

Collaborative Decision Making: Results of Experiments to Identify Limitations of Information Exchanges in Stand and Gate Operations.

Extended Abstract for ATM-2001

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Summary

What are the benefits of exchanging information to build a **CDM** environment?

The A-CDM-D project was set up in 1999 to investigate development of a CDM system. A key part of the project was the evaluation of the operational benefit of information exchange to airlines and other partners in the ATM system.

To achieve this EUROCONTROL organised a data collection process in which several airline and airport partners provided data in an “open book” approach, focusing on **stand and gate operations**. This enabled a detailed analysis of who had what information when, and what was the quality of the information. The goal of this analysis was to decide if there would be a benefit in information sharing and hence from Collaborative Decision Making.

The data allowed the team to identify some specific weaknesses concerning gate and stand management, with the consequence that resources are used sub-optimally and this provides scope for additional aircraft turnarounds.

The analysis demonstrated that while much of the required data is available, it is often not exchanged. The reasons are primarily cultural and commercial. We concluded that the challenge for CDM is not to provide new systems involving considerable expenditure in

technology – instead effort must be focussed on resolving the organisational and procedural issues, in particular removal of the disincentives to communication through badly or thoughtlessly designed processes.

Collaborative Decision Making

Based on previous CDM studies, [Ref.1] identifies different “levels of collaboration” among the potential applications of CDM. The project focussed on the two first levels of collaboration through:

- **Data Sharing**, collecting data from automatic sources (users’ operational environments) and manual sources (users’ inputs). This built up a database of multiple sources of data.
- **Traffic Prediction**, which aggregated all collected data that relate to a given flight, in order to supply a global view of the traffic at all times. Tools enabled us to look at the partial views of the traffic available to each user or a complete gate-to-gate view of the traffic.

The Experiments

Data collection was carried out for two periods of four weeks in October-November 2000. The experiment configuration was as shown in Figure 1.

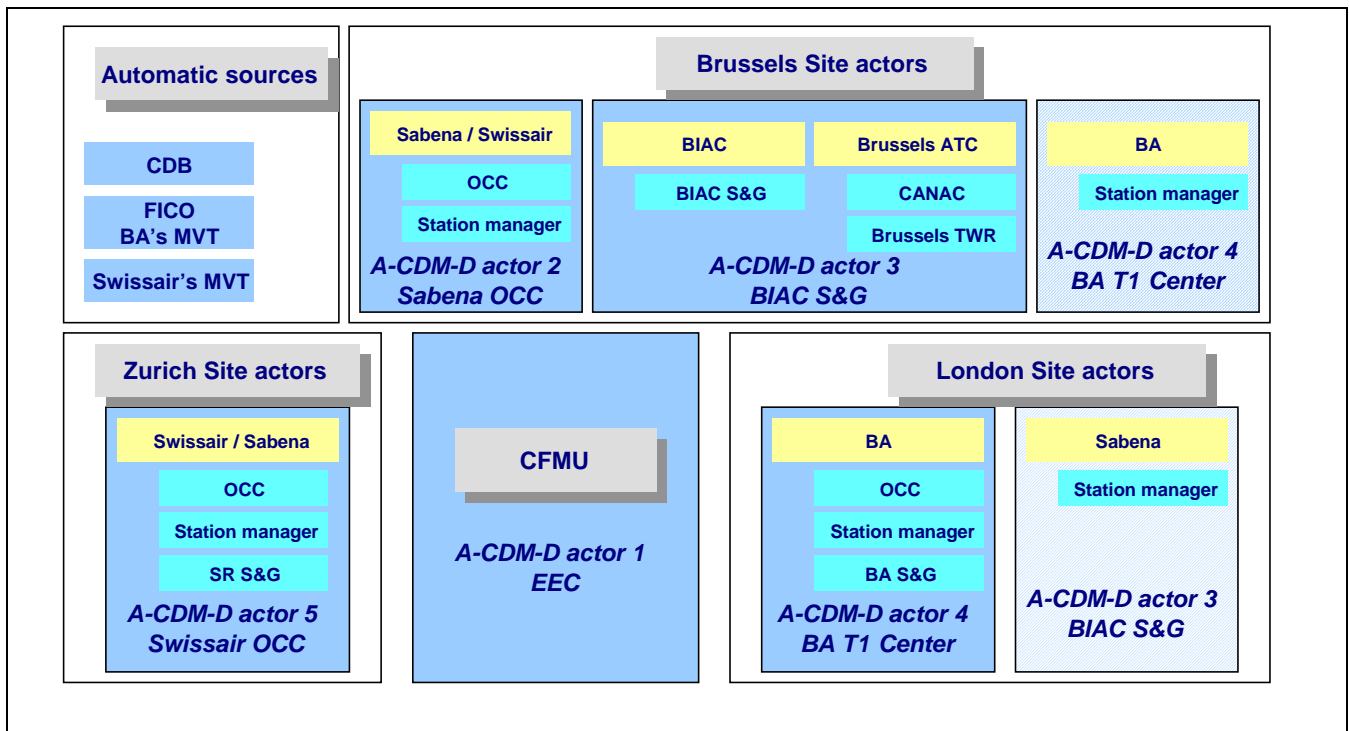


Figure 1: Experiment Organisation

Data was collected by electronic links from Brussels, Sabena, Swissair, British Airways and CFMU systems.

Data was collected manually by having staff monitoring events in the AOC and airport operations rooms.

The data was collated in the Traffic Prediction database at the end of the runs and analysed to understand operations around gates and stands at Brussels (managed by BIAC) and London Heathrow Terminal 1 (managed by British Airways).

Information for Stand & Gate Management

At least three generic functions may be identified in the “Stand and gate management” function:

- **Stand & Gate planning**, ensuring the development of the stand & gate plan, performed at strategic level (seasonal level), pre-tactical level (month level, week level) and tactical level (day of operations level).
- **Stand & Gate allocation**: the allocation during the day of operation (e.g. day of operations level) of a stand and a gate to a given flight.

- **Update of the stand and gate allocation plan**: the update of the plan based on the stand and gate allocation. This action could have an impact on the Pre-tactical level.

Gates can be analysed as a flow constraint. There are a limited number of gates available for each airline that makes the gates a scarce resource. Also, there is a connection between gates and ramp/taxiways. Sometimes aircraft have to wait for each other when they pushback into the same alley or taxiway. Conversely, when an arriving aircraft finds its gate occupied, it must wait on the taxiway leading to the gate or into the alley.

Ramps and taxiways provide a system of queues that lead aircraft departures from the gates to the runways. The taxi-out time, that is the time each departure spends between pushback and takeoff, can be considered as the time each departure spends in the queuing system. There is a strong correlation between the taxi-out time and the number of departures.

Assessment of discrete information

Typically a stand and gate unit issues and receives information from four organisations as shown in Figure 2.

- If the flight is running very late, an update of the in-block time may be received (from the company).

Availability of Additional Data Sources to Stand and Gate Managers

For Brussels to London flights, the airport

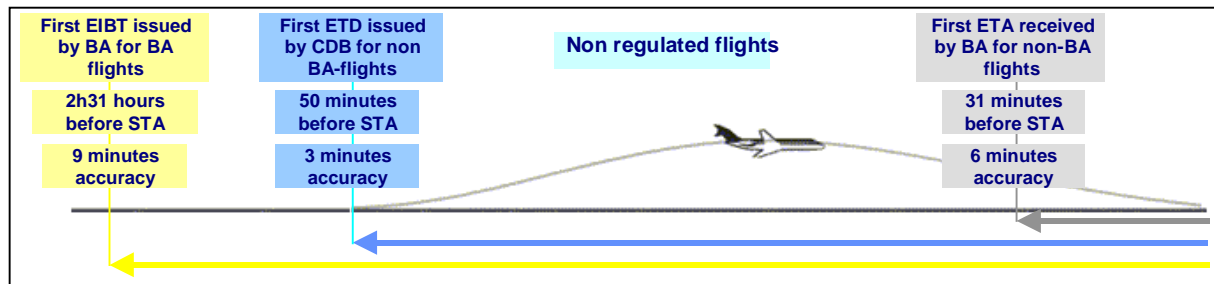


Figure 3: Accuracy of Estimates (Heathrow inbound flights) – non-regulated flights, normal days

database system Central Data Base (CDB) in Brussels computes and updates different values of Estimated Off Block Time (EOBT), reflecting constraints (such as CFMU slots) or potential internal disruptions.

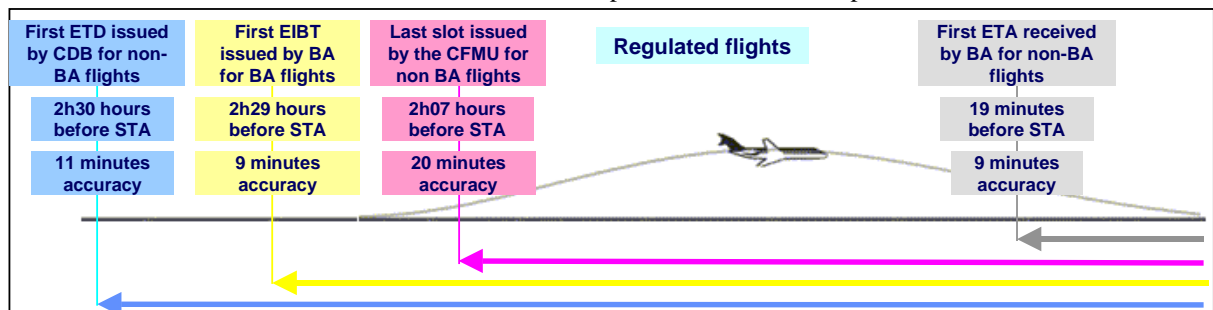


Figure 4: Accuracy of Estimates (Heathrow inbound flights) – regulated flights, normal days

However, the Brussels CDB computes an estimation of the departure time from Brussels on average 2h44 minutes before scheduled time of arrival and with a good accuracy of 9 minutes.

The results are shown in Figures 3 and 4. For non-BA flights during normal days, S&G planners at T1 receive the first EIBT for non-BA flights on average 31 minutes (unregulated flights) or 19 minutes (flow regulated flights) before scheduled time of arrival. The corresponding averages for data accuracy ranges are 6 and 9 minutes respectively. Thus, **whereas the data is quite accurate, the timeliness is poor, and is available too late for much reactivity, flexibility and optimisation of stand and gate allocations.**

For flow regulated flights (i.e. not the complete sample of Brussels-London flights) the CFMU issues the last slot on average 2h08 minutes before scheduled time of arrival. The resulting Computed Time of Arrival (CTA) has an accuracy of 15 minutes.

Thus in principle both of these sources could provide an earlier estimate of arrival time (ETA) for optimisation of stand and gate allocation at T1.

In comparison for BA flights, the T1 operators have available (from their own systems) a first EIBT on average 2h30 minutes (2h31 minutes for normal flights and 2h29 minutes for regulated flights) before scheduled time of arrival, with an average accuracy of 9 minutes. Potentially this allows a greater planning and optimisation of allocations.

However, as EOBT is by nature an estimate, the corresponding confidence or reliability of such data can be questioned since several updates could be distributed before reaching the actual value (AOBT). Discussion with resource managers revealed that they would prefer to rely on either AOBT or ATOT to predict a reliable EIBT, thereby limiting the horizon of the advance warning, and placing an upper limit on the look-ahead in the allocation plan. In practise taxi time variability means

that realistically only the ATOT at the departure airport really provides a sufficient and reliable indication for computing the EIBT, particularly for short haul flights. Such an improvement would require distribution of data to destination airports as soon as the aircraft takes off (e.g. through movement

messages). We see from the experiments that this is rarely the case.

Accuracy/Reliability

The evolution of accuracy of estimates available concerning the different populations of flights was tracked during the experiments, as shown in Figures 5 and 6.

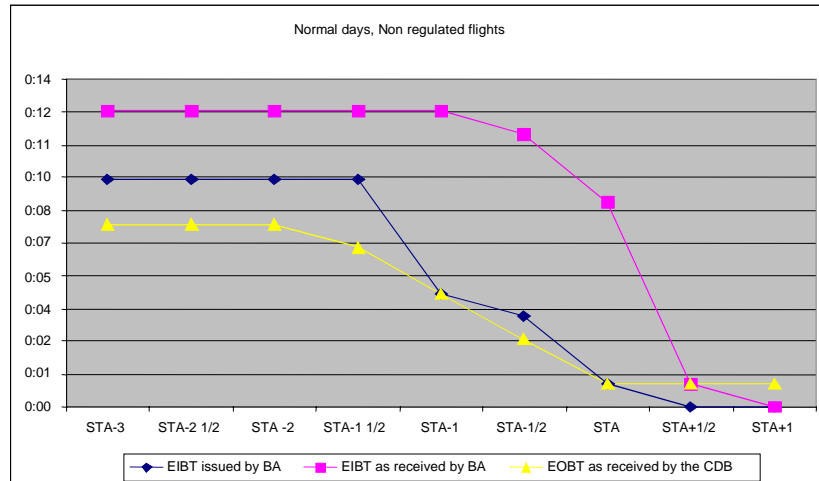


Figure 5: Accuracy of inbound LHR flights – Normal days, Non-regulated flights (minutes)

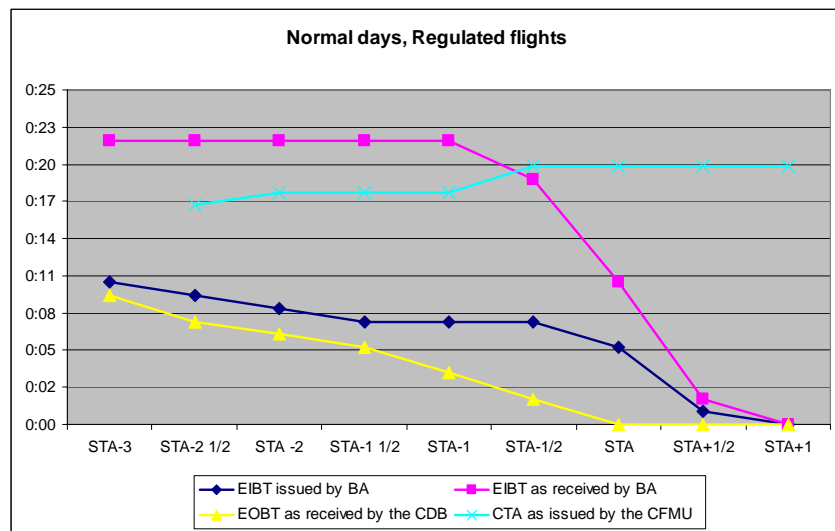


Figure 6: Accuracy of inbound LHR flights – Normal days, Regulated flights (minutes)

It was observed that the EIBT accuracy measured for non-BA flights as received by the stand and gate unit is constant until STA-1 hour (average accuracy: 13 minutes). This accuracy improves rapidly between STA-1/2 hour (average accuracy 12 min) and STA+1/2 hours (average accuracy 1 min) once the flights are in radar coverage.

The accuracy of the in-block time estimates issued by BA for its flights is constant until STA-1/2 hours where improvements can be realised (e.g. after the landing of the previous flight at the outstation). Between STA-1/2 hour and STA, the average accuracy improves rapidly from 10 minutes down to 1 minute. At STA-1 hour (the scheduled time of take-off) the accuracy of BA's own flight data is 5 minutes.

The accuracy of the off-block time estimates received and issued by the Brussels airport CDB follows the same scheme as BA own flight data, but for all flights. This again demonstrates the benefits of distributing estimates by the departure to the arrival airport systems.

Similar evolution of accuracy of estimates can be seen for flow regulated flights (see Figure 6), with low accuracy of EIBT values for non-BA flights until STA-1/2hr but much better EIBT for BA own flights.

For flow regulated flights the CFMU can also provide a CTA. However, this data is not currently updated after slot issue, so it is of little use as an aid to improving EIBTs at T1.

In conclusion, there are several means to improve the accuracy of time estimates available to T1 stand and gate managers for inbound non-BA flights. The most likely improvement would be by extrapolation of the actual take-off time of the aircraft from outstation (which occurs at approximately STA-1 hour). This means that for all practical purposes the best strategy for improving information distribution is to:

- a) distribute indications and warnings of delays
- b) ensure widespread distribution of actuals (i.e. ATOT,...)

Use of Arrival Time Estimates: Brussels Stand and Gate Operations

The poor quality of information available to the destination airport staff concerning non-home based carriers was also observed at the other airports we studied, i.e. Brussels and Zurich. In general the home bases' ATC authority provides the earliest reliable information, which typically extends to just outside the local FIR at the first point of radar correlation.

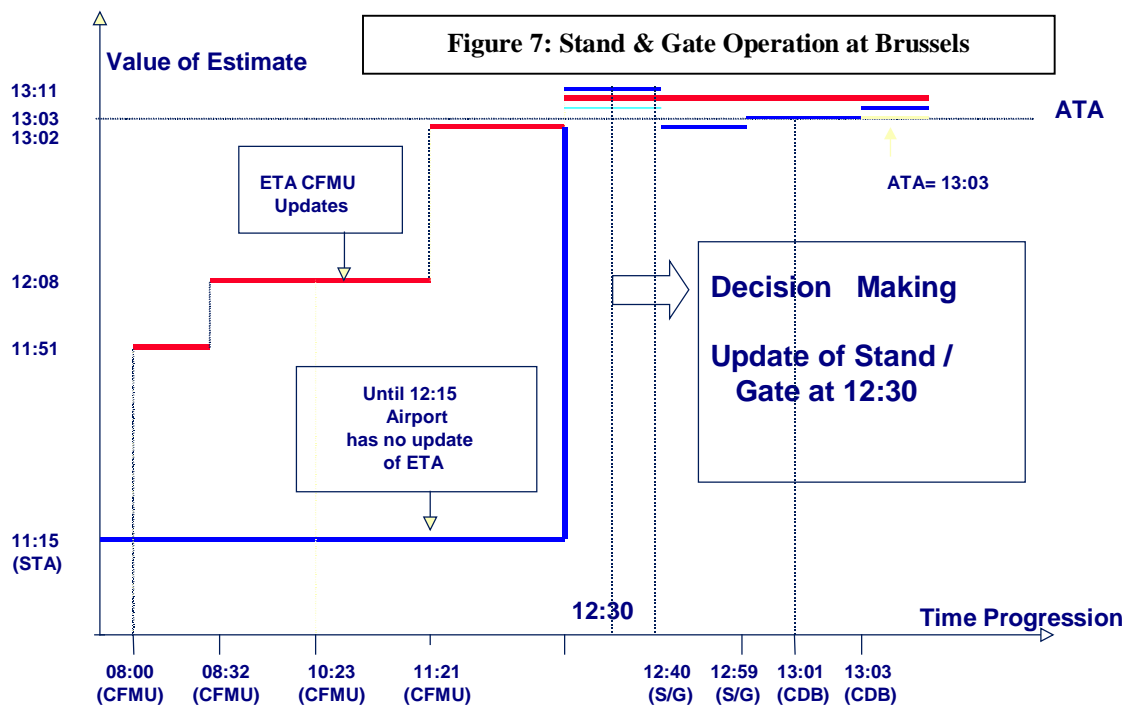
One example is shown in Figure 7 (next page). This example shows in detail the information distributed for a single flight between Zurich and Brussels. Blue lines indicate estimates available to stand and gate whereas red lines indicate estimates seen in other systems. The flight was expected in block at Brussels airport at 1115, and hence a stand and gate allocation was made for the flight concerned. The stand and gate managers eventually received an update 1215. Until that time the stand was blocked for the aircraft concerned. At that point, an update was received indicating AOBT and ATOT, 33 minutes before ATA. However, as shown on the figure, a series of more accurate estimates were distributed by the airline to the CFMU at 0800, 0832 and 1121. If these had been available to the stand and gate management system, the staff there could have reacted sooner.

The consequence of the absence of information exchange was that the stand and gate allocated earlier to the flight were not used for approximately 45 minutes. Grossing up this consequence, **the airport could (ignoring other constraints such as runway limitations) perform several additional rotations daily with resulting extra landing fees and revenues from passengers.**

Review of Results and Conclusions

Observed Weaknesses

The experiments demonstrated that there is a clear difficulty in providing others with accurate, reliable and timely information, and hence there is a need for CDM. Weaknesses detected concerned both distribution of estimates and decisions by the actors (e.g. which aircraft is allocated to which flight).



may be of higher quality (e.g. in terms of accuracy against timeliness aspects) but would be difficult to implement since different competing objectives may lead to inconsistencies.

Completeness

In terms of completeness, most of the required information already exists in existing systems: the issue is to fill information gaps by assuring fuller distribution of this information. Such improvements rely on the will of actors to distribute data that are not available to others and highlight the importance of proprietary issues linked to information distribution.

The Decisions of Individual Actors are Not Known

Of particular note is the way decisions are not distributed. For example, ATC intentions regarding reduced use of runways or taxiways are not widely published. Early information could be used to enable Aircraft Operators to establish priorities for departure.

Quality of Information

Significant discrepancies in quality of information (including completeness of information, accuracy, reliability and timeliness) were noted. Improving the quality of information is the main challenge for all actors. It is felt that timeliness aspect is probably the key aspect for enhancing the overall process.

Similarly Aircraft Operators decisions regarding aircraft changes, connections waiting for a feeder aircraft, etc. are not generally made available to Parking Control. Such data would enable it to plan its operations with efficiency.

The benefit of merging different sources was not measured, as the existence of different and proprietary estimates at a given time reflect different plans. Thus reconciliation of competing plans seems more promising compared to pure and simple aggregation of data. A strategy would be to establish clear responsibilities of each actor for providing, updating and sharing data.

Identification of Challenges

It is easy to identify a global objective such as to increase the overall efficiency of the system. To realise such improvements it is important to consider how each actor's environment (composed of objectives, constraints, individual strategy, behaviour, priorities to access to scarce resources etc.) impacts the others. It is necessary to recognise the difference of objectives. Individually these can be translated in specific "efficiencies" such as performance, costs and return on investments depending on the actor considered.

However, our analyses have found that the aggregation of information in disruption cases

One important aspect that has been noted during experiments was to understand the actors' behaviour regarding the system. While specific actors are provided with inaccurate and unreliable information and complain about this, the reason is that the provision of accurate data by the owners may lead to detrimental effects. Thus, the challenge for CDM is to find a way to remove such disincentives through agreed procedures.

Future CDM Activity

CDM is a process that already occurs widely in many parts of the ATM system: for example locally at airports, or between CFMU and airlines. At the present time these processes are less efficient than is possible because of limitations in the exchange of information on estimates and decisions by the actors.

Acronyms

ACDMD	Air Collaborative Decision Making Demonstrator
AIBT	Actual In-Block Time
ATA	Actual Time of Arrival
ATOT	Actual Take-Off Time
BA	British Airways
BIAC	Brussels International Airport Company
CDB	Central Data Base (at Brussels Airport)
CDM	Collaborative Decision Making
CTA	Calculated Time of Arrival (by the CFMU)
EIBT	Estimated In-Block Time
ETOT	Estimated Take-Off Time
S&G	Stand and Gate
STA	Scheduled Time of Arrival
T1	London Heathrow Terminal One

References

- [1] Potential Applications of CDM. EEC Report 19/1998. Martin et al.

Biographical Note

Peter Martin is a project manager, responsible for the EEC activity on Collaborative Decision Making since its inception.

Olivier Delain is an ATM analyst concerned with a variety of R&D projects, particularly in the flow management domain.

Fadi Fakhoury is a consultant experienced in the airline and transport industries.

These experiments have demonstrated that a lot of information required to improve the processes already exists. It is not distributed because there is insufficient reason to do so, perhaps for simple lack of a clear motivation, for operational or economic reasons, or even because there are clear disincentives in terms of penalties suffered. Our near term work on CDM will therefore concentrate on local airport studies to examine what can be done to remove these barriers to effective communication, and at all times focus on the associated return on investment.

Acknowledgements

The authors would like to thank the participating airports and airlines for their support in this study, and other members of the ACDMD project consortium responsible for the Demonstrator development.