note.— Failure of visual aids for landing (2 phases or total) and failure of the secondary power supply shall be reported to the pilot immediately.

* The procedures described below were developed in 1982.

c) Meteorological installations
   — ground wind speed and direction indicators
   — the runway visual range (RVR)
   Note.— The above installations shall continuously provide current meteorological data.
d) Secondary power supply for the runway lighting system.

2.2.2.2 The working condition of the individual installations and systems is monitored and shown on an indicator in the approach control and in aerodrome control.

2.3 *Category III operations*

2.3.1 *Definition*

a) Category III (a): Operations down to the runway surface, relying on external visual reference during the final phase of landing and down to an RVR of the order of 200 m.
b) Category III (b): Operations down to the runway surface and sufficient visibility for taxiing.
   Note.— The minimum visibility in which taxiing can take place without reliance on visual references (e.g. taxiway centre line lights and stop bars) and avoid collision with other traffic approaching an intersection has been determined as 150 m at Frankfurt Airport.

2.3.2 *Operational requirements for Category III*

2.3.2.1 Category III operations may only take place if the Federal Air Navigation Agency has taken the measures stated in 2.4 and the following systems and installations are in a "fail-safe" operation:

a) Instrument landing system ILS
   — localizer
   — glide path
   Note.— See 2.2.2.1 a)
b) Visual aids for landing
   — runway threshold lights
   — runway touchdown zone lights
   — runway centre line lights
c) Visual aids for taxiing
   — stop bars
   — taxiway centre line lights
   Note.— Failure of visual aids for landing and taxiing (2 phases or total) and failure of the secondary power supply shall be reported to the pilot immediately.
d) Meteorological installations
   — ground wind speed and direction indicators
   — the runway visual range
   Note.— The above installations shall continuously provide current meteorological data.
e) Secondary power supply for the runway lighting system

2.4 *Measures taken by the Federal Air Navigation Agency (see Figures B-3 to B-5)*

2.4.1 *Notification*

a) Category II
   — If either of the first two transmissometers installed in the landing direction show RVR values of 1 000 m or less;
   — and/or if the ceiling or vertical visibility is reported to be below 300 ft;
   — and if the landing weather forecast expects further deterioration of the runway visual range and/or a further lowering of the ceiling, i.e. further deterioration of the vertical visibility;

   the Federal Air Navigation Agency shall give notification to the following offices of the forthcoming commencement of Category II flight operations:
   1) meteorological service
   2) Flughafen Frank-Main AG (FAG) apron control
   3) Rhein-Main military apron control (United States Air Force).

b) Category III
   — If either of the first two transmissometers installed in the direction of landing show RVR values of 400 m or less;
   — and/or if the ceiling or vertical visibility is reported to be below 100 ft;
   — and if the landing weather forecast expects a deterioration of the runway visual range and/or a lowering of the ceiling or vertical visibility;

the Federal Air Navigation Agency shall notify the following offices of the forthcoming commencement of Category III flight operations:
   1) Flughafen Frank-Main AG (FAG) apron control
   2) Rhein-Main military apron control (United States Air Force).

2.4.2 *Procedures*

2.4.2.1 The Federal Air Navigation Agency shall check whether the system, installation and indicator mentioned in 2.2.2 and 2.3.2 are serviceable and in a 'fail-safe" operating condition, and whether the

ALL WEATHER OPERATIONS FRANKFURT/MAIN AIRPORT
OPERATION PROCEDURE

Availability Category II/III

Requirements	CAT II: RVR	≤ 1000 m	+ Trend ↓
	CIG/VV	≤ 300 ft	

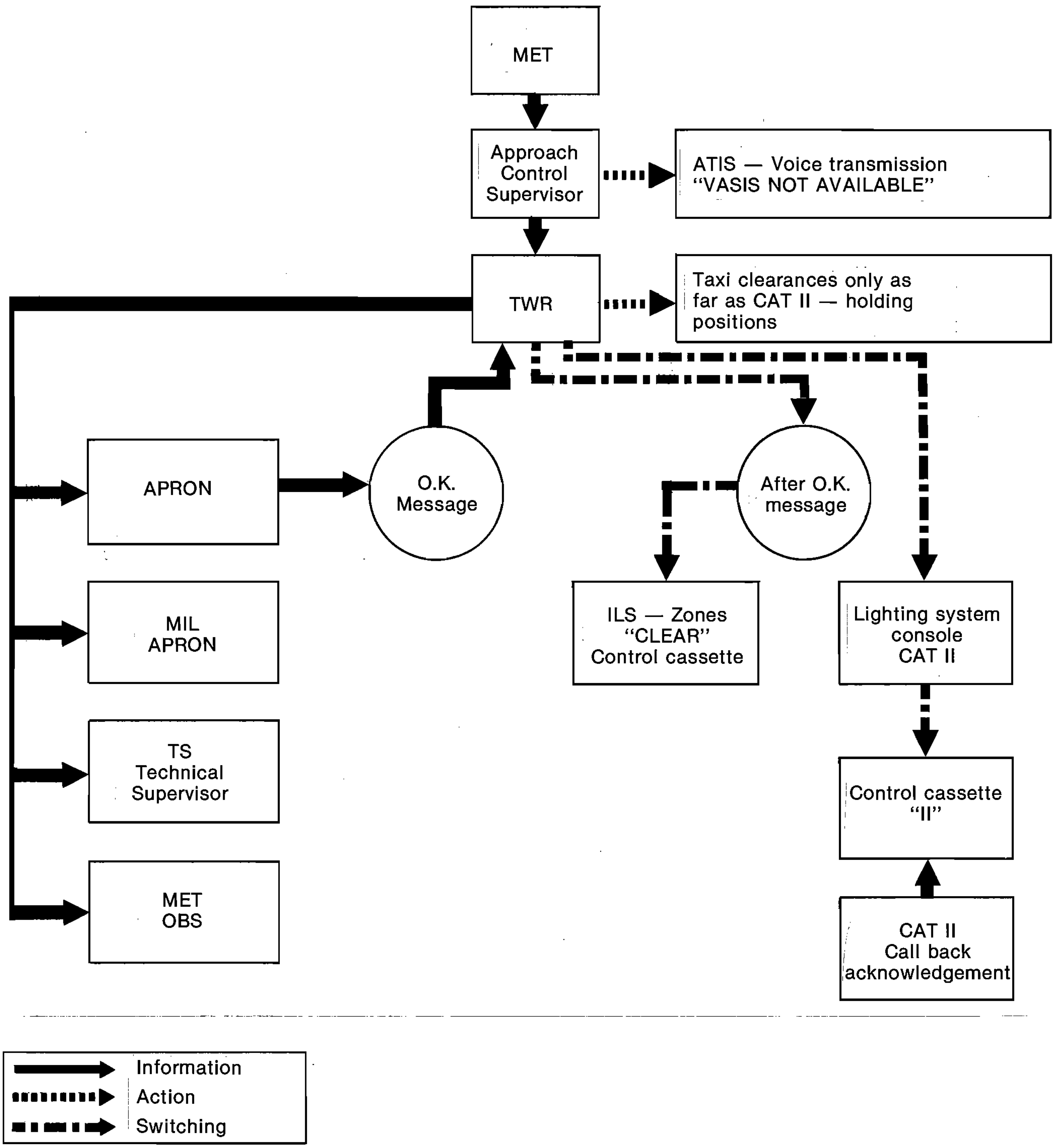
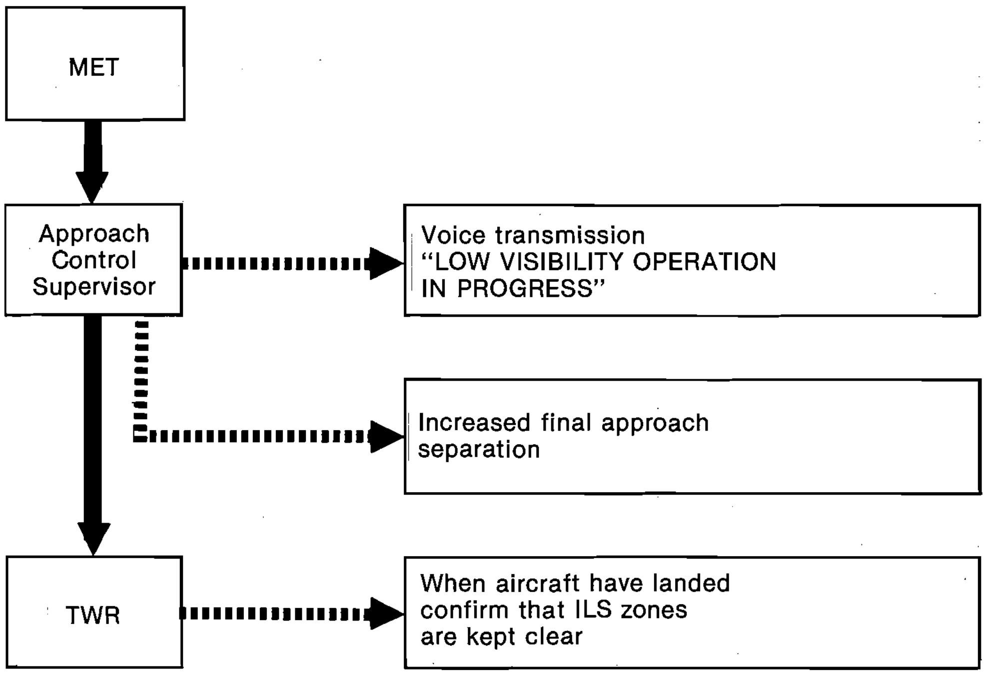


Figure B-3. All weather operations — Frankfurt-Main Airport (Category II/III operations)

ALL WEATHER OPERATIONS FRANKFURT/MAIN AIRPORT
OPERATION PROCEDURE

Category II Operations

CAT II Requirements:	RVR	≤ 800 m	Trend ↓
	CIG/VV	< 200 ft	



System failure	Downgrading
ILS	
— Localizer	CAT I
— Glide path transmitter	CAT I
— ILS zone not clear	CAT I
MET	
— Data for surface wind and/or touchdown zone RVR	CAT I
Lighting and emergency power supply	
Information for pilots only	

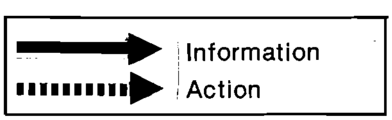


Figure B-4. All weather operations — Frankfurt-Main Airport (Category II operations)

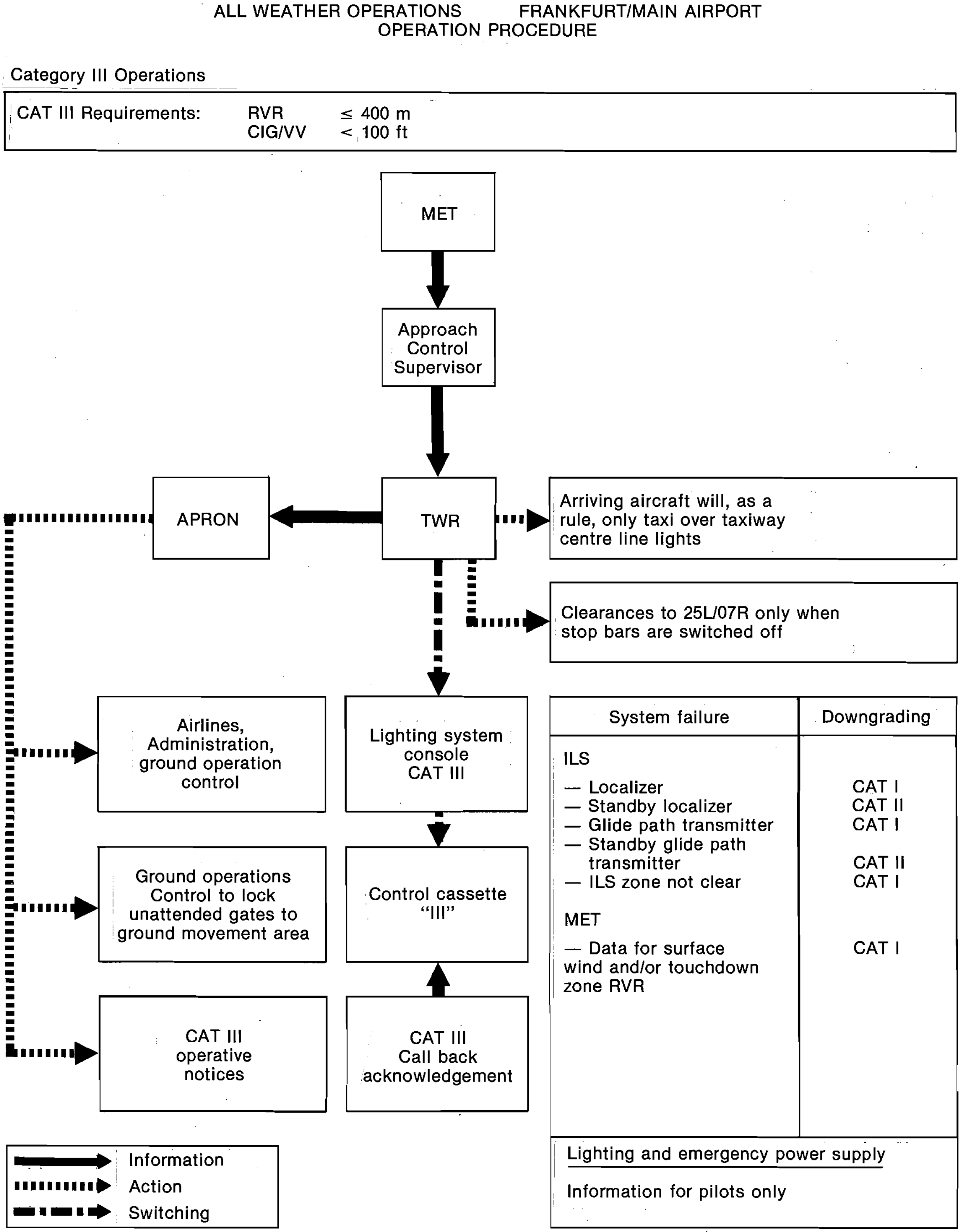


Figure B-5. All weather operations — Frankfurt-Main Airport (Category III operations)

meteorological service facilities are providing the current data, and whether the FAG apron control and the Rhein-Main military apron control have given the required report on obstacle clearance. If all the requirements are met and RVR is 800 m or below and/or the ceiling is below 200 ft, the Federal Air Navigation Agency will give permission for Category II/III ILS procedures using the phraseology "Low visibility procedures in operation".

2.4.2.2 The Federal Air Navigation Agency shall issue operating instructions for Category II/III which give detailed directions to approach control and aerodrome control on the operation of the lighting system and the observance of taxi-holding positions. The Federal Air Navigation Agency is responsible for instructing aircraft to use the recognized Category II/III holding points and if the RVR is 400 m or below and/or the ceiling is below 100 ft for operating the associated stop bars and taxiway centre line lights.

2.4.2.3 The Federal Air Navigation Agency shall also close the service lane to the manoeuvring area by switching the traffic lights to red.

2.4.2.3.1 No aircraft of the type C 5A may be towed within the ILS protection zone on the military apron without the prior permission of the Federal Air Navigation Agency.

2.4.2.4 The Federal Air Navigation Agency shall terminate Category II/III requirements if, for a period of at least 20 minutes, the RVR values exceed 1 000 m for Category II, 400 m for Category III and/or the ceiling or vertical visibility is greater than 200 ft for Category II, 100 ft for Category III and a trend for further improvement is confirmed by the MET forecaster.

2.5 *Aircraft guidance in Category II/III conditions*

2.5.1 After landing on the southerly runway (25L/07R) aircraft shall taxi to the apron area following the green centre line lights without the assistance of a "follow me" vehicle. Taxiway route C(R), W, N should be used after landing on runway 25L and taxiway route C(D), B, A should be used after landing on runway 07R (see Figure B-6).

2.5.2 Clearance to taxi on to the runway for the take-off shall be given by RTF and, in addition, by switching off the appropriate red stop bar. The stop bar will automatically switch on again once the aircraft has passed and the controller can check if the stop bar is operating by using the lighting monitoring system.

2.6 *Measures taken by the Rhein-Main military apron control*

2.6.1 The Rhein-Main military apron control is responsible for all Category II/III requirements within their area and shall prevent traffic from the south crossing the red line north of the military apron

1) Clearance of the 300 m strip of all obstacles higher than 15 m (Category III).
2) Suspension of all traffic, towing and other, on taxiway S.
3) Observance of the recognized Category II/III taxi-holding position on the northern boundary of the military apron.
4) Observance of the special provisions for the positioning of C5A aircraft in the eastern part of the military apron.

In the case of an emergency the United States Air Force fire brigade shall assemble at the Category II/III taxi-holding position.

2.7 *Measures taken by the German Meteorological Service*

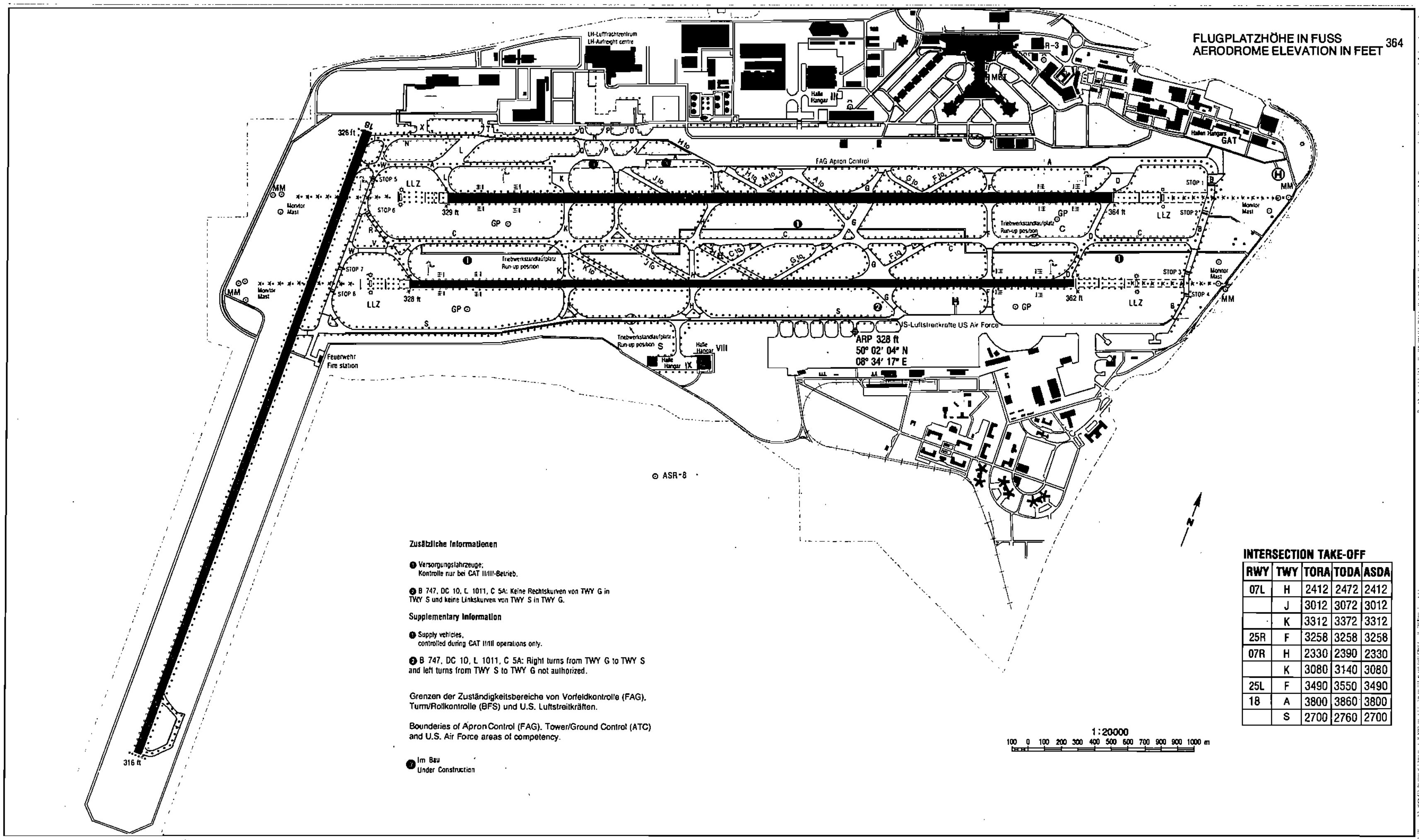
2.7.1 The German Meteorological Service shall make routine reports to the competent Federal Air Navigation Agency office on failures of the meteorological installations serving Category II/III operations or on their failure probability.

2.8 *Measures taken by the airport operator (Flughafen Frank-Main AG — FAG)*

2.8.1 *Apron control*

a) Category II

When the Federal Air Navigation Agency requests Category II readiness, the apron control shall check and make sure that the ILS sensitivity areas are clear of obstacles (e.g. construction machinery, vehicles, etc.). Furthermore, it shall stop any uncontrolled traffic on and in the vicinity of the service lane in the manoeuvring area. All traffic in the manoeuvring area must be authorized, i.e. cleared, by the aerodrome control and all vehicle operators shall monitor by radio the transmitting frequency used by the tower.



Zusätzliche Informationen

❶ Versorgungsfahrzeuge;
Kontrolle nur bei CAT II/III-Betrieb.

❷ B 747, DC 10, L 1011, C 5A: Keine Rechtskurven von TWY G in TWY S und keine Linkskurven von TWY S in TWY G.

Supplementary Information

❶ Supply vehicles,
controlled during CAT II/III operations only.

❷ B 747, DC 10, L 1011, C 5A: Right turns from TWY G to TWY S and left turns from TWY S to TWY G not authorized.

Grenzen der Zuständigkeitsbereiche von Vorfeldkontrolle (FAG), Turm/Rollkontrolle (BFS) und U.S. Luftstreitkräften.

Bounderies of Apron Control (FAG), Tower/Ground Control (ATC) and U.S. Air Force areas of competency.

Im Bau
Under Construction

INTERSECTION TAKE-OFF

RWY	TWY	TORA	TODA	ASDA
07L	H	2412	2472	2412
	J	3012	3072	3012
	K	3312	3372	3312
25R	F	3258	3258	3258
07R	H	2330	2390	2330
	K	3080	3140	3080
25L	F	3490	3550	3490
18	A	3800	3860	3800
	S	2700	2760	2700

Figure B-6. Layout of Frankfurt-Main Airport

The apron control shall increase manoeuvring area safety by closing the access from Ellis Road (i.e. closing the entrance there).
Through the security services co-ordination centre the apron control shall give notification of the commencement of Category II/III operations to the fire and rescue services, the police and to the Federal Border Police.

b) Category III

In addition to the measures required for Category II operations, in Category III conditions the apron control shall instruct the security services co-ordination centre to check and make sure that all unattended entrances to the manoeuvring area are closed. The security services co-ordination centre shall then report to the Federal Air Navigation Agency via apron control that the measures have been completed.
The commencement of Category III operations shall be reported to airline operators, departments, authorities and companies and other operational control services through the "FAG TV Info" system.

Aircraft guidance in Category II/III conditions

— Arriving aircraft shall be guided on the apron area by a "follow me" vehicle in Category III conditions from no later than the end of the existing taxiway centre line lights.
— "Follow me" vehicles shall guide outbound taxiing aircraft to the agreed transfer-of-control points.
— In Category III conditions, vehicles guiding aircraft must not proceed faster than a maximum speed of 20 km/h.

2.8.2 *Aviation supervisory office — general aviation terminal*

2.8.2.1 The Aviation supervisory office shall provide appropriate information on Category III meteorological conditions at the general aviation terminal entrance to the apron.

2.8.3 *Fire fighting services, rescue services and ice and snow removal services*

2.8.3.1 In the case of an emergency the fire brigade, rescue and snow/ice removal service vehicles shall assemble at the recognized Category II/III taxi-holding positions.

2.8.4 *Security services*

2.8.4.1 The security services shall make sure that all unattended entrances to the manoeuvring area are closed and shall report to apron control that this action is complete. They shall also monitor the remaining access ways to the operational area and advise the appropriate users. Apron control shall notify the users of Category III operations on the "FAG TV Info" system.

2.8.4.2 Apron control shall notify the security services co-ordination centre of Category III operations who, in turn, shall notify all attended apron entrances and other airport agencies of the commencement of Category III operations. The apron entrance attendant shall inform all vehicles entering the apron area of the Category III conditions with reference to the Category II/III operational procedures and to Section 7 of the Rules of Conduct and Other Provisions Governing the Traffic in the Manoeuvring Area and on the Apron.

2.8.5 *Aircraft handling control and other operations control units*

2.8.5.1 The individual operations control units shall notify their staff working on the apron of the commencement and termination of Category III conditions and draw their attention to the Category II/III operational procedures, especially to Section 7 of the Rules of Conduct ... etc.

2.9 *Measures taken by the airline operators, fuelling contractors, agencies and other companies*

2.9.1 Airline operators, fuelling contractors, agencies and other companies shall guarantee compliance with the provisions stated in Section 5.4, paragraph 1 of the Airport Instructions. They shall ensure that their drivers and pertinent personnel have been given prior notification of existing Category III conditions and are familiar with the Traffic Rules and Licensing Regulations and with the particular requirements for Category III operations.

2.10 *Rules of conduct and provisions governing the traffic in the manoeuvring area and on the apron*

2.10.1 *General*

2.10.1.1 The provisions of Section A of the Traffic Rules and Licensing Regulations shall apply to all traffic on the manoeuvring area and on the apron in all weather conditions:

1) all vehicle operators or other persons using the non-public operational areas must be familiar with the safety regulations, the Traffic Rules and Licensing Regulations and be authorized to use the non-public operational areas;
2) there is a closed roadway system running through the entire movement area of Frankfurt Airport. All persons driving on the operational areas must closely follow these roadways, service lanes and passageways. Information concerning such movement is contained in Information Sheet 10 of the Traffic Rules and Licensing Regulations.

2.10.2 *During Category II/III meteorological conditions*

2.10.2.1 In adverse weather conditions more stringent safety regulations and traffic rules shall apply as follows:

1) no vehicle shall cross a taxiway unless it cannot avoid doing so. Tunnels and bypasses around taxiway intersections shall be used;
2) in Category II/III conditions, no vehicular traffic shall be allowed on the manoeuvring area. With the commencement of Category II conditions all traffic lights on the service lane parallel to taxiway C shall be switched to red. All traffic must stop immediately and vehicle operators must contact the Federal Air Navigation Agency aerodrome control on the telephone installed at each of the traffic lights and request further instructions.
   Vehicles authorized by aerodrome control to operate on the manoeuvring area in Category II/III conditions shall permanently monitor the ground control frequency.

2.10.3 *During Category III meteorology conditions*

1) No vehicle may operate on the apron in Category III conditions unless urgently needed for the purpose of handling, fuelling, catering and maintenance. The decision on whether a vehicle is required shall be made by the respective operations control units. Other traffic shall require prior permission of the apron control.
2) In Category II/III conditions, aircraft on the apron area shall be guided by a "follow me" vehicle.
3) Notification of Category III conditions must be given on the "FAG TV Info" system and by special signs at the entrances and roadways on the apron.

3. PARIS/CHARLES-DE-GAULLE AIRPORT, PARIS, FRANCE

3.1 *Introduction**

3.1.1 Since its opening to traffic in 1974 Paris/Charles-de-Gaulle has been equipped for Category III operations. The experience gained at Paris-Orly Airport since 1968 was useful in developing the procedures detailed below.

3.2 *General*

3.2.1 Four runways are equipped for Category III operations (see Figure B-7). ILS runways 09, 10 and 27 are approved for all Category III operations; ILS 28 is approved for Category III with decision height not below 15 m (50 ft).

3.2.2 Because of overlapping of categories according to different types of aircraft, only two cases are considered:

Category II: RVR below 800 m but not below 400 m;
Category III: RVR below 400 m.

3.3 *Equipment to be operating when RVR decreases below 800 m*

3.3.1 *Lighting.* Switch on at maximum intensity:

— runway threshold and end lights;
— runway edge lights;
— runway centre line lights;
— touchdown zone lights;
— approach lights;
— high speed turns off centre line light;
— taxiway centre line lights.

No adjustment of lighting controls is allowed during final approach of aircraft. Lighting controls must be locked.

3.3.2 *ILS.* All the elements of ILS used must be operative:

— localizer;
— glide path;
— outer marker
— middle marker.

* The procedures described below are an updated (1984) version of the procedures originally developed in 1974.

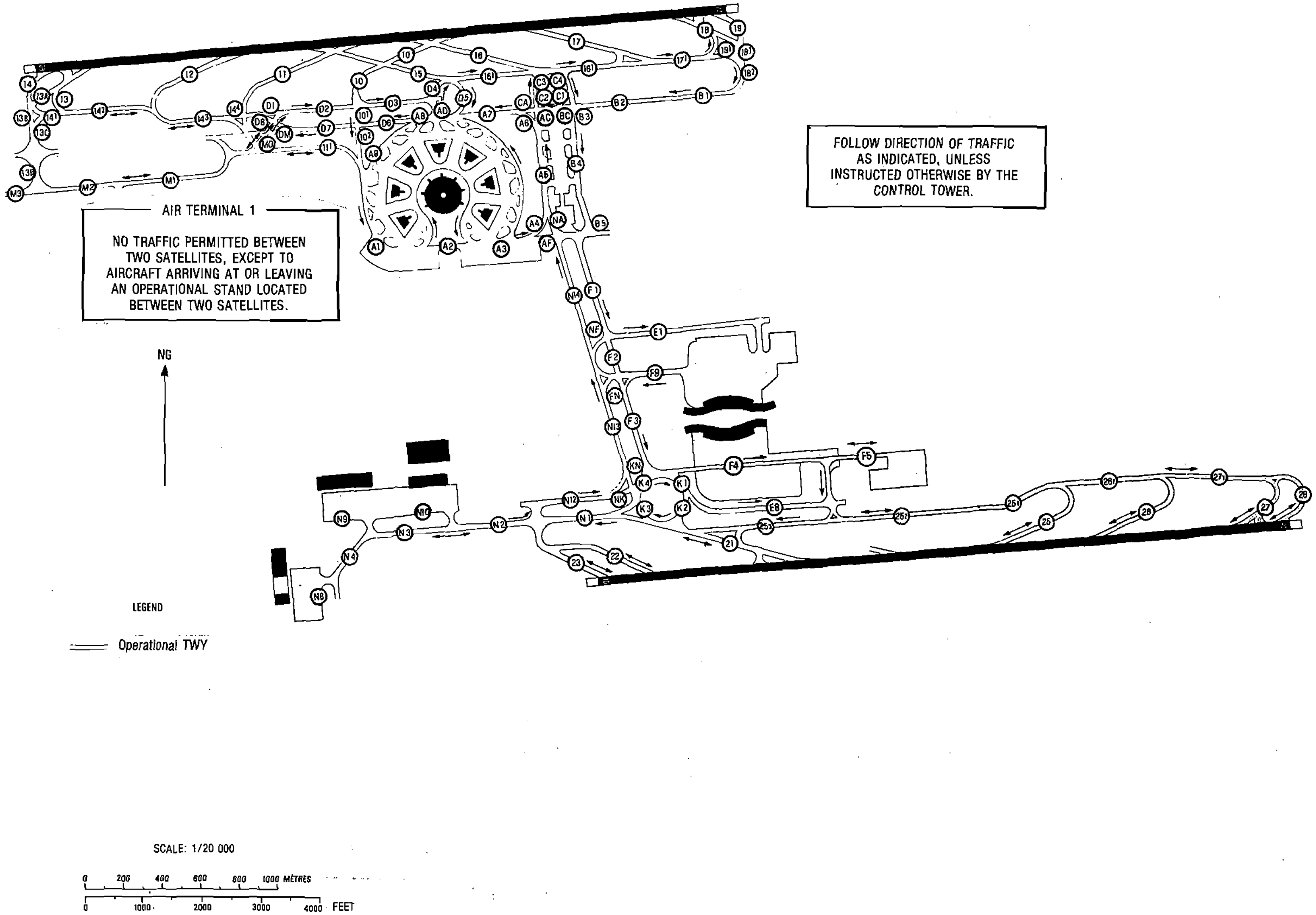


Figure B-7. Layout of Paris/Charles-de-Gaulle Airport

Any maintenance action on ILS is strictly prohibited during the approach. Accordingly, radio-aids maintenance shall be advised when RVR decreases below 800 m.

3.3.3 *Transmissometers.* Touchdown and mid-runway transmissometers must be operative with direct reading at control positions.

3.3.4 *Control positions organization.* As soon as RVR decreases below 800 m a second tower frequency shall be operative:

— runway 09/27: TWR 1 119.250 MHz;
— runway 10/28: TWR 2 120.650 MHz.

3.3.5 *Rescue and fire fighting service.* The rescue and fire fighting service shall be on alert position until weather conditions improve.

3.3.6 *Turboclair.* As soon as RVR is below 400 m the fog dispersal system (FDS) Turboclair installed on runway 09 shall be in operation if wind and temperature are within prescribed limits.

3.4 *Control procedures*

3.4.1 *RVR.* Touchdown zone and mid-runway RVR values must be given to all aircraft on approach and tower frequencies. All significant changes are given. Stop end RVR is given if the value is far below the others. Except in case of worsening conditions, no RVR report is given to an approach aircraft after the outer marker. When Turboclair is on power, for aircraft using it, tower controller replaces touchdown RVR value by "FDS".

3.4.2 *ATIS*

3.4.2.1 *RVR.* No RVR is given on ATIS; the following phrases are broadcast: "RVR available on control frequencies. Check your minima".

3.4.2.2 *Turboclair.* The availability of Turboclair for approved operators is broadcast.

3.4.2.3 *Downgrading of runway category.* The following advice is broadcast: "Runway (number) not available for Category III (or II)".

3.4.3 *Phraseology and alarm*

3.4.3.1 *Phraseology.* All Category II or III approaches must be announced by the pilot. The controller shall ask for a report:

— over outer marker;
— on the runway or going around.

3.4.3.2 *Alarm.* When final approaches and landings are not visible from tower, red alarm (real accident) shall be initiated for all radio communication failures following a loss of radar contact (surveillance radar, surface movement radar) or abnormal moving on these equipments.

3.4.4 *Transponder.* The switching to stand-by position shall be requested after landing only.

3.4.5 *Localizer sensitive area.* The ILS signal is protected if aircraft stop at Category III taxi-holding positions.

3.5 *Special action*

3.5.1 *Action by supervisor*

3.5.1.1 When RVR is below 800 m:

— open a second tower frequency;
— check that lighting is correctly selected and operating properly;
— check locking of lighting controls;
— check ILS status;
— check transmissometers;
— check ATIS broadcast;
— advise: power-station supervisor;
radio aids maintenance supervisor;
rescue and fire fighting service;
movement area surveillance supervisor;
— check Turboclair condition and prepare starting when RVR falls below 600 m.

3.5.1.2 When RVR is below 400 m, if FDS is operating:

— operate the runways facing east (except if it is impossible because of wind, equipment failure, etc.);
— start Turboclair on idle power if users are expected.

3.5.2 *Action by approach controllers*

— give RVR at touchdown and mid-runway;
— respect prescribed spacings;
— transmit to tower all requests for Category II, Category III or Turboclair;
— vector at moderate speed (180 kt at 15 NM from touchdown);

— intercept localizer at 15 NM from touchdown and hand over to tower at that distance.

3.5.3 Action by tower controllers

— give RVR;
— respect prescribed spacings;
— check ILS condition;
— switch Turboclair power on for aircraft using it and switch off after landing;
— use only approved phraseology;
— do not allow an aircraft to enter localizer sensitive area during approaches;
— initiate alarm according to 3.4.3.2;
— inform pilots of all failures of ILS, lighting or Turboclair;
— give Turboclair cross wind if any;
— use surface movement radar to monitor runways.

3.5.4 *Action by ground controller*

— hand over to tower only one aircraft at a time when at the taxi-holding position, and when clear of any preceding traffic;
— use surface movement radar to monitor carefully all taxiing aircraft;
— use surface movement radar to monitor vehicles allowed to travel on manoeuvring area for safety reasons (ATS vehicles, urgent maintenance, rescue and fire fighting service).

Appendix C

Examples of Apron Management Services

1. HEATHROW AIRPORT, LONDON, UNITED KINGDOM

1.1 *Traffic 1983/84*

Passengers	26 749 200	(84 per cent international)
Air transport movements	260 100	
Cargo (tonnes)	469 700	

1.2 *General.* The airport is owned and operated by the British Airports Authority and the air traffic control service is provided by the National Air Traffic Services of the Civil Aviation Authority.

1.3 *Layout.* Three passenger terminals are located in the centre of the airport, and are served by a total of eight piers which are surrounded by 116 aircraft stands. On the south side of the airport is a large cargo terminal which has a further 25 stands. A fourth passenger terminal is under construction which will have a further 22 stands.

1.4 *Stand guidance.* The majority of stands are equipped with azimuth guidance for nose-in stands (AGNIS), complemented by parallax parking aid (PAPA) or side marker boards. The airport authority provides a marshalling service for the remaining stands.

1.5 *Apron maintenance.* The apron areas have their own management organization responsible to the chief of airside safety and operations. Staff of the apron safety unit inspect all aprons regularly, as do members of operations management, and defects are reported to airport engineers for maintenance or repair. Stands are swept by sweeper vehicles when required and, in addition, there is a regular programme for the stands to be wet-scrubbed. Fuel spillages are reported to the apron safety unit who arrange for the cleaning.

1.6 *Visual aids.* All aircraft stands have standard paint markings and all apron taxiways have switchable green centre line lights and stop bars. Most aircraft stands have yellow aircraft stand manoeuvring guidance lights. Aprons are marked in white paint to delineate equipment areas, inter-aircraft stand clearways and airside roads. The boundary between the aircraft stands and the taxiway is indicated by a continuous double white line. This line is also the boundary between the manoeuvring area and the apron area.

1.7 *Air traffic control.* All movements on the airport except vehicles on aprons are controlled by the air traffic control service. As soon as aircraft are pushed back onto the taxiway they are on the manoeuvring area and are controlled by the ground movement controller. Having the manoeuvring area boundary between the stands and the apron taxiway has proved very successful, not only at Heathrow, but at other major British airports. The air traffic control service exercises positive R/T control over all movements on the apron taxiways. This provides high standards of discipline on apron taxiways and also means that the apron management service does not need to employ licensed controllers to exercise control over aircraft movements in the apron area.

1.8 *Apron control.* The apron control room is staffed by employees of the airport authority. Apron control is the focus for information on arriving and departing aircraft and is responsible for the allocation of the majority of aircraft stands at the airport. The allocation of aircraft stands serving one of the central area terminals is delegated to British Airways. Apron control staff have no direct communication with aircraft and all information is passed through the ground movement controller in the tower.

1.9 *Low visibility procedures.* As the apron area comprises only aircraft stands there is very little involvement in low visibility procedures. Low visibility operations safeguarding is carried out on the manoeuvring area by another unit of operations staff.

Apron staff close certain vehicle crossings on taxiways and provide a "follow me" service as required.

2. ZURICH AIRPORT, ZURICH, SWITZERLAND

2.1 *Traffic 1985*

Passengers	9 546 600	(95 per cent international)
Air transport movements	128 230	
Cargo (tonnes)	210 750	

2.2 *General.* The airport is owned by the Canton of Zurich and operated by the Zurich Airport Authority. Air traffic control services are provided by a private company under contract to the Federal Government with the exception of the apron unit which is controlled by the airport authority.

2.3 *Layout.* The apron area is a compact triangular shape and lies in the segment southeast of the intersection between runways 28 and 34. The area is served by two adjacent passenger terminals and a large freight building. One passenger terminal has a finger pier with nine aircraft stands. A second pier is at present being built on the other passenger terminal. The apron comprises 51 stands plus five sectors for general aviation traffic.

2.4 *Stand guidance.* The pier stands of terminal (A) are equipped with the Swedish Safe Gate System, those of terminal (B) with PAPA/AGNIS systems. The remote stands have painted surface markings so that aircraft can self-position and stop without assistance. Marshallers are used only in special cases or extraordinary operating conditions.

2.5 *Apron maintenance.* Airport operations staff inspect the surfaces of the movement area three times daily for serviceability and cleanliness. Any problems are reported to airport maintenance staff. The maintenance staff carry out their own detailed inspection of surfaces two times daily. Maintenance staff are responsible for the cleanliness of the parking stands. Cleaning vehicles are in constant use and stands are regularly vacuum cleaned.

2.6 *Visual aids.* Standard yellow taxiway markings are used with blue edge lights. A system of selectively switchable green centre line routes and stop bars is soon to be installed.

2.7 *Air traffic control.* Control of air traffic on the manoeuvring area is exercised by the air traffic control service. Control of air traffic on the apron area is exercised by a separate unit called apron control (airport authority). The manoeuvring area boundary with the apron control area of responsibility is delineated by various grass areas and standard taxi-holding position markings on those taxiways which link the apron area with the two adjacent runways.

2.8 *Apron control.* Within its area of responsibility, apron control aims to prevent collisions between aircraft and between aircraft and obstacles. It is also responsible for an orderly and expeditious flow of traffic on the apron taxiways and the aircraft stands taxilanes plus the allocation of parking stands. Apron controllers are employees of the airport authority. Their training follows a programme worked out by the air traffic control service and airport authority under the supervision of the Federal Office for Civil Aviation, after which they must obtain and maintain an apron controller's licence issued by the Federal Office for Civil Aviation. Aircraft request start-up clearance from air traffic control (clearance delivery) and then change to apron control frequency for pushback/tow out/taxi clearances. Aircraft are then retransferred to the air traffic control frequency at the manoeuvring area boundary. Similarly, inbound aircraft are transferred from air traffic control to apron control at the manoeuvring area boundary.

2.9 *Low visibility procedures.* Aircraft are guided with the assistance of marshallers and "follow me" vehicles. The need for this service will cease when the ground movement control taxiway lighting is installed together with surface movement radar. Casual maintenance work on the manoeuvring area ceases when the visibility falls to 2 500 m unless authorized airport operations staff are in attendance.

3. MELBOURNE INTERNATIONAL AIRPORT, MELBOURNE, AUSTRALIA

3.1 *Traffic 1983/84*

Passengers	5 405 600	(17 per cent international)
Air transport movements	68 900	
Cargo (tonnes)	107 200	

3.2 *General.* The airport is owned and operated by the Australian Department of Aviation. Airport administration and apron management are the responsibilities of the airport director. The air traffic control service is also provided by the department of aviation but it is not within the jurisdiction of the airport director.

3.3 *Layout.* The airport has one large terminal in which the central portion and associated pier handles international traffic. The two wing portions, and associated piers, are each allocated to a major domestic airline and handle all domestic traffic. There are approximately 25 stands around the three piers serving the terminal. There are two separate freight aprons allocated mainly one each to the domestic airlines.

3.4 *Aircraft stand guidance.* Most aircraft stands are equipped with nose-in guidance systems with side marker boards and side marker lights. The Department of Aviation (D of A) provides marshallers who mainly perform their duties on the D of A apron areas. Various major airlines provide their own marshallers.

3.5 *Apron maintenance.* Operations staff, under the airport director, are responsible for regular inspections of the movement area and any repairs are carried out by airport maintenance staff. Cleanliness of the aircraft stands is a responsibility shared by the Airline Operators Committee and the airport staff. The D of A operates a mobile mechanical sweeper on the apron area and the state of cleanliness is monitored by both airline and airport staff. Fuel spillages are the responsibility of the airline concerned; however, they may request assistance through the surface movement controller (aprons) of the airport ground staff and the rescue and fire fighting service.

3.6 *Visual aids.* Apron surface markings comprise aircraft parking guidelines to provide pilots with guidance from taxiways onto the aircraft stand and aircraft parking limit lines to ensure taxi lanes are not infringed by parked aircraft. Equipment parking areas, equipment limits and airside vehicle roads are also delineated on the apron.

3.7 *Air traffic control.* Activity on the apron area is controlled by a surface movement controller (aprons) from a small control tower overlooking the apron. This controller holds a current air traffic control licence and is also therefore able to exercise control over part of the manoeuvring area. He is responsible for co-ordinating movements on the apron area. There is a geographical boundary between the area of responsibility of the surface movement controller (aprons) and the surface movement controller responsible for activity on the manoeuvring area. However, the boundary is not marked by any painted lines or signs but is associated with a frequency change directed by the controller.

3.8 *Apron control.* An apron co-ordinator works closely with the surface movement controller (aprons) and is responsible for allocating international parking bays, baggage carousels, and for policing the occupancy of parking bays. Each domestic airline has an operating centre from which it exercises responsibility for the usage of its own apron area including the allocation of parking bays. The apron co-ordinator has no direct communication with aircraft and passes information through the surface movement controller (aprons).

3.9 *Low visibility procedures.* There are no special low visibility operations procedures for the apron area. The airport safety officers generally police the movement of vehicles on the apron areas and will provide a "follow me" service if required.

4. FRANKFURT-MAIN AIRPORT, FRANKFURT, FEDERAL REPUBLIC OF GERMANY

4.1 *Traffic 1984*

Passengers	19 031 764	(74 per cent international)
Air transport movements	214 954	
Cargo (tonnes)	772 787	

4.2 *General.* The airport is owned and operated by Flughafen Frankfurt-Main AG. The air traffic control service is provided by the Federal Administration of Air Navigation Services of the Federal Republic of Germany.

4.3 *Layout.* The airport has a central passenger terminal with four finger piers surrounded by 36 aircraft stands. One finger (C-Finger) will be enlarged in 1987 with five additional aircraft stands. The apron comprises a maximum of 82 aircraft stands plus a general aviation apron on the east side of the airport. On the west side there is a large cargo terminal which has 16 additional aircraft stands.

4.4 *Stand guidance.* The majority of aircraft stands are equipped with AGNIS, complemented by PAPA, so that the aircraft can self-position and stop without assistance. The airport operator provides a marshalling service for the remaining aircraft stands.

4.5 *Apron maintenance.* The apron area has its own management organization responsible to the chief of airside operations. Staff of the apron operation units inspect all areas of the apron regularly. Defects are reported to airport engineers for maintenance or repair. Aircraft stands are swept by sweeper vehicles when required and in addition, there is a regular programme for the stands to be wet-scrubbed. Fuel spillage is reported to the apron operation units who arrange for cleaning.

4.6 *Visual aids.* Standard yellow taxiway markings are used and, where they are necessary, edge-lights. Likewise all aircraft stands have standard paint markings. A system of green centre line lights, stop bars and clearance bars on the apron and the manoeuvring area is partly installed and will be developed over the next few years.

4.7 *Air traffic control.* Aircraft movements on the manoeuvring area are controlled by the Federal Administration of Air Navigation Services. Aircraft movements on the apron area including apron taxiways are controlled by the airport operator (FAG apron control), the "apron management unit".

4.8 *Apron control.* Within its area of responsibility, apron control aims to prevent collisions between aircraft and between aircraft and obstacles. It is also responsible for an orderly and expeditious flow of traffic on the apron including the allocation of parking stands. Apron controllers are employees of the airport operator. Their training follows a programme worked out by the air traffic control service and the airport operator. Apron controllers have to obtain a federal flight radiotelephone operator's certificate. Aircraft request start-up clearance from air traffic control and then change to apron control frequency for pushback/taxi instructions. Aircraft are then transferred to air traffic control at the manoeuvring area boundary. Similarly, inbound aircraft are transferred from air traffic control to apron control at the manoeuvring area boundary.

4.9 *Low visibility procedures.* Aircraft guidance during low visibility operations is supported by predetermined taxi routes. Most of these standard taxiways are equipped with green taxiway centre line lights. On taxiways without centre line lights aircraft are guided by the assistance of marshallers and "follow me" vehicles. The need for this service will cease when the ground movement control taxiway lighting is installed together with surface movement radar. Uncontrolled vehicular traffic on the movement area is prohibited when the visibility falls below 1 000 m.

5. PARIS/CHARLES-DE-GAULLE AIRPORT, PARIS, FRANCE

5.1 *Traffic 1984*

Passengers	13 966 543	(89 per cent international)
Air transport movements	133 503	
Cargo (tonnes)	506 440	

5.2 *General.* The airport is owned and operated by Aéroports de Paris. Air traffic control is provided by the French Ministry in charge of civil aviation.

5.3 *Layout.* The airport has two passenger terminals located in the centre of the airport. Terminal No. 2 is currently being extended. A large cargo terminal is located south-west of the airport. There are 153 aircraft stands on the airport, 118 of which can be used simultaneously.

5.4 *Stand guidance.* All stands have painted surface markings. Stands of Terminal No. 2 have a visual docking guidance system. Marshaller service is available from the airport operator and major airlines. This service is provided to all aircraft using Terminal No. 1. At Terminal No. 2 this service is provided only on request.

5.5 *Apron maintenance.* The airport operator is responsible for regular inspections and repairs of the apron. Periodically stands are wet-scrubbed. Fuel spillages are the responsibility of the airlines and fuelling companies. They may request the assistance of the airport operator and of the rescue and fire fighting service in case of a large spillage.

5.6 *Visual aids.* Standard yellow taxiway markings are used to provide guidance to pilots onto the parking stands. White painted lines delineate equipment parking areas, airside vehicle roads and the boundary between aprons and the manoeuvring area.

5.7 *Air traffic control.* All movements on manoeuvring area are controlled by air traffic control service. If pushback will engage a taxiway, ground movement controller approval is required and is given according to aircraft movements only.

5.8 *Apron management.* Paris Airports Authority dispatch (PCO) is responsible for apron management. PCO staff have no direct communication with aircraft. Stand allocation is given via television and strip printer to ground controller who retransmits to aircraft. Manoeuvres inside apron limits are made under operator's responsibility according to established rules.

5.9 *Low visibility procedures.* There are no special low visibility procedures for operations on apron areas. However, exterior lights of aircraft and vehicles should remain on and pilots/drivers are expected to exercise due care and caution.

Appendix D

Taxiway Computer Model
London Heathrow Airport

1. INTRODUCTION

1.1 The following is a brief description of the taxiway computer model developed in 1971 to assess the effects of major changes in the taxiway system and/or operations to ground movement control at London Heathrow Airport. It has been successfully used to show the effects of major new airport features such as terminal buildings, new taxiway construction and changes in aircraft types. Even though only one airport, Heathrow, has been modelled, the programme can be adapted to simulate any airport and be interfaced with a runway model to complete a total simulation of ground operations.

1.2 The model will be in need of major modification by 1988 and, because of its complexity, it is possible that a decision will be made not to carry out any changes and consequently the model will become redundant.

2. THE TAXIWAY MODEL

2.1 The model consists of five programmes. The linkages between these programmes are shown in Figure D-1 and their functions are outlined below based on the block system of control in use at Heathrow (see Appendix B, Figure B-1, map of Heathrow).

2.1.1 *Traffic schedule generation programme.* This programme generates a traffic schedule based on the total number of aircraft expected to arrive and depart in each time period together with the percentage of each aircraft type expected to operate. The schedule is generated randomly taking account of the maximum percentage of each aircraft type, and aircraft are assigned to a particular operator based on the percentage fleet mix of each airline. Arrivals are given an expected time of arrival chosen randomly taking no account of any inter-arrival spacing. Departures are given a scheduled departure time based on the percentage of departures scheduled to depart at set times in each hour.

2.1.2 *Route and stand storage programme.* This programme stores information about aircraft stands on the airport, and the routes to and from these aircraft stands for both arriving and departing aircraft. Any combination of aircraft type and operator can be allocated to a group of aircraft stands and aircraft are allocated randomly to these on the basis of given percentages. Taxi routes are stored between all runway turn-off blocks and each aircraft stand or group of aircraft stands and similarly between the stands and the runway start of roll blocks. Routes are given as standard routes and, where possible, the preferred shortest routes are used.

2.1.3 *Route and time generation programme.* This programme combines a traffic schedule, derived either from the traffic schedule generation programme or from specific data input from the route and stand storage programme. Inbound aircraft are allocated to runway turn-off blocks based on percentage distributions for each aircraft type and operator requirements. Stand or stand groups are also allocated at this stage, hence the aircraft's basic route around the taxiway is determined. Arrival times of aircraft onto the taxiway at the point of leaving the runways are staggered to give at least some minimum inter-arrival spacing regardless of aircraft type. Departure times of aircraft are also staggered from those scheduled, to take account of any company or ATC delays due to congestion that are absorbed on the stand prior to pushback. The output from the programme is a list of aircraft with their associated routings and their arrival times onto the taxiway ready for the simulation programme itself.

2.1.4 *Simulation programme.* This is a "critical event" simulation programme which moves from one particularly important or critical event to the next

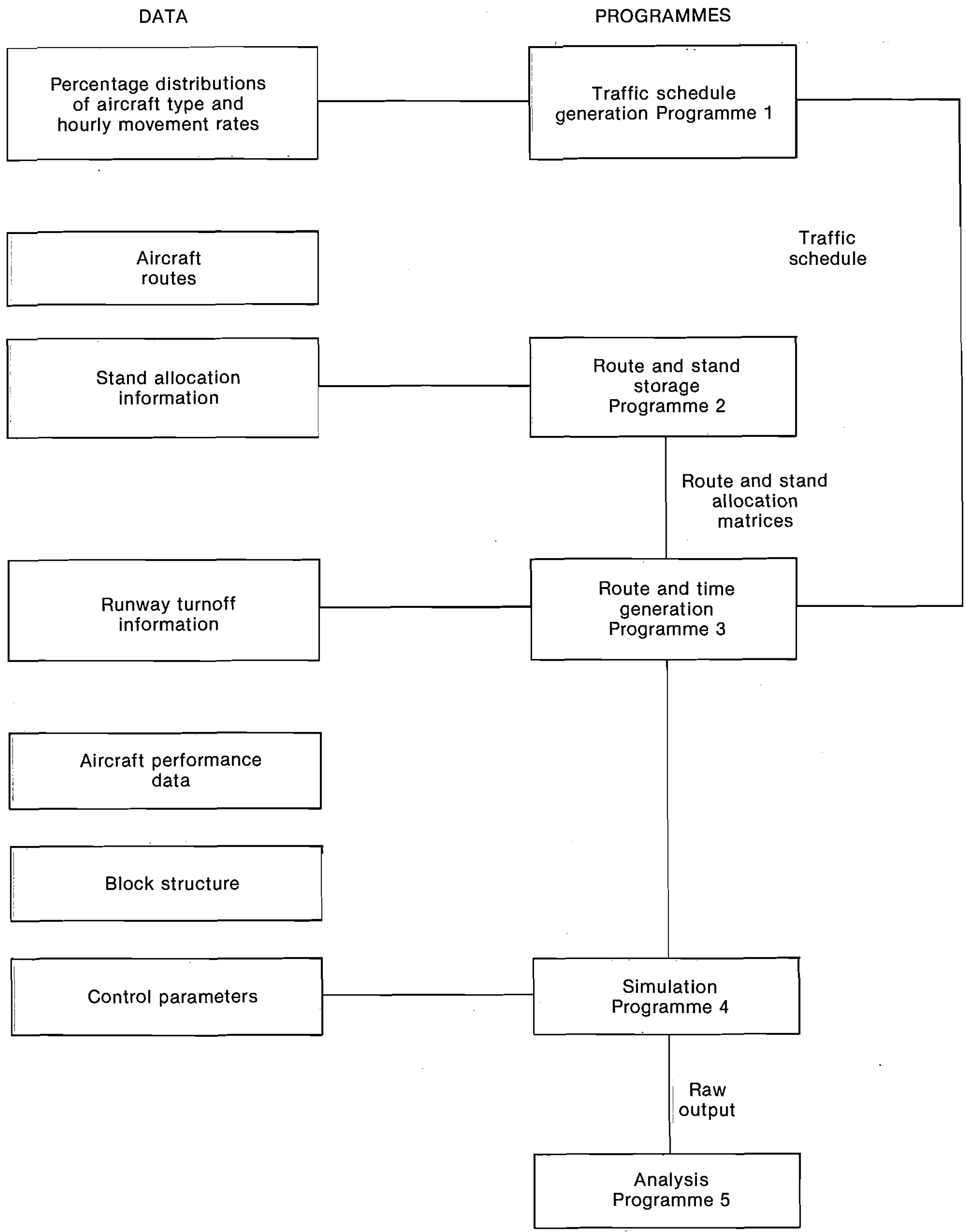


Figure D-1. Linkages between the programmes of the mode

rather than sampling at fixed time intervals. It does not look indefinitely ahead but the situation on the taxiways is considered at the time of each critical event and any route adjustments made accordingly. A "critical event" is defined as when an aircraft enters or leaves the taxiway system or when a conflict occurs between two aircraft on a particular taxiway. Between these "critical events" aircraft move continuously through the taxiway system at a randomly determined speed based on aircraft type. Journey times are calculated on the basis of block length information input to the model.

2.1.5 The taxiway system is taken to include all blocks on an outbound aircraft's route from the completion of pushback to entering the runway holding queue for a departure. All holding is considered to take place in the last block of the aircraft's route and this is not counted towards aircraft journey time. For inbound aircraft the taxiway system includes all blocks from the first block on clearing the runway up to and including the block (or cul-de-sac where appropriate) before entry onto the stand.

2.1.6 The simulation programme moves aircraft around the taxiway with regard to these critical events, noting the time of entry and exit from the system. For outbound aircraft the runway start of roll time is also calculated. Conflicts en route are noted as one of five types: crossing/following, following, crossing, head-on and head-on/crossing. The mode of resolution by stopping, slowing down or re-routing is also noted in the block on which it occurs along with the delay to the aircraft. RT messages and the duration of these messages are counted over set time periods. These messages consist of standard messages when the aircraft enters or leaves the taxiway and specific messages relating to conflict resolution or runway crossing plus some miscellaneous messages. This information is output by aircraft and taxiway block such that it can be read by the analysis programme.

2.1.7 *Analysis programme.* This programme presents the output from the simulation as a series of summary tables. Journey summaries for individual aircraft may also be obtained. The tables give information about aircraft journey times and taxiing delays, stand complex and runway holding delays, numbers of aircraft on the taxiway and in the runway holding queue, movement rates through the taxiway blocks and numbers of conflicts requiring resolution, numbers and lengths of RT messages and total conflict counts by type.

Appendix E

Traffic Rules and Regulations for Surface Vehicles

1. Rules for the regulation of aircraft movements on the ground are contained in ICAO Annex 2 and in the PANS-RAC, but equivalent rules for use by ground vehicles also need to be provided and enforced. At aerodromes without an air traffic control service, the rules and the need for strict adherence to these rules becomes even more important.

2. Except in very poor visibility conditions when special low visibility procedures should apply (see Chapter 5), it is not always practicable to exercise total control over all traffic on parts of the movement area such as the apron. Within the field of reasonable constraint according to conditions authorized in other parts of this manual, safety and expedition depends upon aircraft and vehicles conforming to standard ground movement rules and regulations. Appropriate authorities should establish suitable rules related to the operation of aircraft and ground vehicles on the movement area.

3. The rules and regulations for the ground movement of vehicles should encompass at least the following points.

General

4. The movement area should be fenced or otherwise protected against unauthorized entry and should be provided with controlled entry points. Only vehicles and/or equipment which have a specific and necessary function to perform in connexion with aircraft or aerodrome facilities should be granted admission to the movement area. Authorized drivers should carry a pass. Vehicles cleared for entry should clearly be identified as authorized to be there by having an approved identification token prominently displayed.

Requirements for authorized vehicles and/or equipment operators

5. A vehicle operator SHALL:

a) be knowledgeable of local rules and regulations or be escorted by a person who is conversant with them;
b) be capable of distinguishing between visual signals;
c) give way to aircraft at all times;
d) obtain ATS clearance prior to entering the manoeuvring area and comply with the terms and limitations of the clearance;
e) follow specified routes and guide lines and not encroach upon safety lines;
f) approach aircraft with utmost care, particularly if aircraft engines are running and/or anti-collision lights are operating;
g) obey movement area speed restrictions;
h) where appropriate, be experienced in the operation of RTF equipment and capable of correctly reacting to RTF messages;
i) where appropriate, maintain a continuous listening watch on the ground movement control radio channel, requesting ATS clearance as required by aerodrome regulations and complying with ATS instructions; and
j) be familiar with the aerodrome layout and the signs and signals used on the aerodrome.

6. A vehicle operator SHALL NOT:

a) position a vehicle so as to interfere with the movement of aircraft;
b) pass close behind an aircraft if its engines are running and its anti-collision lights operating, or position a vehicle in a jet blast or propeller slipstream;
c) cross traffic control signals, stop bars or markings without appropriate authorization;

d) leave a vehicle unattended where it may create a hazard; and
e) operate a vehicle during the hours of darkness or periods of restricted visibility unless it is equipped with suitable lighting (see paragraph 7 below).

Requirements for vehicles and/or equipment

7. Vehicles and equipment SHALL BE:

a) marked and lighted as per Annex 14, Chapter 6; and
b) fitted with front and rear lights in accordance with local regulations if operated during the hours of darkness or during periods of restricted visibility.

8. Trailer trains must not exceed the length specified by the aerodrome authority and must have adequate braking systems. They must carry red reflectors at the rear and along the sides as appropriate if used in low visibility or at night.

Appendix F

Performance Objectives for Surface Movement Radar (SMR)

1. INTRODUCTION

1.1 The purpose of providing SMR is to aid the air traffic services in achieving their objectives as defined in Annex 11. These objectives are:

a) to prevent collisions between aircraft;
b) to prevent collisions between aircraft on the manoeuvring areas and obstructions in those areas;
c) to expedite and maintain an orderly flow of traffic;
d) to provide advice and information useful for the safe and efficient conduct of flight; and
e) to notify appropriate organizations regarding aircraft in need of search and rescue aid, and assist such organizations as required.

1.2 At an aerodrome adequately equipped with visual aids, the provision of an aerodrome surface movement radar can make a valuable contribution to the safety and efficiency of ground movement control in reduced visibility and at night. Surface movement radar permits a continuous check on runway occupancy and taxiway usage, allows rapid determination of lighting control requirements and facilitates clearances for aircraft and vehicles. In emergencies it can play a part in the expeditious movement of emergency vehicles and the safe disposition of other traffic.

2. USE OF SMR

2.1 As described in the *Air Traffic Services Planning Manual* (Doc 9426), Part II, Section 5, 4.3.2, SMR may be used to perform the following functions specifically related to the provision of aerodrome control service:

a) provide radar monitoring of traffic on the manoeuvring area;
b) provide routing instructions to surface traffic, using the radar-displayed information, to avoid points of traffic congestion and select aircraft routes to maintain traffic flow;
c) permit issuance of instructions to hold short at intersections to avoid traffic conflicts;
d) provide information that a runway is clear of other traffic, particularly in periods of low visibility;
e) provide assistance in timing of runway operations to improve runway utilization while avoiding conflicts with departing and arriving aircraft;
f) provide, on request, guidance information to an aircraft uncertain of its position; and
g) provide guidance information to emergency vehicles.

2.2 In developing the performance objectives that follow, SMR is considered as a surveillance element of SMGCS; however, its use can be expanded to a more active role.

3. PURPOSE OF THE PERFORMANCE OBJECTIVES

3.1 The purpose behind the performance objectives that follow is to broadly identify the factors that may need to be considered when developing procurement technical specifications for SMR. When using these performance objectives it should be noted that several factors, including the layout and complexity of the aerodrome and operating conditions, influence the design of a particular SMR system. Accordingly, these performance objectives should be reviewed and adapted as necessary taking into account the particular requirements of the aerodrome concerned.

4. OVER-ALL SYSTEM PERFORMANCE OBJECTIVES

4.1 *Coverage*

a) Azimuth — 360 degrees.
b) Elevation — up to 60 m above aerodrome level.
c) Range — 150 to a maximum of 6 000 m (capable of modification to local need within reasonable degrees and at least sufficient to cover the movement area).

4.2 *Target detection*

4.2.1 In weather ranging from clear to 16 mm/h of precipitation and within limits of coverage, targets normally involved in movement should be detected and displayed under the following conditions:

a) 1 m^2 equivalent radar cross section of the target;
b) probability of detection — at least 90 per cent; and
c) false alarm rate — 10^{-6}.

4.3 *Resolution*

4.3.1 The definition of moving or static targets on the operational displays (adjusted for appropriate operating conditions) should be sufficient to:

a) discriminate between targets spaced 15 m apart; and
b) differentiate by target size/shape and speed of movement, between wide-bodied (e.g. B747) and large (e.g. DC8) aircraft, between medium (e.g. B727) and small aircraft (e.g. Cessna, etc.), as well as between aircraft and vehicles.

4.4. *Mapping*

4.4.1 Map pertinent aerodrome features.

4.5 *Information rate*

4.5.1 Information should be renewed at least once every second.

4.6 *Background suppression*

4.6.1 Means should be provided for reducing or eliminating returns from areas within coverage which have no operational significance.

4.7 *Accuracy*

4.7.1 The system error should not exceed 1 per cent of the display range.

5. ASSOCIATED OPERATIONAL OBJECTIVES

5.1 *Display*

a) The operational display should be suitable for viewing at arm's length distance without hooding and, preferably, without screening in bright daylight conditions. The display screen should be non-reflective.
b) There should be no "flickers" discernible to the operator.
c) The display jitter should be less than 0.05 per cent of the display.
d) Variable display ranges between 1 km and 6 km should be provided with off-centring facilities to the edge of the display and appropriate expansion capability.
e) It should be possible to reduce or suppress the luminance of non-operational areas.
f) It should be possible to provide synthetic mapping of the outline of runways, taxiways, aprons and other operational areas, with a brightness control independent of other display data and automatic maintenance of registration with radar range and offset.
g) Capability to provide runway protection and suitable alarm system should be an option.
h) Video mapping and other display features shall remain in registration on change of range or use of off-centring.
i) At least two display channels, independently controllable in range and off-centring, should be provided with the option for increasing the number of channels. The minimum size of display should be 43 cm.
j) It should be possible to operate several display monitors in parallel on each channel.
k) The use of computer-generated display should be an option.
l) There should be capability for automatic recording of radar data.
m) There should be variable magnification zoom facility.

5.2 *Target labelling*

5.2.1 Where target labelling is provided it should comply with the following conditions:

a) *Method of label acquisition:* as decided by the provisioning authority, such as a touchball for manual and automated systems.
b) *Label zone:* throughout the area of coverage.

c) *Label cancellation:* automatic and manual with manual override.

d) *Label brightness:* separate control required.

e) *Label format:* as decided by the provisioning authority. The label writing algorithm should prevent one label overwriting another but, failing this, minimum label overlap must be ensured. Orientation of the labels in relation to the radar target must be adjustable by the controller. Contents must include identification and may include other information such as aircraft type or destination within the aerodrome. Labels must stay in register with change of range or offset. System must cope with closely parked holding aircraft.

f) *Character size:* regardless of range setting, characters must be clearly legible to a controller sitting in a normal working position at arm's length from the display.

— END —

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