Improved Information Sharing: A Step Towards the Realisation of Collaborative Decision Making

Peter MARTIN[1], EUROCONTROL Experimental Centre

Alison HUDGELL[2], UK Defence Evaluation & Research Agency

Nicolas BOUGE[3] & Sophie VIAL[4], Aérospatiale

September 1998

Abstract-- This paper describes a study carried out by a team led by the EUROCONTROL Experimental Centre to investigate improvement of information exchange required for Collaborative Decision Making. The work resulted in the identification of a number of "information gaps" which exist between the actors concerned with Air Traffic Management and Operations. These demonstrated the range of needs that must to be taken into account in development of an information management solution.

Index Terms-- Collaborative Decision Making - Airline Operations Centres - Airport Authorities - Information Distribution - Information Management - Flow Management - Resource Management - ATM Efficiency

I. Introduction

The purpose of this paper is to report on the results of a recent investigation and analysis of the requirements of European aircraft operators and airport organisations for the improvement of information distribution amongst ATM service providers and the user community. Such improvements in information management are crucial to the realisation of the concept of Collaborative Decision Making in Europe.

In particular it was demonstrated that the organisational complexities of the different actors (airlines, airports and ATM) must be considered when developing system-wide information management and distribution solutions.

The work was carried out by a team led by the EUROCONTROL Experimental Centre in Brétigny, France with further effort supplied by the UK Defence Evaluation and Research Establishment (DERA) and Aérospatiale. During the project information was gathered with the active participation of thirteen aircraft operators, seven airports and nine supporting ATC authorities. The authors of this paper appreciate greatly the contributions made by the representatives of each of these organisations to the success of the study.

II. Collaborative decision making

Collaborative Decision Making (CDM) is a concept which has gained widespread currency in ATM research and development [1], [2]. It is recognised as an important approach in trying to make best use of scarce resources such as airport runways, airport terminal gates and Air Traffic Flow Management take-off slots.

A number of different levels of collaboration can be identified in CDM scenarios:

- an enhanced distribution of information to ensure that each user has a good a picture as possible of the situation
- active co-operation to improve planning estimates

[1] Peter Martin is a research engineer at the EUROCONTROL Experimental Centre (EEC), Brétigny-sur-Orge, France. He is project manager responsible for the EEC's work on CDM.

[2] Alison Hudgell is a research engineer at the UK Defence Evaluation & Research Agency (DERA) based at Great Malvern, UK. She has contributed widely to ATM research projects in the UK and Europe and is responsible for DERA work on CDM.

[3] Nicolas Bouge is a project manager at Aérospatiale Espace et Défense and is responsible for European Business Development in the Aérospatiale Air Traffic Management Program.

[4] Sophie Vial is an engineer at Aérospatiale Espace & Défense and works in the Aérospatiale Air Traffic Management Program. Previously she worked on the Ariane 5 development programme.

- a consideration of additional actors' priorities in an actor's own planning processes
- redistribution of decision making responsibility, for example a delegation to users of responsibility for managing the allocation of a scarce resource

The project team carried out a study to identify what information users require to make best use of their own resources. This should provide a basis from which operational procedures and supporting tools may be developed.

III. Project Overview

The project was carried out during 1997-8 and the results are described fully in Reference [3].

Initially an object model of the information distribution processes was developed using the ROSE4 Object Modelling tool with the purpose of developing a baseline understanding.

A set of questionnaires was then developed targeted at identifying what information on scarce resources is lacking and hence the information that is needed to better make use of these resources. Two separate questionnaires were developed, one for airlines and the other for airports and ATC authorities.

Thirteen airlines were contacted and agreed to participate in the study (Air Liberté/TAT, Alitalia, Britannia, British Airways, Cargolux, Easyjet, Magec Aviation, Monarch, Olympic Airways, Regional Airlines, Swissair, Virgin Atlantic and Virgin Express). Similarly seven airport authorities and corresponding ATC organisations agreed to be involved (Aéroports de Paris, RLW-RVA Brussels Airport, UK National Air Traffic Services Ltd/Heathrow Airport Ltd, LVB/Schipol Airport, Swisscontrol/Zurich Airport Authority, Hellenic Civil Aviation Authority, Nice Airport).

Face-to-face interviews were conducted typically taking up a whole day. This gave the opportunity for a full discussion of the constraints and operational problems. In addition some ad-hoc discussions were carried out with domain experts to gain supplementary information and views.

Following each interview a summary was prepared, and the study was completed by carrying out a full analysis of these summaries.

IV. Airline Operational Aspects

A. Organisational Background and Implications

The airline companies interviewed in the course of the project represented a wide sample of the different types of organisations and methods that the future European ATM System (EATMS) will have to accommodate.

Most of the companies interviewed operate mainly within Europe: short-to-medium haul flights within the ECAC-bordering countries represent 70% of their business. The sample included a cargo carrier, a specialised business jet provider, and regional, charter and low-cost operators, as well as scheduled service providers.

Some of the companies operate primarily in the hub-and-spoke model, whereas others operate point-to-point or shuttle flights. All airlines use at least one centre from where the airline planning, operations and commercial activities are managed. Many had complex associations of alliances and subsidiaries, leading to code sharing arrangements and the potential for co-ordinated scheduling and operations. This is not yet widely developed, but it is likely to be extended significantly in the future. Furthermore while many of the airlines operated the majority of their flights from co-ordinated airports, several did not and were thus not subject to significant levels of airport slot control.

The functions of flight planning, fleet management and dispatch were often carried out by dedicated Airline Operations Centres (AOCs), particularly in the larger companies. Several of these had sophisticated computer support systems including world-wide communications links with their aircraft via ACARS.

For the small and medium-sized companies, functions were frequently outsourced to service providers, such as SITA, handling agents and airline reporting offices (AROs) provided by airports. For example, slot management may be dealt with by other airlines, airports (e.g. Aéroports de Paris) or specific service companies (e.g. Transair). Similarly, they often relied on an outside supplier for flight plan preparation and submission service for which SITA and Jeppesen were providers. Handling agents are often used at remote stations (i.e. away from the

airline's main operating base) to assure flight preparation, boarding and dispatch.

Thus some airline companies have only limited or partial links with other actors in the ATM system. **Given the requirement for equitable treatment for all EATMS system users, any solutions for improved information distribution must be easily accessible to all users whatever their operating arrangements.**

B. Operational Issues

1) Airline Operating Concept

Airlines use different operating concepts. For example, European airlines are developing hubbed modes of operation. This approach is not yet widespread except amongst the majors and it is difficult to identify an airline hub in the US sense with its focus on a single company's operations. Such an operating mode is convenient for connecting passengers and switching aircraft and crews, but it imposes certain constraints:

- For the airline, a hub is very delay sensitive. Feeder flights must not be delayed otherwise transit passengers miss their connection and if there are few feeder flights the passengers can experience long delays

- For the airport, transit passengers and their baggage must be transferred from one aircraft to another in a very short time, necessitating sharp peaks in activity in the airport facilities

- For ATC a hub imposes a greater load than point-to-point operations since arrivals and departures are bunched instead of being spread out in time.

All these place a premium on having good information flow within the airline, warning, for example, of late departure. In the US model such information exchange can be assured by the dispatcher-pilot information exchange. In airlines equipped with a datalink such as ACARS, pilot-AOC messages can fill the gap. However in other cases efficiency must rely on prompt communication by the handling agent at the departure airport, and this cannot always be assured.

2) Turnaround Management

Airframe turnaround times range from twenty minutes to an hour and a half for passenger carriers. Typically turnaround can be considered to cover the period from on-blocks to pushback, including disembarkation and boarding by passengers, baggage handling, refuelling and safety checks on the aircraft. Turnaround times depend on:

- Company operating strategy: some airlines plan a greater margin for turnarounds into their schedule to help manage the effects of delays
- The aircraft type: bigger aircraft require longer turnarounds and some types are easier to load and unload by virtue of location of baggage doors on the aeroplane. For example, the minimum turnaround time for a B747 is one and a half hours
- Passenger connection times if the airline operates a hub, necessitating sharp peaks in activity
- Airport, since turnaround times are often longer in international airports
- Whether the flight is short-haul or long haul since short-haul flights are operated with higher frequency than long haul.

3) Management of Delays and Disruption

Between 30% and 100% of the flights of each of the airlines participating in the study are regulated[5]. This result is not surprising: the major activity of the airlines was operating short-haul flights inside Europe where the sky is the most congested.

[5] A regulation is applied by the Central Flow Management Unit to limit traffic flows to safe levels. when demand exceeds capacity.

Thus these flights are subject to chronic delays resulting from insufficient capacity in the airspace and airports concerned.

The key impact of delays is to disrupt an airline's planned flying schedule. In order to maximise the return on their assets airlines try to increase the proportion of time spent flying passengers. However, this means that schedules become tighter and more prone to disruption.

Thresholds quoted for delays that disrupt the company schedule range from zero to 30 minutes. If the delay of a flight is greater than this time, the airline cannot absorb it during subsequent flight or turnaround and the remaining schedule is affected (knock-on delays). Parameters taken into account in determining this threshold are usually the forward schedule and crew working hours, and may vary from flight to flight.

In practice, airlines prefer to deal with chronic delays by accepting the disruption and continuing the schedule dealing with the knock-on delays as best they can. This strategy is usually preferable to cancellation and in fact they seldom cancel because they do not want their customers to switch to a competing airline's flight on the same route and instead prefer to fly half-empty.

However, a separate and arguably more significant form of delay arises in disruption situations such as when fog, snow or an incident such as a strike severely reduces the capacity either locally or throughout a region. When this occurs airlines are very badly affected because the disruption often catastrophically upsets the planned schedule and imposes very high costs through aircraft and crews being in the wrong locations.

On these occasions it is difficult for an airline, even with the appropriate tools, to consider different operational scenarios and their consequences in response to delay disruption. Looking more than one flight ahead is not always rewarding, as so much can happen in the meantime to make plans obsolete.

Hence all the airlines interviewed emphasised the critical importance of providing them with more information, more quickly and more accurately to enable better responses to disruption situations.

V. Airport Operational Aspects

It is very difficult to generalise when discussing airports, to talk about "the typical airport", because every airport is different. Within Europe one can identify major international airports, regional airports, hub airports and airports that are not hubs. There are many different sizes of airport - in terms of surface area, number of runways, number of stands, number of terminals and so on. The level of sophistication of automation and information systems varies, as does the range of facilities available to passengers and airlines. Each airport operates under different constraints: environmental, political, commercial; and there are a variety of problems, for example unfavourable weather conditions, to contend with. For all these reasons, the operational priorities of different airports can be quite varied. Furthermore, the organisation and division of responsibilities varies significantly. **These variations mean that information distribution needs to be flexible enough to accommodate the demands of the different organisations and requirements.**

Airports are very complex enterprises. In general, a number of different organisations are involved in the operation of an airport. The precise boundaries of responsibility for each organisation vary from country to country and from airport to airport, as do the relationships between the different organisations. Each airport is organised as appropriate for that airport, for commercial, historical and political reasons.

For the purposes of this study, the roles of the Airport Authority and ATC Provider were defined in terms of their main responsibilities. **It should be noted that, in practice, more than one organisation may contribute to a given role, and/or a single organisation may fulfil (part of) several roles.**

Airport Authority: Operation of the airport, including:

- terminal management, check-in counters, departure lounges, baggage belts and reclaims;
- provision and allocation of stands and gates,
- guidance and control of vehicles and aircraft on the apron (Apron Control), including provision and operation of follow-me cars and marshallers where required;
- provision and allocation of buses to transfer passengers to remote stands;

- towing operations;
- provision of de-icing facilities.

In addition, in the context of a multi-modal traffic system, the Airport Authority may be considered responsible for providing information and connections to local and regional transport services.

ATC provider: Provision of Air Traffic Services, including:

- control of taxiing aircraft on taxiways and runways;
- control of aircraft approaching and taking off from airport;
- ATC in terminal area and en-route airspace;
- liaison with flow management (CFMU).

To demonstrate the lack of a consistently-identifiable organisation, apron control is the responsibility of an ATC organisation at some of the airports, while at others that responsibility is assigned to an airport management company (although start-up clearance must always be co-ordinated with ATC).

Similarly, responsibility for bus transfers from gate to aircraft, including provision and operation of the buses, may rest with Airlines or Handling Agents. But at some airports buses are a resource owned and managed by the Airport Authority.

In some cases the Airport Authority and ATC Provider roles are carried out by (different parts of) the same organisation. In other cases they are performed by completely separate organisations operating in very different ways. Often, the Airport Authority is a commercial company, while the ATC Provider is government-owned. This can result in a difference in culture and response time between the two organisations.

For example, an Airport Authority may work to encourage a rapid growth in traffic at an airport, while the ATC service cannot respond sufficiently quickly to accommodate the increase in traffic. The result will be delays at the busiest times of day.

Some examples of the actual splits of Airport Authority and ATC Provider roles at airports are:

- At Brussels airport, RLW-RVA performs both Airport Authority and ATC Provider roles. This has led to a very close co-operation between the two operations. Furthermore, the terminal-operating company and the airport side of RLW-RVA have recently formed a joint company (BATC) with Airport Authority responsibilities, resulting in an organisation for Brussels Airport close to that defined at the start of Chapter V.
- At Athens, the ATC Provider and Airport Authority roles are fulfilled by two separate, independently-operating branches of the Greek Civil Aviation Authority (HCAA).
- The major home-base airline operates its own terminal and apron facilities at Athens (Olympic Airlines at West Terminal, for Olympic aircraft only) and London Heathrow (BA at Terminals 1 and 4, for BA and alliance carriers' aircraft). The Airport Authority operates the other terminal(s).
- In Paris, the Airport Authority AdP employs Air Traffic Controllers to provide Tower ATC, and also provides aircraft handling.

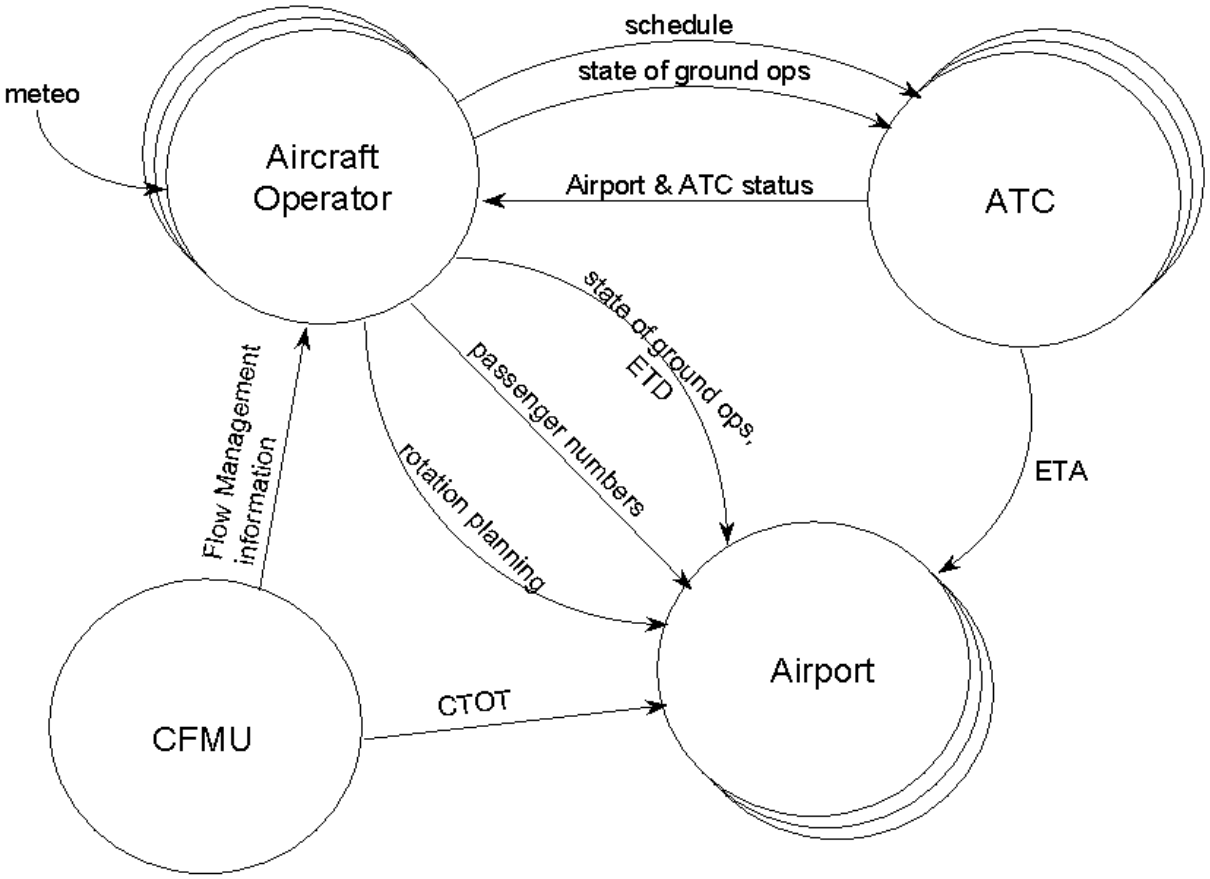
A given item of information will be held by different parties at different airports and will be managed and used differently depending on the culture of the party concerned. Thus a given organisation, for instance the Airport Authority, will see a different "part of the picture", leading it to deal with the situation in different ways. Achieving a consistent picture is essential for good decision making.

VI. Information Gaps

The analysis of the returns from the interviewees led to the identification of "information gaps" or links between entities that appear to be missing. That is not to say, however, that information exchange should be seen as a one-to-one process. Historically there has been a good deal of centralisation in ATM systems, but we must be aware that modern technology is moving the trend towards a more decentralised world view with users being able to seek information over multiple channels.

The information gaps identified by airlines, airports and ATC providers are described in the following subsections. Figure 1 summarises these information gaps.

Figure 1: Summary of Information Gaps



A. Airline Information Gaps

The airlines identified a number of areas in which information would be of particular assistance to them, as described below.

1) Airport and ATC Status Information

Airlines noted that it would also be useful to have a variety of additional information related to airport and ATC status. Examples of information items that were mentioned include:

- pre-tactical data and live updates on airport capacity
- information on airport gates and aircraft parking, and also for alternate airports
- information on terminal, and local and regional transport system problems
- co-ordinated airport and flow management slots
- expected holding times in stacks from ATC so as to better organise turnarounds

The need for more information from airports was particularly strongly felt. For many companies information is readily available concerning the airport where they have their main operating base. However, information concerning other airports served by the company is much more difficult to obtain easily and cheaply.

Once example of this lack of information concerns airport capacity. In the first place, companies often lack basic information on capacity in various situations, whilst also noting that that it may be useful to standardise airport capacity declarations since at present some airports "oversell" their capacity

whereas others allow in extra flights without slots. This information should be supplemented by updates to reflect the real situation (e.g. changes in wind direction) that would provide a basis for the airline to respond by modifying its operations.

Since ECAC airports are increasingly congested, if flights do not arrive or depart on time, the disruption of gate and parking allocation planning results in additional ground delays for the airlines and information. One major carrier noted that it has experimented with having aircraft approaching its main operating airport slow down so as to avoid an irritating wait on the tarmac for its passengers if the allocated gate is not clear. Ideally it would like to do this for other airports it served.

Information on terminals and local transport are also important for companies. For example, early warning of rail or road disruption can enable an airline to modify its operating schedule.

Regarding airspace congestion in and around airports, some companies observed that there is a mismatch of capacity and airport slot allocation, and that it could be helpful to improve co-ordination between the flow management slot and the airport slot.

2) Flow Management Information

Airlines identified a need for more accessible flow management information such as the following:

- pre-tactical[6] forecasting of constrained sectors
- pre-tactical forecasting of likely average delays on particular routes
- tactical[7] information on approximate foreseen delays
- tactical information on possible alternate routes with approximate delay indications
- highlight the timing of regulations in comparison with the flight plan in question
- more information on the reasons behind the delays, such as in which ACCs the capacity/demand balance is creating a bottleneck.

In general, information should be presented indicating what is available rather than what is forbidden. For example, it would be efficient for users if displays could be organised to indicate available slots as opposed to a map of constraints.

Some of the information proposed (constrained sectors, delays) is already available through ATFM Notification Messages (ANMs). This introduces another important consideration in improved information exchange. **Shortage or cost of manpower and effort required to supply or extract information effectively means that it is important to consider manpower issues when developing new applications.** If not, these concerns will prevent the best being made of the available information.

As an example, ANMs give codes for constrained sectors but the keys to localise them must be looked up separately. The time required to find the locations mean that, except for frequently occurring problems, it is not worth the operators investing the time required to find alternate routes to avoid the restrictions.

Clearly, visual map-based displays are an important consideration in improving accessibility. For example:

- Information on capacity, constrained sectors could be displayed with different colours depending on their load levels
- Meteorological data could be overlaid
- Routes affected by routing schemes such as the TOS or CDRs could be highlighted
- A flight plan could be superposed and manipulated by the user (or flow manager)
- Customised filters could be used to display selected layers of the airspace (lower sectors included), selected routes, cities, airports etc.
- Customised alert systems [e.g. by flagging changed information on map display] and data discrimination filters can be introduced.

Given that such facilities could require considerable investment if provided centrally by ATM service providers (as is the case with the current RTA/RCA), an alternative approach would be for a data stream to be provided which aircraft operators or other users could then integrate within their own operational systems.

B. Airport Authority Information Gaps

This section describes information which airport organisations noted was unavailable or could be

[6] ie a few hours before the flight takes off.
[7] ie very shortly before the flight takes off

improved. **As discussed earlier, it should be remembered that airports are typically composed of multiple different organisations which are integrated to varying levels of effectiveness.**

1) Earlier Information on Planned Rotations

Currently, the stand allocation process is necessarily largely tactical. Last-minute delays and rotation changes are inevitable, and mean that stand allocation cannot be completely planned in advance. While recognising this fact, a number of airport authorities would like to be able to plan stand allocations further in advance and more pro-actively than at present. To enable this, earlier and more accurate planning information from aircraft operators would be necessary.

For each rotation at its airport, the Airport Authority needs:

- approximate on-blocks time
- approximate off-blocks time
- aircraft type
- estimated passenger and cargo load

Any strategic planning of stand capacity for the new season's traffic is typically carried out using extrapolated traffic from the previous year. By the time airline schedules giving details of rotations are available to Airport Authorities, it is often too late to make any major changes to the stand allocation plan in time for the start of the season. Instead these have to be made as the season progresses. Earlier schedule and aircraft type information from the airlines could be merged with traffic history to give a more reliable basis for strategic stand allocation planning.

Better quality information from the airlines would benefit the airlines themselves since the airports would be in a better position to provide the services demanded by the airlines.

Rotation information is generally provided by airlines a few days before the start of the season, in time for the Airport Authority to begin pre-tactical planning. Some airlines already provide this information very accurately and very promptly, but there are significant gaps. Therefore, even at this later stage, the information held by individual airlines is generally better than that received by Airport Authorities, and Airport Authorities would benefit from improved accuracy and coverage.

2) Rotation Planning Updates

Allied to the requirement for better baseline information on planned rotations, the Airport Authority needs to receive updates as the airlines' planned rotations change, in order to keep its stand allocation plan in line. Better advance information allows them to plan more pro-actively.

It is not unusual for planned rotations to change a number of times before the flights actually take place. The type of aircraft performing a flight may vary from day to day, as the number of passengers booked on the flight varies. Changes may be made a very short notice, particularly in the case of home-base airlines or those having more than about ten aircraft at the airport.

Some airlines already send rotation planning updates, but often these are not reliable. Some send few or no planning updates, so a change may not be apparent to the Airport Authority until the aircraft arrives at the airport. Sometimes the Airport Authority may have had no advance notification of, for example, aircraft type and so will not know what kind of stand a flight requires until they actually see it (or are informed verbally by ATC).

The effectiveness of Airport Authorities' stand allocation planning is reduced by the fact that planning information is not complete. Out-of-date or missing information from some airlines reduces the benefit of high-quality information from others. An on-time flight which behaves exactly as the Airport Authority expects fits smoothly into the plan, whereas an arrival for which the Airport Authority has incorrect or no information causes a lot more work. Airport Authorities would therefore like:

- advance information on the aircraft type and expected length of stay of all arrivals
- reliable updates on all airlines' rotation planning

Airlines are currently not obliged to send the required information and updates, and may see little direct benefit, particularly from sending all updates as they occur. So many airlines will not bother to send updates when they are busy, and some will never consider it worth the manpower and communications cost. The effort required would be reduced by electronic links such that when an airline updates its own fleet planning (or flight planning) system,

updates to rotation plans are sent automatically to the Airport Authorities concerned. For airlines with manual planning systems, effort required is likely to remain an issue with provision of full planning updates. However, the possibility to provide such automatic links could be considered a requirement for any new systems being procured.

3) Passenger Numbers

The number of passengers expected on a flight is required by the Airport Authority for the allocation of terminal resources and/or transfer buses. However, passenger load often remains unknown, especially for arriving flights. This can lead to waste of the airport's passenger capacity, or to inadequate facilities being provided for the customers (of the airport and the airline). Passenger numbers for departing flights are more readily available to the Airport Authority, via the handler at the airport.

As a minimum Airport Authorities would like to know final passenger load before a flight arrives. This could be provided by the check-in handler at the departure airport, or by the Airline (these may in practice be the same organisation). Passenger load is currently already provided to the Airport Authority for billing purposes in the post-flight phase; all that is required is earlier transmission of this information.

To go further, early notification of expected passenger numbers (preferably with updates) would aid stand/gate allocation planning. However the airlines may consider this commercially sensitive information.

4) Estimated Time of Arrival (ETA)

Another key component of the information about rotations that the Airport Authority needs is the estimated time of arrival (ETA) of a flight. More accurate updates can allow stand allocation to be more pro-active and more efficient. Every Airport Authority interviewed identified a requirement for improved ETAs, although the details of what was required varied from airport to airport depending on what was already available.

Some Airport Authorities (e.g. Nice, Heathrow Airport Ltd (HAL)) receive automatic notification when a flight joins the stack. This notification would be more use to them if they also knew how long it was expected to *stay* in the stack - thus enabling them to derive an ETA.

Accurate predictions of arrival taxi times could improve the accuracy of estimated time of arrival *at the stand*, where an accurate estimate of landing time is already available (for example from the ATC system).

Where the Airport Authority has access to flight plans, notification to them of an arriving flight's actual time of departure (ATD) could be used to update the flight plan information. This would provide a reliable ETA at the earliest possible opportunity.

Information on predicted or actual departure delays could be used by the Airport Authority to update expected arrival times.

One Airport Authority commented that it had considered giving priority to on-time flights, to encourage airlines to send accurate planning information and updates, especially of ETA.

ETA updates could be provided from a number of sources:

- The CFMU has filed flight plans. ETA from the flight plan is not always accurate, but represents an update to an Airport Authority that is working from only airline schedules.
- AOCs may have updates of ETA, derived from pilot reports or ACARS communications. Many airlines already provide their handlers (and sometimes Airport Authorities) with updates of ETA for long-haul flights. However, to send ETA updates for all flights could imply a lot of extra effort and communications costs, which airlines are unlikely to be prepared to meet without justification (preferably in terms of direct benefit to the airline).
- The local ATC system is likely to have accurate ETAs once the flight is in the local FIR. These could be linked directly into the Airport Authority's system. (Systems are already linked at some airports; some others plan links in the future). Accurate ETAs would be available earlier if neighbouring ATC centres' systems were also linked in.
- Information about expected delays and ATD from which ETA might be extrapolated could be sent from the airport of departure.
- The Eurocontrol ASD (Air Situation Display) could provide a centralised source of ETAs. A

number of Airport Authorities noted that the ASD would be most useful if its information were available as an electronic data feed, so that ETAs could be fed directly into their own systems.

Different sources might be most appropriate for different Airport Authorities, or at different times in advance of a flight arriving at its stand. ETA is clearly of great interest to many different parties; a consistent, regularly updated estimate available to all would be widely valued.

5) Estimated Time of Departure (ETD)

As with ETA, ETD is a key piece of information defining a rotation. To be able to predict push-back times more accurately would be a major contribution to Airport Authorities' allocation planning capability. Many Airport Authorities expressed a requirement simply to have ten minutes' warning of expected push back.

Again, a number of different aspects were identified by the Airport Authorities interviewed, the two major items being information on departure delays and on the progress of ground handling operations.

ETD is of interest to many different parties, and a consistent, regularly updated estimate available to all would be widely valued. It appears that the information from which ETD could be determined is scattered across a larger number of sources, and hence an accurate ETD is less likely to be held in electronic form.

These information gaps are discussed in the following two sections.

a) Information on Departure Delays

Departure delays may arise because of handling or technical problems, or as a result of ATC delays - either from CFMU slots, or delays in receiving start-up clearance from the tower. Notification of problems encountered and expected delays would allow the Airport Authority to keep ETD updated.

Currently, information on departure delays most often comes by telephone co-ordination between Airport Authority Operations and the Handler or AOC. Aircraft Operators often avoid informing Airport Authority Operations of problems or expected delays, in case they are asked to move the aircraft to a remote stand for the duration of the delay. (This would allow the Airport Authority to make better use of its available pier service, but is inconvenient for the airline which has to move.)
Moreover, given the present slot allocation system, airlines may be penalised if they declare any delays: if they cannot meet the slot and are not granted a slot extension, they will be put back at the end of the slot allocation queue and incur greater delays. The result is a "wait and see" behaviour with the hope that the problem will be solved before request for clearance time.

A number of Airport Authorities would be interested to receive flow management slots, to warn of expected departure delays and as an indication of ETD. However, they do not generally consider it necessary to prioritise Apron operations in favour of regulated aircraft, so knowledge of flow management slots is not required for that purpose.

b) Progress of Ground Handling Operations

In general the Airport Authority is not aware of the state of airline ground handling operations for a particular flight. Such information would be useful as an aid to prediction of departure time. Confirmation that each part of the operation (cleaning, catering, baggage, boarding of passengers) had been completed would give an indication of whether the flight was ready to depart on schedule. An indication of any problem encountered (lost baggage, lost passenger, late catering with an estimate of the arrival time of the caterers, . . .) would help further.

Much of this information is already passed verbally, for example between the handlers and the pilot, but is not made available to all at the airport who could profit from it. However it is worth noting again the variation in operations between different airports and between different airlines. HAL receive updates on the progress of handling operations for some airlines via ACARS messages; other airlines rely on HAL to pass estimated or actual time of departure to the AOC.

AdP was unusual among the Airport Authorities interviewed in that it is also responsible for handling and Airport ATC, so that the different aspects of airport operations are more closely linked than at many other airports. AdP already passes information on handling delays to the Tower, to improve their estimates of departure times, and noted that it could also provide this information to CFMU if necessary.

A number of Airport Authorities are addressing their requirement for more information about handling operations. For example, Zürich Airport Authority is investigating methods for tight monitoring of the movement of passengers and bags around the airport.

C. ATC Provider Information Gaps

This section describes information requirements noted by ATC providers at airports, particularly Tower control.

1) Estimated Time of Arrival (ETA) and/or Actual Time of Departure (ATD)

At present, most ATC providers at airports have little direct information on the ETA or ATD. An estimation can be obtained from, for example filed flight plans (FPLs) or CFMU slot allocations, but this is subject to a high degree of inaccuracy.

Better quality information would be a significant step to allowing ATC to improve arrivals sequencing and stack management.

2) Airline Schedule Information

Better information from airlines on schedules was believed to be needed by ATC. This would help them improve planning for optimising both arrival and departure schedules.

For example the Dutch LVB noted that they employ different runway combinations for inbound and outbound traffic peaks, and airline schedule information is needed to plan the timings of switches.

Nice ATC noted that they receive no feedback from the IATA slot conference since they are not a co-ordinated airport. Frequently, schedules are available only at the last minute, and often later than the dates when they are supposed to be provided. As a result they proposed that early publication of schedules should be mandatory since this would help airport organisations take more efficient decisions and consequently also help the users.

Charter flight information was found to be particularly variable and special events such as football matches can introduce a high level of uncertainty into planning.

3) State of Airline Ground Operations

It was noted by several ATC (e.g. Greek HCAA, UK NATS, Swisscontrol) that they have no information on the state of airline ground operations. Improving this would bring capacity benefits by allowing ATC to make early planning of taxiing and departure sequence, give time to negotiate slot extensions and help with arrivals planning (since it would be known better when a gate would be free).

Several suggestions for improving the current situation were proposed. These included:

- A ten minute advance warning of the aircraft's call for start-up would be of significant help.
- Several ATC authorities said that that they would like to have general information from airlines on what is going on at the gates.
- Airlines should be responsible for sending accurate information on ground operations progress and delays to the TWR (and CFMU).
- Useful information could also be provided by Apron Control. For example, it would be useful to know if a push-back tractor is available, if a push-back tractor is in place and if the baggage is loaded.

One authority noted that in the future development of their system they will send the planned departure sequence to the airlines, who would have the responsibility to update this planning to reflect unforeseen events during their ground operations.

VII. Issues Outstanding

If the first step in information management is just to provide the required information, the associated step to consider in collaborative decision making is that of data management. The following subsections address particular aspects of data management.

A. Cost of Providing Information

An important concern raised by many of the interviewees was that the overall business case must be justified. Information may well provide a benefit but it is not always easy to identify exactly what that benefit might be in cost terms.

Companies are concerned that the cost of **providing or using** the information is properly considered. Costs of provision include data gathering, new information systems and communications costs. In

particular, costs of information use should not ignore the manpower effort required to extract the key information from what is provided, and this may be significant if the information is poorly presented or has to be located amongst a large volume of other less relevant information.

To better bear the cost of provision of information implementation it is necessary to find routes which emphasise win-win situations between the different actors.

B. Safety and Liability

As for all developments of the ATM system, safety must be of paramount concern in Collaborative Decision Making applications.

New developments should ideally enhance prevailing safety levels, and in any case must not reduce them. There are a number of important safety-related concerns:

- information may not correct
- updates may not be made in a timely way

This will impose costs on implementations: at the least, information must have associated timestamps and checking mechanisms. At the extreme of safety-critical information it will be important to look closely at the solutions implemented.

This introduces the issue of liability: if information is used for operational purposes users need to know who is responsible if something goes wrong.

C. Confidentiality

Closely related to safety and liability is the issue of information confidentiality. Whilst transparency of process and open access to information are essential elements of CDM, the confidentiality of certain information will need to be assured and information will need to be protected from unwanted interference. This includes preventing unauthorised reading or malicious writing, modification or deletion of information.

For example:

- information may be confidential to Aircraft Operators for commercial reasons
- information on certain categories of flight may be confidential to individual states for reasons of national or military security
- information must be safeguarded against misuse by terrorists etc.

These concerns imply the need for a proper consideration of security issues to protect information. It may include adoption of encryption, use of limited access networks and other equivalent methods.

D. Standardisation

Standardisation is a prerequisite for efficient information flows. The diversity of the information processing systems and information usage within the ATM actors is such that the data available from the different information sources exists with different formats or material supports. Gradual convergence of these, steered by aviation authorities, will stem from consensus of the actors.

VIII. Conclusions

The initiative described here was a starting point for the development of CDM applications in the European ATM environment.

The starting point is well recognised: the improved distribution of information. However, in this study the analysis has served to demonstrate the complexity of the organisational structures that will have to be supported in European CDM applications.

Airports must been seen as key players in the information exchange process because they are the focus of both the start and at the end of the flight operations processes. They are complex enterprises which differ greatly amongst themselves: information is available from them more or less easily and with different degrees of feasibility. Also, they currently have many locally-developed information distribution solutions which must be taken into consideration in development of system-wide applications. However, there are significant gains to be made from introduction of new sources of information to aid their decision makers.

Airlines and ATC also have very significant benefits to gain from new sources of information. Once again, the focus for both is on getting airport-related

information, and this is therefore the area in which future work should be focused.

Finally, the interviewees identified the risk of duplication of work on improving information sharing. To avoid this, proper co-ordination of efforts needs to be encouraged and developed at a European (or World)-wide level.

IX. References

[1] Collaborative Decision Making in Aviation Transportation: Improving decision making through shared information. Kevin Kollman - USAirways, Kapri Kupper - FAA ATSCC, James Wetherley - FAA ATM IPT R&D, Michael Wambsganss - Metron Inc. October 1997.

[2] ATM Strategy for 2000+. EUROCONTROL. FCO.ET1.ST07.DEL02. Issue 2.0. May 1998.

[3] FASTER (Future ATFM-AO-Airport Synergies Towards Enhanced opeRations). EUROCONTROL Experimental Centre Report No 332. August 1998. P Martin , A Hudgell, N Bouge, S Vial.

Abbreviations

AdP **Aéroports de Paris**
AOC **Airline Operations Centre**
ARO **Airline Reporting Office**
ASD **Air Situation Display**
ATD **Actual Time of Departure**
CDM **Collaborative Decision Making**
CDR **Conditional Route**
CFMU **Central Flow Management Unit**
DERA **Defence Evaluation & Research Agency**
EATMS **European ATM System**
ETA **Estimated Time of Arrival**
ETD **Estimated Time of Departure**
HAL **Heathrow Airport Limited**
HCAA **Hellenic Civil Aviation Authority**
NATS **National Air Traffic Services**
RLW **Regie der Luchtwegen**
RVA **Régie des Voies Aériennes**