Guidelines on Runway Capacity Enhancement

Part III

Edition: 1.0

Edition date: 29 November 2001

Status: released issue

Class: General public

European Air Traffic Management Programme

Table of Contents

DOCUMENT IDENTIFICATION SHEET

DOCUMENT DESCRIPTION

Document Title
Guidelines
on
Runway Capacity Enhancement

EWP DELIVERABLE REFERENCE NUMBER: 02 01 16 - 1

PROGRAMME REFERENCE INDEX:	**EDITION:** 1.0
	EDITION DATE: 13 February 2002

Abstract

The harmonisation of processes and procedures and the adoption of a common set of Best and Recommended Practices will facilitate “gate to gate” approach in the ECAC area.
Increase in Runway Capacity is as an important element in this strategy and the amount of time that each aircraft occupies the runway (ROT - runway occupancy time) is a key determinant of this. These Guidelines examine both tactical and strategic factors that determine ROT and investigate methods for the measurement of performance. Further, links with both land-side and airspace management are identified.

Keywords

Runway capacity	Provider performance	ATC procedures	Separations
Runway occupancy	Operator performance	Environment	Wake vortex
Traffic mix	Flight operations	Infrastructure	Land-side links
ROT measurement	RWY Mode of Ops	Weather impact	ASM links

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DOCUMENT STATUS AND TYPE

STATUS		CLASSIFICATION	
Working Draft	☐	General Public	☑
Draft	☐	EATMP	☐
Proposed Issue	☐	Restricted	☐
Released Issue	☑		

ELECTRONIC BACKUP

INTERNAL REFERENCE NAME:

HOST SYSTEM	MEDIA	SOFTWARE
Microsoft Windows	Type: Hard disk	
	Media Identification:	

DOCUMENT APPROVAL

The following table identifies all management authorities who have successively approved the present issue of this document.

AUTHORITY	NAME AND SIGNATURE	DATE
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DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION	DATE	REASON FOR CHANGE	SECTIONS PAGES AFFECTED
0.1	06/09/01	Review by AOT/7	All
0.2	23/04/01	Review and approval by AOT/8	All
1.0	29/11/01	Review and Approval by ACG/14	All

EXECUTIVE SUMMARY

RUNWAY CAPACITY ENHANCEMENT GUIDELINES

The ATM Strategy for the years 2000+ calls for a “gate to gate” approach involving Collaborative Decision Making (CDM) throughout the ECAC states. The harmonisation of processes and procedures and the adoption of a common set of Best and Recommended Practices will facilitate this aim across the region.

Increase in Runway Capacity is as an important element in this strategy and the amount of time that each aircraft occupies the runway (ROT - runway occupancy time) is a key determinant of this. These Guidelines examine both tactical and strategic factors that determine ROT and investigates methods for the measurement of performance. Further, links with both land-side and airspace management are identified.

Achieving the optimum capacity from each runway is a complex task involving many factors, both tactical and strategic. In order to effectively manage that task it is essential to measure the effects of changes and to monitor performance of the users. It is important to make a distinction between the determination of the mathematical absolute minima for ROT, which will have an application in the planning of procedures and infrastructure, and the determination of practical and consistent minima, which are commensurate with the operational environment. The latter case will be applicable to the analysis of pilot and controller performance and must recognise the requirement to maintain the confidence of the users and to work within the existing culture of safety.

A system of **performance indicators** that form the basis of measurements and analysis, will be devised. The system will comprise levels of indicators including those at the highest level representing the outcome and the intermediate or process indicators that link lower level performance drivers with the outcome. Harmonisation of this system is essential to allow exchange of information and comparison of performance. For the same reason, common definitions for the elements of runway occupancy are also required and the Guidelines specify these in detail.

Measurements and simulations have been carried out at a number of airports throughout the ECAC region providing vital information both for the ongoing management of runway capacity and for future resource and schedule planning. The following are typical examples:

- LNVL Method - A relatively simple method involving the use of Stopwatches from a central location. Its application is limited to providing average ROT figures broken down by runway, aircraft type and carrier.

- NATS Integrated Method (Hermes II) - This method is based on NATS fast time simulation tool and can be used to assess runway capacity and changes to capacity. The output from Hermes II comprises runway throughput rates and delay estimates.

- EUROCONTROL Method - This method improved on the collection of data by introducing the ROT Recorder Software, removing the need for stopwatches. Data captured using this tool is then processed using the Runway System Capacity Module (RunSysCap). This powerful analytical tool provides unconstrained and sustained capacity figures and sensitivity analyses. Capacity maximisation through optimisation of a variety of factors can be investigated.

- AENA Integrated Method (PICAP) - Programa de InvestigaciÛn de Capacidad de Pista (PICAP) is the Spanish runway capacity research programme. This method also exploits software tools to capture and process data. Similar to Hermes II, fast time simulation techniques are employed to investigate changes to procedures and environment.

By taking the best elements of these methodologies, a system is being developed that will be recommended to all ECAC states as representing the Best Practice for the measurement of Runway Occupancy and Capacity.

Tactical factors affecting runway occupancy include flight operations related items ATS factors. The flight operations aspects include operator performance, effects of company procedures, use of the airfield infrastructure and aircraft performance issues.

Numerous factors relating to the operation of the aircraft affect the amount of time that the runway is occupied and it must therefore be possible for the pilot community to make a significant contribution to the reduction of ROT. Care should be taken to ensure that this is not simply a drive to complete tasks and actions more quickly, as this may erode margins of safety. The distinction is drawn again between theoretical minimum ROT and times that reflect reasonable safe methods of operation, which can be consistent and predictable. The operator performance factors describe the elements affecting ROT that result from the actions or behaviour of the pilot. These, broadly, include experience, familiarity and awareness. Further factors related to aircraft performance, such as spool up times, taxi speed and ground manoeuvre capability, landing weight/speed, use of deceleration devices (autobrakes, reverse thrust), cross/tailwind limitations and effects and surface conditions are described, and their relative importance considered. The Operating/Airline procedures aspects discussed are; requirements following late changes to SID or take off position, accomplishment of checks and procedures and reduced thrust operations.

Amongst airfield infrastructure issues considered are the location and visibility of RETs. Pilots need to be able to determine their position with respect to runway entry and exit points, as well as their speed (and deceleration) as early as possible during the rollout. Anecdotal evidence suggests that this is a significant factor for many pilots and efforts have been made (such as the RETILS at Gatwick) to address this issue and this is an area that requires wider attention.

The selection of RET to be used is considered in relation to taxi distance/time to the terminal and it is emphasised that long rollouts made in order to save taxi time are not acceptable during capacity critical periods.

All these issues are important, to a greater or lesser extent, but in many cases offer only limited potential for improving ROT on a consistent basis. This is due either to physical, economic or safety considerations. Enhancement of pilot awareness is, however, considered likely to provide benefits. It should be stressed that all professional pilots are aware of the need to make expeditious use of runways. It is a principle that is taught from the earliest stages of training and it is an operational practice that is routinely exercised. There is however, a clear conflict between the safety of the aircraft, economic considerations (e.g. brake wear) and also the comfort of the passengers, and the desire to clear the runway at the earliest opportunity. Under normal operations it would not be regarded as the first priority; and rightly so. Whilst it is essential to avoid erosion of margins of safety it is reasonable to believe that a more expedient use of runways can be achieved if the effort is more focussed and informed. It is possible therefore to act in a more expeditious manner on a selective basis and it is likely to be possible to gain some performance advantage from tailoring deceleration techniques to individual situations.

Given more information pilots would be able to make judgements based on actual tactical needs and therefore apply more priority to ROT requirements in an informed manner. Pilots should therefore be presented with information leading them to a deeper understanding of the broad issues but more importantly about specific issues such as times of peak runway occupancy.

Such information should be disseminated in a variety of forms. Company Operations Manuals should contain the background, overall policy and operating guidelines relevant to the Airline/Fleet. This may take the form of a dedicated Company Guide to minimising ROT containing company policy, standard procedures, advice on exit and taxi speeds and detail on available and preferred RETs at all standard destinations. Runway specific information should be included in take off and landing charts tailored specifically for company use (e.g. Jeppesen Charts). The aim should be to raise the profile of runway occupancy and to provide targeted information regarding tactical situations and local infrastructure, procedures and traffic profiles.

The principle of "measure to manage" is extremely relevant and the **measurement of operator performance,** with respect to runway occupancy, is described. The basic principles on which such measurements should be based include:

- measurements which would not challenge the safety drivers in the industry,
- a no-blame culture, and
- clear and unambiguous measurements of performance.

Success in such measurement studies will require that the local pilot community is represented on the management of the study and analysis of the results of the exercise. It must be clear to all concerned that safety remains the priority and that measurements are made with the objective of identifying best and recommended practices, comparing operating procedures and maintaining awareness of ROT issues. It is emphasised that the aim is to record trends rather than measure individual performance.

Methods are described for ensuring that the performance of the core group is recorded by excluding the longest and shortest ROTs measured. This ensures that long times due to justifiable safety reasons, and short occupancy times which may reflect undesirable practice, do not influence the average performance times. The remaining, core group, will therefore represent the normal operating practice of the airline or fleet. The resulting data should then be suitable for airlines to compare their performance with others and modify their training or procedures if required.

The results should be published in anonymous format, specific to aircraft type, in order to illustrate general comparisons between airlines. Individual airlines will be provided with data corresponding to their own fleets so that they can compare their own performance against that of the “Best in Class”. The important characteristic of the published data is that it should indicate trends and relative performance position compared with similar fleets. It is not intended, nor desirable, that the measurements should determine absolute values, nor should it identify individuals.

It is anticipated that such studies will serve two purposes, first to allow companies to learn from the best practices of others and second to elevate the issue of runway capacity in the awareness of the pilot community.

Performance of Air Traffic Services, in relation to the achievement of optimum ROT, is also examined. Planned capacity can only be achieved if controllers effectively apply required separations, procedures and slot times. The correct use of equipment and indeed the serviceability of essential equipment will also have an impact. Performance of controllers in all of these areas will have an impact on runway capacity and as with operator performance this can be measured, allowing the effects of training, procedures or working practices to be reviewed and assessed.

As with operator performance the emphasis should not be on individual performance but generalised to indicate trends and patterns.

Airfield infrastructure and design is reviewed with respect to RET location and design. The ICAO specification is recognised as providing the best design standard but alternate forms should be considered where space does not permit sufficient length between the runway and taxiway. This may include more acute exit angles and a wider paved surface to allow more freedom to deviate from the centre line.

Care should be taken to ensure that RETs are provided that cater for the expected traffic mix on the runway. Empirical research including measurement of traffic activity and also by computer simulation is required in order to determine the optimum spacing and number of RETs. Such information gives the airport the potential to designate preferred RETs for each aircraft type, which in turn can be used by airlines and incorporated into the previously suggested Company guides.

As described above, with reference to operator performance, visual aids that assist in the identification of the RET position are desirable as existing specifications may be inadequate. Further work is required in this area although RETILS (Runway Exit Taxiway Indicator Lighting System) such as those installed at Gatwick are an example of the improvements that can be made.

The traffic mix for a specific runway will have a major impact on the achievable capacity. Whilst the aircraft types will be determined by commercial factors, research has shown that changes to the schedule, sequence or to the mode of operation (for multiple runway systems), will offer capacity improvements. For example, case studies are described that indicate exploitation of mixed mode operations can achieve 25% capacity gain, compared with segregated mode, during departure peaks and 30% gain during arrival peaks.

Schedule issues generate many problems, not least those of a political nature. For this reason a number of associated issues will not be addressed by these guidelines, as these will be discussed and dealt with by other groups. Such issues include:

- Continued existence of “grandfather rights”
- 80% usage rule for allocated slots
- market orientated price mechanisms (slot auctions)
- peak hour landing fees
- demand management
- methodologies for calculation of slots

In practice, absolute optimum **traffic sequencing** is probably unachievable, as this would impose an unacceptable rigidity on airlines as they attempt to exploit market demand, but improvements can be made, in particular where this involves multiple runways.

Fast time simulations are able to predict such factors as punctuality and delay for a given traffic schedule. This can offer airport authorities the ability to test various scenarios or to react in advance to a planned traffic schedule that may present unforeseen runway capacity problems.

One model examined is based on two service indicators;

- Average delay index - the difference between the schedule and the actual operation
- Punctuality index - the percentage of operations within agreed delay limits.

The model focuses on planning aspects i.e. trends rather than absolute correctness. It analyses two profiles reflecting the minimum and maximum traffic schedule and repeats the exercise for a range of linearly extrapolated profiles. This gives graphical information identifying average delays for each schedule. A punctuality index is generated for each schedule showing how this varies as a function of the number of departures.

The mode of operation in multiple runway systems can have a marked effect on the achievable capacity. The document deals with four runway modes of operation i.e.

- Segregated operations
- Semi-mixed arrival operations
- Semi-mixed departure operations
- Fully mixed operations

Eurocontrol has agreed a common methodology for assessing airside capacity including the development of associated tools such as RunSysCap, although other methods also exist.

Models used describe traffic patterns according to the percentage of arrivals and the most stable capacity increases are achieved when runways are operated in fully mixed mode. Stability decreases significantly when runways are fully segregated. Clearly any improvements in capacity are most advantageous when a high level of stability is achieved. In practice this means that when operating at maximum capacity for a segregated operation, any change in the arrival percentage (increase or decrease) will result in a significant reduction in capacity, this affect is less marked for mixed mode operations.

Semi mixed of two types modes are also examined. These are:

- One runway operated in mixed mode and the other for arrivals only. Increases in arrivals are interlaced with departures on the mixed runway. This mode shows stability for increased arrivals but stability is much reduced when the arrival percentage decreases.
- One runway operated in mixed mode and the second for departures only. This shows a similar stability pattern to segregated mode operations.

Local conditions need to be taken into consideration, for example infrastructure differences will significantly modify the achievable capacities. It has been demonstrated that where aircraft are required to cross an active runway a capacity loss of up to 14% may be suffered in, a mixed mode operation.

Capacity gains are also achievable through the use of new or modified **ATM procedures**. The EUROCONTROL Airspace and Navigation Team (ANT) has been tasked with the development and validation of new ATM Procedures, and the maintenance of existing ones. A sub-group, the Aerodrome/TMA ATS Procedures Working Group (ADTMA) is addressing the aerodrome and TMA-related ATS procedures. This working group reports to the ANT through the ATM Procedures Development Sub-Group (APDSG).
A number of priorities have been identified, these include:

- Application of RNAV in the TMA including B-RNAV and P-RNAV
- A-SMGCS procedures
- Simultaneous operations on converging runways. This includes simultaneous converging approaches instrument (SCIA), dependent converging instrument approaches (DCIA) and operations to closely spaced parallel runways.
- Sequencing tools, AMAN/DMAN
- Rationalisation of departure wake vortex separation

The ICAO Air Navigation Commission (ANC) has already approved some elements; these include intersection take-offs, multiple line-ups, visual approaches and departures. Three procedures are still under consideration by the ANC i.e. reduced runway separation, landing clearance based on anticipated separation, and simultaneous intersecting runway operations (SIRO).

Environmental issues and the impact they may have on runway capacity are considered. A number of international groups are engaged in work related to this, including:

- ICAO Commission/Aviation Environmental Protection (CAEP) working group 2. This is investigating noise abatement procedures, environmental guidelines, noise monitoring, and the development of a Global Aircraft Noise Impact Assessment Model (MAGENTA).
- ICAO PANS OPS Doc 8168 gives guidance on noise abatement procedures
- ECAC Abatement of Nuisances Caused by Air Transport (ANCAT) serves as a European forum for exchange of information regarding noise with a view to present proposals to ICAO. They have placed emphasis on the development of SIDs for low speed aircraft, implementation of continuos climb and descent and the use of idle reverse after landing. They have also encouraged support for the ARETA project (RNAV in Extended Terminal Area Operations)

The rate of development of new technology for the mitigation of noise is slowing and capacity increases based on a promise of decreased noise levels cannot be expected in the future. In coming years it is likely that airports will have new constraints, due to environmental reasons, imposed upon them including:

- limits to the area of noise contours
- curtailment of the hours during which airports are permitted to operate;
- curtailment of the number of movements over a given period of time (hourly or daily);
- refused planning permission or extremely long planning processes;
- curtailment of the types of aircraft (Chapter 2 and Chapter 3 aircraft) allowed to operate at specific airports;
- aircraft routings or operating procedures that are not airside capacity optimised;
- financial and economic burdens;
- emissions capping.

In addition to airports with constrained runway systems, these factors may also affect smaller airports with spare capacity. Planning ahead to mitigate these issues is therefore essential to avoid future degradation of available capacity. It is considered essential to adopt an integrated approach to addressing these issues, and a CDM (Collaborative Decision Making) formula is likely to produce the most effective results. CDM will not only help to reduce the impact of external constraints but will build confidence and acceptance within the wider community.

The establishment of internal technical working groups at airports that comprise the expertise of the airport operator, ATS provider and airspace users will allow a series of impact reduction options to be debated and tested before being discussed in community groups. This requires commitment at all levels applied to clear objectives and targets. These partnerships should have access to good information and monitoring systems as well as previous experience of others.

Emphasis is placed on the need for establishing and maintaining good Community relations. This is quite distinct from good PR and involves the formation of local consultative committees involving local elected representatives, amenity group chairmen, local business and tourism representatives and airport CDM stakeholders.

In addition to the important noise control issues, the local community will be concerned with emission controls both on the ground and in the air and also planning issues and use of land. The latter will have very direct impact on future capacity requirements.

A number of other disciplines are linked to capacity issues and these are identified in accordance with the RACE task force terms of reference.

In the **"gate to gate" philosophy** it is important to include all parities involved. This includes:

- Airport access
- Internal airport services
- Passenger handling
- Gates
- Ramp resources
- Real time operations
- ATM and airspace structure

All elements are essential in delivering an optimum operation and therefore in achieving the best possible capacity. Many initiatives have already been successful including:

- Revised European Route Network (ARN Version 3-5)
- Carriage of Basic Area Navigation Systems
- Principle of Flexible Use of Airspace (FUA)
- Reduced Vertical Separation Minima (RVSM)

These are expected to provide a 50% increase in capacity in the en-route environment by 2005. More work is required to resolve such issues as interactions between traffic flows and between adjacent control centres, airspace design where terminal areas are not configured for the optimum performance of modern aircraft. And ATC procedure to improve earlier sequencing of traffic. Sequencing tools are also required that will allow aircraft to exploit the ability to fly continuos descent approaches even in high density situations.

The Guidelines document concludes with Case Studies from a variety of airports that identify

- methods that have been used to measure and forecast runway capacity
- operator performance studies
- ATC procedures - CDA, preferential runway use, increased final approach altitude etc
- environmental factors mitigation.

Introduction

1.1. Context

Following decisions taken at the fifth and sixth meetings of the ECAC Transport Ministers (MATSE/5 and MATSE/6), the new ATM Strategy for the years 2000+ has been oriented towards a comprehensive 'gate-to-gate' environment. This revised strategy integrates airports and airspace users in a coordinated network within which decision-making is based on collaboration and cooperation, i.e. 'Collaborative Decision-Making' (CDM).

This new way of dealing with ATM calls for an ECAC-wide adoption of best practice as the first step in an effective implementation process which will culminate in standard applications at airports. Although the resolution of airport capacity problems rests with the individual states and/or airport authorities, best practice for maximising air-side airport capacity should be used systematically.

Increased capacity is urgently required because congestion is already a serious problem at some airports. A minority of airports generate the majority of demand, and these airports are already operating at their maximum throughput for sustained periods of time. The EUROCONTROL ATM strategy for the years 2000+ focuses on making best use of airport air-side capacity based on the available infrastructure, because new constructions are in many instances strictly limited by political and environmental constraints.

Airport air-side system capacity is significantly influenced by runway capacity, which should therefore be considered as a key determinant of overall capacity and therefore has the potential to significantly reduce the total delay at airports. This will in turn reduce the requirement for airport development and therefore reducing environmental impact and resource use. Bearing this in mind, the Airport Operations Team (AOT) has established a task force to develop guidelines on runway capacity enhancement, including a catalogue of 'Best and Recommended Practices' for ECAC-wide use.

1.2. Scope

Pursuant to the terms of reference (see Annex 1), this document deals with measures to enhance runway capacity. It aims to collect, analyse and qualify current and future practices and plans for enhancing runway capacity in ECAC and other regions. Furthermore, the guidelines contain a catalogue of 'Best and Recommended Practices' relevant to runway capacity enhancement.

The tactical performance of both pilots and controllers in minimising runway occupancy time (ROT) is of prime importance, and should therefore be treated with appropriate priority. Also, a harmonised approach to performance evaluation would help bring about the necessary consistency in performance. The collection and analysis of occupancy data from one airport will therefore be meaningful to others, creating added value.

Besides tactical elements such as pilot and controller performance, the guidelines also address strategic elements that affect runway capacity, such as traffic mix/schedule, infrastructure, runway mode of operations, land-side links and airport operations performance.

In addition to the above factors runway capacity can also be adversely affected by environmental constraints, weather influences and wake vortex separation criteria. The document aims to optimise runway capacity within the framework of these given constraints and describes processes to alleviate and mitigate their effects.

In line with developments as regards ECIP (European Convergence and Implementation Plan), runway capacity enhancement objectives and proposed target dates for implementation will eventually be drawn up.

1.3. Purpose

The purpose of this document is to present guidelines, including a catalogue of 'best and recommended practices', with a view to enhancing runway capacity in order to contribute to the optimisation of air-side capacity at airports within the ECAC area.

1.4. Structure

Runway, taxiway and apron capacities are the three main elements that affect the overall airport airside capacity. As stipulated in the scope and purpose of this document, measures should be presented that are capable of enhancing runway capacity by collecting, analysing and qualifying relevant practices and plans. This includes references to acknowledged best practices or 'case studies' of best-in-class airports. Following recent decisions taken at AOT/7 the document will have to be complemented with the remaining airside components, notably apron and taxiway. However the AOT made the work related to the latter subordinate to runway capacity issues.
This paragraph aims at providing an outline of the structure of the document. It contains an overview of main elements which will be discussed in following chapters. For clarification purposes a summary diagram is set out in paragraph 1.4.5. The document deals with:

1.4.1. Tactical elements

In partnership with airport operators, aircraft operators and ATS providers pilot performance indicators regarding minimisation of runway occupancy times are described in this document. A common approach to the selection of such performance indicators is believed to be necessary if consistent performance is to be achieved at airports throughout Europe.

Trends associated with issues such as controller performance vis-à-vis the number of go-arounds, ATC-attributable incidents, causes of delays, etc. may also be useful, and the principle of 'measure to manage' is recommended.

1.4.2. Strategic elements

The following strategic elements are addressed:

a. Infrastructure aspects such as rapid-exit taxiways, rapid-access taxiways, holding bays;

b. Runway mode of operation (e.g. segregated versus mixed mode), capacity potential, and presence or absence of flexibility;

c. Management of traffic mix with a view to optimising separation as a means of releasing potential capacity. Since schedule shift can be detrimental to capacity, schedule management, which can help smooth demand peaks and provide the necessary firebreaks, is therefore included;

d. Land-side and airspace management elements that affect runway capacity have been identified. As such elements fall outside the remit of this document, they are merely highlighted; best practices related to both have not been collected (Cf. Terms of Reference at annex 1).

e. A set of airport airside performance indicators have been developed with a view to 'measure to man age'.

1.4.3. ATC procedures

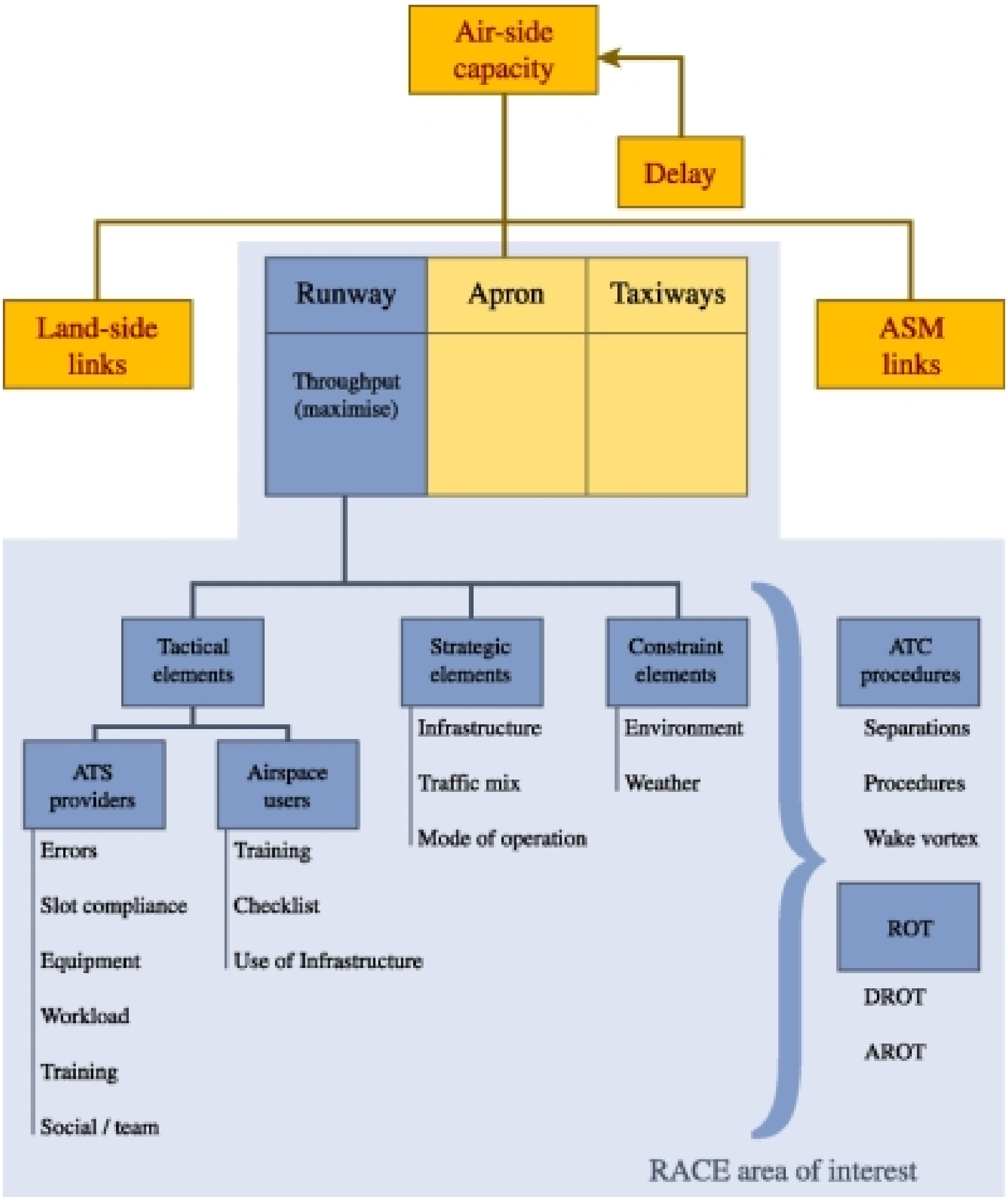
ATC procedures in support of both the strategic and tactical elements duly form part of the guidelines.

1.4.4. Constraints

The effects of environmental legislation on capacity, and concepts to mitigate the impact of this legislation are described. Also discussed are a number of best practices used at airports to balance demand within the framework of environmental legislation.

Both weather and wake vortex categorisation and separations affect runway capacity. These aspects have not yet been taken up, and will have to be addressed later.

1.4.5. Document structure



Elements Affecting Airside & Runway Capacity

1.5. Performance elements in terms of efficient runway utilisation

There is a recognised need to 'measure to manage', which also requires a comprehensive set of internal performance indicators, enabling airport managers to translate the 'best and recommended practices' of the guidelines document into a set of reference parameters or a metric system. A performance measurement system should allow managers to detect the overall effect of their action plans on airport performance, by means of a complete set of linked indicators (e.g. a decision-making tool capable of detecting the impact of a specific action on the whole set of targeted goals). This reference system is needed as a tool to measure performance, set improvement objectives and detect deviations from the desired trends. However, such a system would not be aimed at assessing the performance of individuals within the system.

It is recognised that some objectives, such as those relating to safety and the environment, will be non-negotiable. Others will be subject to trade-offs by managers when analysing the effects which their action plans are having on the selected indicators.

Performance indicators cannot be read in isolation. They should be seen as part of a linked measurement structure with different levels or layers of indicators such as:

- Those at the highest level, which represent the outcome, expected result or effect of the activity: i.e. outcome, effect or lagging indicators. For this purpose typical outcome indicators are runway throughput (whether or not for an accepted level of delay) as a function of the applied separation. Optimised runway occupancy times are particularly important for this particular indicator;
- Those at the intermediate level, which are used as process indicator links between the lowest-level drivers and the highest outcomes or results. They are intended to complete the integrated, balanced indicator system. For this purpose typical process indicators are accommodated under the headings strategic and constraint elements that affect runway capacity;
- Those at the lowest level, used to internally monitor how the specific performance is causing a driver action towards the expected results of the activity: i.e. cause, performance drivers, or leading indicators, including performance drivers of both airspace user and ATS provider. The performance drivers are included in the document under the heading tactical elements that affect runway capacity.

2. Runway Occupancy Time (ROT)

2.1. General

Among the wide spectrum of runway capacity elements reducing the time spent by aircraft on the runway is one of the most important. This does not alter the fact that ROT is inextricably linked to other issues such as wake vortex separation minima and minimum separation standards for both arrival and departure. Minimising the separation between arriving and departing traffic is equally crucial in reducing ROTs. Even environmental aspects, such as use of preferential runways, etc., may also have an impact on occupancy times. An in-depth analysis of factors which influence runway capacity is set out in the remainder of the document; this chapter concentrates on runway occupancy times.

Studies have shown that, depending on the traffic mix, runway capacity can be increased between 5% (in the case of single-runway airports) and 15 % (multiple-runway airports) by reducing ROTs. A more marked example is the 19 % capacity increase achieved over a period of 3 years on the single runway at Manchester. Reduction of ROT is therefore the key issue, in fact the main challenge of this document. The interaction between the tools that will help to reduce ROT and the reduction itself should therefore be considered as the essence of this task.

It should be stressed that increasing runway capacity by minimising runway occupancy is a matter of seconds per operation. Indeed, aircraft that unnecessarily occupy the runway for additional seconds potentially provoke delays of at least one order of magnitude greater, i.e. minutes or worse. If this develops into a domino effect, then overall system capacity will be reduced, causing losses of slots. On the other hand, the saving of a few seconds per movement can represent an important capacity increase. For example, saving 5 seconds per movement has the potential to increase capacity by 1 to 1.5 movements an hour (source: NATS). The quantum leap from seconds to minutes (or more) should be borne in mind when considering issues such as definition and measurement of ROT.

Enhancing runway capacity is not necessarily a matter of seeking absolute minimum occupancy times but rather one of achieving consistent performance, thereby building up the confidence of pilots and controllers which is necessary to optimise runway capacity. This striving for consistent average occupancy times might appear to contradict the objective of minimising ROTs. However, this is not the case because a **distinction should be made between the purely mathematical recording of data (relating to absolute ROT minima) and the operational environment in which air traffic is handled. Indeed, operational and/or safety requirements are the determining factors that influence the theoretical minima**. Operational/safety actions taken by both pilots and controllers could therefore justify exceeding these minima, for reasons such as aircraft characteristics, traffic mix, pilot performance, runway system lay-out, meteorological conditions, etc. It should therefore be noted that when measuring ROTs and performance data, a clear distinction should be made between the operational context within which the traffic is handled and the recording of real-time runway occupancy data

Airports do not at present have a common view or definition of ROT, which makes the assessment and implementation of collected best practices more difficult. Harmonised definitions are therefore proposed. In developing these definitions, consideration has been given, inter alia, to the runway occupancy variables in the strict sense of the word, and also to issues such as pilot and controller performance, measurement and simplicity. Simple definitions will hopefully reduce the possible margin for error to a minimum (of the order of one second), whereas some of the contemporary methods generate errors as high as four seconds. Furthermore, they will facilitate accurate, automated measurement techniques, and also post-processing.

Furthermore, runway occupancy measurement should only apply in CAT I conditions or better, because the occupancy times of the runway in CAT II/III conditions becomes less relevant owing to increased separation requirements. Until more advanced tools exist to handle traffic in low-visibility conditions, the guidelines should not address runway occupancy time measurements for CAT II/III.

IN SUMMARY

- *the document refers to absolute minimum ROTs when measurement methodologies are addressed, as opposed to average ROTs in an operational context*

- *in both cases the trend is much more important than the individual measurement.*

- *there can never be a trade-off between runway capacity and safety. The objective must therefore be to reduce runway occupancy time (ROT) while maintaining current or improved safety levels*

2.2. Need for Harmonisation

In line with both the European Air Traffic Control Harmonisation and Integration Programme and the ATM Strategy for the years 2000+, the tabled 'Guidelines for runway capacity enhancement' advocate continuation of a uniform approach through collaborative decision-making and performance-driven policies. Only in this way can misinterpretation and or incorrect conclusions regarding the subject be avoided. A catalogue of best practices needs a set of commonly agreed definitions which are not susceptible to misinterpretation. The measurement of an assortment of data, not only ROT data but also performance- related data, also constitutes an inextricable part of the core of this document.

2.3. Description

2.3.1. ICAO recommended practices

In substance, the following ICAO material is considered in support of the development of ROT definitions.

- **Separation for arriving aircraft**
  Required because a landing aircraft will not normally be permitted to cross the beginning of the runway on its final approach until the preceding departing aircraft has crossed the end of the runway in use, or has started a turn, or until all preceding landing aircraft are clear of the runway in use.
- **Landing clearances**
  An arriving aircraft may be cleared to land if there is reasonable assurance that the prescribed separation will exist when the aircraft crosses the runway threshold, provided that a clearance to land is not issued until a preceding landing aircraft has crossed the runway threshold.
- **Runway holding position**
  A designated position intended to protect a runway, an obstacle limitation surface, or an ILS/MLS- critical/sensitive area, at which taxiing aircraft and vehicles must stop and hold, unless otherwise authorised by the aerodrome control tower.

2.3.2. Reference lines in support of the definitions

The basic principle of what follows aims to determine the real occupancy of the runway for both arriving and departing aircraft. A distinction should therefore be made between arrival and departure runway occupancy times, ROTA and ROTD respectively. However, whereas a sole ROTA definition seems to meet the prerequisites, the ROTD definition needs to be further broken down into its component parts, namely the sum of line-up time (LUPT), wait time (WAIT), flight crew reaction time to ATC take-off clearance (FRTT) and take-off time (TOFT). To this end, use is made of the above-mentioned ICAO definitions.

Four reference lines will have to be identified in support of ROTA/ROTD, such as the threshold, the aircraft tail vacating the runway, the crossing of the stop bar at the holding point, and the main gear lift-off from the runway. The crossing of these reference lines has the potential to generate separate measurable variables.
It is felt that on departure the runway is occupied from the moment the holding point has been crossed until the aircraft's main gear has lifted off from the runway. This stems directly from ICAO's definition of the runway holding position, which states that the runway is no longer protected beyond the stop bar. Indeed an early clearance for line-up or take-off can be altered until such time as the aircraft has effectively crossed the holding stop bar. From that moment onwards, the runway must be considered to be occupied.

Other arguments in favour of opting for the crossing of the stop bar as the reference line are the fact that:

1. aircraft receiving an early take-off clearance at considerable distance from the holding position would have rather long ROTDs, because of the distance to be covered to the stop bar. Good anticipation by the controller would therefore be penalised by long ROTDs, which is not acceptable;

2. aircraft standing in the holding bay waiting for an optimised line-up/departure sequence would be at a disadvantage vis-à-vis aircraft receiving line-up/take-off clearance at the holding stop bar or whilst still taxiing. Quick pilot response times in dense traffic situations would translate into long ROTDs, which would kill all incentive to perform better. This too is unacceptable.

Logically, the same reasoning could be applied to ROTA when vacating the runway. Here too, the departure holding stop bar (or a reference line at the same distance from the centre line on RETs) could serve as a protection line for the runway. However, unlike in the previous case, the following aircraft is still at a considerable distance from the preceding aircraft which is vacating the runway. In the worst case scenario, a code 4 runway 60 m wide would require a holding position at 90 m from the centre line. Under these circumstances, an aircraft would need to cover a distance of only 60 m, plus its own length, from the runway edge to be beyond the stop bar. At exit speeds of 15 to 30 kt, this distance is equivalent in time to a maximum of 8 seconds (minimum 4 seconds) plus the time equivalent of the aircraft length. It is therefore logical to conclude that vacating aircraft, provided that taxiing is not interrupted on the exit taxiway, will in all cases be safely beyond the runway protection line, even if the ROTA is measured at the time the aircraft's tail vacates the runway. This notion of movement is reflected in the definition by the present participle of the verb vacate (see ROTA definition: '…aircraft's tail vacating…'). Hence the ROTA should not needlessly be lengthened to 'until tail behind the stop bar'. For these reasons, it is proposed that 'tail vacating the runway (edge)' be taken as the reference line for the ROTA definition.

So far, two separate lines have been identified in support of the occupancy definitions, namely the stop bar for departing traffic and 'tail off the runway for arriving traffic'. Two more need to be defined: the main gear lift-off from the runway, and the threshold crossing, for departing and arriving aircraft respectively.

From a safety point of view, in mixed-mode operation a landing aircraft is not normally permitted to cross the threshold until the preceding departure has crossed the end of the runway in use or has started a turn (which can be initiated before the crossing of the runway end). Separation from the preceding aircraft is intrinsically deemed to have been observed before the next landing clearance could ever be issued. It should also be noted that once the main gear is off the runway, the departing aircraft has exceeded the decision speed. The pilot's decision to continue take-off has therefore already been taken, by which it is understood that the departing aircraft will clear the runway. Taking due note of the above, preference is given to "lift-off of the main gear" as opposed to "crossing of the runway end" or "starting of the turn prior to the runway end". Moreover, the moment of main gear lift-off represents a clear and measurable variable, whether determined visually, via the ACARS system, or more generally via a datalink system.

In the ICAO definitions of landing clearance and separation for arriving aircraft, the importance of the threshold is emphasised. From a definition point of view, it should be noted that occupancy time in the arrival phase is not measured from the moment ATC clears the aircraft to land, but from the moment it crosses the threshold. ROTA data so far collected all refer to the threshold as the 'key line'. Consequently, this line should be maintained as a reference for the ROTA definition.

2.4. Runway occupancy time definitions

A schematic overview is included in annex 1, appendices A and B.

2.4.1. Arrival runway occupancy time (ROTA)

The time interval between crossing the threshold and the aircraft's tail vacating the runway.

2.4.2. Departure runway occupancy time (ROTD)

The time interval between crossing the holding stop bar and the main gear lifting off the runway.
The ROTD is further broken down into the following measurable variables:

- **Line-up time (LUPT):**
  the time interval between crossing the stop bar and the moment the aircraft is fully lined up.
- **Wait time (WAIT):**
  he time interval measured between the completed line-up and the ATC clearance for take-off.
- **Flight crew reaction time to ATC take-off clearance (FRTT):**
  the time interval between the ATC clearance and commencement of take-off (roll).
- **Take-off roll time (TOFT):**
  the time interval between the moment the take-off roll has been initiated and the moment the main gear is off the runway.

Further, **Flight crew Reaction to ATC Line-up Clearance (FRLC)** has been identified as a typical performance indicator and has been defined as follows: the time interval between the completion of ATC clearance delivry for either line-up or take-off and commencement of taxiing to line-up.

When collecting ROT data, care must be taken to avoid double counting, e.g. an ATC clearance for line up behind a preceding departure or arrival and its resulting line-up time should never be recorded for that aircraft, until

- the preceding departing aircraft's main gear is off the runway; or
- the preceding arriving aircraft's tail vacates the runway.

If this is not done, clearly the time both aircraft occupy the runway will be counted twice (in the case of multiple line-ups), which will adversely affect the ROT.

The same reasoning applies to early issue of line-up/take-off clearances. The time lapse between the moment the ATC clearance is given and the crossing of the holding stop bar should be counted as taxiing time and NOT as line-up time, because the runway is not occupied until the stop bar has been crossed (a given clearance can after all be altered before the stop bar).

2.5. Conclusions

The previous paragraphs have given a clear indication of the extreme importance of reducing runway occupancy time if runway capacity is to be enhanced. Considering that current and future traffic demand require urgent improvements to be made, and given the fact that the whole air traffic management system is interlinked, common and unambiguous definitions are required. Furthermore, the ROT reductions are a matter of seconds, which lends weight to the use of automated techniques to measure the identified variables, not only to measure ROTs but also to record data regarding performance of aircraft types, pilots and controllers

The harmonised definitions of runway occupancy times have been established taking due account of all the following elements, each of them having the potential to be measured accurately against time:

- time lapse to the following and preceding aircraft;
- crossing of threshold and holding stop bar;
- ATC reaction times and line-up and take-off clearance times;
- pilot response times to both line-up and take-off clearances;
- pilot line-up and take-off times;
- touch-down zone (time);
- deceleration time;
- exit at a specified distance from the runway (or centre line);
- main gear off the runway;

3. Methodologies to measure ROT and Post-Processing Techniques

3.1. Introduction to measurement techniques

It is generally acknowledged that the time during which the runway is occupied is the key issue when for determining runway capacity, in particular on departures. Preliminary capacity studies undertaken by EUROCONTROL have demonstrated an unequivocal relationship between greater ROTDs and decreases in runway capacity (and vice versa). Similarly, higher ROTAs have a significant impact on capacity, in particular in the case of mixed-mode runway operations during arrival peaks. We would reiterate that individual ROT that losses in the order of seconds can generate capacity losses one order of magnitude greater. The knowledge that ROT reductions in the order of seconds between movements can give rise to an increase in declared capacity reinforces the requirement to accurately measure occupancy times as a first priority - 'every second counts', to quote from a UK runway capacity seminar.

Several techniques, of varying accuracy, can be used to measure ROTs. Obviously the simplest way of collecting data is to seek expert advice. Pilots, ATC and airport operations experts can usually provide relatively accurate estimates of the data to be measured. The major disadvantage of this technique lies in its subjectivity. Indeed, experts may not be neutral, and may reflect their own perception and/or interest in their estimates. Nevertheless, this technique may in some cases be the only option because of budgetary restrictions, time constraints and/or lack of manpower, etc.

Another technique for measuring ROT data consists in using stopwatches located at one centralised observation point or several remote positions adjacent to the runway. Basically, this method is easy and does not call for any intellectual prowess. Nevertheless, from a practical point of view it requires continuous concentration, the absence of which directly impacts on the data accuracy. The exercise becomes even more challenging because of the amount of data which have to be collected for successive movements over sustained periods of time. This includes resetting, starting and stopping the stopwatch while listening to the radio frequency and writing down the intermediate results but also keeping a close watch on the runway exit, on the wheels-up location, on the threshold crossing or the start of the take-off run. Performing this kind of an exercise with only one person per runway and traffic flow (inbound or outbound) may be unrealistic if accuracy is a requirement. On the other hand, a team of several people, dispersed to appropriate locations adjacent to the runway and traffic flow, requires additional coordination and perfect synchronisation. This technique would therefore appear to be relatively inefficient, if not enhanced by some automated tools.

Recording errors are mainly due to the manual ROT data collection and to the level of concentration required for sustained periods of time. In order to minimise these errors, fully automatic ROT recording techniques are highly recommended. Firstly, because fully automated systems avoid human errors such as parallax, subjectivity and personal perception. Secondly, automatic systems also preclude individual interpretations which are inherent to manual data collection processes where several persons are involved. Thirdly, automatic data collection reduces the pre-processing and post-processing times. Lastly, the size of the sample to be collected can be increased at no additional cost, unlike with the previous techniques for which manpower has been shown to be the limiting factor.

The following paragraphs give an overview of contemporary ROT measurement methodologies. In some cases the associated post-processing techniques are also described.

3.2. Example methodologies

3.2.1. The LVNL method

In the Netherlands (LVNL), ROTAs at Schiphol have been measured by means of one digital stopwatch per observer per runway. The data is collected from one central location, the control tower, which provides a clear view of both the threshold and the exit taxiways. The time data are synchronised using the Dutch speaking clock service. A level of accuracy of ±4 seconds has been noted because of the long distance from the observation point to the threshold and exit taxiways, but also as a result of parallax effects. Average ROT data are broken down by runway in use, type of aircraft, local carrier and other factors. The analysis also measured the average ROTA per exit taxiway.

3.2.2. The NATS integrated method

3.2.2.1. ROT Measurement

In the NATS methodology, ROTAs and ROTDs are measured twice a year for both landing and departing aircraft from one central point: the visual control room.

Two groups of staff perform the ROT measurements as follows:

- trained ATC staff use stopwatches to record their visual observations, which are backed up with positional information from the surface movement radar;
- a second group, made up of trained students from NATS' operational research department, records only visual observations using stopwatches;
- both groups monitor the radio frequencies in order to correlate the data to be measured with the aircraft call signs;
- the data produced by the two groups are compared as a confidence check, after which they are merged.

Recorded data serve to identify ROT trends and is also used to evaluate airline performance.

3.2.2.2. HERMES II method

The operational service provided by NATS is supported by an analytical service that calculates runway capacity. This runway capacity assessment process is based on NATS’ own fast-time simulation tool, the HEuristic Runway Movement Event Simulation (**HERMES II**). This tool is designed primarily to meet the requirements of airports which are already operating close to capacity. Unlike some other models, HERMES II takes into account the variability in operational performance and punctuality.

HERMES II is suitable for the assessment of current capacity, and also for the assessment of capacity changes which may result from:

- changes in air traffic control procedures,
- the introduction of new technology,
- improvements to airport infrastructure, such as new runway exits.

Regular assessment of capacity has enabled airlines and airport operators to maximise their commercial return by exploiting trends in traffic demand and technical developments in air traffic control.

Inputs taken into account by HERMES II include the following:

- The traffic schedule, which may be specified in detail or summarised by the model.
- The runway layout and rules for the allocation of arrivals and departures to multiple runway systems.
- Traffic taxiing across runways.
- Rules for the safe separation of traffic.
- Data on runway occupancy times and aircraft separation achieved in practice, derived from data collected by airfield observers.

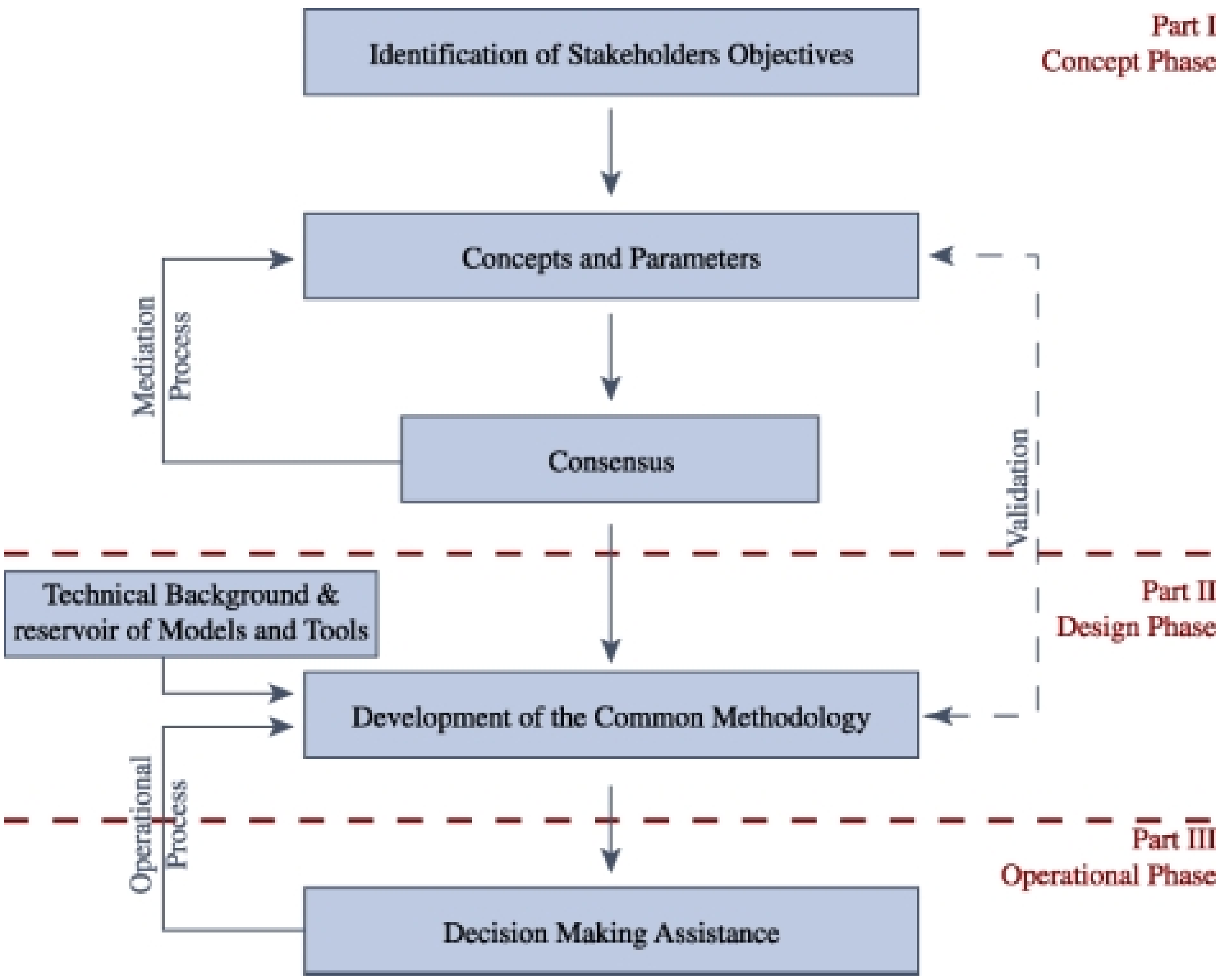
Outputs from HERMES II include runway throughput rates and delay estimates.

3.2.3. EUROCONTROL method

3.2.3.1. Background

In 1999, the Belgian Ministry of Mobility and Transport requested EUROCONTROL to perform a runway system capacity assessment analysis to support the Brussels International Airport authorities in the implementation of EC Regulation 95/93 on slot coordination. The recording of accurate ROTs at peak periods for both inbound and outbound traffic was part of that study. Initially, the 'stopwatch' technique was used, but it was quickly abandoned because of its inaccuracy. EUROCONTROL consequently developed a measurement technique which made use of a ROT recorder software package.

In addition, supported by the activities of the Airport Capacity Modelling Task Force (ACAM TF), the Airport Operations Unit and concerned stakeholders are in the process of developing a model which will have the potential to assess unconstrained[1] and sustained[2]. The three airside components will therefore have to be addressed, namely the runway system, taxiways and parking positions.

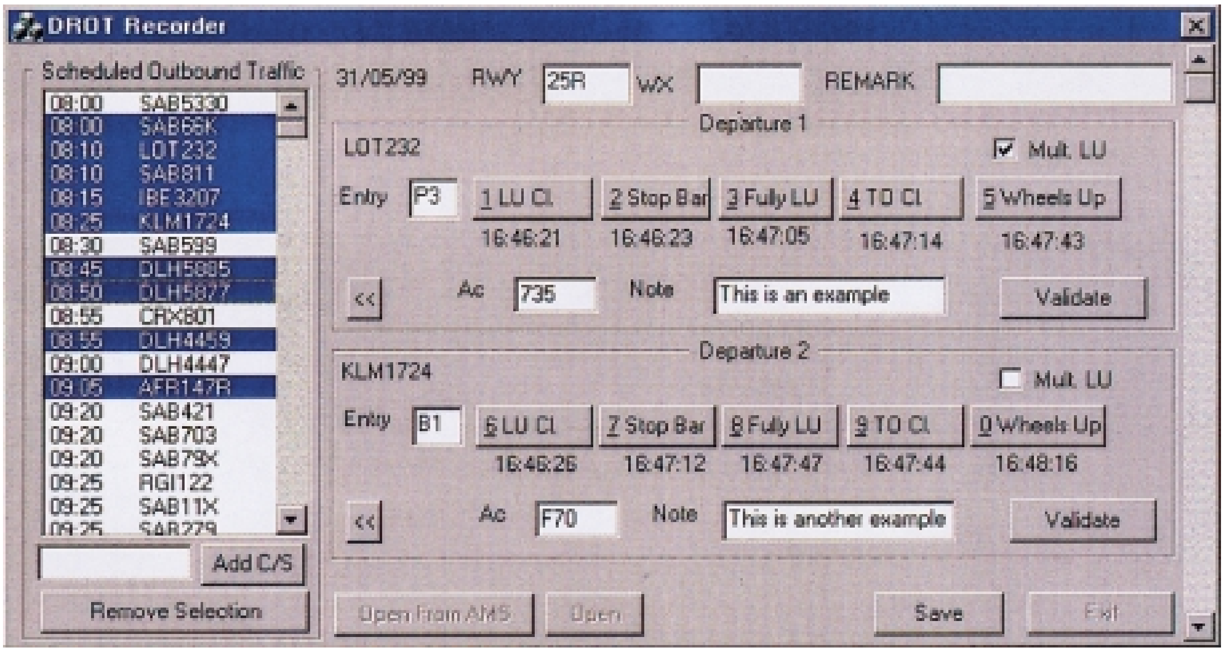


[1] Unconstrained runway capacity is the maximum runway throughput, or flow rate, which can be achieved under ideal conditions (to be difined), regardeless of level of service but in accordance with safety standards and recommendations.

[2] Sustained Runway capacity is the maximum runway throughput, or flow rate, which can be achieved over a sustained period of time when aircraft operate under IFR, under specific traffix mix, in good weather conditions, with good ATM/runway system management, in accordance with safety standards and recommendations and with an acceptable maximum delay for a limited period of time (to be defined locally).

3.2.3.2. ROT recorder software package

This package enables time recording by clicking on pre-selected boxes which contain information as shown in the following table. The list of planned movements can be downloaded and customised prior to the data collection exercise. As ATC usually works with ATC call signs which may differ from those mentioned in the flight planning, a converter allows switching between commercial call sign and ATC call signs. The list of planned flights is in a chronological order to make the recording easier. Movements can be arranged in sequence (see Figure, LOT 232 and KLM 1724) and recorded simultaneously so that multiple line-up operations can be analysed. The recorded data can be exported to the current software packages for post-processing.



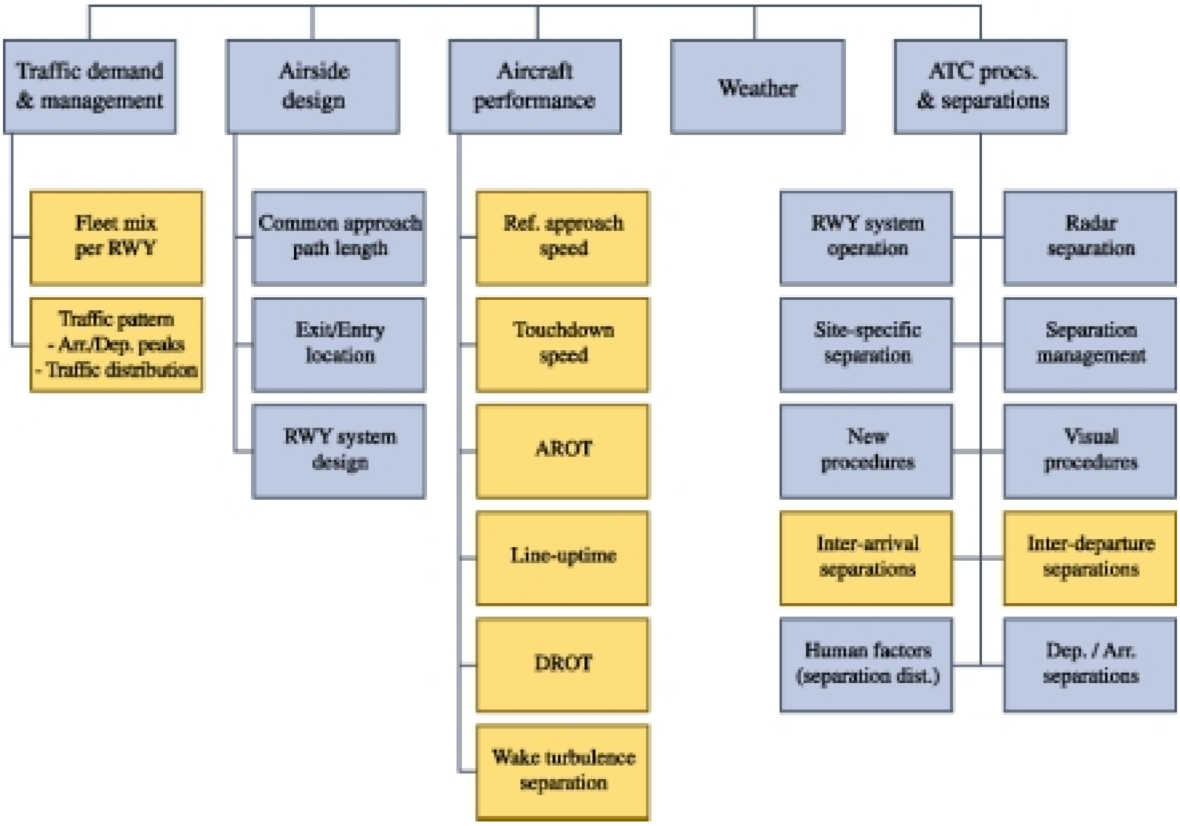
This software package proved its efficiency by reducing the time spent on ROT measurement, which became considerably easier. There is, however, still an element of manual data collection involved, and this technique still requires listening in on the radio frequency whilst concentrating attention on several different locations on the airport runway system.

The EUROCONTROL ROT recorder software package is a valuable pre-processing facility to prepare data for use in the RunSysCap module.

3.2.3.3. Runway System Capacity module (RunSysCap)

The RunSysCap module contains an analytical model allowing capacity assessment of the runway system, including assistance in optimising its capacity feature. Some probabilistic functionalities will be built in to reflect variations in day-to-day airport, aircraft and ATC operations.

The inputs required to run the RunSysCap component are presented next.



In addition to providing unconstrained and sustained capacity figures, sensitivity analyses can be undertaken with regard to a multitude of factors which have an impact on capacity, such as implemented hub strategy, multiple line-ups, departure sequencing and traffic distribution on different SIDs, runway-use strategy, departure airspace constraints, arrival separations, and ATC controller training.

The RunSysCap optimiser allows investigation of capacity maximisation through the optimisation of different factors such as traffic mix, runway-use configuration, (rapid) exit taxiways or traffic distribution per active runway.

RunSysCap has proved to be a powerful analysis tool for various scenarios, keeping study costs to a minimum. It will have the potential to support strategic decision-making and complements more time-consuming and costlier fast-time simulators.

The capacity assessment model will be further extended to include a parking position module which will assess stand capacity based on:

- the aircraft classification used for stand capacity assessment (this classification may differ from the one used for runway system capacity assessment);
- the number of gates per aircraft type;
- the gate allocation process
- the airline/market segment exclusivity (e.g. airline versus cargo usage of gates);
- the average stand occupancy times (including required pre-docking and post-docking times, taxi-in and pushback times);
- the long-term parking positions and related maximum time (after which aircraft have to be parked on a remote parking position).

3.2.4. AENA integrated method

3.2.4.1. Background

Programa de Investigación de Capacidad de Pista (PICAP) is the Spanish runway capacity research programme. Although an initial capacity study was conducted at Madrid–Barajas Airport in 1996, PICAP was officially launched in 1997 by the AENA ATS Directorate. The objective was to obtain detailed information on operations to and from runways at Spanish airports. This would eventually lead to accurate capacity figures and so better meet user needs. The AENA ATC DIVISION (DCCA) undertook this task with the support of INECO Consulting, a firm providing expertise in air transportation in Spain.

3.2.4.2. Justification for PICAP

Until 1997, Spanish airport capacity figures were mainly based on local managers' operational experience supported by theoretical calculations. It was decided that this method was unsatisfactory and not commensurate with the high quality of service that AENA is expected to provide. For this reason, and in order to accommodate the increasing traffic demand at Spanish airports, a need was identified to create a methodology capable of providing not only accurate data giving a better understanding of airport operations but also further information on true runway capacity.

The aim was to obtain, through the application of this new methodology, reliable measurements of all the different aspects of airport runway operations. "Bottlenecks" would be identified, and operational enhancement proposals supported by a simulation process would then be presented to ATM/airport managers. This would assist them when evaluating alternative proposals for future improvements.

3.2.4.3. PICAP process

Once an airport has been selected for analysis all the relevant operational documentation related to that airport is studied (AIPs, LoAs, ATC procedure manuals, etc.). The airport is then visited and the purpose of the study is explained to, and operational issues are discussed with, the local ATC/airport managers.

Real-time operational data such as runway occupancy times, use of RETs and RATs, traffic mix, meteorology, etc. are collected taking advantage of the unique observation facilities offered by the control tower. This task is accomplished by trained and qualified staff, supported by specific data-acquisition software tools.

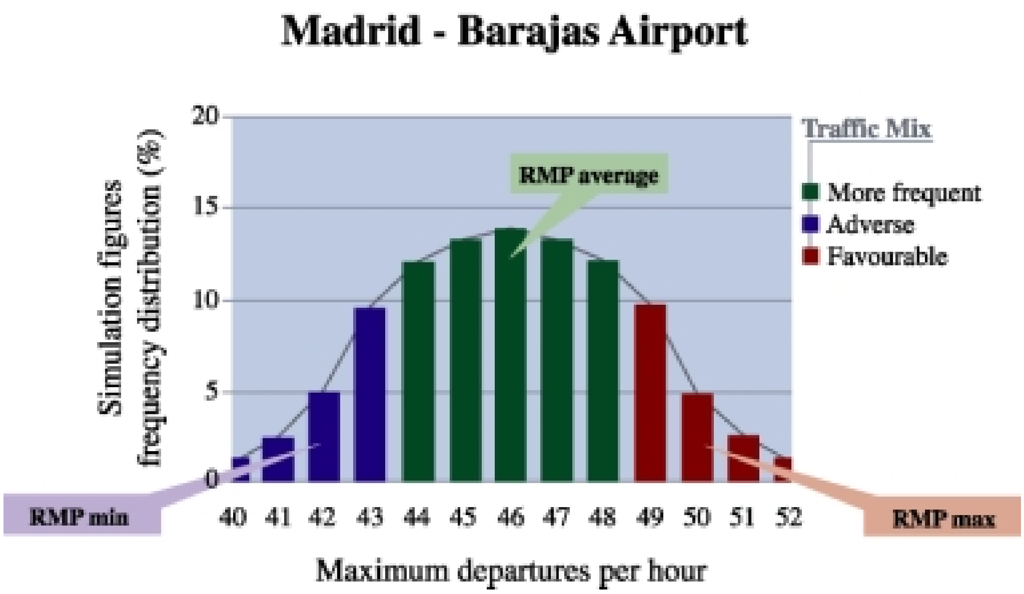
For this purpose, the PICAP Team has developed a software package which is easily and quickly adaptable to any airport. These tools have not only made the measurement of real-time data significantly easier but have also considerably reduced post-processing time.

The time needed to complete this task depends on the amount of data required to produce reliable statistical margins.

Once the collecting process is concluded, all the data, supplemented by those obtained from radar, are checked and approved by the PICAP technical team and post-processed by specific statistical software. This provides the technical staff with sufficient information to obtain an in-depth understanding of the airport's operation and to identify critical aspects in ATC and flight operations procedures, infrastructures and installations.

Using fast-time simulation, a methodology has been developed to determine the maximum number of operations which can be scheduled without exceeding a defined delay level. The simulation process, fed by the outputs from the previous operational analysis, has two phases:

The first is an initial attempt to determine runway capacity. To achieve this, they define the performance indicator RMP "Rendimiento Máximo de Pista" (maximum runway throughput) as the maximum number of operations which can be performed on a given runway(s), in a given period of time, in accordance with the operational rules, and taking no account of delays. The aim is to determine, in terms of probabilities and in known sets of conditions, the upper and lower limits of the maximum runway movements. The following figure shows a generic example, to make these concepts easier to understand.



Probability distribution of RMP (maximum number of departures per hour)

Because of the different factors affecting runway operations, there will be more than one value for the maximum number of movements (RMP) and the solution to the problem will generally be a range of values. As the example above shows, a useful way to display the RMP figures is a frequency distribution: vertical values (blue, green and red) represent the probability, obtained through simulation, for each maximum number of operations shown in the horizontal axis (RMP). The colour code indicates the impact of the mix of the traffic on the probability distribution for RMP: the worse the mix of the traffic, the lower the capacity.

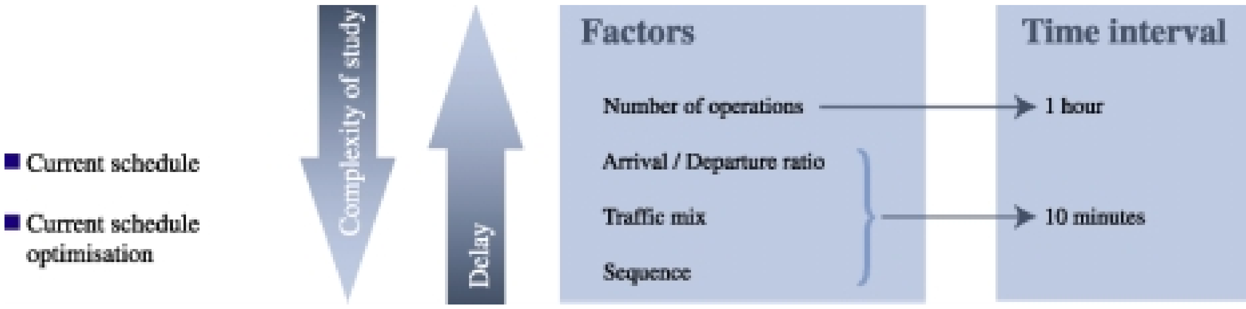
The results of the first phase provide information on the capability of existing procedures and infrastructures. This in turn makes it possible to identify any existing or expected imbalance between capacity and demand. In further, more detailed research on the problem, delay indicators need to be taken into account.

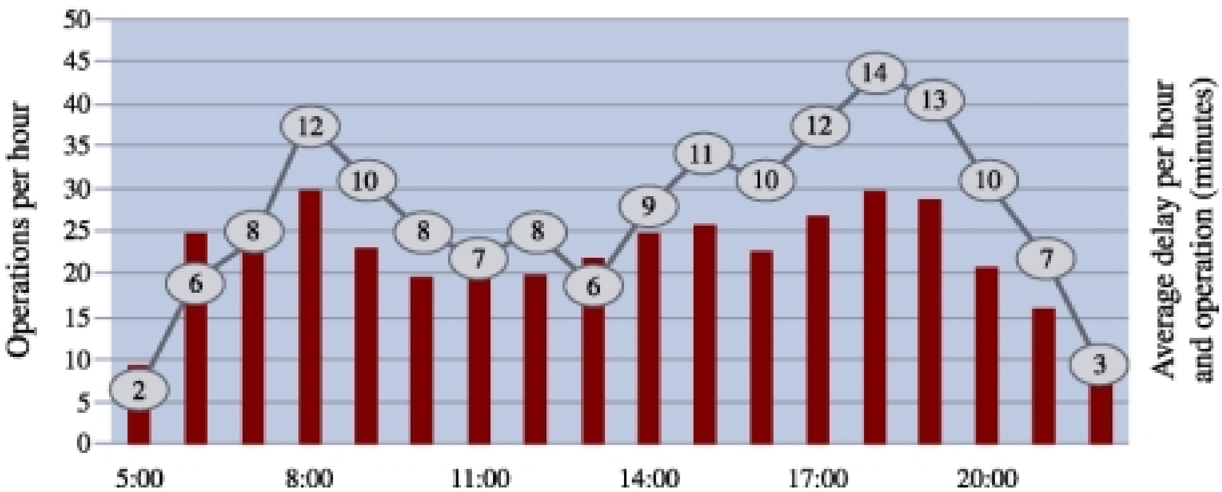
The objective of the second phase is to ascertain the relationship between schedule and delay, in the hope that enhanced scheduling will allow capacity to better accommodate demand.

Four factors are considered when studying delays:

- number of operations;
- arrival/departure ratio;
- traffic mix;
- sequence.

They are arranged in order of complexity of the study. Whenever a new factor is included, the complexity increases, but this allows the relationship between ‘delay level’ and ‘scheduling’ to be more accurately determined. It is therefore possible to modify the schedule taking the effects of the new factor into account. On the other hand, given the increasing number of possibilities which have to be weighed statistically, the duration of the study will probably need to be reduced. The following diagram illustrates the aforementioned relationship.





Scheduling factors affecting delays

Once the relationship between schedule and delay is known for a particular scenario, and demand is taken into account, it will be possible to propose a scheduling hypothesis.

The whole study must be considered as an iterative process, including feedback during both phases. The final objective is to achieve the highest possible capacity enhancement.

Phases	Indicators	Main scope	Achievements
Phase 1	Maximum runway throughput - overload mode - (operations per time unit)	Procedures Infrastructure	ENHANCEMENT PROPOSALS
Phase 2	Delay level in accordance with the scheduled operations distribution (minutes per operation)	Scheduled - demand	SCHEDULING HYPOTHESIS

Summary

An “Operational Report Document” contains conclusions on airport operations, clearly identifying “bottlenecks” and therefore enabling airport and ATS authorities to take appropriate decisions to reduce or remove them. A “Simulation Report Document” contains information on the simulation input criteria, as well as conclusions not only on the current airport performance but also on a set of enhancement proposals.

The final stage of the PICAP process comes in the form of collaborative decision-making. All parties involved in the airport operation (ATC, airport authorities and aircraft operators) are presented with the conclusions and recommendations of the study and invited to participate in the discussion to improve the airport’s operation.

3.2.4.4. Results of PICAP to date

By April 2001, 17 of Spain’s 43 airports have been studied using PICAP. More than 30,000 runway operations have been analysed, and there have been more than 15,000 hours of simulation. The remaining 26 airports are expected to be studied over the coming years (2001/2004).

As regards capacity, PICAP has proved to be a reliable methodology on which the decision-making process should be based. Significant capacity gains have been achieved at several Spanish airports as a result of PICAP application. Since the winter of 1997, the overall capacity increase can be quantified as 150 new operations in the Spanish airport network.

	Season		Capacity Gain	
Airports	Winter 97	Summer 2000	Operations	%
Alicante	18	30	+12	67%
Barcelona	40	52	+12	30%
Bilbao	12	14	+2	17%
Fuerteventura	10	12	+2	20%
Gran Canaria	26	34	+8	31%
Ibiza	16	22	+6	37%
Lanzarote	12	17	+5	42%
Madrid	50	74	+24	48%
Málaga	30	35	+5	16%
Menorca	16	16	0	0%
Palma de Mallorca	42	60	+18	42%
Tenerife Sur	24	35	+11	46%
Vigo	10	10	0	0%

Capacity gains at Spanish airports (Summer ‘97 - Summer 2000)

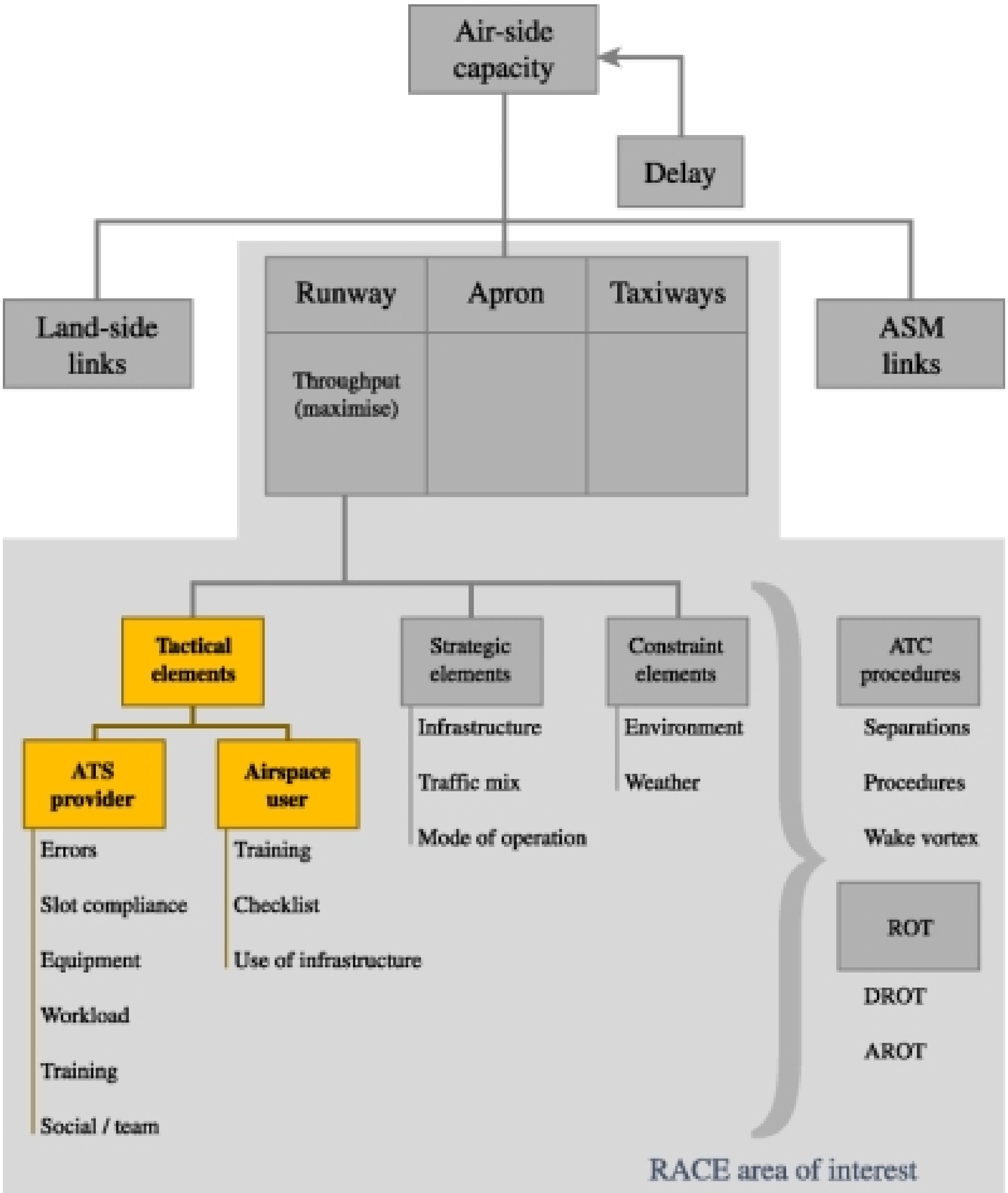
At busy airports such as Madrid and Barcelona, detailed studies of operational performance have been developed following the initial runway capacity assessment. These two airports are in fact subject to continuing evaluation.

- Barcelona – El Prat Airport: Study on simultaneous intersecting runway operations, SIRO (1998).
- Madrid – Barajas Airport: Assessment of the impact of low-visibility procedures (1999).
- Madrid – Barajas Airport: Study and proposal to reduce runway separation on the same runway (1999).
- Madrid – Barajas Airport: Study on the viability of using runway 36R for departing turboprops only (1999).

Other airports where various types of specific study have been conducted using the flexible capabilities of the PICAP methodology are:

- Canary Islands: Evaluation of common scheduling at Lanzarote and Fuerteventura Airports (1999).
- Palma de Mallorca Airport: Study on best practice for runway configuration usage (1998).
- Tenerife Sur Airport: Work in progress at the holding area. Determination of impact on runway capacity.

Enhancement



Elements Affecting Airside & Runway Capacity

4.1. Tactical capacity enablers

All of the elements affecting airport airside capacity are linked, but some are easier to influence than others. ‘Quick wins’ in this respect can be found in the performance of airspace users and ATS providers. These two elements and their links are further explored below.

4.1.1. Flight operations factors that affect ROT

4.1.1.1. Introduction

Many factors, both strategic and tactical, that influence Runway Occupancy Time (ROT) are outside the control of the pilot. However, as the last element in a complex system the pilot may be the final determining factor in the success of the practices employed to improve runway capacity. All measures designed to reduce ROT assume that the aircraft will make the most expeditious use of the runway, within the bounds of a safe operation, in a manner that permits ATC to adopt the most efficient strategies. The method of operation of pilots and in particular their awareness of the issues is therefore of prime importance.

Given that the required outcome is minimum ROT, and therefore enhanced throughput, the flight operations related performance drivers that influence this must be determined. It should be noted that some measures may be contra-indicated due to flight safety, passenger comfort or economic considerations; these are discussed in detail. The objective for this section, therefore, is to:

- examine the performance drivers involved in order to determine those that may be used to decrease runway occupancy times
- Make recommendations where modification to the performance drivers is indicated.

It is recognised that stakeholders operate in very different environments, and that what is considered as a normal operating procedure in one place would be regarded as unacceptable, or inefficient in another. However, it is desirable to move towards a harmonised approach to optimising runway occupancy times.

4.1.1.2. Measurements

The pilot contribution to runway occupancy reduction can be measured and this will be discussed in detail in par. 4.1.3 below. Taken in isolation the objective should be to minimise these times.

The times that will be measured will be:

- Flight crew reaction time to line up clearance (FRLC)(departures).
- Line up time (LUPT)(departures).
- Flight crew reaction time to ATC take off clearance (FRTT)(departures).
- Take-off roll time (TOFT)(departures)
- Threshold to Tail-off runway time (ROTA)(arrivals).

However, runway occupancy time cannot be considered in isolation, other factors such as safety, passenger comfort and economics should be considered. It must be emphasised that the aim should not be to reduce these times to the lowest theoretical limit but the measurements should be used to compare various methods of operation in order to allow airlines to share best practices within the constraints of flight safety and the discretion of the pilot.

4.1.1.3. Overview of flight operations factors

The main flight operations elements that affect the occupancy time are listed below:

4.1.1.3.1. Braking distance

In simple terms, the more runway that is required to decelerate to a safe speed, the longer the runway will be occupied. Although the braking distance required for a given aircraft type and weight is defined in the aircraft manual, in reality this is variable according to numerous factors. These factors, or performance drivers, are discussed below and may be subject to variation in order to reduce the ROT.

This variability is compounded by the fact that the braking distance itself does not necessarily correspond to a predictable runway distance as it is dependant on the actual touchdown point of the aircraft. Although the pilot will aim to touch down at a nominated point (typically the 1000ft point) the aircraft may float further due to a variety of factors. Any extra distance covered will inevitably increase the landing roll out required and consequently the runway occupancy time.

4.1.1.3.2. Selection of Exit

As aircraft are designed to stop from V1 at MTOW during a take off run, the landing stopping distance is not normally a limiting factor. This excess in stopping performance results in the option to select from a number of available exits on most runways.

In practice the exit selected may not be the most favourable in terms of ROT as other factors such as passenger comfort and brake wear are an important consideration. There will therefore be an inevitable trade-off between minimising ROT and taking due consideration of other factors.

4.1.1.3.3. Safe Exit Speed

Before an aircraft can turn off the runway the speed must be reduced to a safe level. This speed cannot be precisely defined but depends on the exit type, the aircraft type and the surface conditions.

For example a B747 may be able to exit at a RET at 30 – 40 kts but must decelerate to 5 – 10 kts to leave at a 90∞ exit taxiway. In wet conditions these speeds may be reduced to 20 – 30kts and 5 - 6kts respectively. There is an element of uncertainty regarding actual exit speeds as they will ultimately depend on the judgement and discretion of the pilot in view of prevailing conditions and the braking action experienced.

4.1.1.3.4. Response to Line-Up/Take-Off Clearance

The ability of the pilot and the aircraft to move from the holding position to the runway centre line and then commence the take off roll is clearly of critical importance in minimising the take-off runway occupancy time. In general terms this is constrained by the ability of the aircraft to spool up and accelerate to taxi speed and also by the speed at which the aircraft can safely negotiate the turn at heavy weight.

4.1.1.3.5. Essential Actions/Method of Operation

Irrespective of the speed at which the aircraft may be able to move from the holding position to the take off position there may be other factors that add time to the take off ROT. Certain essential actions are required prior to take off including checks, engine stabilisation, performance data download, navigation function selections etc. The method of operation chosen by the airline or specified by the aircraft or engine manufacturer will have an impact on this factor.

This also affects the landing ROT as the braking distance required and indeed the touchdown point will be influenced by the method of operation used by the airline.

4.1.1.3.6. Summary

It can be seen therefore that numerous elements influence the ROT outcome. These do not act independently but are influenced by and connected with others. The following paragraphs examine the performance drivers that are involved in these elements. They have been divided into:

- Pilot performance aspects
- Aircraft performance aspects
- Airline procedures aspects
- Airport/Runway/Taxiway layout

4.1.1.4. Performance drivers

Depending on prevailing circumstances a number of factors will affect the amount of time that an aircraft occupies the runway. Such factors have been identified following consultation with a variety of airlines and from discussions at RACE meetings. These performance drivers have been identified for two reasons. Firstly, to determine if there are procedures that can be accomplished more expeditiously. Secondly, to provide information for those who are less familiar with flight operations activities, so that they can be more aware of the various constraints and of the effect they have on runway occupancy times.

4.1.1.4.1. Pilot performance aspects

Pilots are regulated by a number of different agencies at any one time:

- Operating limitations set by the aircraft manufacturers;
- Additional regulations imposed by the carrier's own national regulators;
- Operating policies and procedures established by the carriers themselves;
- Local limitations set by the regulators and airports concerned;
- ICAO standards (detailed in the various documents referred to below).

This will lead to occasions when the pilot may operate in ways that appear to conflict with recognised best practices for reducing ROT.

Experience on Type

All pilots will be naturally cautious when inexperienced on the aircraft type. Although it is not normal practice to have two inexperienced pilots operating together the handling pilot may be so and it is therefore likely that, following flight safety considerations, caution will override the need to be expeditious.

Familiarity with locality.

The effect described above is also apparent if a pilot (even when experienced) is unfamiliar with the layout and characteristics of a particular airport. It is likely that more concentration is required when taxiing and this will reduce his input to minimising ROT.

In addition, some airports are recognised for their "unique characteristics", and pilots must undergo specific familiarisation training before operating into them. An airport can be designated as "special" either by government regulators or by the carrier for a number of reasons, but these usually break down into one of two categories; terrain or complex procedures. Pilots will, inevitably, operate in a more cautious manner at such airports.

Conversely, pilots operating from their home base will be more familiar with the airport layout (e.g. position of RETs) and procedures, and will therefore have additional capacity to devote to other aspects of the operation which may result in consistently lower ROTs.

Pilot awareness of need to minimise ROT

Expediency on the runway is a normal operating practice for pilots and it is generally addressed at all levels of training. Awareness may be categorised in two parts:

- Strategic awareness: that is the understanding of the general issues involved and of the importance for the continued efficient use of available runways. This also includes the awareness of airport infrastructure in terms of location and configuration of RETs and of specific airport procedures and requirements.
- Tactical awareness: this is the immediate knowledge of other air traffic requirements. Whilst pilots will generally be aware of traffic around them they may not necessarily be aware of the immediacy of the need to vacate the runway or expedite the take-off; e.g. a pilot is not necessarily aware of the range of landing traffic when lining up to take off.

In general pilots are able and willing to act in more expeditious manner when they are aware of immediate issues. When balancing the opposing requirements of safety, economy and passenger comfort against runway occupancy time, it is essential that they are fully aware of the air traffic situation. In addition, a broader awareness of runway capacity issues will help to keep the subject in focus.

Autoland Practice

This study focuses on attempts to reduce runway occupancy times when the weather is CAT I or better. However, regardless of the facilities provided by the airport and the equipment on board the aircraft, pilots must have satisfactorily completed specific training in order to operate in CAT II or CAT III conditions. They are also expected, even in comparatively good weather, to occasionally practice the techniques involved. The level of training and amount of recent experience required are determined by the airline's regulator. This will necessitate a small number of autolands being performed when weather conditions do not dictate CAT II/III operations. An autoland will often require a longer landing run and therefore a longer ROT. This is due to the fact that the autopilot flares slightly higher and holds the aircraft off the runway whilst controlling the rate of descent for a longer period than the average pilot flying manually.

Control Hand Over

In many airlines it is company policy for all taxiing to be performed from the left hand seat. If the pilot flying is in the right hand seat control must be handed over during the landing roll prior to exiting the runway. It has been reported that this can lead to a less than optimum roll out. To explain this it is important to understand the sequence of events during landing. As previously described the touchdown point will vary due to individual pilot technique, or a deliberate hold off to produce a smoother touchdown. Also gradients or "humps" in the surface will affect this as will changes in wind strength/direction during the flare. If the pilot is conscious of the need to stop in a specified distance it is possible to mitigate some of these factors and put the aircraft down closer to the predicted position. Inevitably however the priority and direction of most of the pilot's concentration will be on controlling the aircraft. Once touchdown has been achieved the priority will be the transition from flight to controlled deceleration and the deployment of spoiler, thrust reversers and brakes. Only when this has been established will the priority of the pilot transfer to exiting the runway. The speed at this point may be down to 100 kts or less.

It can be seen that the runway exit is always a lower priority to the pilot until later in the landing run. If the pilot flying is not actually going to complete the manoeuvre it is possible that, during periods of high workload, less important considerations will not influence his actions at all.

4.1.1.4.2. Aircraft performance aspects.

Engine Spool Up time

A typical sequence of events following a take off clearance when lined up on the runway is that the brakes are released and an intermediate power setting is manually applied (e.g. 70% N1). The engines spool up and there will be a brief pause to ensure that RPM, temps, pressures etc stabilise before take off power (e.g. TOGA) is selected. For a large aircraft this may occupy a significant proportion of the ROT. For example from take off clearance until significant movement is observed can take up to 15 sec for a B747 400. This is essential, as an engine that hangs during spool up directly to take off power could cause sufficient asymmetric thrust to cause the aircraft to leave the paved surface.

Under certain environmental conditions some aircraft require even longer to ensure that the engines have stabilised if intake icing is likely to be encountered. For example some aircraft require 30 secs stabilisation when the OAT is 10deg or below and visible moisture is present.

Taxi Speeds

Taxi speeds, in particular turning capability, are a major limiting factor in attempting to reduce ROT. For example, when
negotiating a 90∞ turn such as when entering the runway, a large aircraft such as a B747 may be unable to taxi faster than 5-6 kts, especially in the wet. Any attempt to taxi faster than this will cause the nose wheel to lose traction and slide. White painted runway markings exacerbate this problem. For any aircraft type the combination of acute turning angles and heavy weight will result in very low taxi speeds.

When vacating the runway, RETs alleviate this problem but there are also practical limits to the speeds that can be achieved and profound difficulties in defining these precisely. Although 40 kts for large aircraft and 60kts for smaller aircraft have been suggested as reasonable maximum speeds for entering RETs in dry conditions, some operators are reluctant to be specific. As an example, the following is an operations manual extract from an airline operating a mixed fleet of wide and narrow body aircraft within the ECAC region and beyond. It refers in particular to its own destinations and is not a general comment on all airports:

"…it is not possible to state a maximum entry speed for Rapid Exit Taxiways (RET). The design of RETs differs from airfield to airfield, with angles of 30° or 45° to the runway centreline being commonly used. Moreover, the actual angle employed in a particular RET installation and the subsequent distance available for deceleration after the runway has been vacated, is not currently available to the pilot…"

Irrespective of any recommendations the onus will always be placed on the pilot to determine the safe speed and exit at the appropriate time.

Landing weight and Speed.

The landing weight of the aircraft has a significant impact on the distance required to decelerate to a speed at which the aircraft can safely manoeuvre clear of the runway. Two apparently identical aircraft in similar circumstances may well require very different runway lengths in which to complete their landing run due to differences in landing weight. A heavier aircraft has more energy to dissipate during braking but also has a higher speed on landing than a lighter aircraft. Both factors indicate a longer landing run and possibly longer ROT assuming the same degree of braking is applied throughout the landing role.

As an example of the variation in landing speed a B757 may vary between 127kts and 132kts and a B767 between 138kts and 146kts. These speeds will be increased in gusty wind conditions. The quoted figures are airspeeds but what really matters is the groundspeed, which will be significantly higher in tailwind conditions.

Use of auto brakes.

Autobrakes provide several settings that dictate the rate of deceleration the aircraft. For example rates typical for a B767-300 are:

Setting	Deceleration rate Feet/sec/sec	Stopping distance from 130KTS, Still Air, Sea level Feet
1	4	6300
2	5	5000
3	6	4200
4	7.5	3400
Max	11	2600

By comparison, a B747 400 using a moderate setting will have a stopping distance of 6824ft reducing to 4856ft at Max autobrake.

Settings will be selected depending on the distance available, the landing weight and prevailing conditions. Although some operators consider the distance to most suitable RET, this is not a universal practice. Other operators will simply specify a standard setting that should be used unless conditions, or pilot judgement, dictate otherwise. The benefits of using autobrakes are that braking is applied at the earliest effective moment and the initial application of brakes is smooth. This will invariably result in a shorter stopping distance in comparison with manual braking.

Autobrakes will bring the aircraft to a full stop and therefore, under normal conditions will be overridden by the pilot once braking has been established and the aircraft is under control. Manual braking will then be modulated to achieve the most suitable exit. This is particularly important as retaining autobrakes when it is clear that exit at the next RET is unachievable may cause the aircraft to decelerate too much resulting in a slow taxi to the next available exit. Conversely, it may be apparent that the autobrake setting will not achieve sufficient deceleration to exit at the desired RET, increased manual braking may then be employed to ensure a safe exit.

Use of reverse thrust.

The use of reverse thrust on landing increases the rate of deceleration and can therefore reduce the ROT. In practice, however, reverse thrust is normally used in combination with autobrakes and spoilers and reduces the load, and therefore wear, on the brakes. In this case increasing reverse thrust will not significantly affect the landing distance. The reason for this is that the autobrake setting selects a defined deceleration rate and modulates the brake pressure to achieve this. The addition of other deceleration devices, such as reverse thrust will merely cause the brake pressure to decrease in order to preserve the deceleration rate. It is possible that with a low autobrake setting moderate reverse and spoiler may generate sufficient deceleration and wheel brakes may not be applied until the speed has reduced and spoilers and reverse thrust become less effective.

As the use of reverse thrust at high power settings results in considerable noise and vibration in the cabin (depending on aircraft type), it is not normally employed to its maximum potential during normal operations in order to enhance passenger comfort.

At some airports the use of reverse thrust above idle power may actually be prohibited at certain times.

In some aircraft types brake wear is so significant that initial deceleration results from spoilers and reverse thrust alone. For example some operators of DC 10 aircraft do not initiate braking, under normal conditions, until speed has decayed to below 120kts. It is therefore important to ensure that reverse thrust is initiated as effectively and expeditiously as possible.

Brake cooling requirements.

Obviously vigorous application of the brakes results in extra wear to the tyres and brake assemblies, and more heat being generated by the units than would otherwise be the case. As aircraft may not depart until their brakes have cooled to within specified temperature limits, sometimes a trade-off has to be made between the reduction of ROTA and the possibility of a loss of a departure slot due to hot brakes. This is not normally a significant factor, but may be relevant when a fast turnaround is required.

Initiation of nose-wheel steering

After landing, full nose wheel steering must be available before vacating the runway. A limited degree of nose wheel steering, sufficient for directional control on the runway, is available through the rudder pedals (7∞ for B757/B767) but a hand tiller must be used for ground manoeuvring. The speed at which this can be accomplished varies from aircraft to aircraft, but for commercial jets it tends to be in the region of 70 knots. Although this is seldom a limiting factor, aircraft are unable to take advantage of taxiways, even those designed for rapid exits, prior to reducing speed to below this level.

Crosswind / tailwind limitations.

Wind can have a very significant effect on the rollout time. This may be caused by a higher groundspeed resulting from increased airspeed during gusty conditions or, the effects of a tailwind or crosswind. If conditions are challenging then the pilots attention will, rightly, be focussed on controlling the aircraft safely during transition from flight rather than on the most efficient RET to take.

Surface Conditions

Wet or slippery surfaces will reduce the braking capacity and extend the landing run. In addition speed must be reduced to a lower level in order to exit at a RET or normal exit than would be acceptable in dry conditions.

4.1.1.4.3. Airline/Operating Procedures Aspects.

Late Changes

In the event that a SID or route change is given after a line up clearance this will require the new data to be entered into the Flight Management System by one pilot and then checked and confirmed by the other before being activated. This can be a time consuming process. A similar process is required for older non EFIS models where NAV beacons have to be selected, checked and identified, and NAV instrument settings made.

At some airports the ability to take off from an intermediate point on the runway provides ATC with options either to push an aircraft ahead of the queue when this will improve the traffic mix, or to expedite a take off for an aircraft just taxiing out. This may enable them to accommodate extra movements due an improved wake vortex sequence by taking an aircraft from further back in the holding queue, or to expedite a take off for an aircraft taxiing out. In most cases the revised take off position will still give more than sufficient runway length but the crew are required to check the performance data from the new position and calculate revised reference speeds. These calculations must then be checked and the new speeds “budgged” on the ASI (airspeed indicator). Whilst this is not a prolonged exercise it can cost valuable seconds and may reduce the ability of the crew and ATC to react to a capacity increasing opportunity.

Taxiing out on one engine.

This is an economic procedure that should not adversely affect runway occupancy times (assuming all engines have been started prior to reaching the holding point).

Accomplishment of check-lists and briefings.

During the course of a flight a number of check lists are utilised and crew briefings carried out. The items on the check lists are largely dictated by the manufacturers, but the carriers have some latitude as to when the various check list items are conducted. These variations must be approved by the carrier's regulatory authority. In some cases pilots are required to carry out checks on the runway prior to take off. This practice can increase the ROT. It is believed that this represents a small effect and most known cases involve simple procedures such as switching on weather radar, strobes and transponder.

Reduced Thrust Take-Off

In the majority of departures the power and take off run available exceeds that required to satisfy take off performance requirements. It is possible therefore to reduce the amount of power used and still retain the ability to stop from V1 or to continue the take-off on one engine following V1. In order to conserve engine life and maintenance costs, a reduced power setting is calculated that will retain the safety margins required by the published regulations. This is a take-off procedure that has a marked economic benefit but that can increase runway occupancy times by a matter of a few seconds.

The economic benefits for the airline are important, not to mention the very significant safety contribution gained from operating engines at de-rated thrust during the critical take of phase.

4.1.1.4.4. Airport/Runway/Taxiway layout

Location of terminal(s) in relation to the runway.

If the airport terminal is located close to the roll out end of the active runway it is economic and logical, from the carrier's view-point at least, to taxi the aircraft for as short a distance as possible. This implies that minimum braking will be used in order to continue to the far end before leaving the runway. Whilst this is economically efficient for the airline it is detrimental to the ROT. Consideration must also be given to the disadvantages created when taxiing involves crossing an active runway, thereby occasionally increasing the runway occupancy time of departing traffic.

Location and Visibility of RETs

Given that the transfer of attention from controlling the aircraft and establishing deceleration to consideration of the best exit occurs relatively late during the roll out, it is essential that the locations of all available exits can be easily and rapidly determined. Many pilots report that this is not a straightforward task as RET visibility is variable from airport to airport. This is an important consideration as braking must be adjusted early enough to achieve a turn off at the required RET at optimum speed. The RETILs installed at Gatwick have been designed to help alleviate this problem. Clear evidence is not available at the time of writing to judge the effectiveness of this measure, although pilots suggest that any improvements will be worthwhile. It has been suggested that the clear indication (lighting) of all available RETs is essential to allow the pilot to make an early judgement and decision.

Clearly the position of RETs but also the deceleration distance between both the runway and taxiway centre lines is of utmost importance and these must be placed to capture the widest spread of traffic.

4.1.2. Limitations

It is important to be aware that any consideration of "best practices" must be set against a background of limitations to what can be reasonably and safely achieved. Before considering the modification of performance drivers the following paragraphs outline the areas which may limit the capability of pilots to achieve theoretical minimum ROTs.

4.1.2.1. Flight Safety Issues

The period between line up/take off clearance and starting the take off roll is not a time to be rushing or attempting to save seconds. The only priority for the pilot at this point is to ensure that the aircraft is correctly configured and safely positioned, that ATC clearances are understood and complied with, and that the position and activity of other aircraft are known. Similarly, on landing the overriding responsibility for the pilots remains the safe and controlled touchdown and deceleration of the aircraft. The runway exit to be used must always be a secondary consideration at this time.

The pilot is the last line of defence in flight safety terms and carries the ultimate responsibility for the safety of the aircraft. It is neither reasonable nor sensible to demand reductions in margins of flight safety in order to achieve runway capacity improvements. In this area pilots must remain the final arbiter of what is acceptable.

4.1.2.2. Economic Factors

Aircraft Brake units are an extremely costly item. As an example, cost may range from approximately € 80,000 for a BAe 146 to over € 150,000 for a B747. The number of landings achievable from a set of brake units varies according to aircraft type but is approximately 2000 under normal conditions for a BAe 146. Repeated heavy braking may reduce this by 25%. Airlines are unlikely to adopt recommendations that require them to routinely increase deceleration beyond current normal practice.

Similarly, the economic benefits of de-rated take off thrust, coupled with the improved engine reliability, will not be eroded by any recommendations to improve ROT.

4.1.2.3. Passenger Considerations

The use of maximum, or even heavy, braking and/or the use of high power settings in reverse thrust is extremely disturbing for passengers. These practices generate considerable noise, forces and vibration, to which passengers are not normally exposed. This can be a frightening experience for many. Irrespective of the costs involved in the additional stress to brakes, engines and airframe, it is unlikely that airlines would sanction this practice on a routine basis.

4.1.2.4. Physical Constraints

As previously stated there are physical limits to the speed at which aircraft can turn on the ground. It is not possible to be definitive about this as the speed depends on numerous varying factors such as weight, environmental conditions, surface conditions, aircraft type and pilot familiarity and judgement at the time.

4.1.3. Best Practices

Whilst immediate actions are influenced primarily by safety considerations, operational and commercial factors form a normal part of the operating procedures for pilots. Therefore, whilst the preceding paragraphs have outlined safety and commercial constraints, there must be scope, within these limitations, for airlines and pilots to review the method of operations and the procedures adopted, to take account of ROT considerations. In summary none of the following should be read as a simple request for pilots to expedite but as a suggestion for a considered review of procedures.

This section describes the Best Practices that are recommended for pilots to follow in order to minimise runway occupancy times. As discussed above pilots are subject to many regulations and procedures that may preclude the adoption of these practices. This exercise is not intended to be proscriptive but rather to encourage the considered review operational practices amongst the pilot community with runway occupancy time in mind.

4.1.3.1. Crew Awareness and Training

It has already been stated that pilots understand the importance of minimising runway occupancy from an early stage in their training. However, as pilots play an important part in the effort to reduce ROT it is essential that the issues involved are emphasised on a regular basis. This will provide the pilot community with the opportunity to review ROT issues within the constraints of their operational requirements and flight safety limits. This should include information about traffic growth patterns and current and projected runway usage. The provision of facts and information can only serve to raise the profile of runway occupancy issues and more closely involve pilots, as important contributors, in the most efficient use of runways. Two recommendations are proposed:

- It is recommended that all aircraft operators produce a company policy that may be incorporated into the Operations Manual. This should be introduced during the airlines initial pilot training programme and may be periodically reviewed or discussed during recurrent training sessions. The policy statement should raise the awareness and importance of runway occupancy and where possible, subject to flight safety limitations, give guidance to pilots on recommended speeds and procedures. This may also include the nomination of preferred RETs at specific airfields.

- Many airports already have pilot working groups comprising representatives of base operators. This practice is encouraged and should include ROT related issues. This will allow the airport and pilot representatives to develop local procedures and suggest preferred exits retaining existing margins of safety. The specification of preferred RETs should be by aircraft type and may be published in the AIP. The working group should meet on a regular basis to review monitor performance and manage the performance measuring discussed in para 4.1.3.9.

4.1.3.2. Line up/Take off

Evidence suggests that some companies require checks to be carried out on the runway prior to departure. It is possible that different companies operating similar types adopt differing practices in this respect. Whilst evidence for this is not conclusive it is recommended that where possible company procedures should be reviewed in order to eliminate the requirement for checklists to be completed whilst on the runway.

In the event that a crew is waiting for the download of performance data this should be accomplished off the runway. Within this document is a recommendation that ATC should give due consideration to this requirement and not penalise crews by putting them to the back of the queue.

It has been suggested elsewhere that ROT overall is reduced when aircraft proceed at normal taxi speed to line up even if this results in stopping briefly in the line up position. This evidence appears contrary to the practical experience of all pilots questioned on this topic. A large aircraft may take 10 – 15 secs to develop any significant forward motion after coming to a complete stop and pilots will do their best to avoid this situation. It seems reasonable that a middle ground exists and that a line up clearance should indicate that a roll straight into the take off will be highly likely and pilots are invited to accept this assurance. It has been suggested that airlines could provide crews with take off performance data based on a take off positiona short distance into the runway. This would allow pilots to continue to roll at slow speed in expectation of a take off clearance. This practice would only apply where sufficient performance margin exists and on runways that were capacity critical.

The problem of late changes has already been discussed. It is recommended that, at airports where this option is likely to be employed, airlines formalise a procedure for the preparation of alternative take off performance prior to taxi. It is known that some crews already do this.

4.1.3.3. Engine Spool Up

If it is known that a prolonged engine stabilisation will be required (e.g. 10 – 30 secs) it is important that ATC are made aware of this. Whilst this should not unduly delay the aircraft it may provide the controller with advance information to provide the most effective sequencing. It is therefore recommended that ATC should be informed prior to taxi if this will be a requirement on the runway.

This will allow ATC to arrange the most efficient use of the runway. It should be emphasised that such co-operation should not result in the aircraft being penalised in terms of take off time.

4.1.3.4. Deceleration techniques

The majority of airlines specify a balanced combination of medium autobrake setting, moderate reverse thrust and spoilers, converting to manual braking as controlled deceleration is established. This practice reduces stress an wear on the aircraft components, provides for safe, controlled and efficient deceleration, and is comfortable for passengers.

Whilst no change to this practice is proposed it is suggested that consideration is given to the distance to the preferred RET and that this is reflected in the selected autobrake setting provided that this does not necessitate heavy braking. This assumes favourable environmental conditions. It is possible that company policy may provide recommendations for autobrake settings for specific runways.

Further, airlines are encouraged to emphasise during normal training that the operating pilot should be aware of and take active consideration of the proposed runway exit, during the initial phase of landing, even though he/she may hand over control during the rollout.

4.1.3.5. Runway Exit Speeds

It is not possible to define standard speeds for exiting the runway as this varies between aircraft types and between exit types and is highly dependent of environmental and surface conditions. In addition, due to the variety of RET configurations it would not be sensible to attempt to generalise according to aircraft type. The decision of which exit to take and what constitutes a safe speed will always be the decision of the pilot after controlled deceleration is established.

There appears to be a wide range of practice amongst airlines that have been consulted with regard to standard exit speeds. In some cases the approach has been to leave the assessment of a safe exit speed entirely up to the pilot given the prevailing conditions. Others have attempted to give general guidance.

It is considered possible that more specific guidance, than has previously been attempted, is possible. It should be emphasised that this guidance should be driven by individual airlines for use by their own crews.

4.1.3.6. Taxi to Terminal

It is recommended that taxi distance and time should not be considered when selecting the RET to be used. Pilots should always vacate the runway by the most expeditious exit consistent with safety judgements. Naturally, this measure should not apply when traffic conditions are not critical to runway capacity.

4.1.3.7. Published Information

Information in an easily useable format on the configuration i.e. angle and length of RETs is not readily available to pilots. It is recommended that this is clearly separated out in AIPs. Furthermore, companies providing in flight documentation e.g. approach charts and landing charts should consider including this information.

This latter point should also be noted by airlines who should consider inclusion of this information in company guides.

4.1.3.8. Company Guides

As discussed in para 4.1.3.1 it is considered good practice to increase awareness amongst pilots of the issues surrounding ROT. Clearly the airline is best placed to provide this information, tailored specifically for it's own pilots and type of operation. Companies are therefore recommended to produce a Company Guide that may contain the following information:

- General information regarding runway capacity issues and the importance of minimising runway occupancy times.
- Suggested techniques or company policy such as autobrake settings, exit speed guidance etc
- Preferred RETs at each destination in consultation with AIP information. This could be extended to reproduction of this information in Company pages in charts manuals (e.g. Jeppesen etc)
- Special considerations for specific airports such as advice to prepare alternate take off performance data

This guide should be regularly maintained and may be a part of a controlled document such as the Operations Manual.

4.1.3.9. Performance Studies

The use of Performance Studies is an important issue. It is inevitable that airports will have a requirement to measure ROTs in order to confirm or improve their own procedures and to develop future planning requirements. This information can also be used to give indications of pilot contribution to ROT.

The measurement of pilot performance could potentially become a contentious issue if it is not proposed in the correct context or managed in association with the pilot community. The studies go to some lengths to ensure that the objective is not to encourage ROT reduction at the expense of erosion of safety margins. Low ROTs are not recorded as these may reflect non desirable methods of operation and hence reduction in margins of safety. Similarly, excessively long ROTs may have been due to unavoidable delays and should therefore not reduce the ranking for a particular type or operator. This results in data that can be used to provide a general comparison between the same fleets from different airlines according to the standard operation of the bulk of the pilots. The resulting information should be used anonymously and the aim should be to allow airlines to observe, objectively, how others operate and compare that with their own operation. The studies should never be an incitement to "beat a competitor" but rather to encourage open debate regarding best practices and to keep the issues of runway occupancy fresh in the minds of all associated with runway operations.

Take off and landing are periods of dynamic change, and a heavy responsibility rests with the pilot in ensuring the safety of the aircraft during these phases of flight. It is not wise therefore to question individual performances on specific occasions and it should always be assumed that the pilot acted with the best of intentions given the conditions and events at the time. It is, however, reasonable to investigate the aggregated performance of an airline or fleet in order to determine the overall performance resulting from the specific type of operation compared with other companies.

The overall objective is to increase runway capacity and therefore to provide a better service for passengers and so this issue is of clear interest to pilots and airlines. It is recommended, therefore, that airlines participate in working groups at their base airports which should ultimately produce benefits in the expediency of their own operation. Pilots are encouraged to participate in such studies and to become actively involved in the management of them and in the analysis and use of the resulting information.

4.1.3.10. Consistency of performance

Whilst pilots may be able to save small amounts of time on individual departures or arrivals it seems likely that the biggest gains will come from an ATC centred strategy that ensures the most ROT efficient flow of traffic. The contribution from pilots will be:

- Efficient and expeditious use of runways
- A consistent and predictable performance

It is of great importance that controllers are able to plan ahead on the basis of the predictable behaviour of aircraft occupying the runway. All preceding recommendations are therefore aimed at encouraging the dual approach of sensible expediency based on a predictable performance. This in particular means that controllers will know which RET will be taken in the vast majority of landings and the average time that the aircraft occupies the runway.

Airlines are therefore recommended to nominate preferred RETs by aircraft type, this should be done with reference to airports own preferred RETs if possible.

4.1.4. Airspace user performance measurement methodologies

4.1.4.1. Introduction

The purpose of monitoring flight crew performance and analysing and distributing this data is to encourage all airlines to improve performance to best-in-class level, while still ensuring safe operation.

While pilot performance indicators such as line-up and take-off times are collected with a view to reducing runway occupancy time and hence increasing capacity, flight safety is paramount. The presentation of the data must not challenge the safety culture, or allow the conclusions of the survey to be set aside by any suggestion that the recommended process is in any way unsafe.

In the context of safety, it is important to maintain an objective approach. This means that confidentiality need to be maintained when discussing the comparative performances of flight crews. In exceptional cases, the identity of the best crews could be disclosed, with their agreement, where their training methods have been identified as exceptionally effective.

Flight crew should have a common measure of performance at all European airports, and a harmonised approach to performance feedback is advocated throughout the ECAC States.

BAA plc, in partnership with airlines and NATS, has been running a program to measure pilot performance. Studies made at Gatwick and Heathrow are included in Annex 5.

4.1.4.2. The process

The process consists in:

- collecting a large number of data points for individual movements. These data points relate to pilot performance drivers;
- analysing the data and preparing pilot performance scores;
- reviewing with the air traffic service provider the interpretation of the results and agreeing the message to be promulgated;
- preparing and distributing the results;
- arranging follow-up meetings with the major carriers and preparing further material for their own internal use;
- reviewing the outcome of the measurement, the comments from the partners and modifying the measurement process or style of presentation for the next round.

4.1.4.3. Data collection

It is important to ensure that sufficient samples are collected to draw a meaningful comparison between fleets. The purpose of data collection for performance measurement is different from that of determining runway capacity. Whilst the latter aims for the highest accuracy, the trend is more important when comparing performance of fleets. Acknowledgement of the potential for data variation caused by weather, observer data entry and ad-hoc flight deck issues focuses the attention on the principle of significant variation from the achievable best-in-class level and avoids the distraction of unwarranted debate on the accuracy of the numbers. However, aiming at cost-efficiency it is advocated to use the same tools for both ROT and performance measurement. In an environment where the difference between the best-in-class and others is a matter of seconds, maximum accuracy is required. This level of accuracy will be achieved through utilising automated tools for items such as times of crossing the threshold, touch-down, lowering nose wheel and vacating the runway, supported by details of call sign, aircraft type and notes on any significant factors, etc.(see chapter 3 Methodologies to measure ROT and post processing techniques). Particular note of the quality of radio-phraseology and adherence by carriers to the proper protocols should be taken. A busy controller, whose goal is equal and efficient treatment of all, is unlikely to note poor performance by carriers.

4.1.4.4. Analysis methodology

The process should be based on:

- measurements which would not challenge the safety drivers in the industry;
- a no-blame culture; and
- clear and unambiguous measurements of performance.

The no-blame culture excludes itemised reporting of individual flights. The purpose of the methodology should not be to highlight poor operating practices but rather to encourage efficient runway utilisation. Excessive delays are therefore excluded in case they are safety-related, for example caused by additional flight crew checks. Similar reasoning also excludes the most rapid responses.

By rejecting extreme measurements, there is an implicit assumption that the remaining results will reflect the overall standards set for the fleet by the airline training regime. Clearly, there may be fleets whose training procedures and associated training methods will more effectively limit excessive delays on the runways. The loss of this information is the price that must be paid for the broad acceptance of the method.

The pilot performance score based on the average performance of the group (defined as the characteristics of the 'core' pilot group) compares the fleets of common, or similar, aircraft types. The airline fleet whose core pilot group has the best performance is defined as the best-in-class. Each airline fleet is 'scored' according to the percentage of that airline's core pilots who match the performance of the best-in-class. This approach gives a good indication of the relative difference in pilot performance.

4.1.4.5. Reviewing the results

Prior to dissemination of the results, it is sensible for the airport and ATS provider to review the evidence that they have gathered. It is important not to debate the interpretation of the statistics but rather the process.

4.1.4.6. Feedback

The feedback to airlines on pilot performance measurements is extremely important and should be tailored to the individual airport characteristics and fleet safety requirements. If the range between pilots in the fleet is significantly higher than the best-in-class, this might imply that the training regime is producing inconsistencies in the procedures.

BAA experience has shown that presentation by comparison with best-in-class did not challenge safety. There was no adverse criticism on this point from any of the consulted airlines (see annex 5: case studies on user performance measurement in Gatwick and Heathrow).

4.1.4.7. Follow-up

It should be borne in mind that relative performances are compared. Indeed, if a second survey were to indicate that the difference in the average performance between the best-in-class and the others is decreasing, this might be an indication that the others had improved whilst the performance of the best-in-class had not changed. It might also indicate the performance of the best-in-class had deteriorated. A combination of the two would be the more likely explanation. Furthermore, an unexpected improvement in one fleet automatically degrades the performance of the others, and it is this mechanism of challenge and response which it is hoped will improve the overall performance of the fleets.

A great deal of the benefit will be due to the commitment of airport operations directors to engage in dialogues with the fleets through which very practical steps can be identified beneficial to all : airports, the airlines, or the ATC service. Generally, the Operations Director will write to all airlines but also invite ten or so of the major airlines to review the results of the year. At these meetings the facilitator will also offer to prepare further data for the airline to present 'in-house'. For example airline XXX may wish to have a histogram showing its relative performance and these will be prepared by the airport.

It should be noted that not all problems have a local solution.

4.1.4.8. Conclusion

In order to achieve efficient and possibly harmonised performance levels at airports throughout the ECAC area (and beyond), attention needs to be focussed both on a blame-free culture when comparing performance data, and on the cross-fertilising benefits of open discussions between all the partners concerned, such as the airline representatives, the airport operators and the ATS providers. The first element will guarantee openness on the part of all concerned, the second encourage continuous improvements. It is said that one must **“measure to manage”** and that is why not only in improving performance measurement techniques (e.g. with surface movement radar and multilateration) but also in ensuring that the presentation is accepted by the aviation community.

4.1.5. Elements affecting ATS provider ROT performance

The performance of the ATS provider has a major influence on ROT, runway throughput and therefore runway capacity. This influence is felt in the setting of the declared capacity and the control of corresponding demand through optimal sequencing, correct application of separations and the management of delay. This is done whilst also ensuring that objectives relating to safety, cost effectiveness, efficiency and impartiality are met.

A number of performance drivers that affect ATS provider performance have been identified, these may be:

- Application of separations;
- Application of procedures;
- Slot compliance;
- Errors;
- Equipment serviceability;
- Use of equipment;
- Training;
- Social and team factors.

4.1.5.1. Application of separations

This is closely linked to the efficiency in handling the overall traffic sequence. If the separations applied are greater than those required, then the benefits of sequence optimisation for runway capacity is lost.

The ability to measure achieved against required separation is therefore important, and may reveal potential improvements in ATS provider performance or in the separations required.

4.1.5.2. Application of procedures

As with the application of separations, the application of procedures has an impact on sequence efficiency and runway capacity. Measurement of how well these are applied, as well as their efficiency and effectiveness, is therefore an important parameter.

Application of procedures includes adoption by an organisation or States of global procedures, application of local procedures (e.g. those related to infrastructure or airspace), and procedures relating to environmental restriction/ mitigation policies.

4.1.5.3. Slot compliance

Airport slots are issued on the basis of an airport's declared capacity, and are used to ensure that there is a balance between demand and available capacity. Missed slots may upset this balance and have an adverse impact on runway throughput. The monitoring of slot compliance and the identification of reasons for non-compliance can help identify deficiencies (e.g. lack of holding bays or runway access taxiways).

4.1.5.4. Errors

Although a sensitive area, the measurement of errors is an important aspect of performance. In ATC, and particularly with respect to the runway, the fact that an error occurred only once may be significant, as the result can be catastrophic. The recording of errors is important in identifying where deficiencies lie and determining appropriate corrective action.

The type of error data believed to be of interest are incidents (e.g. go-arounds, runway incursions, loss of separation), and communications and procedural errors.

4.1.5.5. Equipment serviceability

Problems of equipment serviceability will have a varying effect on performance, for example failure of the surveillance system can result in increased voice communications and reduced situational awareness, thereby increasing workload and reducing ability to optimise the traffic sequence. Failure of an IRVR system may, however, have a negligible effect (depending on weather conditions).

Data on equipment serviceability can help in assessing its effect on performance and hence it's relative importance.

4.1.5.6. Use of equipment

Equipment and its use can have a significant impact on workload. The aim of automation is of course to reduce workload and the likelihood of errors occurring by providing the user with the information he needs, when he needs it, and reducing the need to communicate directly with other parties.

However, if automation is not correctly specified, the effect may be the opposite, with increased workload resulting from poor HMIs and lack of trust in equipment capabilities. Poorly specified and designed equipment may end up not being used at all, resulting in a waste of time and money.

To this end, measurement of the manner in which equipment is used can help in assessing its effectiveness, its effect on workload and improvements which might be made (both in the equipment itself and in the manner in which it is used).

4.1.5.7. Training

Differences in individual performance may be linked to training (among other factors), but the aim of performance measurement for the purpose of maximising runway capacity is not to examine the performance of individuals. The assessment of performance in this context would be linked to identifying and rectifying deficiencies which have been identified in other performance parameters (e.g. lack of training associated with automation).

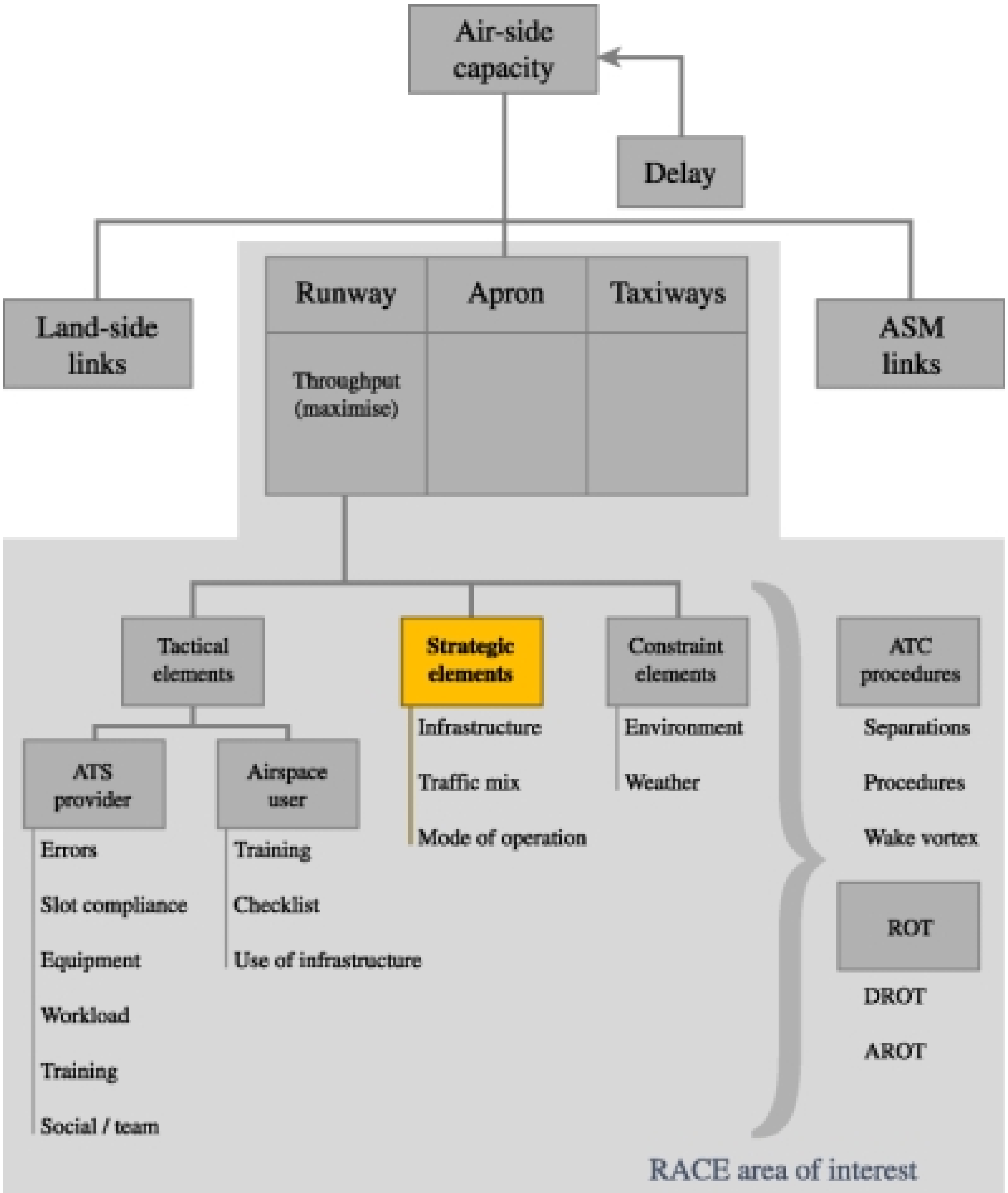
OJT activities may have an effect on runway capacity as inexperienced trainee controllers learn the skills required to maximise traffic throughput. An assessment of this element may help in determining whether or not a simulator could be beneficial, and if so how effective it could be.

4.1.5.8. Social/team factors

Although of a more general nature and not specifically related to runway capacity, the conditions under which an individual is working have an effect on his performance. Obvious factors include morale, esteem and the effects of shift working. Less obvious may be the loyalty to a team/shift, unit and employer (loyalty to a team above the unit may result in inconsistencies in performance between teams; loyalty to a unit or employer may influence the sense of service provision with respect to competitors).

Within the team environment of ATC, job splitting and amalgamation in response to fluctuations in demand are common (e.g. combining ground and tower positions). Measurement of the effectiveness of this practice could be useful in identifying correct staffing levels and roster patterns.

4.2. Strategic capacity enablers



Elements Affecting Airside & Runway Capacity

4.2.1. Infrastructure and design

4.2.1.1. Introduction

Efforts to minimise ROT through improved pilot and controller performance require runways to be equipped with sufficient entry and exit points suitable for the expected traffic mix, and facilities to allow the optimum departure sequence to be established from a pool of traffic waiting close to the runway. Pilots also need to be able to determine their position with respect to runway entry and exit points as well as their speed (and deceleration).

The following paragraphs give guidance on the provision of runway entry and exit taxiways, holding bays/bypass areas and visual aids. This guidance describes the current requirements and recommendations of organisations such as ICAO and gives examples of current 'best practices'.

4.2.1.2. Rapid exit taxiways

The provision of correctly designed, positioned and well marked rapid exit taxiways (RETs) is crucial in minimising runway occupancy time (ROT) and thereby increasing runway throughput and airport capacity. The RET is, however, only part of the formula, and compromises in the ideal design and positioning of exits may be required in the interest of achieving the consistent performance necessary in determining and achieving the capacity of a runway (i.e. exits should not be designed and located to match the performance of the 'best' pilots).

Thus, the efficiency of an RET (or series of RETs) is dependent on matching the design and positioning to the performance of the aircraft and pilots comprising the expected (design) traffic mix.

The implementation of standard operating procedures (e.g. standard approach speeds) will help in the both the planning and the optimal use of exits.

In the future, efforts should be made to coordinate with aircraft manufacturers so that the performance of new aircraft is matched, as far as possible, to existing runways and associated infrastructure (including RETs).

4.2.1.2.1. Design

ICAO define a high speed exit (or RET) as 'a taxiway connected at an acute angle and designed to allow a landing aeroplane to turn off at higher speeds than are achieved on other exit taxiways'.

ICAO also recognises that the establishment of a single world-wide standard for the design of RETs has many advantages through pilots becoming familiar with their configuration.

Although there are a number of different designs throughout the world today (for example the FAA standard and other site-specific designs such as those to be found at Paris CDG), the most widely accepted and utilised design is that of ICAO. This design is widely implemented in Europe.

If the space between the runway and parallel taxiway is insufficient to accommodate the ICAO design RET, with its straight portion for deceleration before joining the taxiway system, then there is evidence to support the use of the FAA modified design. This design is widely used in the USA and compensates for the lack of a straight portion through a design which enables the aircraft to decelerate whist turning off the runway and joining the taxiway system. It is also wider than the ICAO exit, giving the aircraft more space to deviate from the taxiway centreline whilst turning off the runway and during deceleration. The use of exit angles smaller than the ICAO recommended minimum of 25° may also help in this situation, but aircraft may take longer to vacate the runway strip (particularly heavy aircraft).

Accepting that a consistent performance throughout Europe is the objective, then current best practice may be as follows.

Best practice

- With the exception of the final 'stop end' exit, all exits to be used by landing traffic should be RETs;
- Perpendicular exits may be retained for use by crossing traffic (e.g. Madrid, Paris CDG, Frankfurt);
- RETs should be designed in accordance with the provisions of ICAO Annex 14[3] (e.g. Madrid, Vienna, Munich, Frankfurt, Manchester), except that:

- where the distance between the runway and taxiway is insufficient to accommodate a straight section of sufficient length then:

  - the exit angle could be reduced to less than 25° to a minimum of 20°[4] (e.g. Paris CDG), or;
  - the FAA 'modified' standard could be used (e.g. Miami, Orlando, Baltimore).

Rationale

The adoption of an already widely accepted and implemented design will result in the consistency of performance required to reduce the average ROT. Consistency of operation, which in turn promotes confidence in pilots and controllers, is vital in calculating and achieving a runway's potential (unconstrained) capacity.

Although there may be deficiencies in the ICAO standard RET, these are outweighed by the improvements in performance which come from familiarity with its design (e.g. low average ROTs are achieved at London Heathrow, despite known deficiencies in exit design).

If pilots are to be encouraged to exit at relatively high speeds, then it is important that the exit design is such to allow safe deceleration, preferably through the provision of a straight portion (as per ICAO) between exiting the runway and joining the main taxiway system.

4.2.1.2.2. Number and position of RETs

In order for benefit to be derived from the design of an RET, the runway has to equipped with a series of such exits, correctly positioned with respect to the performance characteristics of the expected or 'design' traffic mix. It has been estimated by the FAA that a 30m reduction in the distance between threshold and exit reduces ROT by 0.75 seconds. Conversely, the ROT of an aircraft which overruns an exit increases by 0.75 seconds for each 30m it has to travel to the next exit.
Guidance on the positioning and number of exits is given by ICAO (Annex 14 and the Aerodrome Design Manual). In particular, the Aerodrome Design Manual gives guidance on the positioning of exits on the basis of an extensive survey of the observed performance of traffic at 72 airports. These data do not, however, differentiate between dry and wet runways, and date back to 1980. Similar guidance on the positioning of exits is also given by the FAA in Advisory Circular 150/5300-13 (Airport Design), which appears to be based on more recent performance data and addresses both wet and dry runways.

In their methodologies, both ICAO and the FAA have separated aircraft into four performance bands, ICAO's based on threshold speeds and the FAA's on aircraft weight. However, these categories may not be suitable, and an airport may prefer to categorise traffic according to the performance of the 'design' traffic mix.

A better assessment of the correct position and number of exits could perhaps be obtained through a detailed examination of the performance characteristics of the actual fleet mix expected to use a runway. This examination should be done in cooperation with the (major) operators which will be using the runway, as they would be in a position to provide detailed performance data based on the aircraft type, routes flown (and hence landing weights), operating procedures (e.g. brakes/reverse thrust) appropriate to the local conditions (e.g. weather, wind and runway gradient). Design and actual exit speeds also need to be considered (e.g. RETs designed in accordance with ICAO guidelines could theoretically be used at exit speeds of up to 50 kts, but in reality speeds are probably lower).

[3] *Pilots may need to be advised of RETS that are not designed in accordance with ICAO provisions*

[4] *In reducing the exit angle to less than the ICAO recommended minimum of 25°, consideration has to be given to the extra distance that an aircraft will have to travel before clearing the runway strip, particularly in the case of heavy aircraft.*

A third methodology for determining the optimum position and number of RETs is a computer simulation and optimisation model which has been developed in the USA by Virginia Technical University on behalf of the FAA. This tool is able to estimate the optimum position of RETs based on detailed aircraft performance data and the RET design. Results from this model indicate that:

- a 15% reduction in ROT is possible by reducing the exit angle from 30° to 20°;
- such 'super acute' exits could enable exit speeds of up to 68 knots (35m/s), enabling;
- ROTs in the order of 36-40 seconds.

However, the status of this tool (and the above results) is not known and an evaluation of its applicability in the European context would be necessary.

The overall aim would be to have a minimum number of exits, positioned so as to 'capture' the largest percentage of traffic, with the lowest average ROT for each category and for the overall runway.

Experience indicates that the number of RETs should be limited to a maximum of three (plus a standard exit at the runway end).

Best practice

a) RETs should be positioned according to the predicted actual performance of the 'design' fleet mix, taking into account any achievable improvement in exit speed (e.g. Madrid, Paris CDG, Paris Orly, Manchester, Vienna);
b) Such an assessment should be made in conjunction with the (major) aircraft operators, who should provide actual performance data relating to aircraft types, landing weights, operating practices and ambient conditions;
c) The number of RETs should be limited to three, plus a standard exit at the runway end (e.g. Madrid, Barcelona, Munich, Athens/Spata).

Rationale

Performance of the design fleet mix in local ambient conditions is the critical factor in assessing the optimum position and number of RETs. This information can only be obtained locally, through a collaborative process involving the airport and aircraft operators.

4.2.1.2.3. Visual aids

Visual aids (including signs, surface marking and lighting) play an important role in a pilot's situational awareness (position and speed). In an environment where ROT needs to be kept to a minimum, this situational awareness becomes particularly important and a pilot is required to identify his (nominated) exit as early as possible during roll-out so that he can adjust his deceleration accordingly (or make an early decision to continue to the next exit).

Thus as regards RETs, the requirement is that as soon as possible pilots are able to:

- locate their preferred (or nominated) exit;
- determine the distance to go;
- assess speed and deceleration.

Once the pilot has entered the RET the requirement is to assist the pilot in knowing:

- position with respect to the exit centreline;
- speed and deceleration;
- distance to taxiway intersection;
- when he has vacated the runway.

Current guidance on the provision of visual aids is given by ICAO (Annex 14 and the Aerodrome Design Manual).

Visual aids which comply with the provisions of ICAO meet some of the needs listed above (speed and position with respect to centreline), but they may be inadequate as regards early identification of exits and distance to go. Efforts are being made to address these deficiencies through the installation of the 'Runway Exit Taxiway Indicator Lighting System' (RETILS) at some airports, but data to support their effectiveness are not yet available.

Best practice

- ICAO standard centreline lighting and marking should be provided for all RETs (widely applied throughout Europe).

- Distance-to-go information should be provided to the pilot by:
  - use of RETILS for night/reduced visibility (e.g. London Gatwick, Madrid);
  - equivalent markings for day/good visibility.

Rationale

Visual aids provide the pilot with situational awareness (position, speed and deceleration), and assist him in the early identification of his preferred or (nominated) exit, in the adjustment of his deceleration and speed during roll-out, in safely exiting the runway, and in reducing his speed on the RET prior to joining the taxiway system.

Standard application of visual aids throughout Europe will assist in the provision of such situational awareness.

4.2.1.2.4. ATC procedures

Appropriate procedures can play an important role in the optimised planning and use of RETS.
One of the difficulties in selecting the correct position and number of RETs is the variety of performance characteristics of aircraft. This variety stems not only from the aircraft's physical characteristics (such as type, weight etc.) but also the way aircraft are operated by the pilots.

Best practice

- A preferred exit should be nominated for each aircraft type (or class). Pilots need to be aware of such nominated exits prior to commencing their approach (e.g. via AIP or ATIS).

- The preferred exit should be clearly indicated to the pilot so that he can adjust his deceleration and speed during roll-out. A second 'back-up' exit should also be indicated to the pilot (e.g. Madrid, Barcelona, Brussels).

- If a pilot is unable to leave at the preferred exit, there should a clear procedure to follow. Such a procedure should involve rolling to the next (indicated) exit at best speed consistent with safety and informing ATC.

Rationale

The use of nominated exits in conjunction with standard approach speeds has been proven to further reduce average ROT through its application in Spain and Brussels.

4.2.2. Traffic mix and traffic schedule

4.2.2.1. Introduction

An optimised mix of the traffic may generate additional airport capacity, in particular at airports which operate at maximum capacity for sustained periods of time. This section therefore focuses on the impact of mix of the traffic within the wider context of strategic demand scheduling, assuming that the half-yearly scheduling exercises could be fine-tuned through tactically re-arranging the mix of the traffic. It should, however, be noted that discussions held within the European Commission gave initial indications of the highly political aspects of this dossier. Although it seems generally accepted that a technical amendment of the current slot allocation procedures would be required, this falls completely outside the remit of the work of the runway capacity enhancement initiatives. Indeed other panels are discussing this highly political issue, as a result of which **a number of issues will not be addressed in the runway capacity enhancement guidelines**, including

- methodologies to calculate airport slot capacities;
- 'continued' existence of grandfather rights;
- 80 % usage rules for allocated slots;
- transparency and impartiality of slot allocation procedures;
- demand management versus efficient utilisation of existing airport capacity;
- market-oriented price mechanisms; the so-called "slot-auctions";
- peak-hour landing fees.

From the an ATM perspective, it is true to say that a well-balanced mix of traffic will undoubtedly have a positive impact on runway capacity. Such a uniform flow of traffic scheduled according to indicators such as aircraft type (read MTOW) would enable controllers to plan ahead and arrange the best possible mix of the traffic for each airport. This would, however, restrict airlines in their flexibility to adopt market-driven policies based on demand. It is not uncommon for an airline to change the aircraft type it is operating subject to short-term demand variations on certain trajectories. Politico-economic deregulation processes force airlines to apply extremely flexible fleet-planning processes with a view to anticipating what is coming. It is therefore unlikely that airlines will be able to accept stringent strategic scheduling rules, which leads to the obvious conclusion these are not realistic from the user point of view.

Notwithstanding the stated difficulties in strategically moulding demand in order to achieve an optimised mix of the traffic on the day of operations, it is deemed necessary to introduce a tactical component which will clearly demonstrate the capacity benefits of an optimised mix of the traffic.

For the above-mentioned reasons the RACE-guidelines will address only the following aspects:

- the impact of a tactically (re-)arranged mix of the traffic so as to optimise runway use;
- the planning benefits of airport system performance indicators in the context of strategic scheduling.

4.2.2.2. Traffic mix

The impact of an optimised traffic mix on runway capacity will be demonstrated by means of a methodolog developed jointly by AENA and INECO. The figures refer to a real traffic mix taken from Madrid- Barajas airport.

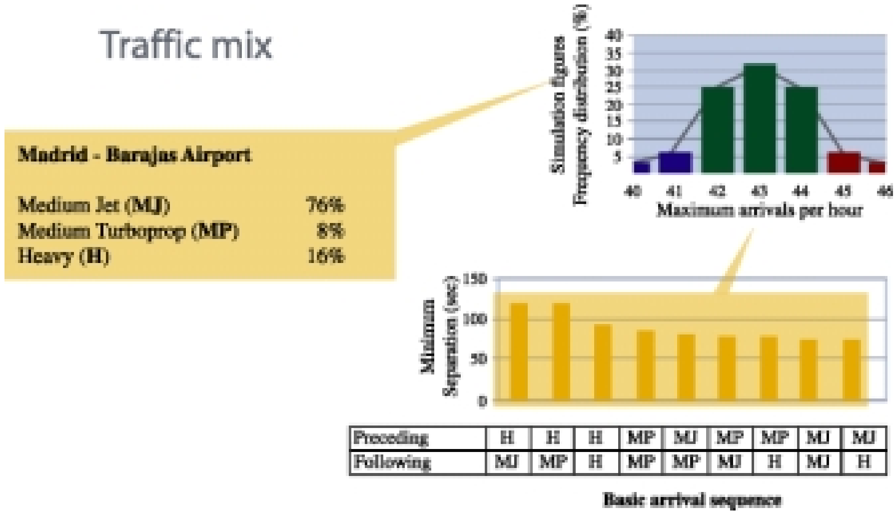
The traffic mix is defined as the combination of the following elements:

> *'the traffic that operates regularly into an airport, as a function of aircraft category, type of flight rules, procedures and any other pertinent feature for a given traffic schedule'*

For a given traffic mix, the possible arrival sequences can be observed at the bottom of the following figure (it should be noted that for the purpose of this case study, light aircraft have not been considered). Additionally, the required separation in seconds, per combination of preceding/following aircraft, has been displayed as a histogram above the previous data.

The histogram in the top right sets out the probability distribution of events versus the number of arrivals which can be operated on the runway, taking due note of both the required separation and the traffic mix. For example:

- the probability that 42 arrivals per hour can be operated is 25%;
- the probability that 40 aircraft or less can be operated is 100%.

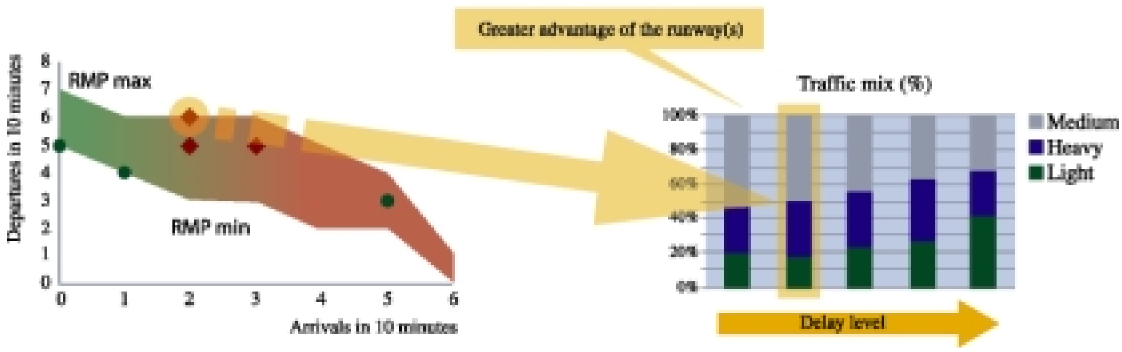


MADRID/BARAJAS Airport: relationship between fleet composition, arrival spacing an maximum runway throughput

It can be concluded that for a given mix of traffic, the number of movements which can be accommodated on the runway decreases in direct proportion to increases in required aircraft separation. In other words the sequencing of aircraft types (wake vortex categories) for arrivals is a determinant for runway capacity. Runway capacity can thus be enhanced by re-arranging the mix of traffic. The foregoing does not consider the level of delays.

Optimisation of the traffic mix

Starting from an initial RMP[5], and taking into account the known (or expected) aerodrome flight schedules it is possible to optimise the runway operations by acting on the traffic mix in the critical time periods (peak hours, saturated ten minutes, shoulder periods, etc.). The Figure below, which is the result of two simulations[6], is intended to illustrate this process, and hence demonstrates the connection between the runway throughput and the 'optimised' traffic mix per accepted level of delay. However, the higher the RMP, the lower the probability of achieving this maximum, thus leading to an increased probability of induced delays.



[5] RMP (Rendimiento Màximo de pista): maximum number of movements that can be handled on a runway per time period, for a given set of conditions

[6] On the left, the probability of RPM if there is less traffic and the mix is better arranged.On the right, the extent of the induced delay per traffix mix.

It should be noted that in this process the departures are always calculated as a function of the arrival volume of traffic, simply because as a matter of principle arriving traffic has priority over departures.

The graph on the left-hand side refers to the probability distribution of events mentioned above. Indeed the set of curves (RMPmin, RMPmax and intermediates) are indications of probabilities as a function of the mix of traffic e.g. for a given time interval (in this case 10 min), and for 3 arrivals the probability of accommodating 3 departures is higher than 6 departures, the last number being the optimum mix of traffic. The combination of the y departures per x arrivals can be arranged such that the induced delays are minimised, which intrinsically corresponds with the 'optimum' traffic mix for a set of conditions.

By means of this simulation it is possible to

- determine the required traffic mix for an accepted level of delay, and
- impact on the traffic mix to reduce the level of delays.

4.2.2.3. Traffic schedule

The impact of strategic[7] flight schedules on airport capacity can be obtained by analysing service quality indicators, such as average daily delay and punctuality index. Indeed, delays not only reflect the airport/ATC system performance but can also give indications of the intrinsic potential of that system to cover a certain demand, or in other words to cope with a strategic schedule. The same logic can be applied to the punctuality index. An airport/ATS system which can accommodate all scheduled traffic within agreed margins of delays, or when performing at its best level without any form of delay, could be accepted as an indicator of efficient planning/scheduling. Fast-time simulation models capable of adapting a validated reference scenario to a current flight schedule would provide planning factors which include early indications of the impact of the traffic schedule on the airport operations.

One such fast-time simulation model is used by the Spanish PICAP team. It would be naïve to suppose that it is the only and/or best-performing model in the ECAC area. There are other fast-time simulation models which, for a number of reasons, it has not yet been possible to make available. In time, this PICAP model will certainly need further refining, but it has proven effective in a number of cases. It is based on a combination of two service quality indicators which when applied to a linearly adapted reference scenario, so as to reflect the current flight schedule, allows analysis of the impact of the traffic schedule on delays, and therefore on capacity. These two indicators are:

- average daily delay: the daily difference between the scheduled time of operations and the time at which the operations are actually performed.
- punctuality index: the percentage of operations performed within the agreed/tolerated delay limits.

The model works with typical schedule profiles which do not vary throughout the simulation. Because of this linear de/increase in the reference scenario, it is assumed that the variation of the traffic mix over the traffic schedule is constant. Normally this is not the case, but it is considered to be of minor importance given that the impact of a schedule variation on traffic mix is minimal, as a result of which output will not be drastically influenced. Moreover the model focuses on planning aspects, and therefore on trends rather than on absolute correctness.

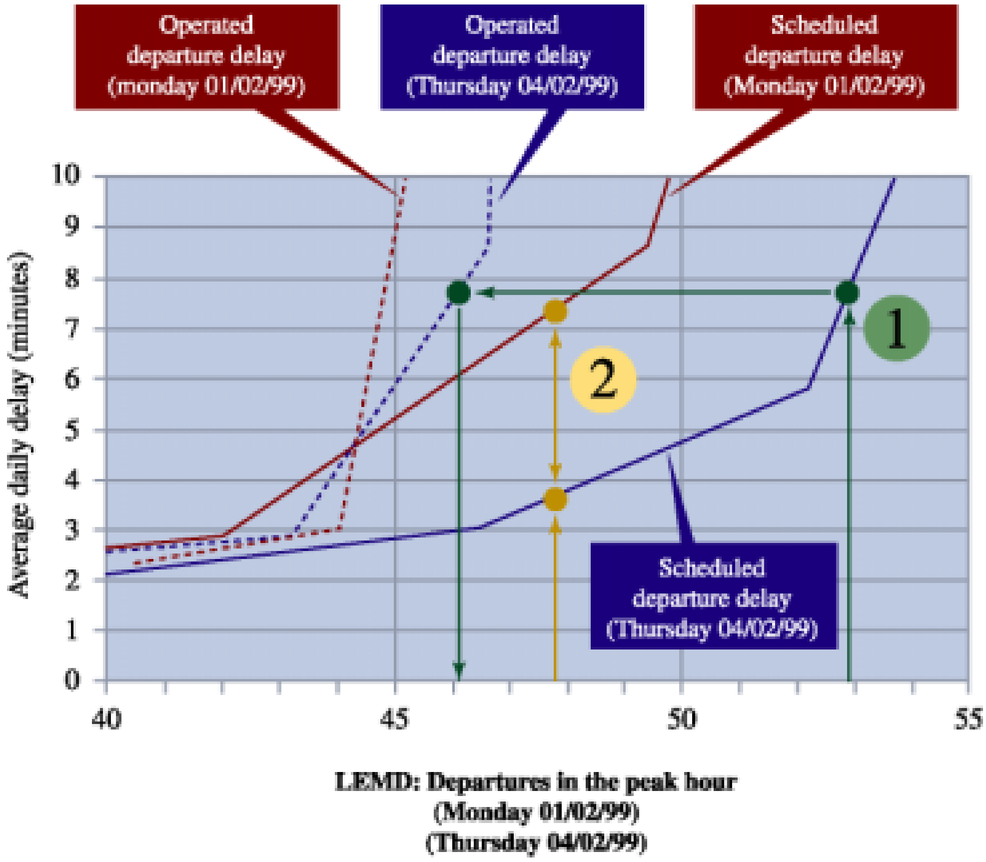
To simplify matters, the schedule can be characterised by the scheduled flights during the peak hour.
Average daily delay curves in relation to the peak hour

At first, two days of traffic schedule are identified, one reflecting the minimum, the other the maximum, traffic schedule and corresponding delay. This exercise is repeated by the fast-time simulator for the full range of linearly extrapolated profiles, generating two curves, both setting out the range of scheduled delay variation (blue and pink curves). The same exercise is undertaken for the operated departures, which in turn leads to a comparable graph that sets out the number of operated departures versus the daily average (dotted blue and red curves). Both the scheduled delay and the actual operated delay are plotted on the same graph.

[7] *Strategie and tactical according to CFMU definitions*

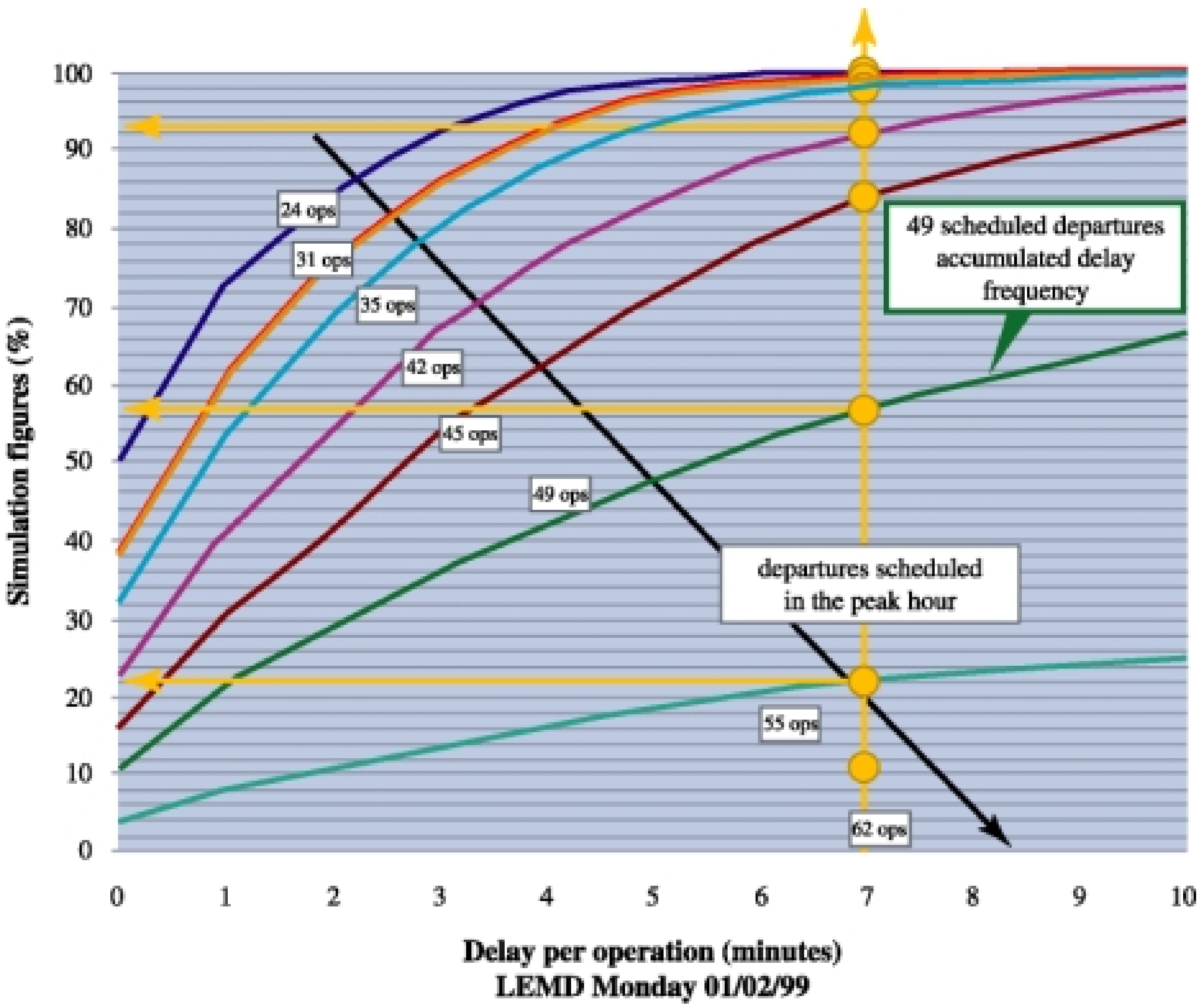
The graph allows the following:

- for a given (planned maximum) number of scheduled departures, the number of operated departures can be obtained for an agreed average daily delay, e.g. 53 DEPs correspond to maximum of 46 operated DEPs (green arrows);
- if an agreed level of delay is the criterion, then the graph gives an indication of the operated number of movements for both a minimum and a maximum scheduled number of movements in the peak hour;
- the area covered by number 2 shows the variation in average delay for a given number of movements at the level of scheduled flights;
- also, the operated flight interval for an accepted level of average delay can be deduced from the graph by looking at the intersection of the horizontal line at say 8 minutes' delay with the curves of the operated flights for the minimum and maximum days of operation, i.e. an interval of 1 DEP (45-46 departures).



The following figure[8] represents, for a representative daily schedule, the variation in the number of scheduled departures per punctuality index and the agreed level of delay. It should be noted that the percentage of operations with a delay equal to or less than the agreed maximum decreases in proportion to the increase in the number of scheduled departures. For example, if the agreed level of DEPs is 7 minutes

- 93% of the traffic would comply with this criterion if 42 DEPs were scheduled,
- only 23% would be able to comply with the criterion if there were 55 scheduled operations.



Delay in relation to Airport Peak-Hour Operations

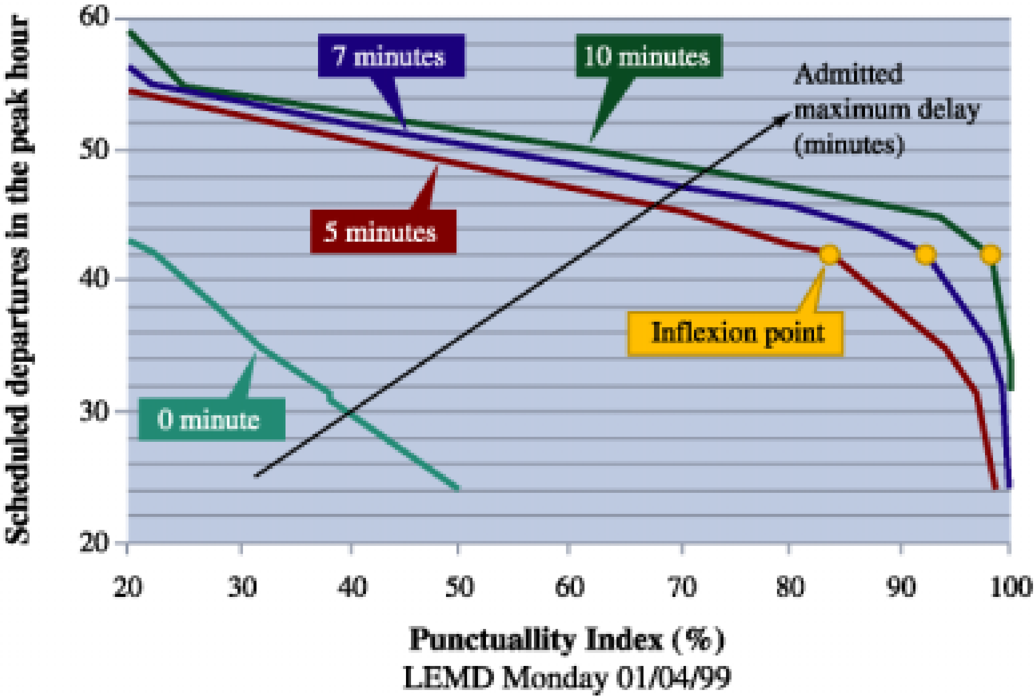
[8] *One curve corresponds to one fast-time simulation exercise*

Punctuality Index

A punctuality index can be associated with each of the simulated schedule profiles. This is illustrated in the following Figure, which shows how the punctuality index varies as a function of the number of scheduled departures in the peak hour for different values of accepted/agreed delay.

Furthermore, the profiles of the curves illustrate two things:

- firstly, that the sensitivity of the indicator is inversely proportional to the gradient of the delay curve;
- secondly, that all the curves, irrespective of the delay value, behave in he same way with an inflexion point at the same number of scheduled departures.



Example

A simulation based for example on an accepted level of delay of 10 minutes and a DEP traffic schedule of 50 movements in the peak hour would lead to a punctuality index of approx. 54%.

This means that 54% of the departures will experience delays equal to or less than 10 minutes, and that 46% of the traffic will experience unacceptable delays of more than 10 minutes. Thus unless a significant loss of punctuality is at the cost of an increased schedule, the airport/ATC system should avoid working in the low-gradient zone.

According to this particular scenario, a planning tool would indicate that demand exceeds airport capacity, which should trigger mitigating action and/or adaptation of the initial assumptions. These managerial planning factors could be made available sufficiently in advance of the date of operation, in order to remedy the situation, if considered appropriate by the local airport authorities.

4.2.3. Runway mode of operation

Leaving aside interdependency for simultaneously arriving or departing traffic on parallel or near-parallel runways, this chapter essentially deals with four runway-use configurations, namely segregated operations, semi-mixed arrival and semi-mixed departure operations, and fully mixed operations. The intention is to compare the pros and cons of each, from a capacity enhancement point of view.

It should be noted that runway mode of operation is closely related to local circumstances such as the positioning of (parallel, near-parallel), and spacing between, runways, runway length, land-side/air-side infrastructure, traffic mix, environmental restrictions, operational requirements, availability of landing aids, etc.Because of the interdependency of a number of these elements, it will not be possible to indicate unequivocally which mode of operation - (semi-)mixed or segregated – will perform best in all circumstances. It is not in fact the implementation of mixed operation in itself which is the objective, but increasing runway capacity. Whether this is achieved through mixed mode or a combination of operating modes should not be important. However, leaving aside local characteristics, it is true to say that for pairs of runways, the mixed mode of operation has capacity benefits over semi-mixed operations, which in turn generate more capacity than the segregated mode. It is also acknowledged that an operating mode which works well at airport A may not necessarily have the same capacity benefits at apparently similar airport B, because of minor local differences.

EUROCONTROL's commonly agreed methodology for assessing air-side capacity provides a means to support this task. Indeed, based on these commonly agreed capacity concepts, the capacity envelope characteristics for each of the runway-use configurations can be analysed with a view to determining the optimum combination under given circumstances.

4.2.3.1. Runway operations versus capacity envelopes

(based on a paper submitted to the ATM20021 Seminar, March 2001)

Capacity can vary considerably depending on the type of runway-use configuration operated and the percentage of arrivals.

The percentage of arrivals in a runway system fundamentally depends on its traffic demand pattern and operated traffic distribution. For any airport, several arrival and departure peaks characterise the traffic demand distribution, each of them being distinguished by a specific percentage of arrivals in the runway system. These peaks themselves depend on several factors, including the biannual slot co-ordination schedules and possible hub operations of the home carrier.

Possible capacity gains lose their added value when they are not sustainable over time. Capacity gain can therefore not be considered in isolation, but should preferably be related to its stability, especially since only one capacity number is normally declared for slot coordination purposes. It will become clear in the following paragraphs that capacity remains relatively stable and constant when a pair of runways is operated in full mixed mode. The stability suffers, however, as soon as one of the two runways is used for arrival or departure only. This instability becomes even more explicit over the full capacity envelope for the segregated mode of operations.

4.2.3.1.1. Segregated mode

As illustrated in the following figure, the capacity envelope of segregated operations (in green) bears a resemblance to a "Chinese hat", the top of which is referred to as the maximum inflection point. Intuitively, maximum capacity for a given runway system should be observed when the maximum capacities for each arrival and departure runway are achieved. This optimum fluctuates around the '50% arrivals' point, which is a function of the ratio of maximum capacities of both arrival and departure runways. The greater the ratio, the further the maximum inflection point moves towards the higher arrival percentage values, and vice versa.

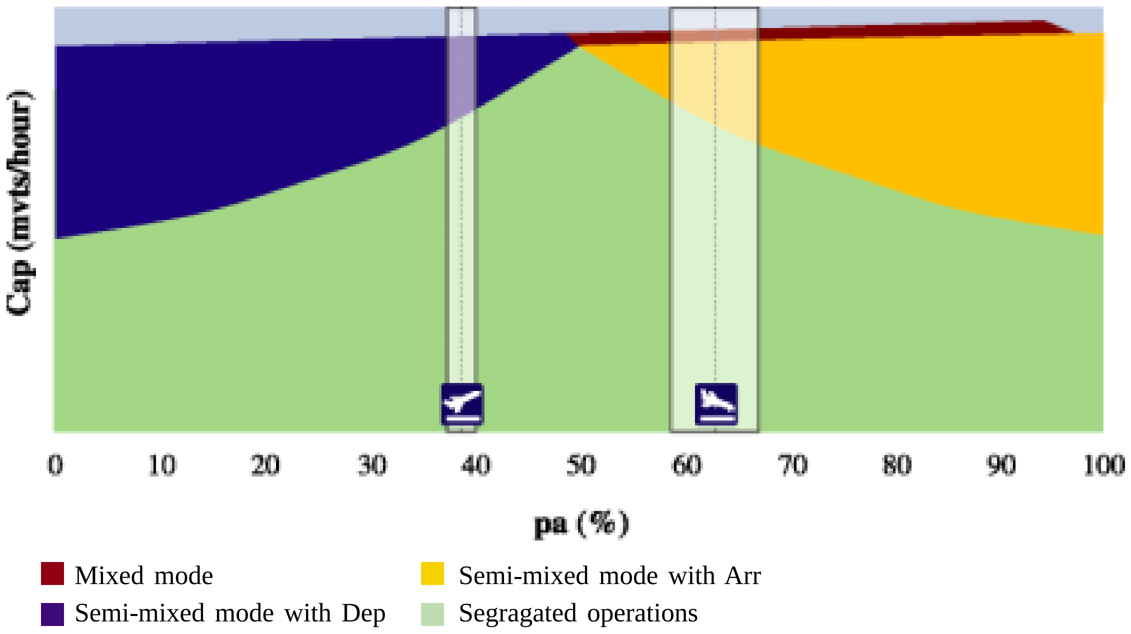
Segregated operations are relatively unstable. Indeed, the gradient of the capacity envelope is relatively steep on either side

- increasing for arrival percentage values prior to reaching the maximum inflection point, and
- decreasing after this point.

This means that capacity varies rapidly for minor changes in the arrival percentage during departure peaks or arrival peaks. The nearer the maximum inflection point, the less stable the runway-use configuration. We can see that for numbers of movements towards the extremes of the segregated curve (e.g. for arrival percentages between 0%-20% and 80%-100%) the behaviour of the curve is relatively more stable than for well-balanced arrival/departure figures, but at a smaller number of movements per hour.

Runway system capacity, stability & potential analysis

Segregated mode of operations vs mixed mode



Various runway-use configuration for 2 independent runways

4.2.3.1.2. Semi-mixed mode with arrivals

If one runway is operated in mixed mode and the second is used for arrivals only, then the arrivals on the mixed mode runway will be constrained by its departures. Logically, the maximum capacity of the runway system will be achieved by operating inbound traffic demand at first on the arrival runway until close to saturation point, followed by interleaving the remainder of the arrivals with the departures on the mixed mode runway. The first portion of the capacity envelope fits with the ascending part of the curve for segregated operations. Beyond the maximum inflection point the arrival percent increases, at the expense of the number of departures. This second portion of the capacity envelope matches the mixed operation capacity curve until a second inflection point that matches mixed mode of operations with pre-emptive priority to arrivals.
The capacity curve for semi-mixed mode with arrivals indicates a high degree of instability during the departure peak (exponential variation of capacity), because only one runway is used for departures, which are also interlaced with arrivals on the same runway.

4.2.3.1.3. Semi-mixed mode with departures

For the semi-mixed mode of operations with departures, the first part of the capacity envelope is linear up to the maximum inflection point, as in the case of segregated operations. Beyond the maximum inflection point, capacity is optimised by accommodating outbound traffic on the departure runway. The system acts in the same way as with segregated operations, because the total number of movements decreases as a function of the growing number of arrivals. It should be noted that semi-mixed mode with departures has an instability zone during inbound traffic peaks. Indeed, the capacity curve decreases rapidly in line with the percentage increase in arrivals, resulting in relatively deep decrease in the number of movements per hour.

4.2.3.1.4. Mixed mode

In mixed mode, both landing and departing traffic are mixed on both runways. The capacity of a mixed-mode runway is largely driven by the separations between arrivals, with departures being interleaved between them – known as Arr/Dep/Arr separations. The figure shows a capacity curve which behaves linearly and in direct proportion to the arrival percentage, with an inflection point characterising any mixed-mode operation with pre-emptive priority to arrivals. The above Figure clearly indicates an almost constant and stable capacity curve for this kind of operations. This feature is typical of the mixed operation, and is eminently suitable for planning purposes.

4.2.3.2. Practical observations

(see also Annex 5: Case studies of Charles De Gaulle, Heathrow and Helsinki)

4.2.3.2.1. Mixed operations

Mixed operations involve operating parallel streams of arrivals on each of the runways, with departures interleaved between them. Capacity can be lost if the arrival and departure flows are too widely spaced. The capacity benefit comes from taking advantage of the wake vortex spacing between arrivals to insert departures. Indeed, when runways are operated in mixed mode, wake vortex is no longer the major capacity constraint, neither for approaching nor for departing traffic.

Mixed operations can generate a significant reduction in ground movement congestion and/or the numbers of aircraft crossing runways, because good planning would direct the aircraft to use the runway nearest to its terminal or stand.

Mixed mode allows flexibility in handling traffic peaks, as priority can be balanced between arrivals and departures on one or both runways.

Airports which generally or at particular periods have high percentages of heavy aircraft should be aware that a higher percentage of heavies (long runway occupancies) has a negative impact on ROT in mixed mode. The higher the percentage of heavies, the stronger the argument in favour of segregated mode.
When two runways are used for departures, capacity is not simply doubled, because optimum divergent sequencing of operations cannot be operated on the same runway. This capacity constraint increases with the dependency between the departure runways.

The number of go-arounds is higher in mixed than in segregated mode

The mode of operations is highly dependent on the local infrastructure. For example, it is obvious that with a terminal in the middle, the mixed mode would be recommended. Moreover, the risk of taxiway congestion following bottlenecks has decreased. However, the impact of mixed operations on the taxiway system when the terminal and apron areas are not between the pair of runways can be considerable. Crossing the inner runway to reach the departure queue on the outer runway is a good example of such a constraint. (It has been demonstrated that during departure peaks, aircraft crossing the active runway may reduce capacity gain by 14% if only one crossing location is available. Multiple crossing points are the appropriate way to mitigate this constraint).

4.2.3.2.2. Segregated operations

The major disadvantage of segregated mode is that because of aircraft wake vortex, streams of arriving and departing aircraft have to be comparatively widely spaced, and potential runway capacity is thus wasted.
In segregated operations, lack of flexibility will be noted owing to unused capacity on one of the runways, whilst excess of traffic may be experienced on the other.
Segregated operations in combination with a number of procedures followed in order could be used to minimise the effects of aircraft noise (see Annex 5: Case Study Heathrow).
Segregated operations are easier for ATC to work with. Although approach and ground control workload does not fall within the scope of this heading, it is of paramount importance to assess the impact of the operation of various runway-use configurations on controller's workload.

4.2.3.3. Conclusions

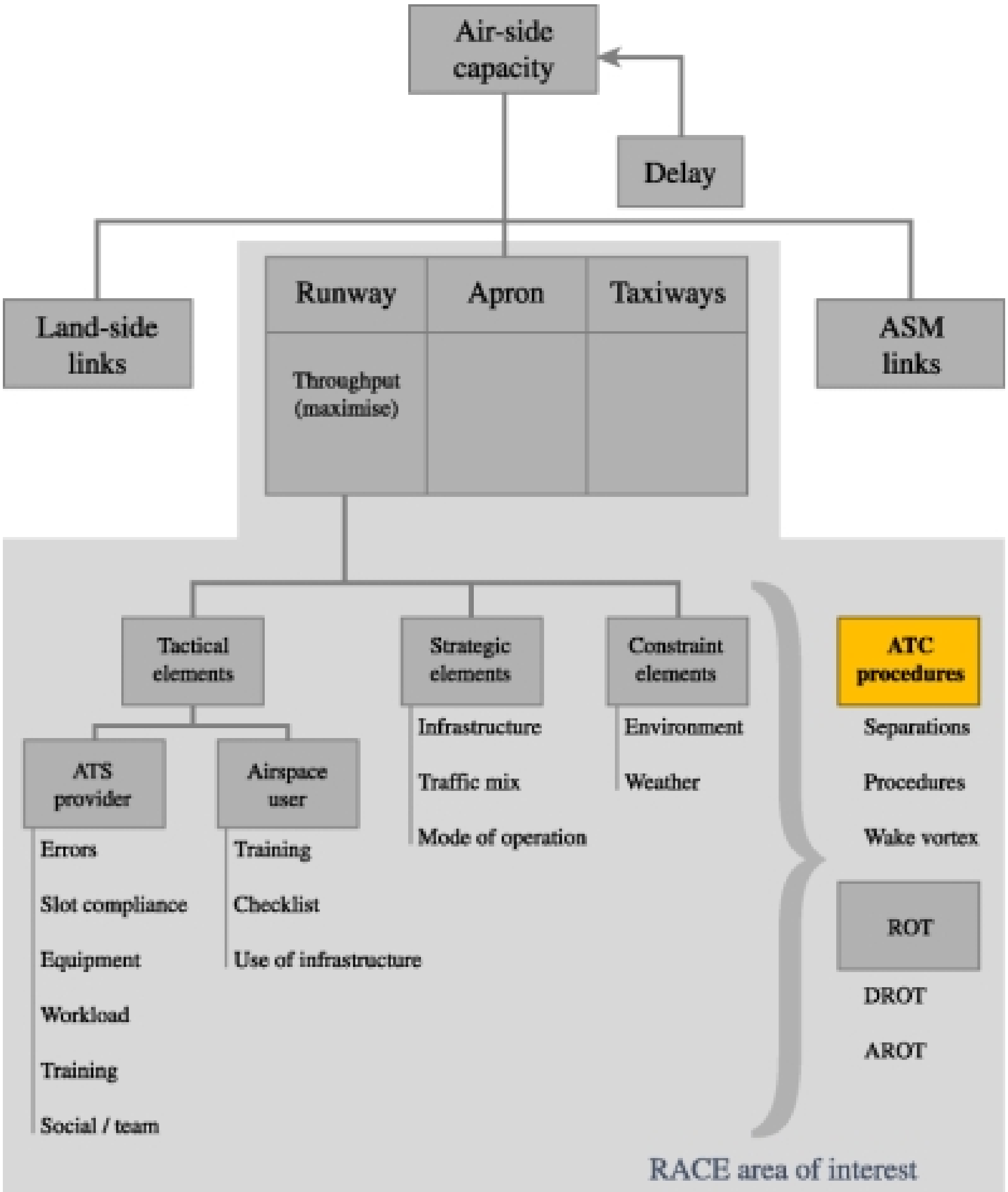
The capacity benefits of mixed operations come from:

- taking advantage of wake vortex spacing, as a result of which arrivals and departures can be interleaved;
- optimising the applied separation minima for both arrival and departures;
- reduction of ground movement congestion by use of the runway nearest to the terminal or stand.

The quoted benefits can be enhanced by implementing one or a combination of the following measures:

- simultaneous independent parallel approaches, through the use of a radar-based final approach monitoring aid;
- a departure radar concept also for mixed mode;
- a tactical traffic management tool for ATC as an aid to balancing runway utilisation and optimising arrival and departure flows on parallel runways.

4.3. ATC procedures



Elements Affecting Airside & Runway Capacity

4.3.1. Introduction

Following the reorganisation of EATCHIP into EATMP, the Airspace and Navigation Team (ANT) has been tasked with the development and validation of new ATM Procedures, and the maintenance of existing ones. In the context of the 'gate-to-gate' strategy, the ATM Procedures Development Sub-Group of the ANT addresses all ATS procedures, thus including aerodrome and TMA-related ATS procedures.

The need for extensive coordination with other bodies, both international (such as ICAO/AOPG, EC and AOT) and internal (e.g. RACE TF), has been emphasised, with a view to avoiding duplication of effort.

4.3.2. Priorities

The Airspace and Navigation Team (ANT) decide priorities, taking due account of the stakeholders' needs, including the operational requirements of AOT:

The following priorities have currently been set:

- Simultaneous operations on converging non-intersecting runways, subdivided into:
  - Simultaneous converging instrument approaches (SCIA) to non-intersecting runways.
  - Dependent converging instrument approaches (DCIA).
  - Operations to closely-spaced parallel runways.
- Development of procedures for A-SMGCS, in conjunction with the development of procedures for low-visibility operations.
- Runway operations, including runway incursions.
- ATM procedures for the application of RNAV in the TMA, sub-divided into:
  - B-RNAV.
  - P-RNAV.
- Rationalisation and optimisation of wake turbulence constraints for departing aircraft.
- ATS procedures to support Sequencing tools, AMAN/DMAN and combined AMAN/DMAN.

4.3.3. Current status of aerodrome-related ATS procedures

To date, the APDSG has concentrated its efforts in three areas, namely:

- manoeuvring area operations;
- ATS procedures to facilitate the use of RNAV in Terminal Airspace; and
- operations on converging non-intersecting runways.

4.3.3.1. Manoeuvring area operations

The focus of the group has been on runway safety, in particular on runway incursion issues. The APDSG has therefore started to collect information on incursion-related accidents/incidents, as a result of which the ATM procedures concerned will have to be addressed (ICAO provisions, specific conditions for application, RT phraseology used, LoA). Furthermore, a proposal has been submitted to and approved by ICAO regarding ATC procedures in relation to the crossing of runways.

4.3.3.2. RNAV in terminal airspace

The current ATS procedures in support of the use of B-RNAV are considered to be fully established. There is no requirement for additional developments.

The use of P-RNAV, however, is subject to in-depth study, in particular with regard to flight planning procedures, nomination of SID/STARs in a mixed-mode environment, R/T phraseology, and the vertical guidance to be given on a 3D route.

Operations on converging non-intersecting runways
It is intended to develop general procedures for converging non-intersecting runways which could be forwarded to ICAO for possible inclusion in ICAO documents.

4.3.3.3. Operations on converging non-intersecting runways

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4.3.3.4. ATS procedures monitored by ICAO

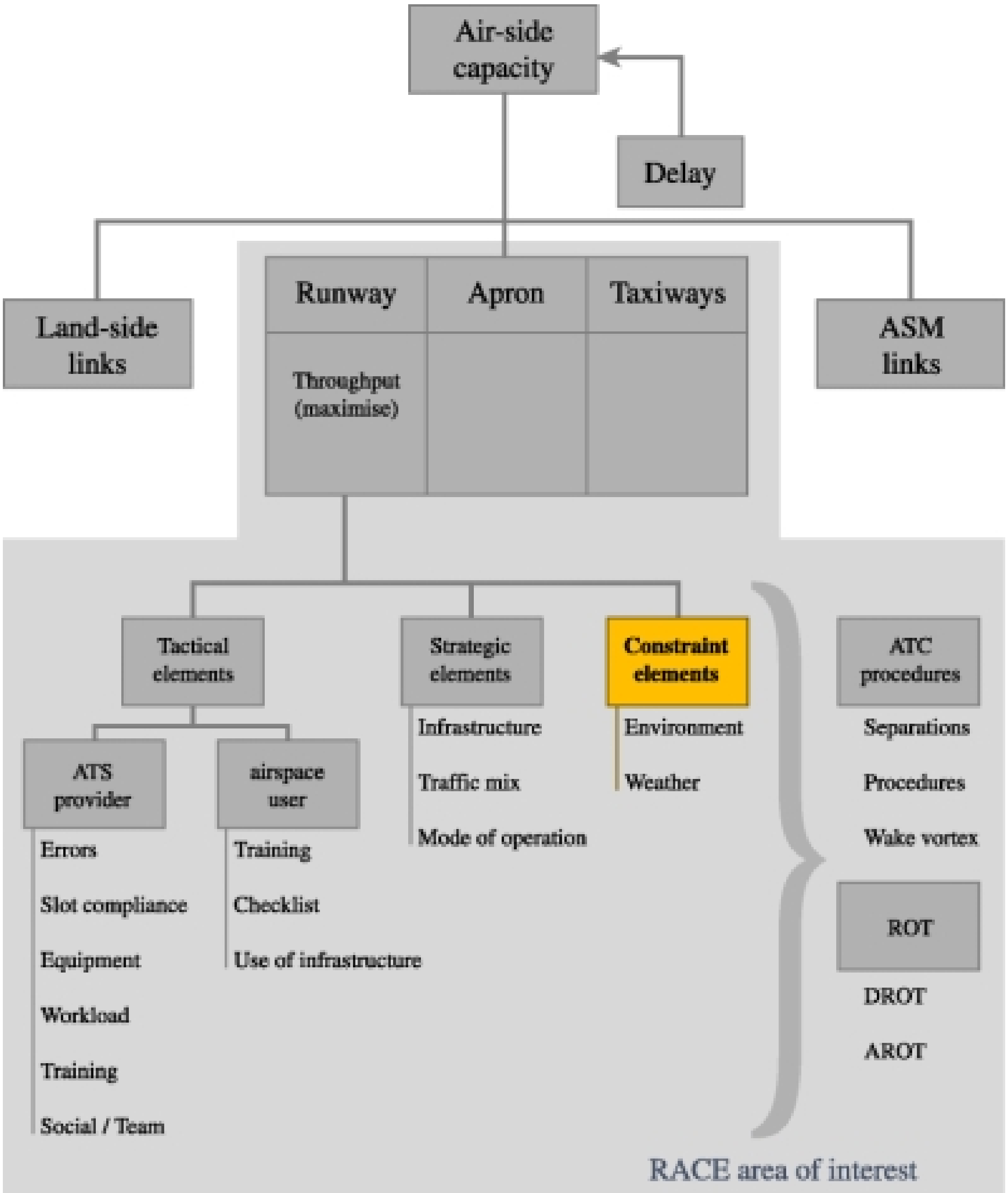
Seven of the original APATSI ATS procedures have been processed by ICAO, and four of them have been circulated by ICAO for formal consideration by states, namely

- intersection take-offs;
- multiple line-ups on the same runway;
- visual approaches;
- visual departures.

The three remaining procedures (see below) are still subject to discussion by the Air Navigation Commission (ICAO/ANC):

- reduced runway separation on the same runway;
- landing clearance based on anticipated separation; and
- the concept of simultaneous intersecting runway operations (SIRO).

4.4. Constraints



Elements Affecting Airside & Runway Capacity

4.4.1. Environment

4.4.1.1. Introduction

The revised EUROCONTROL Convention, the adopted EUROCONTROL ATM 2000+ Strategy and the EUROCONTROL Environmental Policy and Strategy all recognise the crucial importance of environmental aspects and therefore require the Airport Operations Programme (AOP) to consider them accordingly. Within the framework of the AOP, the Runway Capacity Enhancement Task Force (RACE TF) has been established to collect best practices concerning optimised use of available runway capacity. The aim of this section is to reflect how environmental implications could affect runway capacity in terms of making optimum use of available capacity whilst remaining within the context of the environmental legislation in force. Furthermore, it incorporates guidance material on measures to mitigate or reduce the airport-related impact on the environment. It also provides a non-exhaustive suite of best practices at a number of European airports.

4.4.1.2. Regulatory and legislative environmental constraints

A variety of international, regional, national and local regulatory, legislative and planning agreements can impact on airport capacity. The most important include:

- the Kyoto Protocol on reduction of greenhouse gases (EU committed to 8% reduction);
- ICAO Annex 16, Volume I – Noise Standards, and Volume II – Emissions Standards;
- World Health Organisation (WHO) Guidelines for Community Noise;
- EU regulations on noise and emissions;
- national third party risk standards, which could limit air traffic growth;
- national and international habitat directives, which could limit physical growth;
- national and local noise legislation, which could create limitations on air traffic routeings and ground operations at airports;
- the air quality legislation of the EU and some ECAC Member States, which could limit ground access to the airport; and
- local planning agreements, which might include air traffic, third party risk or environmental impact limits
- Conversely supporting land use planning policy can help to unlock or safeguard future airport and runway capacity if agreed in partnership and vigorously applied

4.4.1.3. International work

This value of supporting international work may seem remote to individual stakeholders involved in maximising runway capacity at a single airport. The outputs from this work however have a significant potential to affect the future growth potential for air transport and hence the market size and value for each airport stakeholder. So each individual has a vested interest in identifying how they can most effectively support these projects. They should also take a proactive influencing role either directly or through appropriate organisations.

The following paragraphs give an overview of international developments regarding regulatory and operational measures, together with mitigation techniques and example methodologies applied at some ECAC airports.

4.4.1.3.1. ICAO-CAEP WG/2

The ICAO Commission/Aviation Environmental Protection (CAEP) Working Group 2 – Airports and Operations was established to consider environmental issues related to airports and aircraft operations in the vicinity of airports.

The work programme of WG/2 is included in Annex 3, Appendix A to this paper, and includes the following issues:

- Noise abatement operating measures
- Land-use planning
- Environmental guidelines for airport planning
- Airport noise monitoring
- Development and validation of a Global Aircraft Noise Impact Assessment Model (MAGENTA) for assessment of optimal noise control strategies.

In addition, the WG/2 Work Programme refers to providing material to update the Airport Planning Manual, Part 2 – Land Use and Environmental Control (Document 9184). Annex 3, Appendix C provides an overview of the issues covered and summaries of the relevant topics of land-use planning and third party risks.

4.4.1.3.2. PANS-OPS Document 8168

Guidance on preparing noise abatement departure procedures is currently provided in PANS-OPS, Document 8168 Volume 1, Part V - Noise Abatement Procedures. The guidance provided in the PANS-OPS calls for two types of procedures:

- ICAO Procedure B is designed for noise mitigation in areas close to the airport;
- ICAO Procedure A is designed for noise mitigation during later take-off stages.

Owing to safety considerations, however, operational restrictions sometimes overrule environmental aspects. These include:

1. Glide path or approach angle not more than 3°, although at some airports glideslopes of more than 3° are required for obstacle clearance. It should be noted that these do not provide for CAT III auto-land capability.
2. The aeroplane must not be required to be in a configuration other than the final landing configuration at any point after passing the outer mark or 5 NM from the threshold of the landing runway, whichever is earlier.
3. ILS intercept height not greater than 3000 ft altitude.

4.4.1.3.3. ECAC-ANCAT PLANO task force

Following discussion by ECAC's Group of Experts on the Abatement of Nuisances Caused by Air Transport (ANCAT), it was agreed to create an ANCAT Task Force on Procedures Linked to Abating Noisy Operations (PLANO). The main purpose of this Task Force was to serve as a European forum for exchange of information on operational noise mitigation procedures around airports and the further development of such work, with a view to presenting proposals for consideration within ICAO. The Terms of Reference are included in Annex 3, Appendix B.

The following PLANO recommendations were fully supported by the ECAC-ANCAT/50 Meeting in March 2000:

ANCAT should encourage its Members to put more emphasis on the environmental aspects in the relevant EURO CONTROL Working Groups, in particular with regard to:

1. the development of specific SIDs for low-speed aircraft;
2. the implementation of continuous descent and climb
3. the use of idle reverse after landing.

Furthermore, ANCAT should encourage its Members to support the ARETA project (Future ATM with RNAV in Extended Terminal Area Operations), in particular the environmental aspects. A summary of the ARETA project is contained in Annex 2, Appendix E.

4.4.1.4. Airports' Airside and the Environment

Although the runway is the most critical link of an airport’s operational capacity, environmental constraints have the ability to affect any aspect of the airside and thereby directly or indirectly runway capacity and/or ROT. Stakeholders therefore need to consider the environmental constraints which apply to the air-side as a whole.

At and around airports, air traffic affects and is affected by a variety of adverse enviro-social issues, such as:

- noise disturbance from aircraft in the air
- ground noise, including aircraft, airside vehicles, engine testing and auxiliary power units (APUs) as well as other equipment such as ground power units (GPUs) emissions to air from aircraft and the effects on air quality (and congestion) from airport ground transport associated with infrastructure construction and expansion;
- land use and land use planning;
- water and soil pollution;
- vortex strikes;
- airport waste; and
- increasingly in the future, third party risk

4.4.1.5. Airport airside capacity implications

Air-side capacity and the potential to develop and use airside assets can be significantly affected by the response of society to the adverse and beneficial impacts of air transport. As the rate of development of mitigation technology slows, so the continuing growth in the total number movements at an airport will produce increasing adverse impact trends. In the case of noise this shift from a reducing to an increasing impact will be a new experience for many airports. Historically, many capacity increases have been granted on the promise of reducing or limited increase in environmental impact but this argument will no longer be available to some airports. This increasing trend in adverse impact will further stimulate social and political awareness and concerns. Increasingly therefore, Airports may be obliged to enter into negotiation with local stakeholders to set 'responsible' growth constraints. In addition (and less attractive) will be an increasing trend for airports to have constraints imposed upon them including for example :

- limits to the area of noise contours
- curtailment of the hours during which airports are permitted to operate;
- curtailment of the number of movements over a given period of time (hourly or daily);
- refused planning permission or extremely long planning processes
- curtailment of the types of aircraft (Chapter 2 and Chapter 3 aircraft) allowed to operate at specific airports.
- aircraft routings or operating procedures that are not airside capacity optimised
- financial and economic burdens
- emissions capping (emerging)

Other potential environmental capacity constraints may arise naturally or as a result of matters outside of aviation's control including for example:

- the affect of changing weather patterns arising from climate change
- reducing fuel availability

It is not however, just the constrained runway systems that are at risk from environmental and social constraint. Many smaller and developing airports have 'spare' runway capacity that can be compromised by the failure to plan, safeguard (through land use planning controls) and deliver maximum environmental and social capacity. It cannot be stressed enough that an airport should start to address these issues well before announcing that additional capacity is required.
For example land use planning around a runway needs to be in place for many years before its value to an airport's plans for additional capacity is realised. Another example is noise monitoring where it takes years to develop the skills and data set to allow accurate and confident negotiation of permission to grow. The collection and distribution of best practices can help to shorten this learning process by learning from others.

4.4.1.6. Balancing runway capacity versus environmental protection

It can be seen from the above that new runways and other major infrastructure developments are becoming increasingly difficult to deliver at all and even if realised they can take too long to deliver. This problem tends to exist because the stakeholders at an airport have not invested enough time and resources into understanding environmental and social effects, developing partnership between supporting stakeholders, planning a response in advance and demonstrating commitment and delivery of environmental control and mitigation. In any case, failure here will almost certainly result in constraint.

It is increasingly important for every stakeholder to play an active role in slowing down the rate at which air transport uses the available environmental and social capacity if growth in aviation's benefits are to be sustained. In collaboration therefore, aviation stakeholders must be able to give decision makers confidence that as an industry, we can deliver the required environmental control and mitigation whilst maximising the increasing positive contribution that our growth makes to the sustainability of the communities that we serve.

Without compromising safety levels, capacity, efficiency and environmental protection are the major interacting issues to be taken into consideration when developing, defining and evaluating runway capacity enhancement measures. Where these aims coincide, there is a powerful driver for growing the aviation business and the case for change is clear. For example the ability to increase runway throughput by training and awareness throughput is more rapid and more economically and ecologically efficient when compared with provision of new infrastructure.

It is not often the case however, that the key factors (capacity, efficiency and environmental protection) are mutually supportive. There can even be conflicting aspects within the same subject. For example, some noise reduction techniques may necessitate longer procedures both in distance and time, resulting in extra fuel burn and associated emissions. In this kind of conflict, the needs and voice of the local community often outweighs the needs of society as a whole and care must be taken to correctly weigh the various arguments and for decision makers to understand what their mandate really is. It is also important in this regard to understand the nature of community disturbance and community response to disturbance before locally derived constraint is imposed on an airport. For example, whilst complaints are not always a reliable metric of noise impact trends, they are a useful indicator of the future political focus.

Other measures with the potential to reduce noise, resource use and emissions impact may have a detrimental impact on capacity and hence the socio-economic benefits arising from airport development. This tension between sustainability drivers will require careful balancing in terms of conflicting national, global and local needs.

4.4.1.7. Aviation response to the need for balance

Working in partnership with airspace users, some airport operators have successfully reduced the impact of airport operations and development on the environment, in particular by reducing noise, fuel burn and gaseous emissions. This momentum needs to be maintained and accelerated, and the best practice replicated throughout Europe, so that future growth in air traffic will remain acceptable to surrounding communities and the general public.

4.4.1.8. Concepts to mitigate or reduce environmental impact

In order to meet growing demand while remaining within the context of the environmental legislation, a number of ECAC airports have implemented, and are continuing to develop wide-ranging control and mitigation measures. These have resulted in less noise and fewer emissions relative to growth, thus freeing additional capacity, generating more jobs and economic benefits for a proportionally reduced noise impact.

Relevant concepts, directly applicable to runway capacity, are detailed in the following paragraphs

- The importance of an Integrated approach
- Noise
- Community relations
- Air quality
- Planning

4.4.1.8.1. The importance of an integrated approach

Alleviating environmental and social capacity at an airport requires both the maximising of an airports positive sustainability related impacts (jobs, inclusion, culture, leisure, economic etc) and the minimising as far as possible the negative ones. This however is not the sole responsibility of any single entity and requires a Colaborative Decision Making (CDM) approach. In taking things forward, the CDM partnership must also realise that most impacts and mitigation techniques interrelate and it is important that a decrease in one adverse impact does not increase a more critical negative impact elsewhere for example improving track adherence can assist planning restrictions on the ground. Another is that a decrease in noise impact can have a more significant adverse effects in terms of emissions, fuel burn and capacity and thereby jobs and economic benefit. Minimising environmental impact therefore calls for an integrated approach both vertically and horizontally to ensure that conflict is minimised and synergy is maximised. In terms of runway environmental issues the following partnership is typical of a successful airport set up:

Airport Operator (AO). The AO will normally supply the environmental and master planning expertise and delivery of associated infrastructure such as engine test bays, sound insulation or fixed electrical power etc.. In terms of environmental issues they usually initiate and facilitate the CDM process usually linked to development plans and a wider influencing strategy aimed at securing growth. The airport operator will usually own and operate to the environmental and performance data from monitoring systems required for progress. Airports will usually be the main interface with other stakeholders such as the community and local planning authorities. Other airports for best practice and regulators including fiscal and environmental

Air Traffic Services (ATS). ATS will provide overall safety checks and the ability to introduce and systemise new procedures. They have access to simulators for testing purposes and may also have the ability to provide certain data feeds to the airport's monitoring systems to help to improve understanding of the issues. They will also have some requirement to practically apply some of the noise and emission abatement techniques (such as the reduction in non-standard departures – challenging unacceptable performance and so on. ATS will be the main interface with other stakeholders such as safety regulators, en-route providers and airspace design.

Airspace Users. Airspace Users manage and operate the equipment that generates the main impacts and are therefore key in delivering the new techniques etc. They have access to simulators for testing purposes. On a longer term basis their fleet replacement and scheduling requirements will also have a major affect on the environment around airports. They are instrumental in collecting the money that will finance the initiatives (even if indirectly) and will be the main interface with other stakeholders such FMS software houses and aircraft manufacturers .

The establishment of internal technical working groups at airports that comprise the above expertise allows a series of impact reduction options to be debated and tested before being discussed in community groups. The CDM approach ensures that stakeholders are fully engaged at the outset and will therefore understand:

- the importance of the measure to the future of their business
- what are the limits, trade-offs (e.g. emissions, fuel burn, cost and capacity versus noise) the capacity implications for any proposed measure
- what is required for success
- what roles are being played and by whom
- and what their combined efforts are achieving

Simple enthusiastic partnership is not sufficient for success and the following aspects will ensure that the absolute maximum benefit is derived:-

- Top commitment from all stakeholders at the highest level because without this up-front, adequate priority will not be placed on this topic and any agreement is liable to countermand.
- Clear objectives and targets supported by specific performance criteria expressed in terms relevant to the business plan (e.g. where environmental limits are fixed - additional hourly runway movements due to noise control measures)
- Adequate information and monitoring systems
- Good access to best practice to avoid proposals that have failed badly at other airports.
- Good modelling and forecasting systems and techniques.

4.4.1.8.2. Noise control

The requirements for noise control varies enormously at different airports and with different cultures and communities. There are some key themes that are common to many airports but the best mix of measures will need careful local selection:

- Systems to monitor noise and track keeping. These can range from simple manual systems, to sophisticated fully integrated noise, track, weather and emissions systems that essentially offer a real time and historic map of the key environmental impacts. The latter can automatically flag-up exceedence of airport standards and can even filter out non-standard procedures to avoid incorrect challenges to non-compliance.
- Modelling systems that can be used to assess future development options and the implications for growth.
- Preferred runway. This is simply a commitment to maximise the direction by which aircraft depart/arrive at a runway and can have significant beneficial capacity implications if conflict, management and infrastructure are not optimised.
- Over-flying the least number of people or the least number of sensitive receptors (schools and hospitals etc.) In order to be effective this requires that SIDs and noise routes coincide and that CDM groups continually review procedures and performance. In some cases local communities (normally beyond the contours that bite on planning restrictions) may ask for a spreading of over-flight. Policies to restrict the hours of operation or noise in sensitive hours. This usually takes the form of a night noise policy. The restriction can take the form of an absolute ban on movements, a restriction in movement numbers, a restriction to peak noise events, a restriction based on a noise budget or contour. Care must be taken to ensure that such action does not shift the burden elsewhere, and that the disturbance the policy is aimed at is real.
- Fiscal policies to encourage adherence to airport standards or the improvement in the environmental performance of the fleet. The voluntary change to less noisy more modern fleets at those airports where capacity is very tight.
- Management of non standard procedures such as vectoring or releasing aircraft from the need to follow a SID. Obviously this important in maximise the numders of flight subject to control. Used carefully hoewethe adoption of tactical procedures designed to alleviate impact (e.g. early turn on quiet aircraft to avoid capacity problems causing a noisy aircraft from deviating from the preferred noise routings).
- The use of standard noise abatement procedures such as ICAO and modified ATA noise abatement procedures (set out in Appendices D and E).
- Ground noise mitigation techniques such as the provision of fixed electrical power, engine test bays, avoiding congestion at the runway holding points, care in the use of reverse thrust (notwithstanding safety), noise barriers and so on.
- The spreading of best practice amongst ATC and Operator personnel.
- Promotion, training and awareness.

4.4.1.8.3. Community relations (CR)

The community surrounding an airport are directly affected both negatively and positively by its existence. An airport will therefore figure highly in the life of the surrounding communities and the adverse effects will be central in their dealings with elected representatives and other decision makers. They may well form amenity groups to co-ordinate their voices. These are networking and becoming increasingly effective at blocking the plans for growth at individual airports and at a national/international level are increasingly influential regarding aviation as a whole.

A good relationship with this community is therefore essential to maximising capacity and the community are a good source of sound advice regarding what issues are important to them and what priorities the airport should adopt. It cannot be stressed enough that engaging with the community and developing an open door approach to their needs and concerns is fundamental to unlocking capacity for growth.

CR must not be confused with ‘PR’ which is usually a one way process of announcing an airport’s success to the world (normally the media). CR is an ongoing dialogue with local people who may from time to time, be instrumental in approving an airports plans to increase capacity and may also have a better grasp of what issues should be addressed by an airport and how urgently.

The following approaches have worked well at many airports in the ECAC area but again it must be stressed that local circumstances will dictate what combination of measure will be the most effective:

- Establishment of formal consultative committees with sub groups looking at technical or mitigation type initiatives, typically these committees comprise the airport stakeholders, local elected representatives, amenity group chairman, local business and tourism interests and regulators. Very often the main committee are observable by the public. This is an excellent mechanism to ensure that all CDM stakeholders hear first hand the concerns of the public, it also allows the airport to present plans for responsible growth gaining buy-in or valid comments from community representatives before a full scale publicity campaign.
- Working alongside local academic institutes, health agencies and environmental regulators to better understand the positive and negative impact of their growth and operation in order to take this into account in setting their strategy and plans for development
- Operating a dedicated CR department whose role is to offer an interface with the wider community, to receive, respond to and report complaints and concerns and to act as a conduit for outgoing information and as an internal 'ombudsman' on behalf of the community. The CR department may also administer open days and other community events designed to offer an exchange of views, debate and an input of local concerns into the heart of the airport machine. Some airports have CR oriented visitor centres on site and/or operate CR outreach centres in local libraries and other public meetings where local people can talk to real airport people. CR staff may attend public meetings, village/parish councils and local authority committees to establish a network for dialogue.
- Fund mitigation schemes such as sound insulation programmes (links to planning section) or vortex damage repair schemes and may also provide funds available for social research programmes, independent opinion surveys, supporting local community and environmental schemes or arts sponsorship and the like.
- Many airports have entered binding local agreements that enshrine their commitment to the local environment and the local community in order to win agreement to growth. This requires extensive historical information, a detailed understanding of the practicalities of delivering improvements and a clear vision of the future. It takes a long time to develop sufficient skills to use this mechanism and should not be approached without adequate skills.

4.4.1.8.4. Air quality

In terms of air quality, this is rapidly catching up to noise as critical issue and this process will accelerate as EU and national air quality standards are applied, exceeded and reported. Crucially it should be borne in mind that as air emissions are migratory, poor air quality in the vicinity of an airport is not necessarily as a result of airport emissions. It is also generally accepted however that aircraft at height above the ground greater than 300 metres play little role in ground level air quality. The main source of air quality problems for an airport are therefore ground transport and aircraft on the ground or very close to the runway. In general, when it comes to emissions airports are seen as single entity so any measure that alleviates the emissions burden arising from any part of the airport systems can offer capacity benefits to the core activity – airport airside capacity..It is therefore appropriate to act upon all generators of emissions, such as

- aircraft both in the air and on the ground;
- ground transport both airside and land-side;
- fixed plant such as terminal heating systems;
- fugitive emission from processes and spillage, etc

All of the above can contribute to reducing the total emissions from a airports which will reduce the extent to which environmental capacity is used, freeing capacity for peak operations

The following measures have been useful to airports in controlling overall emissions:-

- **Aircraft on the ground** - In addition to working with stakeholders to optimise the fleet characteristics, aircraft procedures can have a major influence on the air quality capacity used by a runway. For example aircraft leaving stand too early and joining an existing queue at the runway threshold is costly, generates avoidable emissions and indicates poor runway capacity utilisation. Conversely A number of aircraft (generally not more than 8) in the holding bay permits ATC to optimise the sequence. Therefore, it can be concluded that trade-offs will be required. Further, the use of single engine taxying can also be more efficient than running more than one engine at lower power settings. However at the risk of not being able to line up and take off when instructed. Increasingly also the concept of flexible airport capacity is being considered. This is to say where the more remote areas of an airport are only used in periods of peak demand, as a result of which the environmental and cost benefits can be very significant.

- **Aircraft in the air** – Emissions from aircraft in the air can be reduced in 3 main ways;

  - Ensuring the time aircraft spend in stacks is minimised
  - Ensure that the correct balance is struck between noise and emissions when designing sids and stars
  - The use of R-NAV SIDs and STARs
  - The use of CDA when demand allows

- **Ground Transport** –The benefits from decreasing access by car go much further than emissions (e.g. congestion, land use, safety etc) but emissions to air is a key driver and many governments and planning authorities are demanding a commitment to inter-modality as a prerequisite to allowing airport expansion.

- **Provision of fixed electrical power** (and in some cases pre conditioned air) to stands allows an aircraft APU to be switched off for at least part of a turnaround. This is not only good for emissions but for also for ground noise.
- **Energy efficiency** – The management of energy in terminal and ancillary buildings offers a major opportunity to reduce emissions and cut costs. Depending on the base line assessment saving of around 15-25% are possible from technical solutions like sub metering, co-generation, lighting control, variable speed drives for electric motors, improved new building specifications and remote intelligence building controls.

4.4.1.8.5. Planning

Encroachment of residential and other non-essential land uses can seriously reduce an airports environmental capacity and generate other issues such as third party risk, compensation claims, and land availability problems. Effective land use planning is not always easy to enforce (planning restrictions may be flouted or overturned on appeal) and only when all stakeholders recognise the strategic importance of an airport to a region's society and economy will planning requirements be actively upheld.

Once harmonised, airport and local planning has been agreed in principle it is important to identify potential future impact for a variety of topics such as noise, land take, ground access and third party risk in order to agree the best format for controlling land use. This approach, coupled with selective land acquisition, is a key factor in safeguarding future capacity for growth.

In almost every sense maximum capacity is unlocked by doing more with less. In the case of land, the approach should be to unlock the maximum capacity for growth and then be very sparing and efficient in its use. For example increasing public transport and free up car parking land for terminal development which in turn frees up space of critical apron or other airside uses. In other words, to have an under-utilised or sprawling airport for the sake of appearances can actually reduce the potential capacity of available land. Once and airport is constructed it is always very difficult and expensive to re-organise it in a more effective way. Where possible therefore airport land should be safeguarded for strategic use and serious consideration should be given to locating less central activities offsite (e.g. remote parking and check-in) etc. Also new communications technologies will also offer an opportunity to become space efficient and investment in these may be more effective than in building facilities on land with potential airside uses.

5.Links with adjacent areas

5.1. Land-side elements which affect air-side operations

The terms of reference of RACE, which determine the structure and content of 'The Guidelines on Runway Capacity Enhancement', include instructions to simply identify links between land-side and air-side. This specific task should be seen in a wider overall ATM context. A more suitable title would therefore be 'airport considerations and the effects of airport infrastructure on overall ATM performance'. In line with the task assigned, the scope of this section has been limited to enumerating elements which have an influence on runway capacity rather than searching for solutions to the identified issues.

Links

5.1.1. Airport capacity

Current airport capacity is affected by varying constraints, and the implementation of a means to measure unconstrained capacity is tantamount to assessing the real problem. The EUROCONTROL analytical model, which has been specifically developed for this purpose will provide a means of genuinely identifying constraints and promoting actions to maximise the use of all available capacity. This model should be introduced without further delay.

5.1.2. Schedule co-ordination

This is the very core of a large number of problems. Congested airports may wish to be fully coordinated in accordance with EC Regulation 95/93, but in a number of cases slot adherence monitoring may not be implemented accurately enough to prevent slot abuse. Fines are not the answer - they only encourage system abuse. A prime example of this theory is the decline in abuse in Palma de Mallorca from 20% to 2% in summer 1999. The key to success is mutual problem-solving and working together. Slot monitoring and slot abuse committees, where they exist, give evidence of huge success. Collaborative decision-making by the slot monitoring committees in the UK should be considered as best practice.

5.1.3. Airport access

Most passengers and those accompanying them use private cars to and from the airports, which causes congestion of the access roads, in particular during peak hours. The importance of high-speed train access in particular, and a well-organised public transport system in general, cannot be sufficiently underlined, because a proportion of the delay is attributable to the transport system. Substantial required to improve surface transport wherever possible.

5.1.4. The airport

Airports need to be functional, efficient and user-friendly for both the passengers and the airline operators (the same can be said of other parties active on a given platform, such as ground handling companies, etc.). For various reasons, this is sometimes not the case. In some instances, new airports and improved airport facilitation within ECAC cannot provide enough facilities to meet demand or to accommodate current or planned European legislation. Such examples are 100% hold baggage screening, passenger segregation, and the handling of passengers with reduced mobility (PRM).

- Following decisions taken by ECAC, 100% of all hold baggage must be screened by 31 December 2002. This decision will require drastic capacity increases for most European airports (a doubling of current capacity at the very least), so as to avoid additional delay.

- Segregation of Schengen and non-Schengen passengers.
- Passengers who are unable to move as quickly as others, such as people in wheelchairs, the elderly, children and pregnant women. It should be noted that the number of PRM passengers has risen to as much as 25% of the total passenger population.

Further self-check-in desks should be generally accepted as an efficient and economic means of reducing queuing times in the terminal building, and therefore reducing passenger delay.

It is a well recognised fact that planning and construction of new facilities greatly depend on lengthy local decision-making processes, most of them influenced by environmental considerations.

The increased use of airport terminal facilities by third parties can create a further severe lack of facilitation space and lower the quality of service delivered at some airports, many of which already lack the space to meet both service and quality commitments. These practices affect the entire land-side operation of the airport and can contribute to delay, missed slots, etc., where passengers are unable to present themselves in time for boarding. Late arrival of passengers should also be considered a factor, but it should be borne in mind that airport operators have less influence on this parameter than airline operators. Airlines should adapt their policies according to the facilities provided at a given airport, to efficiently process passengers, including the provision of advance and accurate travel information.

All these issues have to be pursued with airport partners and service providers if service and quality levels are to be achieved.

It is inevitable with demand increasing that new airports and the expansion of existing facilities should continue. Lack of airport slots and misuse/abuse of the slot system will further add to this demand. Likewise, environmental issues have already begun to reduce capacities at constrained airports. Schiphol, Madrid, Paris Orly and – potentially – Roissy-Charles-de-Gaulle, and all the Italian airports are prime examples. Such measures can only result in greater daytime pressure, increased delays, the real affect being damage to the environment. We have to seek better ways of managing the problem by improving understanding and introducing new procedures to reduce environmental impact.

The airport world itself is changing. With the trend towards privatisation, some airports are becoming very entrepreneurial and seeking to raise revenue in any way possible. The loss of duty-free revenue is also a possible additional factor, prompting airports to seek solutions to maintain revenue. This could result in a greater share of non-aviation revenue than aviation revenue (as is already the case for some airport operators). It is not clear to what extent this trend will impact on capacity management. However, it could lead to an increase in the number of commercial outlets in the terminals, forcing airport operators to rethink passenger facilitation in order to include the new parameters in their planning strategies.

Several ECAC airports are currently underused owing to various types of constraints, whilst others offer more capacity than they can achieve, both types are detrimental to the ATM system. This is yet another example of where, if applied, EC Regulation 95/93 could provide a mechanism to manage the situation. Regular capacity assessment as defined by the Regulation would provide the appropriate course of action. Madrid, where, a capacity enhancement programme has been established with the involvement of all the stakeholders, should be considered as best practice. Similar exercises have been carried out in Barcelona, Palma de Mallorca and Brussels. Other airports are planning such exercises.

5.1.5. Internal airport services

Adequate facilitation and resources are required to meet demand. At a number of airports, this is a problem which cannot be underestimated. Inadequate planning, resource allocation and equipment can lead to congestion, poor processing of passengers and consequential delays. Airline behaviour also plays a role and should not be underestimated. This all adds up to missed slots.

Both passport and security control also need adequate resources to cope with demand, and they need to be fully coordinated with the airport operator in order to create an efficient facilitation environment while maintaining security at its highest level. All too often, vast queues form owing to insufficient resources in these vital areas.

Sufficient resources are one way of solving the problem. Another possibility is to have the security checks at the departure gates, which most probably would resolve the creation of bottlenecks. However, this would involve more security personnel spread over a wider area. Other benefits can be obtained by routeing passengers from dedicated flights through a fast passport control checkpoint.

However, it should be borne in mind that airport operators may not have the desired influence over these areas, as the provision of security often depends on the national authorities (ministries, etc.). Internal airport bottlenecks need to be solved by CDM with all the stakeholders. Everyone involved must be made to realise that they are part of the problem. All of this again results in missed slots.

5.1.6. Gates

Gate holding areas allow more timely processing of passengers, but in many cases, even where gates exist, passengers are not processed until boarding time. It is, however, important not to limit this issue to the presence – or absence – of contact stands, as the need for such facilities greatly depends on the configuration and operation of a given airport. The nature of airline operating services at some airports may also have an influence on gate management and gate allocation policies, as is often the case with low-cost and charter carriers. Remote stands may sometimes be the better answer, and efficient operation then depends more on efficient coordination between several parties (airport operator, airline, passenger handling and transportation, etc.).

5.1.7. Ramp resources

Adequate resources are vital to all operations. If resources are inadequate, the chances of meeting approved airport and ATC slots are reduced to unacceptable limits. Airline policies and behaviour also play a major role in this respect. It is relevant to point out that such problems occur more frequently where there are monopoly service providers. This is predominant at a large number of tourist airports.

5.1.8. Real-time operations

On the day, real-time management of slots in the ATM system is a vital key factor, as much capacity is currently lost owing to a lack of systems and communications to make optimum use of this availability. This calls for CDM between the ATS provider, the airlines and the airport authorities in order to make best use of on-the-day capacity. A missed slot is worthless.
Implementation of enhanced ATC procedures will lead to improvements. Likewise, the action taken at Madrid, Barcelona, Heathrow and Gatwick to produce informative briefing for operating crews and ATC needs to be implemented ECAC-wide. This promotes the importance of the individual in the ATM system and has led to significant improvements where it has been applied.

5.2. Airspace management elements which affect airport airside operations

5.2.1. Introduction

Traffic forecasts based on past trends show a demand of 15.8 million movements within Europe by the year 2020. This volume of traffic will demand a quantum increase in airspace and airport capacity. Many initiatives have been successful in increasing capacity in the en-route environment. These include inter alia:

- the introduction of a revised European Route Network (ARN Version 4);
- the requirement for the carriage of Basic Area Navigation Systems (B-RNAV) ;
- the principle of the Flexible Use of Airspace (FUA);
- the Reduced Vertical Separation Minima (RVSM) Programme.

These improvements to the European Air Traffic Management System are predicted to provide an increase in capacity of over 50% in the en-route environment by 2005.

It can, however, be argued that the biggest challenges have yet to be met in the form of airports and terminal airspace. In future, airports and the immediate airspace around them will be brought increasingly into focus. Indeed, airport congestion, already a problem at many major airports, is likely to become an even more serious constraint. Runway availability may be perceived as the ultimate constraining factor. This shift of emphasis towards the airports and associated terminal airspace will become a major challenge in the immediate future.

Enhancement of the capacity of terminal airspace has been an ongoing and coordinated activity of EUROCONTROL and its stakeholders for the past 7 years under the auspices of the Airspace Optimisation Programme. The 'gate-to-gate'[11] concept has extended the scope of this activity to the airport domain. In this context, the inter-relationship between airports and associated airspace should be studied to identify problem areas and to determine what actions are necessary to enable capacity benefits to be achieved. It is also very important not to examine a particular location in isolation, but to consider it in its regional context. This is even more important at locations where airports are situated in close proximity to one other.

Capacity at an airport cannot be considered in isolation, as there is a complex interaction between the airport infrastructure and the surrounding airspace. Furthermore, the combined analysis of airport and airspace is critical, as constraints which appear in the airspace may, in fact, originate from the ground, and vice versa.
This may be illustrated by the example of the Zurich terminal area, where radar spacing of 20 NM is sometimes applied. When examined more closely, the reason for such spacing is due to the position of the Instrument Landing System Glide Path for runway 16. This precludes heavy aircraft from passing the holding point when an arriving aircraft is within 20 NM of touchdown.

The interaction between airports may also result in a situation where a capacity-enhancing initiative at one airport introduces a constraint on an adjacent airport, resulting in an overall loss of capacity.

Factors that have an influence on this subtle interaction between airport and terminal airspace can be grouped into four main categories: environmental factors, airspace design, ATC operating procedures and the availability/ configuration of runways.

5.2.2. Interactions between airport and terminal airspace

European airspace consists of a number of national areas, many of which, in aviation terms, are small. In addition, within these national areas, the airspace may be further divided into regions. This leads to locations being developed without regard to the needs of adjacent, interacting, locations, leading in turn to a sub-optimal airspace organisation. Cooperative planning should be promoted between locations in close proximity. It is essential that airspace and airports be considered as a continuum, and that design and management procedures be revised as necessary to take full advantage of advanced technology

5.2.3. Interacting traffic flows

Many areas of terminal airspace have interacting traffic flows. These may be between adjacent locations or even at the same location (arriving and departing flows). Such interaction leads to additional controller workload in order to resolve conflict situations which could possibly result in capacity constraints. The designated method of remedying this constraint involves de-conflicted arrival and departure routes, either geographically or vertically. This may be based on new technology such as advanced navigation systems, or in the future on the use of VTOL operations.

5.2.4. Airspace design

Many terminal airspace structures were designed for a previous generation of aircraft with significantly lower performance than modern fleets. This results in an airspace organisation which may not be appropriate for today's requirements. Thought is being given to redesigning terminal airspace, for example re-sectorisation to allow continuous climb and descent profiles to be accommodated.

5.2.5. Environment

Airports are built to serve populated areas, and, even if initially constructed some distance from the main areas of population, are subject to urbanisation.
Aircraft operations in the vicinity of such populated areas are increasingly subject to restrictions, leading in many cases to 'environmentally capped' capacity at airports. Solutions could be sought using advanced navigation systems (RNAV) to enable more flexible and accurate navigation, thereby reducing noise impact on populated areas.

5.2.6. ATC operating procedures

ATC letters of agreement between adjacent sectors do not reflect present-day requirements. At many locations, there is an increasing need at least to commence initial sequencing of traffic at a much earlier stage than at present. This lack of initial sequencing leads to an overload of the sequencing sector capacity due to aircraft bunching and consequently holding requirements. A need has been identified for revised operating procedures and training to provide for sequencing in sectors associated with the initial stage of arrival. In this situation, arrival managers may become a prerequisite in areas of high-density air traffic.

5.2.7. Runway configuration

Many airports in Europe have a converging runway configuration. The full runway capacity for such configurations cannot be achieved, especially under Instrument Meteorological Conditions (IMC), owing to current operating procedures and lack of ATC support tools. The development of new ATC procedures to allow for Simultaneous Converging Instrument Approaches (SCIA) or Dependent Converging Instrument Approaches (DCIA) utilising a Converging Runway Display Aid (CRDA) will allow for increased runway utilisation especially under IMC.

5.2.8. System requirements

Airspace users are increasingly driving towards more cost-effective operations with the use of onboard advanced navigation systems. Greater emphasis is therefore being placed on the need to achieve continuous climb and descent profiles and to reduce track mileage flown, because this reduces fuel burn and provides cost savings.

Trials implemented at certain locations in Europe, together with a number of simulations carried out, indicate that it is possible to achieve these goals but only in low traffic density situations. Indeed, in medium/high traffic density situations, the requirement to provide maximum capacity compromises the ability to allow for CDAs and the use of advanced navigation systems, because it is more difficult to accommodate such a descent profile in an arrival sequence. In addition, in high traffic density operations, track mileage may be extended to provide a traffic sequence in order to maintain optimised runway capacity.

The need for the introduction of controller sequencing support tools has been identified at a number of locations in Europe, in order to ensure that controller workload remains within acceptable margins. Tools such as MAESTRO (Paris) and COMPAS (Frankfurt) provide additional support for sequencing. The EUROCONTROL initiative with regard to arrival management is ARETA (ATM with RNAV in the Extended Terminal Area), which will provide the controller with action advisories in the form of speed, level and track information, in order to

- increase overall efficiency;
- reduce delays;
- reduce costs;
- reduce environmental impact;
- reduce workload for controllers and pilots;
- improve capacity.

ANNEX 1:

TORS OF RACE TF

AIRPORT OPERATIONS TEAM (AOT)

RUNWAY CAPACITY ENHANCEMENT TASK FORCE (RACE-TF)

Creation date: 18/05/99	Chairman: Gregory De Clercq
DSA/AOP	Secretary: Paul Adamson

TERMS OF REFERENCE

Introduction

In order to increase airport air-side capacity at both major and secondary airports, use of the runway(s) should be optimised. A task force of experts is therefore needed to enhance runway capacity.

Objective

The objective of the RACE-Task Force is to enhance runway capacity in order to contribute to the optimisation of air-side capacity.

Authority

The RACE-TF is created by the EATMP Project Leader and reports to the AOT.

Tasks

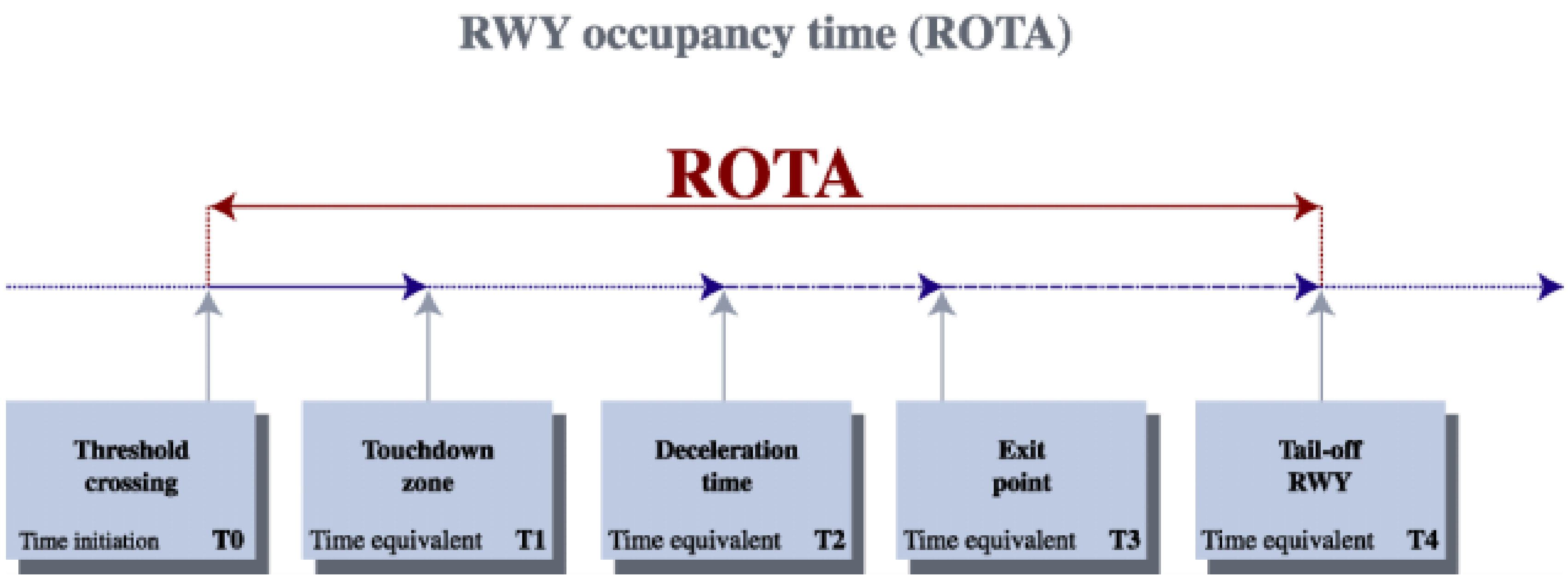
- Collect, analyse and qualify current and future practices and plans for enhancing runway capacity in ECAC and other regions.
- Establish runway capacity enhancement objectives and propose target dates for their implementation.
  - Publish a guidance document regarding runway capacity enhancement measures and encourage its use throughout ECAC.
- Encourage and monitor the implementation of such objectives.
- Identify the links with both land-side and airspace management.
- Provide guidance to AOT on the application of enhanced technologies.
- Develop harmonised models to measure pilots' and controllers' performance in terms of efficient runway utilisation.
- Maintain a close relationship with the Airport Airside Capacity Analytical Modelling Task Force (ACAMTF).

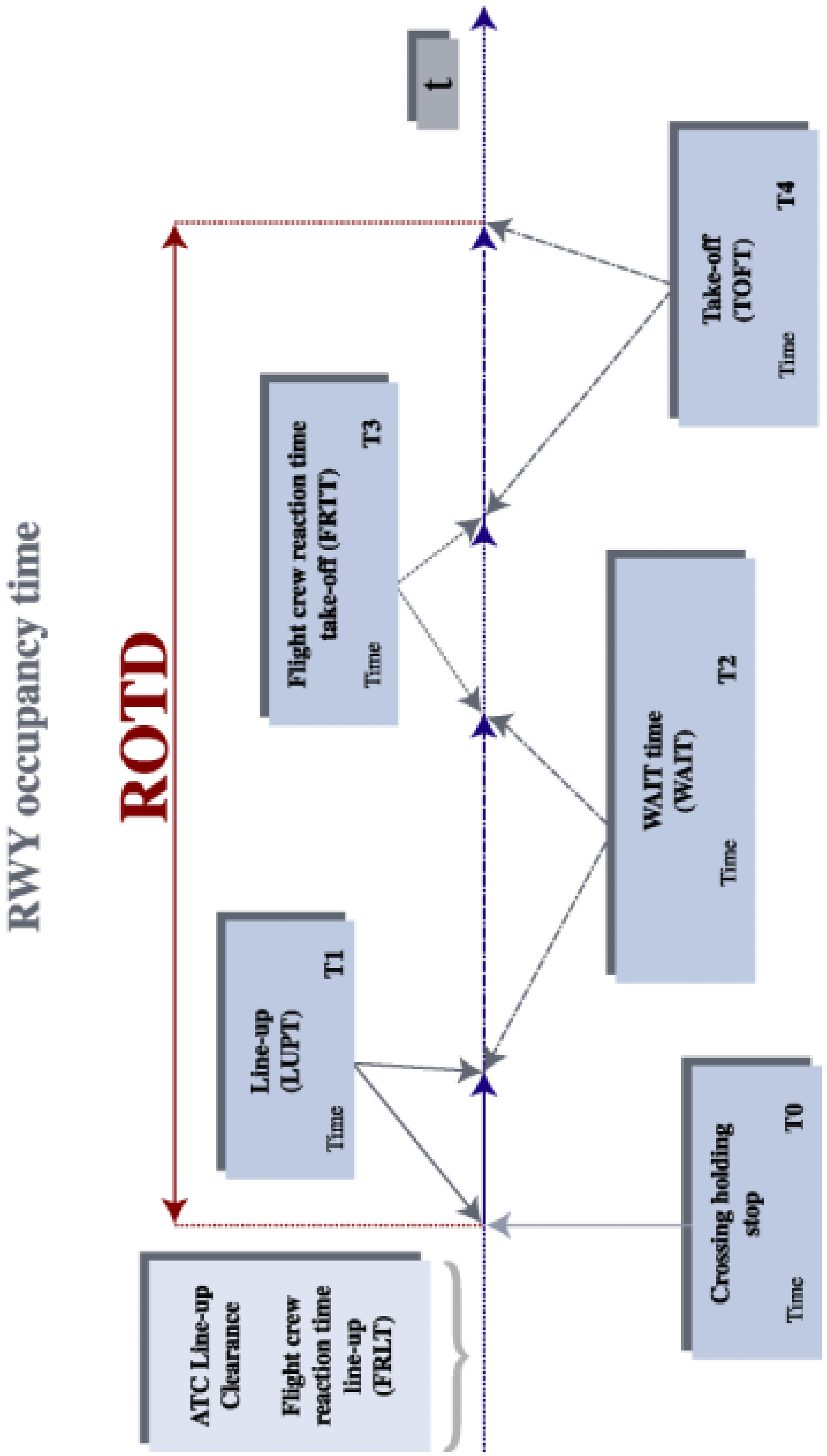
Participants

ATS representatives from ECAC Member States, representatives of ICAO and other international organisations, representatives of user and airports organisations/associations, including the pilot community, EUROCONTROL Agency experts

ANNEX 2:

ROT DEFINITIONS


RWY occupancy time (ROTA)
ROTA
Threshold crossing
Time initiation T0
Touchdown zone
Time equivalent T1
Deceleration time
Time equivalent T2
Exit point
Time equivalent T3
Tail-off RWY
Time equivalent T4


RWY occupancy time
ROTD
t
Take-off (TOFT)
Time
T4
Flight crew reaction time take-off (FRTT)
Time
T3
WAIT time (WAIT)
Time
T2
Line-up (LUPT)
Time
T1
Crossing holding stop
Time
T0
ATC Line-up Clearance
Flight crew reaction time line-up (FRLT)

ANNEX 3:
ENVIRONMENT

ANNEX 3
APPENDIX A

ICAO-CAEP WG/2 WORK PROGRAMME

Noise abatement operating measures

- Define a menu of operating procedures and strategies which are conducted in a safe manner to reduce aircraft noise exposure around airports, while minimising the effects on capacity and on pilot workload.
- Examine and assess noise abatement operational procedures for helicopters.
- Develop guidance material and standardised analytical techniques for evaluating alternatives.
- Develop guidance material for establishment and operation of noise abatement flight track corridors.

Land-use planning

- Identify practices and techniques for long-term compatible land-use protection around airports.
- Assess the success of these practices and techniques.
- Develop guidance material for creating and encouraging appropriate land-use planning around airports.

Environmental guidelines for airport planning

- Examine the impact on the environment of ground activities related to aircraft operations.
- Investigate the environmental impacts of airport infrastructures, construction, expansion and operation.
- Provide material to update Airport Planning Manual, Part 2 – Land-use and Environmental Control (Document 9194)

Airport noise monitoring

- Compile data on methods used to describe aircraft noise exposure and applications of the data.
- Collect data on characteristics of airports with noise and/or flight path monitoring systems.
- Collect details of airport noise monitoring systems such as capabilities, data stored and technical support.
- For a suitable sample of airports, compare calculated and monitored noise levels.
- For a range of aircraft types and operating conditions, compare measured noise levels with certified noise levels.
- Examine changes in measures noise exposure over a representative time period.
- Update advisory documents on methodologies and applications of noise contouring and monitoring.
- Fully develop and validate the Global Airport Noise Impact Assessment Model.

ANCAT Task Force on Procedures Linked to Abating Noisy Operations (PLANO)

Terms of Reference of PLANO

❶ The Task Force on Procedures Linked to Abating Noisy Operations (PLANO), shall have as its main purpose to:

- serve as a forum for exchange of information related to current and planned operational noise mitigation measures around airports;
- undertake further development of such measures, recognising developments in ICAO-CAEP WG/2, with a view to presenting proposals for later consideration within CAEP.

❷ In addition to experts from Member States, the TF may also comprise participants from the European Community and EUROCONTROL. Observer Organisations representing operators, pilots, manufacturers, and airports shall likewise be invited to take part in the work of the TF.

❸ The Rapporteur of the TF shall normally be responsible for the issuance of written or oral progress reports at each regular meeting of ANCAT.

❹ The Work of the Task Force shall be completed prior to the CAEP/5 meeting in 2001.

AIRPORT PLANNING MANUAL (ICAO DOC 9184, Part 2): LAND USE AND ENVIRONMENTAL CONTROL

The Airport Planning Manual Part 2 is currently up-dated by ICAO-CAEP WG2. It provides guidance material on:

- Environmental impacts associated with aviation activities
- Environmental consequences and control measures
- Land-use
- Land-use planning
- Land-use administration
- Cases of effective land-use management (Amsterdam Airport Schiphol, the Australian Experience, Washington Dulles International Airport, and Brazil)
- Land use guidelines for the avoidance of bird hazards
- Fact sheets on land-use measures in various countries.

Land-use planning – Chapter 5 (General)

The problem of noise in the vicinity of airports can only be solved by pursuing all possible means for its alleviation, and the benefits which can be derived from proper land-use planning can contribute materially to the solution. Although in many instances the benefits to be derived from land-use planning may necessarily be long range, any solution to the problem is also likely to be long term. Efforts to correct situations detrimental to proper land use around airports should not be ignored because of the time required for such measures to become effective. This is particularly appropriate to applications of land-use planning to existing airports where it is recognised that the ability to make immediate land use changes is limited, but where it is also important to prevent additional encroachment of incompatible land uses as aircraft source noise decreases and noise contours retreat closer to the airport boundary. There are substantial benefits to be gained from the correct application of land-use planning techniques to the development of new airports. The value to be derived from proper land-use planning should not be overstated but, on the other hand, it is believed more attention should be paid to this useful tool.

Third party risks – Chapter 5 (General)

Airports are centres for air traffic in the air transportation system. Consequently, their presence causes a convergence of air traffic over the area surrounding the airport. For the population living in the vicinity of an airport this implies involuntary exposure to the risk of aircraft accidents.

Although the public is generally aware of the fact that flying is a very safe mode of transportation and hence the probability of an accident is very small, the increasing frequent noise associated with aircraft passing overhead acts as a strong reminder of that possibility, that sooner or later one might come down.

In order to prevent a predominantly emotion-driven role of third party risk in the evaluation of airport development options, objective and accurate risk information is required to provide guidance to local and national authorities, the population around airports and the airport operators. Because no adequate method for third party risk assessment existed world-wide, the National Aerospace Laboratory (NLR) of the Netherlands was contracted by the government of the Netherlands to develop a comprehensive method for the assessment of third party risk around airports, and to apply this method to the development plans of Amsterdam Schiphol Airport.

Risk contours can now be calculated using this method and appropriate measures of the same type as for noise contours can be established.

ADDITIONAL TAKE-OFF AND APPROACH NOISE ABATEMENT PROCEDURES

Modified ATA Procedure

For aircraft licensed in accordance with ICAO Annex 16 Chapter 3 as well as B 737-200s insofar as the noise levels for take-off pursuant to ICAO Annex 16 Chapter 3 have provably been reached by supplementary equipment.

Take-off

- Take-off flap/slat setting, take-off thrust
- Acceleration to V2 + 10 kts
- Climb to 1500 ft GND maintaining V2 + 10 kts.

At 1500 ft GND

- Climb thrust
- Accelerate to Vzf (clean speed) + 10 kts maintaining a constant rate of climb (minimum 500 fpm)
- Flap/slat retraction according to schedule (if Vzf + 10 is higher than 250 kts, request clearance from ATC)
- Normal transition to en-route climb.

Advantages of the modified ATA procedure (fast and shallow) over the IATA procedure (slow and steep) procedure:

- Less noise directed towards ground owing to lower pitch angle
- Noise impact of shorter duration on measure points owing to higher flyby speed
- Reduced speed difference between exhaust jet and surrounding air, leading to less noise generating turbulence
- (above items outweigh lower vertical profile)
- Fuel saving, less emission.

Future ATM with RNAV in Extended Terminal Area Operations (ARETA)

Executive Summary

The ATM 2000+ Strategy identifies flow management and terminal air traffic control as two areas where operational improvements are required. The strategy also recognises that ATM services must provide enhanced flexibility and efficiency, must extend levels of automation and communication support and must allow collaborative decision-making.

The EUROCONTROL Agency and the Member States have been addressing these areas in a number of projects over the year. However, there are two ongoing EUROCONTROL activities which have the potential to provide significant short-term benefits, namely Arrivals Management (AMAN) and Area Navigation (RNAV) in the terminal area.

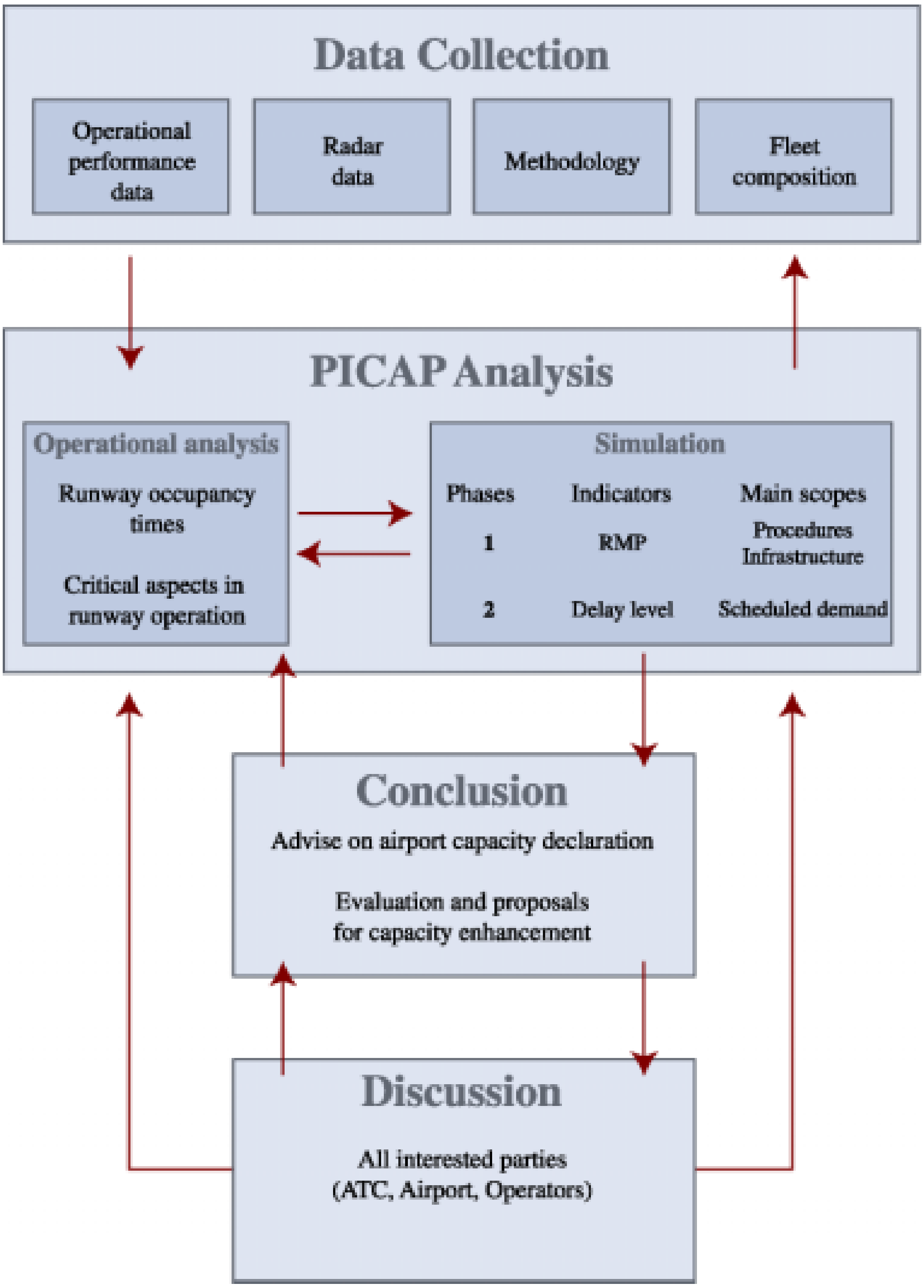
AMAN with RNAV offers the potential for increasing the flexibility of terminal operations and improving system efficiency, which may in turn result in some gains in capacity. Moreover, it will facilitate the use of engine-idle continuous descent approach (CDA) in medium to high-traffic densities, thereby significantly reducing the costs to the operators and generating environmental benefits.

Trials at Frankfurt and Schiphol have shown that the implementation of CDAs and RNAV procedures in the terminal area can bring significant cost savings and environmental benefits. In the case of CDAs, fuel savings in excess of 100 kg per approach have been achieved together with appreciable noise reductions. It has been estimated that, if 100% of the approaches to CIP Class 1 and 2 airports within the ECAC area were flown as CDAs, at a conservative estimate the annual fuel savings (based on EUR 0.2/kg kerosene) would be in the region of EUR 100M for Class 1 airports and in the region of EUR 37M for Class 2 airports.

ANNEX 4:

AENA INTEGRATED EXAMPLE METHODOLOGY

PICAP METHODOLOGY



ANNEX 5:

CASE STUDIES

CASE STUDIES BASED ON OVERALL BEST PRACTICES AT GATWICK AND FRANKFURT

Any airfield attempting to build, or to maximise runway capacity should consider a number of actions detailed below. These actions are in no particular order, and may be undertaken simultaneously and on an ongoing basis.

Runway occupancy leaflet

A leaflet should be produced which will explain to aircrew the importance of expeditious movement on and off the runways. To allow an element of pre-planning, the positions and locations of RETs should be detailed.

An explanation of ATC procedures in use should be included to confirm they are fully understood by aircrew. Examples to be considered for inclusion are the use of conditional clearances and the “land after” types of procedure.

Details comparing pilot performance between different airlines may be included to promote best practice. This should be grouped by aircraft type to enable valid comparisons to be made.

User performance

To allow comparisons to be made and to establish where improvements are possible, a programme of measurement should be initiated. This should include elapsed times for line-up, start of roll and time required to vacate the runways after landing.

Airline coordination

A close working relationship with senior pilots from airlines that operate at the airfield must be established. Such liaison will assist in identifying and disseminating best practice.

In addition to liaison with senior pilots, regular forums are recommended between line pilots and operational controllers. New ideas can be discussed and techniques developed to increase efficiency.

Separation of final approach

Subject to ICAO guidelines, the use of reduced radar separation of 2.5 NM on final approach should be employed whenever possible.

Airfield infrastructure

In conjunction with the airfield authority and representatives of based airlines, the existing infrastructure should be examined to establish where improvements are possible. New RETs/RATs and taxiways must be considered if these would enhance capacity.

This examination should be on a regular basis and be reviewed in the light of changing traffic profiles. For example, an increase in the number of heavy aircraft may necessitate an additional RET near to the end of the runway.

Any changes considered can be modelled to establish the likely capacity benefits. This information can be used to produce a cost-benefit analysis of the proposal.

Capacity declaration

The capacity declaration should be constructed carefully using an established modelling technique. Peaks of traffic that cannot be sustained by the runway must be avoided, as these lead to congestion and reduced efficiency.

A slot performance committee should be established to ensure that, whenever practicable, airlines adhere to their coordinated runway slots.

A process must also be introduced to ensure that there is an established procedure for extra flights to obtain runway slots.

Air traffic control

A coordinator role should be established in the VCR to take overall control of the air traffic operation. This person should be the focus for all issues that may impact on the operation.

Close liaison should take place with controllers from area control to establish close working relationships. Regular best practice meetings should be held, to be attended by as many operational controllers as possible.

Flight Operations Committee (FOC)

Ensure that an FOC is established at the airport. In this forum, matters of joint interest can be discussed and improvements identified that may be introduced by both ATC and airlines.

The capacity declaration should be discussed and explained within the FOC. It is essential all airlines/flight crew are aware of the level of traffic demand to improve their understanding of why runway performance must be optimised.

Summary

It is stressed that the work discussed in this paper is seen as a joint approach to improving efficiency by ATC, airlines, IATA and the airport authorities.

All improvements to the operation must involve common effort and consensus in order to enable real improvements to the operations to be obtained.

CASE STUDIES ON OVERALL BEST PRACTICES AT MADRID AND BARCELONA

General

Since 1997, the main Spanish airports - such as Madrid and Barcelona - have been eligible for a PICAP[12] study, as a result of which decisions could be made regarding changes in runway capacity. The PICAP team is a multidisciplinary group of ATM/CNS experts, officially established by AENA in 1997 to obtain a thorough knowledge of the Spanish airports' runway operations so as to provide accurate capacity figures and therefore better meet users' requirements.

PICAP methodology has proved to be a reliable decision-making process through which significant capacity gains have been achieved at a number of Spanish airports. To date, 17 of the 43 Spanish airports have been analysed. More than 30,000 operations have been collected and more than 15,000 hours of fast-time simulation have been conducted. This exercise covers 80% of the total number of movements. The remaining 26 airports are expected to be studied in the coming years (2001/2004). Between winter 1997 and the present, it has been possible to quantify capacity benefits of the order of 150 additional movements for the complete Spanish airport network.

The PICAP operational studies involve all the parties concerned, such as airspace users, airport authorities, ATS providers, IATA, etc., with the result that:

- roles and responsibilities are clearly identified;
- participants have at their disposal identical set capacity constraints when discussing enhancement measures;
- effective collaborative decision-making processes (CDM) are established.

MADRID-BARAJAS AIRPORT

The construction of a new runway 18R/36L has undoubtedly been the main capacity enabler, as a result of which declared capacity increased to 74 movements per [?] (dated winter 2000) and 78 (39 Arr / 39 Dep) for summer 2001. However, several other operational capacity enhancement initiatives have helped to maintain these capacity improvements, such as:

Monitor user performance

Briefing sessions have been held to explain and discuss:

- the HIRO concept;
- the need to reduce ROT (since 1997, more than 4,500 movements have been recorded with a view to analysing pilot performance in order to minimise ROT);
- the new ATC procedures.

ATC departure procedures

- Intersection take-offs (general implementation for turboprops following an agreement with airlines and taking into consideration the length of the runway).
- Reduced runway separation (still in the CAA approval process, implementation expected in the course of 2001).
- Special departure procedures for turboprops (environmental constraints and restricted airspace in the vicinities of the airport are delaying the implementation of these procedures).
- Departure sequence optimisation.
- Improved ATC co-ordination procedures.

ATC arrival procedures

- Approach speed limits.
- Implementation of APATSI procedures such as reduced runway separation.
- Feasibility of 2.5-NM radar separation on final approach to runway 33.

Airfield infrastructure

- Construction of new RETs on the landing runway (RWY 33).
- Construction of a new runway (36L/18R).

Other Indicators

- Quantification and analysis of number of go-around/missed approaches and identification of the reasons.
- AIP.
- Approach speed limitations.
- Minimum runway occupancy time (arrival and departure).
- Recommended RETs to vacate the runway (together with their corresponding R-LDA).

LEMD : SUMMARY

CRITICAL ASPECTS	PROPOSALS	ENHANCEMENT	
Fleet composition	Improvement of scheduling	Better use of runway capacity	In progress
	Special turboprop SIDs	Average increase in departures (23%)	Medium term
Departure separation	Intersection take-off	Reduction in runway occupancy time (13%)	Applied
	Reduced runway separation	Aerodrome separations in accordance with LoA separations	In process
	Early turns		Medium/Long term
South configuration	Amendment of procedures	Both configurations balanced	Medium term
	Improvement of DEP sequence		Medium/Long term
	Improvement of DEP sequence	Better use of runway capacity	Medium/Long term

BARCELONA-EL PRAT AIRPORT

The capacity enhancement initiatives taken at Barcelona are of a similar nature to those applied at Madrid. Following the analyses undertaken by the PICAP team, a number of capacity enhancement initiatives have been recommended. The implementation of these enabled the declared capacity to be increased from initially 40 (winter '97) to 52 movements per hour (winter 2000)

Monitor user performance

Briefing sessions have been held to explain and discuss:
the HIRO procedural concept.
the need to reduce ROT (since 1997, more than 10,000 movements have been recorded with a view to analysing pilot performance in order to minimise ROT). Recorded average pilot reaction times of 8 seconds are considered indications of good performance.
The new ATC procedures.

ATC departure procedures

- Intersection take-offs.
- Improved ATC coordination procedures.

ATC arrival procedures

- Approach speed limits.
- Implementation of APATSI procedures such as reduced runway separation.

Airfield infrastructure

- New RETs (3 RETs available on runways 07 and 25).
- Holding area enlargement (RWY 07/20).
- New RAT (RWY 20).

Other indicators

- AIP.
- Recommended RETs to vacate the runway (together with the corresponding R-LDA).
- Minimum runway occupancy time (arrival and departure).
- Approach speed limitations.

CASE STUDIES ON USER PERFORMANCE MEASUREMENT AT GATWICK AND HEATHROW

(Developed by BAA plc)

Since 1995, BAA, in partnership with airlines and NATS (the local ATS provider), has been running a program to measure pilot performance. The purpose of monitoring flight crew performance and analysing and distributing this data is to encourage all airlines to improve performance, while still ensuring safe operation, to best-in-class level.

The method has been adopted at both Heathrow and Gatwick. The focus at Heathrow is on the occupancy of the departure runway. Gatwick has concentrated on the landing phase. Initially, both phases of the operation were measured at Heathrow. However, the Heathrow exits, while due to be improved, are not perfect. In the circumstances, it was thought important not to let issues of infrastructure design detract from the message regarding the importance of pilot performance, and consequently arrival performance measurement was temporarily curtailed.

Data collection

To collect the data, BAA uses the Psion 3a because, as a refurbished item, it is cheap, robust and easily programmable, it has a good life from 2 AA batteries, and the memory inserts hold about 10,000 movement records. Data are transferred to a PC for analysis. The program is able to record a time-stamped history of the events associated with an arrival and a departure movement.

Analysis methodology

A pilot performance score based on the middle 50% of delay observations (defined as the characteristics of the 'core' pilot group) compares the fleets of common, or similar, aircraft types. The airline fleet whose core pilot group has the lowest maximum delay is defined as the best-in-class. Each airline fleet is 'scored' according to the percentage of that airline's core pilots who match the performance of the best-in-class. This approach gives a good indication of the relative difference in pilot performance.

Summary

Step	Comment
Group similar aircraft fleets	e.g. aircraft of a similar wake vortex category
Define core pilot performance as the performance of the middle 50% for each airline/fleet combination	e.g. the airline flight crew excluding the best and worst 25 % of performance
Identify the airline which is the best-in-class for each group	e.g. the airline with the best performance when 75% of the flight crew are considered.
For each fleet compute the score as the percentage of core pilots who match the performance of the best-in-class	e.g. if 40% of pilots achieve the level set by 75% of the fleet which is best-in-class, the fleet has a score of 2*(40-25) = 30 %

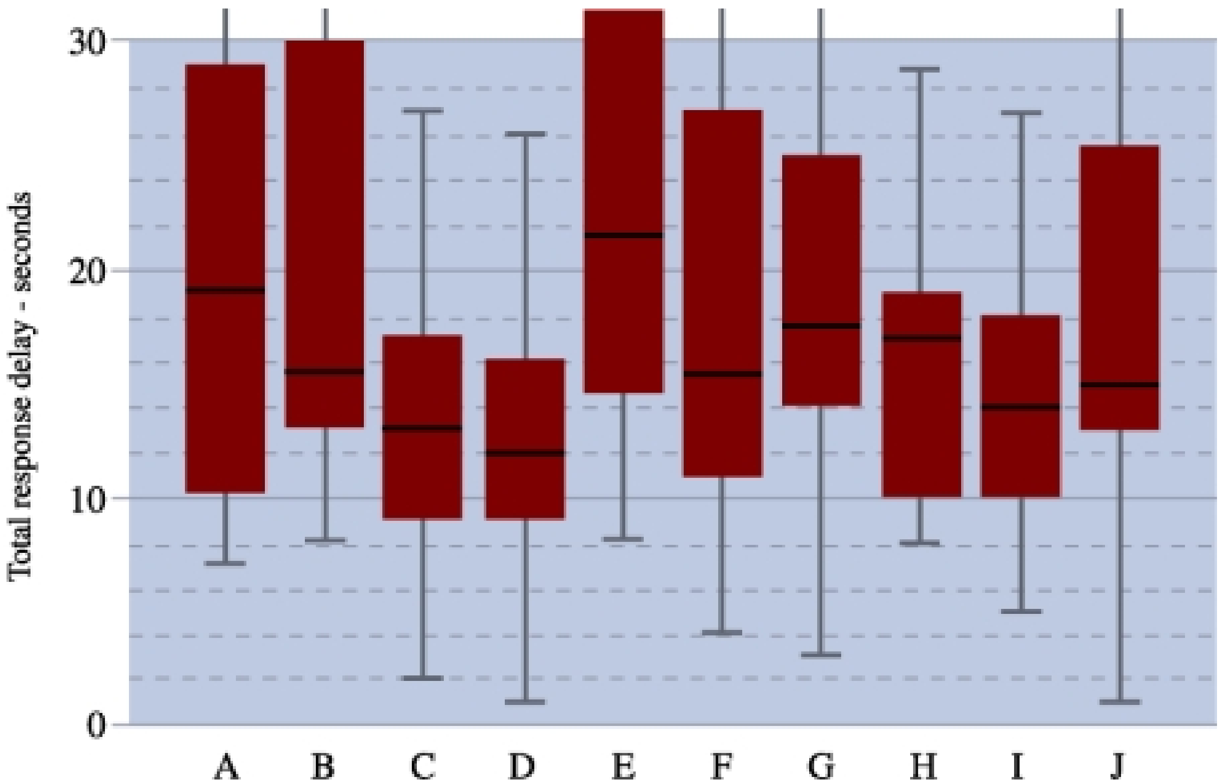
Example interpretation

The following figure shows the time lapse between take off clearance and start of roll for a B737 and an Airbus 320 following a B757. This is defined at the total reaction score.

The figure shows, for each airline denoted A to J on the x axis, the performance of the middle 50% of the pilots as a red box. The airline whose core pilots have the quickest overall reaction time is D. All the core pilots of D are below this time, approximately 13 seconds, so they score 100%. The next best airline is C, and their score is say 95%. Fleet E has a very low score, say 5%. It should be noted that the various European States have different rules for the wake vortex category of departing B757 aircraft, and this figure reflects the national differences.

HEATHROW SURVEYS

RESPONSE TO B737/EA32 FOLLOWING B757

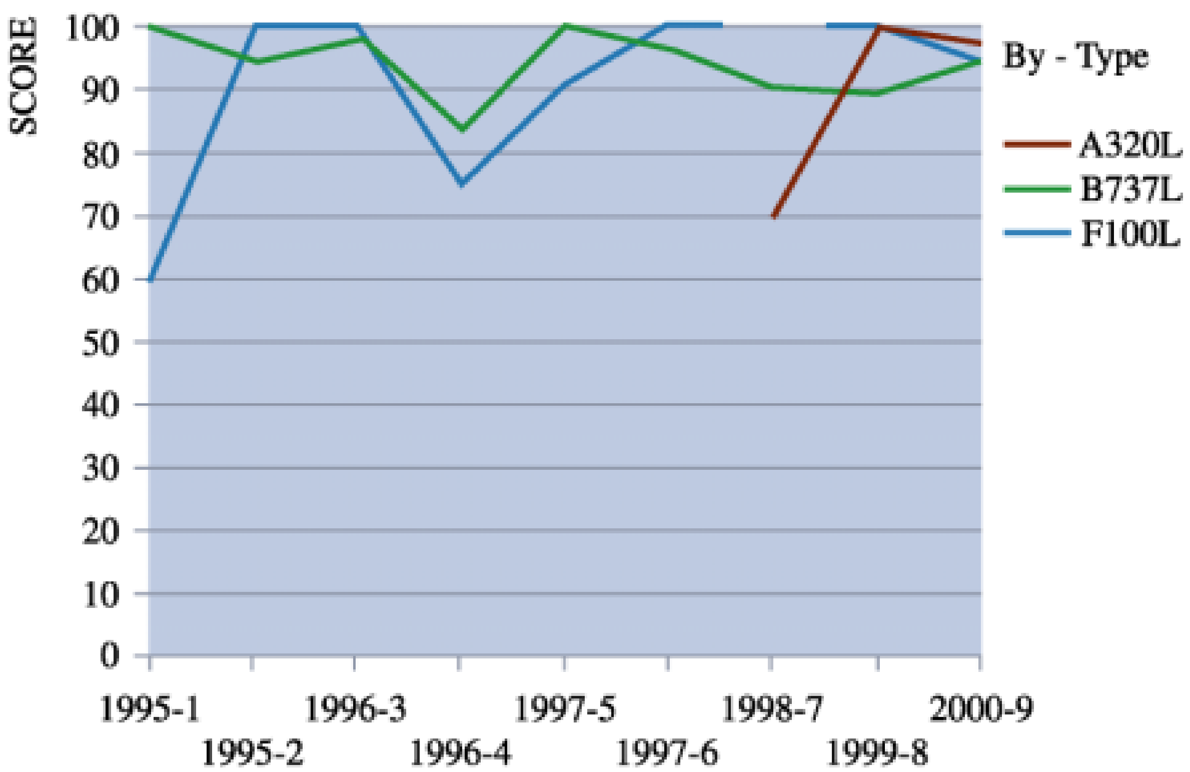


Reviewing the results

BAA and NATS started the process by publishing performance data which mirrored that input into the Hermes model. This is a tool which NATS uses to determine the declared runway capacity. They reported scores for pilot line-up times and reaction to 'take-off' clearance once the aircraft was lined up on the centre line of the departure runway. The benefit of the approach was that the two groups could compare the basic data which were collected and thus check the quality of data collection.

It has subsequently it was noted that the reaction and line-up scores do not expose the delays caused by rapid line-ups who react slowly to take-off clearance or by slow line-ups who receive clearance on the roll. It is inappropriate to use a measurement process which allows a flight crew with significant delays between take-off clearance and take-off to achieve a good score for a quick reaction because they took 90 seconds to line up and 'reaction' was measured only once they were lined-up. Likewise, it is important not to debate the interpretation of the statistics but rather the process. For example, because of the simplifying assumptions in the method used, the core pilot group may not be the same pilots assessed for line-up and reaction.

LINE-UP SCORES



To maintain consistent ease of analysis, it was subsequently decided to measure the reaction time from the time the take-off clearance was issued, and the reaction performance score has been issued on this basis since 1998.

Additionally, a follow-on score has been calculated which measures the time between a previous start-of-roll and the next aircraft being lined-up ready for take-off. It is specifically directed at the loss of capacity caused by pilots who line up slowly in an attempt to second-guess the moment at which the controller will issue take-off clearance. Their objective is to avoid the aircraft coming to a dead stop. The observations show that the benefits of a rolling take-off are outweighed by the delays generated by pilots who take too long to line up.

Feedback

When the process was initiated, the feedback took the form of scores only. Each airline would receive a graph in the general form of the Figure below.

After a period of years, BAA arranged a seminar with airline representatives. There was a common consensus that presentation by comparison with best-in-class did not challenge safety. There was no adverse criticism on this point from any of the 100 participants. On the contrary, there seemed to be a general desire for more detailed information and for the specific times which were measured.

After the Summer 2000 measurements, this issue was addressed by adding times to the individual feedback sheets. It should be noted that BAA decided that the principle of comparative performance by the core pilot groups was still important, and this has been carried through in the presentation. However, the opportunity has been taken for like-on-like comparisons with directly similar aircraft rather than between groups which include say B737s, A320s and MD80s.

The two tables in the feedback show the A320 and B737 fleets of British Midland. In terms of the A320 category, British Midland had the 100% score for Summer 2000. With a count of 952 movements, their performance had been chosen as a statistically meaningful best-in-class. It should be noted that they were between 2% and 6% above the airline with the best times, but its sample was too small to be considered statistically significant.

Mode	Airline	Aircraft	Count	low Core	High Core	Range	Excess
Line-up	BMA	A320	952	36	53	17	2%
Reaction	BMA	A320	952	11	18	7	6%
Follow-on	BMA	A320	952	37	58	21	4%

Mode	Airline	Aircraft	Count	low Core	High Core	Range	Excess
Line-up	THY	B737	44	36	52	16	0%
	BMA		1695	35	54	19	4%
Reaction	THY	B737	44	11	18	7	4%
	BMA		1695	12	20	8	18%
Follow-on	THY	B737	44	38	56	18	0%
	BMA		1695	37	59	22	6%

The B737 fleet is not best-in-class, although it is very close. In this case, reference data from the best performer is provided to improve the insight of the management pilots. If the low core was much greater than the best-in-class, this might imply that the actions prior to take-off were constrained by some procedural issue - perhaps the pre-take-off checks. BA, for example, undertook a review of take-off-checks and, while increasing the number of items overall, actually reduced those required after the aircraft was on the runway. If the range between pilots in the fleet is significantly higher than the best-in-class, this might imply that the training regime is producing inconsistencies in the procedures.

With a total count of 44, as in this reference fleet, only 22 movements are being included in the comparison. The fleet captains can decide what weighting to apply to the data.

Follow-up

A great deal of the benefit is due to the commitment by the BAA Operations Director to engage in a dialogue with the fleets. This is a public statement of the importance which the company attaches to efficient operation by its customer airlines. It is also an opportunity to identify the very practical steps which can be taken by the airport, the airline, or the ATC service provider. Not all problems have a local solution.

For example, for some aircraft fleets the authorised maximum taxi thrust at certain base airports may be influenced by the high percentage of light aircraft which can potentially suffer from jet blast. Consequently, the fleet SOPs may restrict thrust at all airports in order to minimise the potential for error at the home bases.
Some States, but not all, classify a departing B757 as heavy. The effects of this are illustrated by the delays in the previous Figure. Such anomalies can be removed only by an ICAO decision on unified treatment of aircraft.

There are, however, local solutions. For example, some fleets require a satellite down-link for take-off trim, flap and thrust settings. Prior to the survey, these aircraft would often line up without clearance, blocking the runway until it was received, because they feared losing their place in the departure queue. Discussions between all parties involved have now established that aircraft awaiting settings will not lose their place in the queue as long as they notify the departure controller in good time. Similarly, the expectations for pilot performance at HIRO sites has been clarified by the carriers' including the briefings in the pilot notes.

The flow of information is also two way. The increasing proportion of big twins has increased some delays. This is because of the greater spool-up times and the very high thrusts. (A B777 engine at idle has the take-off thrust of a DC9). As a result, airports have been made aware that stand gradients which were acceptable in the 1960s now are too steep for the big twins.

CASE STUDIES ON ENVIRONMENTAL ISSUES AT SCHIPHOL AIRPORT HEATHROW AIRPORT SALZBRUCK AIRPORT

SCHIPHOL AIRPORT

In order to accommodate the growing air traffic demand, the following measures have been implemented at Schiphol Airport with a view to reducing the environmental impact.

The continuous descent approach (CDA) procedure

At Schiphol a new approach procedure has been introduced on runway 06. This noise abatement procedure is called the CDA. Inbound traffic approaches Schiphol from a higher altitude of 6/7000 ft without level-off segments. Compared to conventional approaches, CDAs show substantially lower fuel consumption and less noise exposure on the ground. This reduction in footprint noise will also reduce the effects of night traffic, with the result that fewer complaints can be expected from the surrounding communities. Furthermore, a reduction in footprint noise can be turned into acceptance of higher traffic volumes.

However, owing to uncertainties in approach time prediction, the separation between approaching aircraft has had to be increased substantially. The typical landing interval had to be increased from 1.8 to 4 minutes. This measure clearly reduces the airport capacity dramatically. It prevents the procedure from being applied efficiently outside the quiet night-time period. As a consequence, the present CDA procedure can only be applied during quiet night hours when traffic densities are low. This reduces the potential benefits of the CDA procedure considerably.

Research is currently being carried out on both the cockpit and the ATC aspects, with a view to improving the accuracy and predictability of the CDA flight procedure in order to restore the separation distances to the level achieved by conventional procedures. The ultimate goal is an advanced continuous descent approach (ACDA) procedure that can be used even during peak hours.

Preferential runway use

Schiphol Airport has introduced a preferential runway use system. Owing to noise abatement procedures, the use of a non-preferential runway for take-off and for landing is not permitted unless specifically requested by the pilot for safety reasons. Runways to be used at Schiphol will be selected by ATC according to the preferential runway system, provided that the visibility is more than 2000 m and the cloud base is above 200 ft. The advantage of this is to manage the capacity better within the framework of the existing environmental legislation. Violation of this legislation could result in the closure of a particular runway or more stringent measures. The system is based on the following principles:

- Traffic safety prevails at all times.
- Departure and landing will normally take place on separate RWYs.
- In preference, a RWY equipped with ILS will be selected for landing.
- The preferential sequence for selecting runways to be used depends on the combination of noise impact and traffic handling.
- Wind criteria serve as guidelines for selection of the RWY combination(s) from the preferential sequence. These are in accordance with the guidance material laid down in ICAO Annex 16 (Noise).
- Deviations from an assigned RWY in order to obtain a shorter taxi route, departure or approach pattern are not permitted.
- The interlaced use of runways based on 4 specific periods (start-peak, landing-peak, off-peak and night).

Noise abatement procedures

The combined implementation of the following procedures has proved highly efficient in terms of noise abatement:

- ICAO take-off and climb procedure A;
- preferential runway system;
- minimum noise routeing;
- CDA procedure to RWY 06;
- reverse thrust above idle not to be used from 2200 to 0600 hrs.

Increased final approach altitude

A procedure has been evaluated whereby the final approach altitude was increased from 2000 ft to 3000 ft. This procedure produces a noticeable noise reduction and is already in force during night hours at Schiphol. The ultimate goal is to apply this procedure over a 24-hour period. A preliminary airport capacity study indicated that no serious problems are to be expected as regards ATC and airport capacity.

ILS/MLS glide-slope angle from 3° to 3.2°

The effect on noise reduction of increasing the ILS/MLS glide-scope angle to 3.2° as opposed to the currently used 3° has been evaluated. The main conclusion from this evaluation is that the combination of a 3.2° glideslope approach with full flaps resulted in more aircraft noise on the ground than a 3° glideslope approach with reduced flaps. On the basis of the "Kosteneenheid" noise calculation results, there was also a recommendation not to implement a 3.2° glideslope for approaches to RWY 27 (Buitenveldert) at Schiphol Airport.

HEATHROW AIRPORT

At present, Heathrow is handling 62 million passengers and over 440,000 movements a year. The following measures have been put in place to allow these movements and passengers to be handled within the context of the current environmental legislation.

Reducing environmental impact

The BAA Heathrow noise teams have a modern noise monitoring and flight track monitoring system to monitor and measure aircraft and airline performance in a number of areas. The focus has been on the following areas:

- noise monitoring for infringements of fixed limits by departing aircraft;
- improving compliance with aircraft noise preferential routes for departing aircraft;
- monitoring the use of continuous descent approaches, especially at night;
- carrying out arrivals noise studies to understand more about the variations in noise levels.

Night time restrictions

The UK Government places comprehensive night-time restrictions on aircraft operations at Heathrow. There is a movement limit for each scheduling season, and a noise quota count for each season, and neither limit must be exceeded. The movement limit is 5,800 movements per year. Night is defined as 2330 to 0600 local time, but there are scheduling restrictions on the noisiest aircraft between 2300 and 0700 local time.

Continuous descent approach procedure

CDA has been a requirement at the London airports since the mid-1970s. Flight crews are requested to apply the CDA in line with the UK Aerodrome Information Publication (AIP). CDA performances by individual airlines are reported, and every effort is made with operators and ATC to increase the use of CDAs, especially in the 0400-0700 period. ATC, BAA and users are working jointly to improve the rate of CDA approaches.

Final Approach Spacing Tool (FAST)

To enable Heathrow airport to achieve its maximum arrival runway capacity, it is vital that the achieved spacing between aircraft when crossing the outer marker, some 4 NM prior to touchdown, matches the required minimum. A Final Approach Spacing Tool (FAST) has been developed to assist air traffic controllers achieve arrival landing rates with increased accuracy and consistency.

NATS is planning an operational trial of FAST later this year. This should assist controllers in optimising route-ing to join the ILS (thereby reducing the amount of holding?) and may also increase the likelihood of arriving aircraft achieving continuous descent approaches (CDA). BAA Heathrow will monitor the trials.

Preferential runway use system

Heathrow operates a preferential system of runway use in order to minimise take-offs over the largest areas of population. A runway alternation system is in operation whereby one runway is used for landings and one for take-offs until 3 p.m. each day when they change round. This has recently been extended to cover the night period.

SALZBURG AIRPORT

The introduction of low-noise turboprop and jet aircraft types for regional services has had a very positive effect on noise contours around airports. In particular, regional airports often located close to urban zones or densely populated areas, have benefited from the operation of regional aircraft and their ideal noise contours. Modern high-bypass-ratio engines used for larger aircraft lead to shrinking noise-affected areas around airports. Data collected from some European airports reveal that, despite a marked increase in the number of movements, the noise zones around airports are decreasing and, in fact are shrinking rapidly. This trend has enabled some airports to extend their operating times for quiet aircraft types, thus offering more needed capacity.

The experience of Salzburg's W.A. Mozart Airport shows a clear reduction of aircraft noise by 80%, even though air traffic movements have increased by 114%. This experience follows the introduction of the following measures.

Chapter 3 aircraft operations only

In 1991 Salzburg Airport introduced a policy of Chapter 3 aircraft operations only. Furthermore, the airport is currently differentiating even within Chapter 3 with regard to aircraft operational hours.

Environmental strategy

One of the most important elements of the airport’s environmental strategy is cooperation with the Environmental Department of the City of Salzburg to control the noise situation around the airport with the help of a noise and flight-track monitoring system.

Acoustic exchange rate

A study based on noise monitoring data showed that between 1988 and 1995 the noise level has decreased from 66dB to 59dB despite an increase in movements from 11,002 to 23,563. Furthermore, the study showed that 365 takeoffs of hushkitted aircraft (Chapter 2 aircraft modified to Chapter 3) would produce the same noise energy as the current 25,000 commercial movements.

A comparison was made of aircraft types by emitted noise energy. The noisiest Chapter 3 aircraft of the MD80 family operating in Salzburg was taken as a reference with the following exchange rate:

- 1 MD80 = 2 A310s
- 1 MD80 = 5 B757s
- 1 MD80 = 10 Fokker 100s
- 1 MD80 = 40 Dash 8s
- 1 MD80 = 50 Canadian Regional Jets

Hushkitted aircraft

This study, based on 20,532 movements, defined the negative impact of hushkitted aircraft, which create noise exceeding the noise levels of Chapter 2. A hushkitted B 727 has the same noise energy as:

- 3 B767s
- 8 A320s
- 20 Fokker 70s
- 40 Canadair Regional Jets

CASE STUDY ON COMMUNITY RELATIONS
MANCHESTER AIRPORT PLC

Introduction

Manchester Airport PLC (MAPLC) is owned by the 10 local authorities of Greater Manchester. As a result, MAPLC are fully aware that without the support of local people and to an extent without local people having a feeling of ownership and influence, they will not be able to maximise airport capacity.

This philosophy also includes internal and external partners and has supported delivery of significant capacity enhancements for example:

- The delivery of a second full length runway just 10 years after first announcing the need;
- The increase in declared hourly movements from the original single runway from 42 to 50 per hour in the period from 1994 to 2000;
- A general acceptance that provided disturbance was contained or reduced, increased night time activity could take place (the core of the previous night flying policy centred around fixing movement numbers rather than noise impact).

Approach

MAPLC have operated an open door policy for many years to better understand and influence MAPLC's activities and plans. This process is supported by:-

- A partnership strategy covering the environmental, social and economic aspects of the airport's development and operation. This embeds the strategic importance of Manchester airport in supporting policy, economic strategies, regeneration programmes, planning activities and the like;
- An active community relations programme (described in greater detail below);
- Formal and independently chaired external consultative committees and joint working groups which in the context of this report are valuable sounding boards for capacity enhancement projects;
- Internal MAPLC effective and efficient delivery mechanisms as part of corporate strategy and the business planning process (e.g. published policy, departmental work-plans, personal development targets etc);
- Partnership programmes with other airport stakeholders to ensure consistent aims and active support and collaboration on joint capacity programmes – e.g. CDM;
- Published standards, targets and community agreements with supporting management processes and systems, including comprehensive performance monitoring with regular and independently verified reporting of progress;
- The establishment of the centre for sustainable aviation which is a research facility at one of Manchester's universities investigating the future opportunities, influences and constraints facing aviation on the long term.

Detailed Programme

The community and social aspects of the airports growth and development belong to those involved in developing and operating the airport. Senior officers include community targets in their business planning process. In addition to this, various specific programmes such as an independent education action zone, one of the largest arts sponsorship programmes in the UK, and ground transport related subjects have dedicated support teams.

In terms of general community relations generated by the airside this largely relates to noise and air emissions. MAPLC employ a small team covering this activity including such activities as :

- Facilitating ongoing formal consultative processes with amenity groups and elected representatives;
- Regular liaison meetings with local environmental regulators, pilots, health authorities etc including bespoke reports to feedback performance against plan;
- Providing regular outreach centres in community buildings and at local events;
- Meeting with local amenity groups and individuals;
- Social/environmental related complaints handling;
- Producing and issuing community information bulletins;
- Reporting airline and ATC compliance with agreed noise and aircraft track keeping limits (in accordance with community design reports);
- Reporting airport compliance with community agreements;
- Administering the noise insulation (26,000 houses) and vortex repair schemes;
- Administering the community trust fund which uses money including that levied in noise fines to sponsor good works in the locality.

CASE STUDIES ON RUNWAY MODE OF OPERATIONS AT CHARLES DE GAULLE AIRPORT HEATHROW HELSINKI

CHARLES DE GAULLE AIRPORT

Application of mixed-mode operations for the two pairs of runways, and segregated mode per runway pair. In other words for each runway pair, arrivals and departures will be operated under segregated mode. A possible increase in capacity of as much as 50%-60% is expected through the following

- Implementation when the 4th runway becomes operational.
- Operating arrivals and departures on the outer, respectively inner runway.
- The spacing between the pairs of runways is such that independent parallel operation can be conducted.

HEATHROW AIRPORT

During peak periods, Heathrow operates its parallel runways in segregated mode so as to equalise the distribution of aircraft noise. The present declared capacity could be increased to 92 movements per hour if mixed mode operation were implemented. For political reasons, however, this is not acceptable at present. A number of measures have therefore been analysed to increase the throughput in segregated mode for both arrivals and departures. These include the following:

Arrival capacity

- reduction of radar separation from 3 to 2.5 NM (subject to wake vortex spacing);
- reduction of ROT;
- implementation of a typical wake vortex spacing table, different from ICAO and based on a large vortex encounters database;
- time-based final approach spacing instead of distant-based separation criteria, guaranteeing arrival capacity under all wind conditions.

Departure capacity

- improvement of SID routes and reduction of ROT lead to an increased declared capacity number (+ 2 movements). This includes the tactical use of ATC radar headings instead of standard SIDs;
- reduction of departure separations, relative speed differences are taken into account;
- improvement of departure sequencing by means of re-ordering of the traffic at the holding position, and multiple line-up techniques.

HELSINKI AIRPORT

In the wider scope of capacity assessment analysis at Helsinki-Vantaa Airport, the following modes of operation have been assessed: segregated operations, semi-mixed mode with arrivals, semi-mixed mode with departures, and full mixed mode of operations for the two independent runways 22L/R (see following figures).

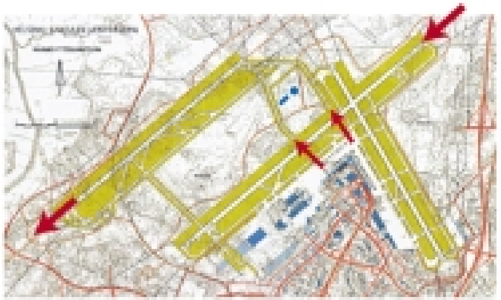
It should be mentioned that these results should be placed in their proper context, namely the specific operational conditions of Helsinki-Vantaa Airport. No two airports are similar, and any comparison with other “look-alike” airports would be dangerous.

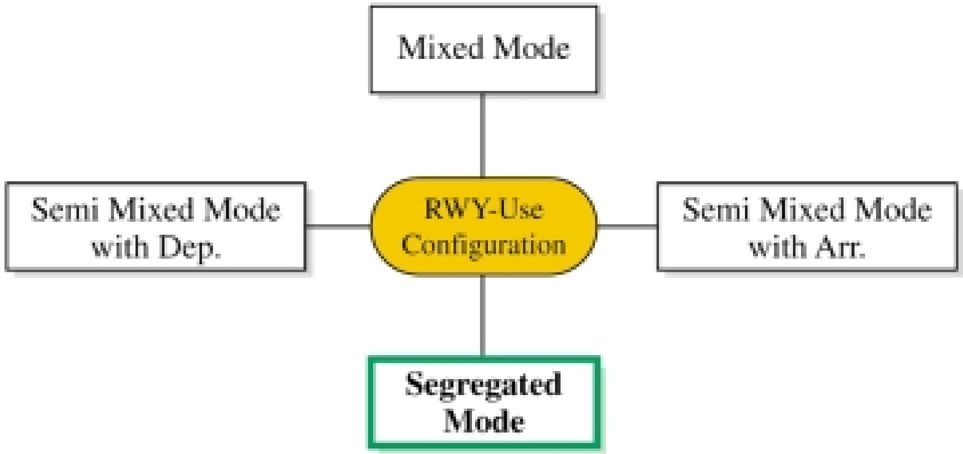
Runway system capacity assessment

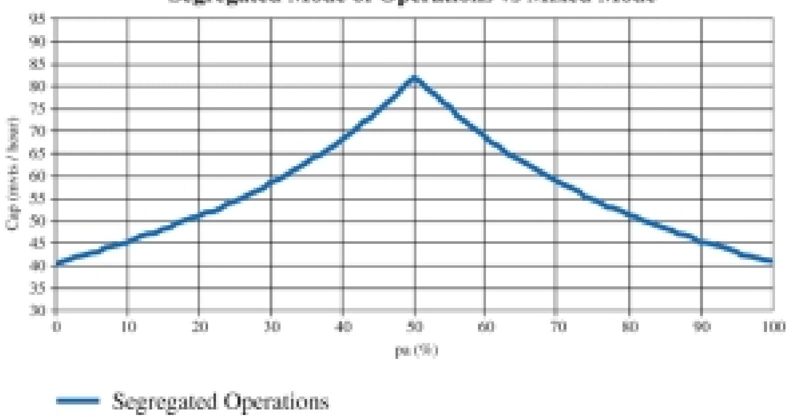
Segregated mode of operations vs mixed mode of operations

Feb. 2001

Segregated Mode of Operations





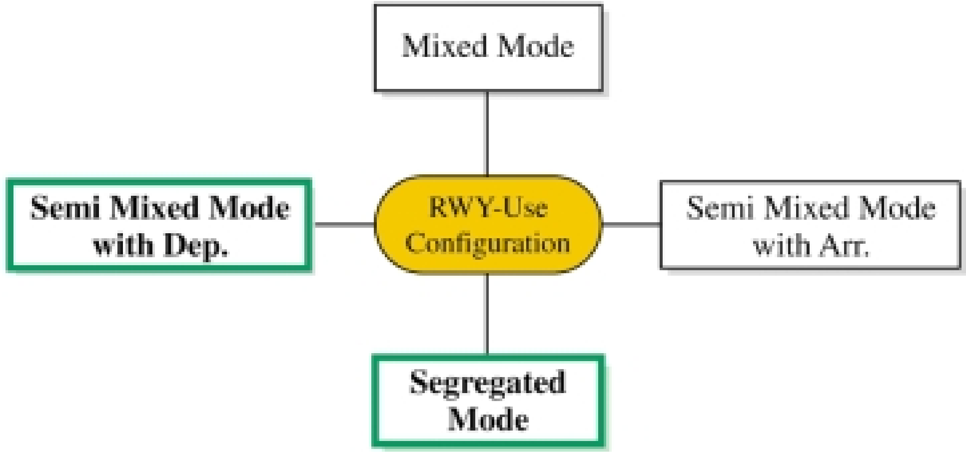


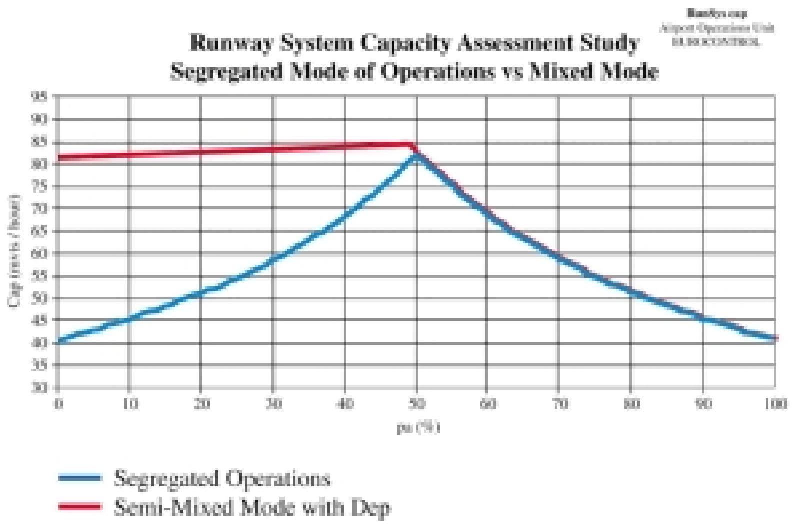
Runway system capacity assessment

Segregated mode of operations vs mixed mode of operations

Feb. 2001

Semi Mixed Mode with Dep.





	Departure Only	Departure Peak	Balanced Period	Arrival Peak	Arrival Only
pa	0	39	50	63	100
Arr.	0%	25%	0%	0%	0%
Dep.	100%	25%	2%	0%	0%
Total	100%	25%	1%	0%	0%

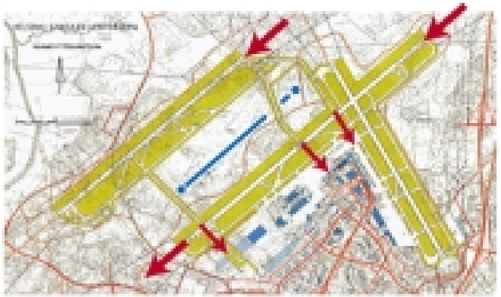
- **25% Capacity Gain during Dep. peaks**

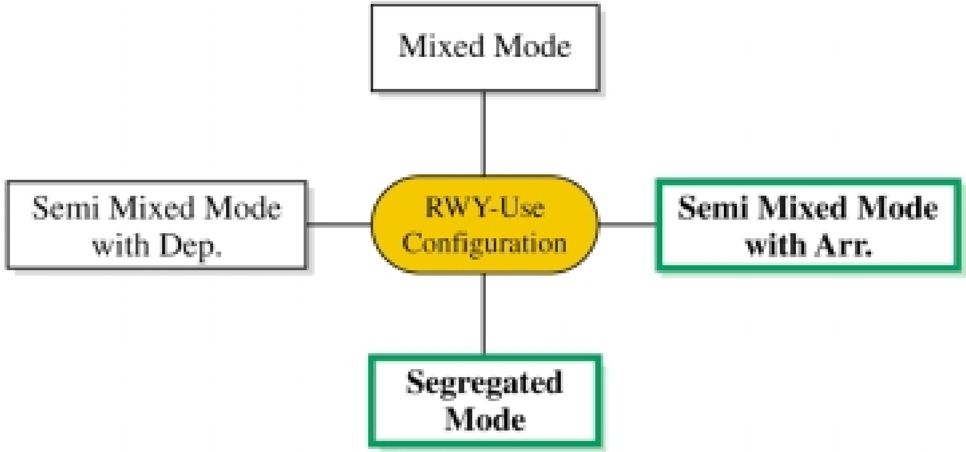
Runway system capacity assessment

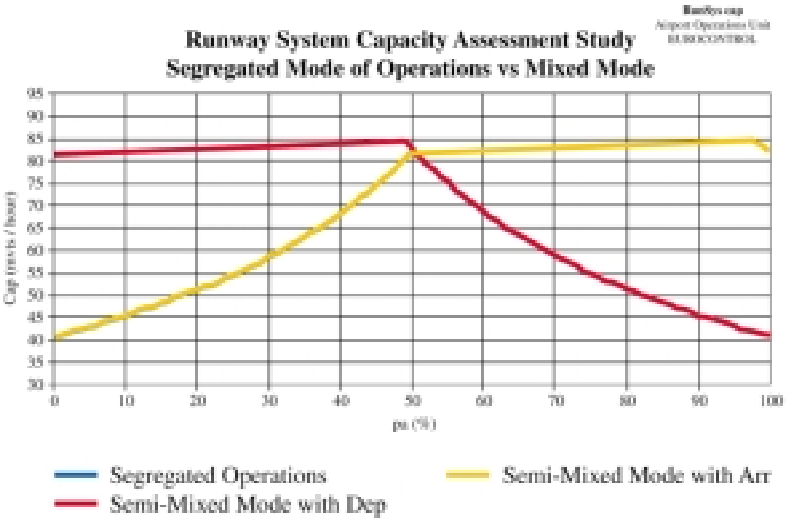
Segregated mode of operations vs mixed mode of operations

Feb. 2001

Semi Mixed Mode with Arr.







	Departure Only	Departure Peak	Balanced Period	Arrival Peak	Arrival Only
pa	0	39	50	63	100
Arr.	0%	0%	0%	28%	100%
Dep.	0%	0%	0%	23%	0%
Total	0%	0%	0%	26%	100%

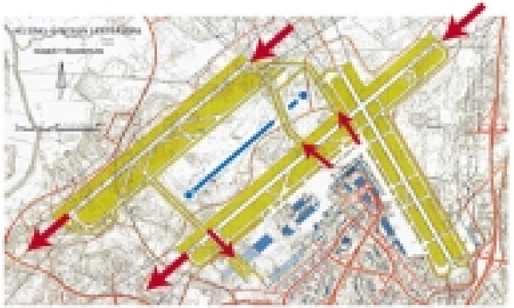
- **26% Capacity Gain during Arr. peaks**

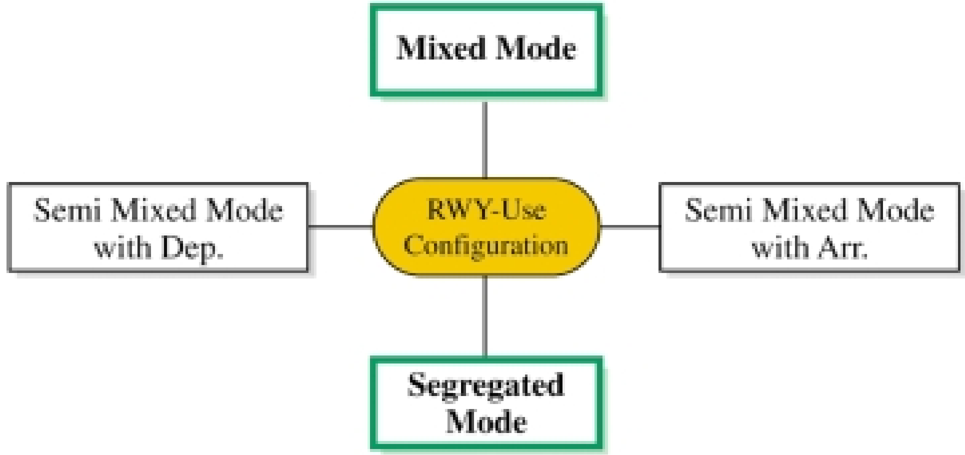
Runway system capacity assessment

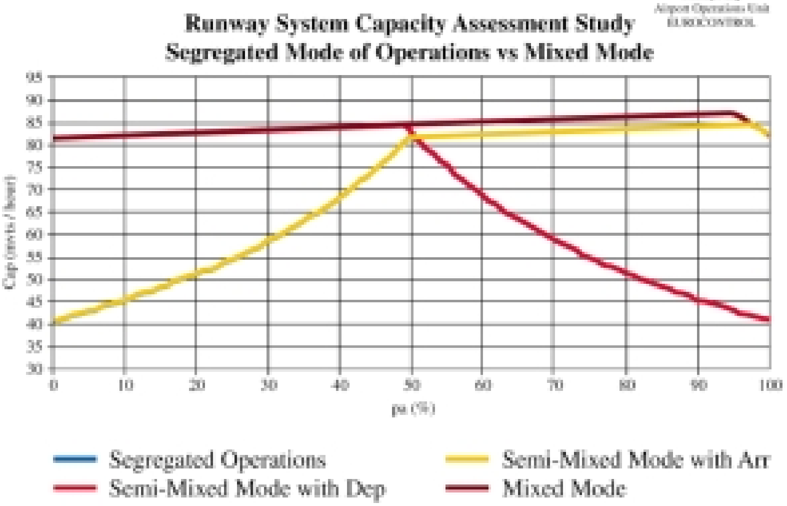
Segregated mode of operations vs mixed mode of operations

Feb. 2001

Mixed Mode of Opeations







	Departure Only	Departure Peak	Balanced Period	Arrival Peak	Arrival Only
pa	0	39	50	63	100
Arr.	0%	25%	3%	31%	100%
Dep.	100%	25%	3%	29%	0%
Total	100%	25%	3%	30%	100%

- **25% Capacity Gain during Dep. peaks**
- **30% Capacity Gain during Arr. peaks**

Runway system capacity assessment

Segregated mode of operations vs mixed mode of operations

Feb. 2001