ATFM studies with COSAAC

Forewords

A new activity was born in 1992 for the "Eurocontrol Experimental Centre" (**EEC**) with the objective of defining and validating new flow management concepts. This evolved into a full work programme of studies including performance aspects of the "Central Flow Management Unit" (**CFMU**) operation and optimization studies.

The development of the "**COmmon Simulator to assess ASM and ATFM Concepts**" (**COSAAC**) by the "Performance, Flow, Economics and efficiency" (**PFE**) business area was decided to answer some of the challenging questions raised by the ATFM studies.

The objectives of PFE are:

- to undertake macroscopic studies on the ATC infrastructure, demand patterns and capacity issues in order to assess the overall performance of the traffic management system,
- to conduct studies on the optimization of the current flow management system, define and evaluate new concepts for flow management and control,
- to undertake economic and institutional studies on the ATM system.

These activities imply research studies, operational case studies, simulations, prototyping and economic studies.

COSAAC is adapted to strategic and pre-tactical studies and simulations in the fields of airspace design, airspace management and air traffic flow management (ATFM). It helps in evaluating the cost of a set of capacity constraints mainly in term of total delay generated, delay distribution, individual delay generated by each capacity constraint. According to this, an ATFM slot allocation module is included in COSAAC.

Simulation methodology

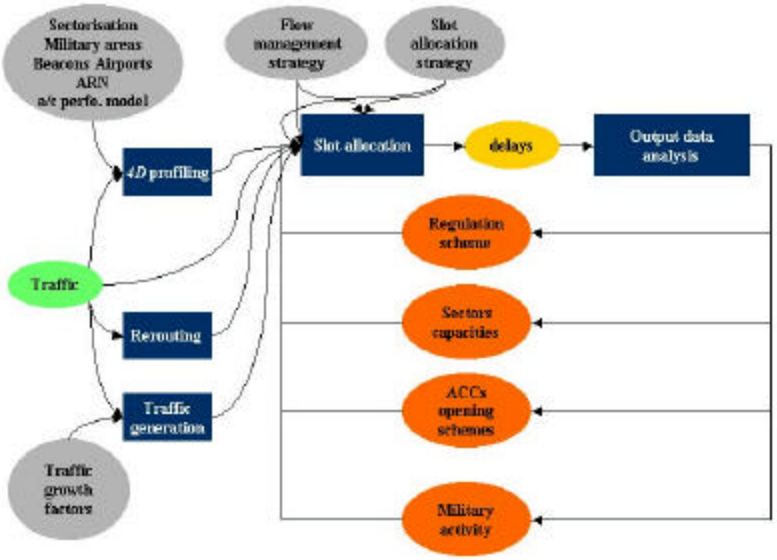

Figure 1 – COSAAC simulation methodology

COSAAC helps to evaluate the cost of a set of capacity constraints (*figure 1*, orange ovals).

Traffic demand (green oval) can be adapted to a new sectorization[1] (for example), to a future time horizon (by applying traffic growth factors), to a new ATS Route Network, a new SRS (using the internal rerouting module), available CDRs (by using the CARAT tool).

Then, flow management strategies and slot allocation strategies are applied to the new traffic demand for satisfying capacity constraints.[2]

Total delay generated, delay distribution, individual delay generated by each capacity constraint, periods of delay generation, fairness indicator of delay distribution, are given (yellow oval). All this information is graphically presented (see *figure 3*).

After expertise of simulation results, the ATFM specialist can loop back on traffic, capacity constraints, slot allocation strategy… and restart a new session.

In the near future, the integration of the results coming out from WOODSTOCK[3] project (EEC/PFE) dealing with traffic complexity and ATC workload, will be done. Using the *4D* profiler included in COSAAC, any change in sectorization or/and in traffic assignment could give new ATC workload of which a new capacity value can be derived.

Functionalities

COSAAC is both a prototype with a powerful HMI designed for ATFM operators involved in strategic and pre-tactical activities and a fast-time arithmetic ATFM simulator.

Initially, COSAAC's ancestor has been designed as a cooperative tool and not as a prosthesis of the ATFM expert's brain:

- The information has to be presented at the right time, at the right level. This characteristic has been kept and COSAAC's HMI is based on levels of representations

[1] Sectorization, beacons, military areas borders can be edited using the EVEA tool (developed by the "Centre d'Etudes de la Navigation Aérienne", CENA).

[2] *Figure* 1 shows that flow management strategies and slot allocation strategies can be considered independently and alternatively as input data or as operational constraints on the ATFM simulation activity.

[3] WOODSTOCK stands for "Wide Object-Oriented Data Standard Traffic Observable Complexity Knowledge". This project is developed by PFE.

and data granularity: the ATFM problem can be diagnosed at the level of several ACCs, of one ACC, of a group of sectors, of one sector, of flows and finally down to the individual aircraft.

- Being a cooperative tool, COSAAC works in a ***what-if* mode** to:
  - **Manage capacity** including military activity. Each sector or group of sectors can have a different capacity according to an operational mode: with/without military activity, weekday/weekend, for example.
  - **Analyse the traffic demand** and compare it to the available capacity of a sector, any traffic flow, a CFMU traffic volume…
  - **Perform a slot allocation** identical to that of CFMU or using alternative algorithms, all modules being developed within the **ISA**[4] project. This allows the evaluation of new slot allocation and flow management strategies in term of total delay generated by all capacity constraints, total number of flights that have been delayed, individual delay generated by each capacity constraint, periods of delay generation for improving ACCs configurations, delay distribution, fairness indicator of delay distribution.
  - **Reroute traffic flows** manually or automatically and optimally with **CARAT**[5]. Each flight of a traffic flow can be rerouted individually or according to the representative flight of the group of flights it belongs to.
  - **In/de-crease traffic demand.**
  - **Apply a Gaussian noise to departure hours** to simulate operational disturbances and evaluate potential capacity overloads after slot allocation, for example.
  - Apply any kind of action to the traffic by writing *C* code lines in a pre-defined function body.

For each of the last four actions, scenarios can be saved into text files. One scenario can be restored at any time.

Modified traffic demand can be saved after application of one or several actions above.

Input/output data

Input data that are mandatory to ATFM analysis are:

- airspace environment: a sectorization, beacons and airports locations, aircraft performance model;
- flight plans archives.

For improving traffic demand/capacity comparison and for performing a slot allocation, capacity values (for sectors, traffic flows, airports) and/or flow management measures, are required.

Output data can be presented under various forms: bar chart (number of a/c per *Dt* minutes, per slice of flight levels, delay per sector/regulation, distribution of delay…), tree (origins and destinations linked to one sector), *3D* (for sectors and traffic flows), double *2D* (sectors, sector load, traffic flows, beacon load, vertical flight path and flight path on ground), flight plans list (including strips), text file (in the input format for COSAAC or spreadsheet compatible), screen dump. *Figures 2* and *3* give examples of these graphical representations.

[4] ISA stands for “Innovative Slot Allocation”. This project is developed by PFE.
[5] CARAT stands for “Computer Aided Route Allocation Tool”. This project is developed by PFE.

Figure 3 - traffic demand bar chart, vertical flight path, strips, sized traffic flows, sectorization… are part of the available output formats of COSAAC

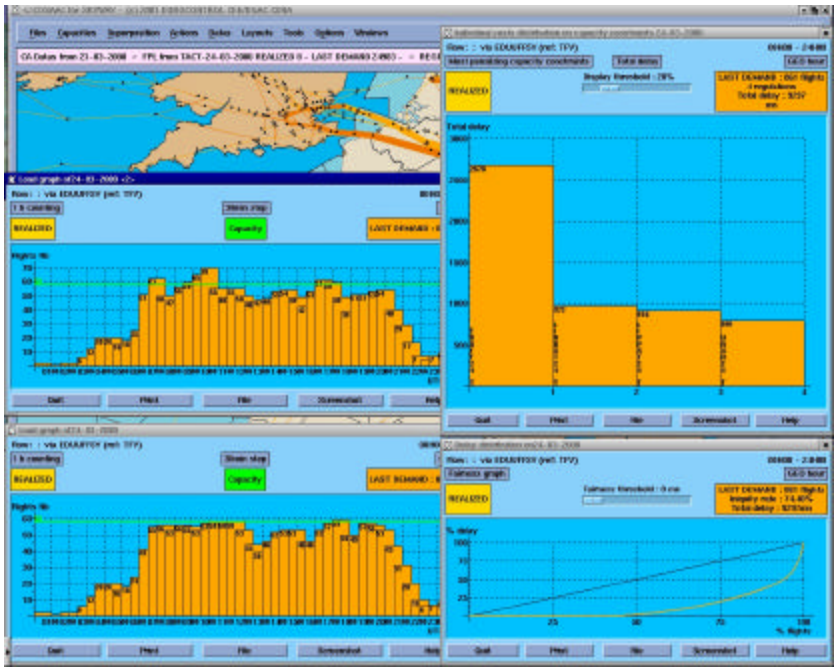

Figure 2 – On the left, traffic demand for EDUUFF5Y traffic volume before and after slot allocation. The green line represents the maximal flow rate.

On the right, individual delay generated by each capacity constraint which has contributed to, at least, 20% of the total CFMU delay and distribution of ground delay.

Technical elements and benchmark

COSAAC can be used in a stand-alone mode on any UNIX station including Linux laptop.

The following benchmark is based on a Pentium *III* - 750 MHz - 512 MB RAM laptop under Linux.

Table 1- benchmark

Data (one average traffic day)	**ECAC ENV data**	**Regulation plan**	**Flight plans file**	**ISA/CASA capacity constraints generation**	**ISA/CASA slot allocation**
Short description	Sectorization, beacons, airports, a/c performance model, ACCs descriptions, traffic volumes and flows	One day flow management measures.	CFMU ALL_FT format.		
Data size		200 regulations	28000 flight plans		
Time to load (in *s*)	< 5	< 1	15..20	20..25	25..30

Partnership and studies

COSAAC is being developed by PFE in cooperation with the “Centre d’Etudes de la Navigation Aérienne” (CENA).

COSAAC is used to investigate new ATFM concepts and for carrying out simulations in support of the day-to-day ATFM process, in cooperation with CFMU.

Within COSAAC studies, can be listed:

- In the context of CHIEF, evaluation of ACCs configurations alternatives and traffic flow re-assignment between Barcelona, Aix-en-Provence, Bordeaux, Switzerland and Milano Padova.
- Evaluation of the impact of data-link.
- Preparation of the contingency plan in case of total TACT/CASA failure.
- Preparation of the Dublin and Shannon ACCs contingency plan.
- Many other studies concerning traffic reassignment, ACC configuration improvement and more generally evaluation in term of ground delay of any action on the aeronautical environment or on the traffic that can be translated into a capacity or a variation of capacity.

Conclusion

The continuous challenge between traffic growth and capacity increase having each its own objective, makes it essential to develop tools that can help experts in evaluating efficiently and very quickly the relevance of a solution or which solutions appear to be of a particular interest (or the contrary!) before conducting further analysis on real-time simulator for operational qualification.

In the PFE business area of the EEC, COSAAC is one of these fast-time arithmetic simulators which help air traffic flow managers and airspace designers in evaluating the cost of any set of capacity constraints. COSAAC is seconded on site by the "TACT Automated COmmand Tool" of the CFMU for final operational qualification.

Contacts

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