

Attempt to evaluate data-link gains using OPAS arithmetical simulation

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1 Introduction

Several attempts to assess the capacity gains (and therefore the delay reduction) have been performed within the preparation stage of the European programme Link 2000+ whose purpose is to co-ordinate the data-link deployment in Europe from 2002 to 2007.

In particular, an arithmetical simulation carried out in the upper airspace sectors from Germany using the Eurocontrol CAPAN simulator has retained our attention. The associated report [6] has been disseminated in the Link2000+ business case context. This report presents inter alia the definition of all controllers' tasks and their duration in a data-link and a non data-link environment.

The object of this note is to present an attempt of a similar comparative study on the French airspace and using the facilities existing in CENA, namely the OPAS simulator.

2 Process

The basic principle of the study is to consider that the introduction of data-link makes the controllers' work decrease. This has been modelled by reducing the time used by certain tasks on an fixed basis (see annex A and B for details). We have only considered a 100% equipment rate.

Take note that the point here is not to discuss the validity of the data-link introduction modelling : in particular, we could reproach this method for not taking into account the likely occurrence of new tasks.

The initial idea was to carry on an identical simulation on the French airspace using the CENA OPAS simulator in order to compare the results with those of the CAPAN simulation. The same controller's tasks modelling had to be used and the same reductions of time to be applied to the controller's tasks.

After consideration of the CAPAN simulation report and discussion with experts (Jean-Michel LENZI from Eurocontrol and Lionnel MAUGIS from CENA), it appeared that we were lacking important data, namely the conditions of controllers' tasks triggering. Unfortunately this piece of information wouldn't be configurable because it is hard coded in the CAPAN software.

So we finally preferred to start from CENA modelling which has the advantage to have been finely tuned within the framework of several studies, including a recent study intending to compare the traffic structure in France and in Germany.

The introduction of data-link has then been modelled in the same way as in CAPAN, namely while applying an fixed reduction to certain tasks (see annex B).

3 Simulation

The OPAS model used simulates air traffic by means of fixed time steps, and requires no human intervention (no pseudo-pilot nor controller) : it simulates completely the control actions resulting and counts different events likely to intervene in the controllers' work.

The baseline scenario corresponds to the actual air traffic environment of June 1999, in France and in Germany. It includes 110 en-route sectors above FL 245 from the German and French centres.

The traffic sample includes 14 876 flight plans for Tuesday 1st of June 1999. It is extracted from the CFMU archives, more particularly from the TACT/CASA system, and corresponds to the final traffic demand, that is to say to the flight plans filed, then regulated, but not yet controlled. In this sense, the traffic sample is somewhat different from the traffic which has really flown, but would not challenge the results nature, in view of the hypotheses retained.

The control load model is based on the definition of the control tasks, associated with the different events recorded during the simulation exercises. The operational restrictions (procedures and limitations in level on the routes) have been obtained by analysis of the TACT traffic, in order to have the same reference in both countries.

The time necessary to carry out a simulation, that is to say recording of events, the computation of workloads and of traffic flow per sector (110 sectors, 14876 flights) was 7 minutes on a Sun Ultra 80 workstation.

4 Results

Two scenarios have been compared : one scenario with no equipped aircraft acting as baseline and one scenario with 100% equipped aircraft.

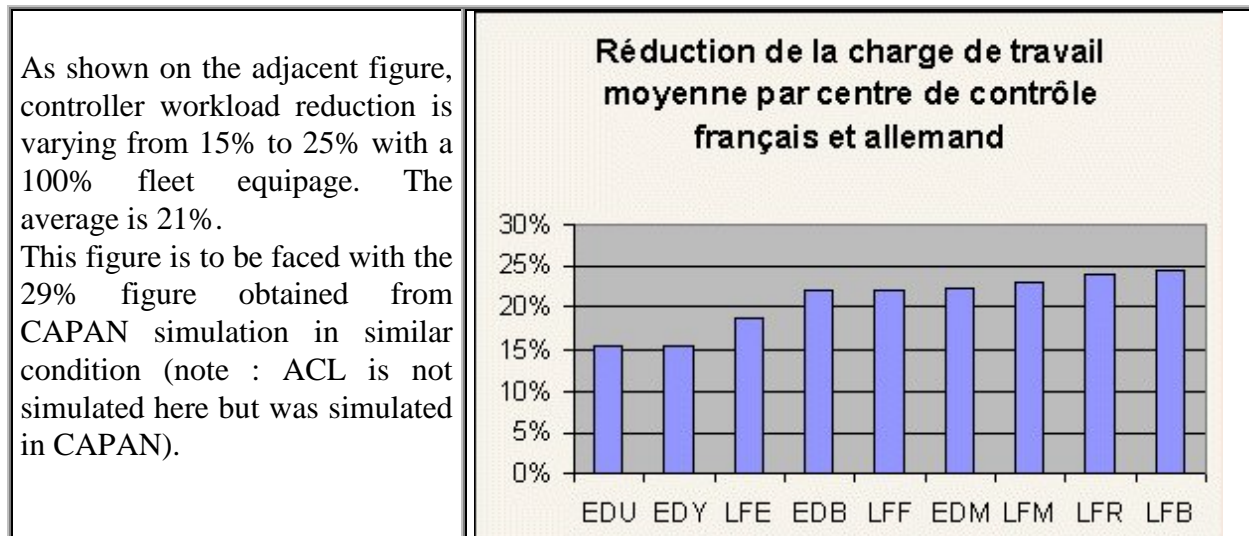
The following task workload reductions have been applied (see annex A for details) :

		frequency	without dl	Reduction	with dl
Surveillance	Stable aircraft	Once per minute	3s	-1s	2s
	Climbing ac	“	5	-1	4
	Descending ac	“	6	-1	5
Co-ordination In	Stable aircraft	Sector inbound	20*	-8	12*
	Climbing ac	“	25	-8	17
	Descending ac	“	25	-8	17
Co-ordination Out	Stable aircraft	Sector outbound	10*	-4	6*
	Climbing ac	“	15	-4	11
	Descending ac	“	15	-4	11

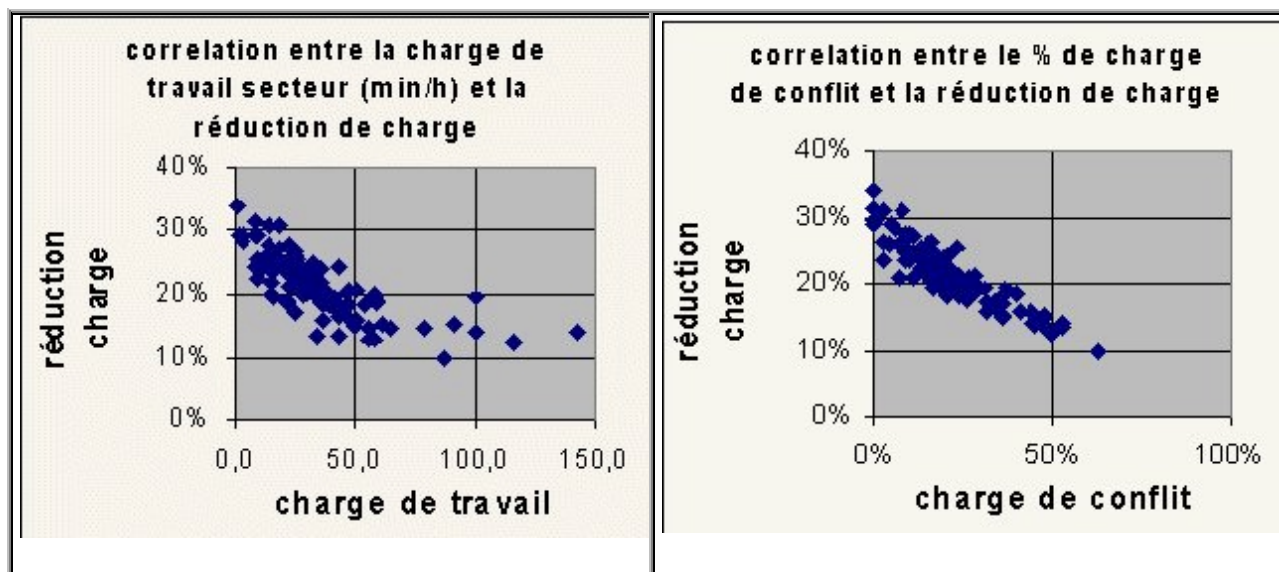
* : an additional duration of 10 seconds is applied in case of inter centre co-ordination.

** : Such a reduction scenario could happen with ACM and CAP services. ACL service has not been considered.

Though a lot of information is available from the simulation, only the major results are presented hereafter.

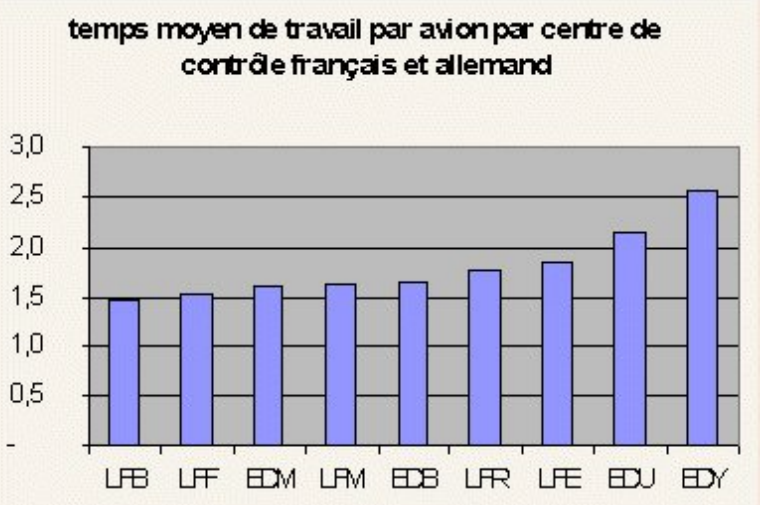


The graph below shows that the workload reduction decreases as the sector load increases. This can be explained by the fact the sector load is mainly linked to the conflict management workload which is not affected by the data-link introduction.

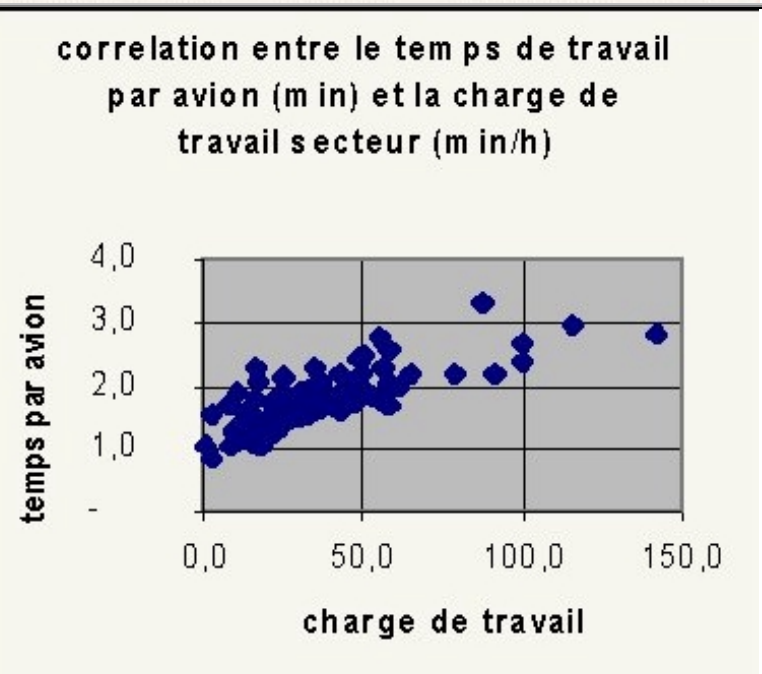


Some additional information :

The graph below gives the mean working time (in minutes) per flight in each French and German centres.



The graph beside shows that the mean working time per flight increases when the sector load increases.



5 Conclusion

This very short study has shown that the OPAS simulator let us observe more or less identical results to these of Eurocontrol tools for the data-link introduction, the main difference being that we master all parameters.

One must remind that the global validation of this type of studies requires to publish not only the studies results but also the models parameters in order to be able to reproduce the results.

A possible continuation of this study would consist in refining modelling :

- Studying more finely the time reductions for the tasks proposed, and defining several scenarios ;
- Taking into account the new tasks which would be possibly created by the introduction of the data-link.

This activity requires a further definition / analysis of the working methods in a mixed data-link environment (equipped / not equipped aircraft). These activities should be supported by real-time simulations.

6 References

- [1] Simulation Based Planning for the assessment of advanced EATMS concepts : the OPAS system, L.Maugis, CENA technical memo, May 1997
- [2] An experimental study of ATM Capacity, May 30, 1997, FAA-EUROCONTROL Seminar, Bretigny, L.Maugis, JM.Alliot, N.Durand, JF.Bosc
- [3] Assessment of RVSM procedures with the OPAS system, Review of the General Concept of Separation Panel, ICAO Brussels, October 1997, L.Maugis, D.Malescot
- [4] CATS : a complete air traffic simulator, Digital Avionics Systems Conference, University of California at Irvine, 1998, JM Alliot, N.Durand, JF.Bosc, L.Maugis
- [5] Techniques de détermination de la capacité : statistiques et simulations. Note technique CENA NT97-286. L.Maugis, JB.Gotteland, Decembre 1997.
- [6] LINK2000+ : Fast Time Simulation to assess the Impact of Data Link on Sector Capacity

Annexe A : OPAS simulation parameters

The Table below shows the list of simulated tasks and the tasks affected by data-link.

 (* OPAS (Outil de Planification ATM et Simulation) CENA/RFM/L.Maugis *)
 (* Copyright (c) 1998 CENA/ENAC Laboratoire d'Optimisation Globale *)
 (* Module [Task] : *paramètres de charges de contrôle en secondes* *)
 (* la simulation est effectuée sans résolution de conflit mais avec détection *)
 (* prise en compte des services data-link ACM (changement de fréquence) *)
 (* et CAP (présentation paramètres avion) *)

(* Application d'une *réduction de charge de travail forfaitaire due au data-link* sur les tâches suivantes : *)

(*	taches de coordination In	-8s	*)
(*	taches de coordination Out	-4s	*)
(*	taches de surveillance cyclique	-1s	*)

CFT_OVRTK_STABLE	110	(* conflit de 2 avions stables en dépassement *)
CFT_FACE_STABLE	200	(* conflit face à face de 2 avions stables *)
CFT_CROSS_STABLE	170	(* croisement de 2 avions stables *)
CFT_LWCROSS_STABLE	230	(* croisement à angle faible de 2 avions stables *)
CFT_OVRTK_EVOL	150	(* idem mais au moins l'un des 2 est évolutif *)
CFT_FACE_EVOL	240	(* « *)
CFT_CROSS_EVOL	210	(* « *)
CFT_LWCROSS_EVOL	270	(* « *)
SURV_BEACON	8	(* passage de balise - changement de cap *)
SURV_CFL	15	(* consigne de niveau quand il y a des procédures *)
SURV_TOPC	12	(* fin de montée *)
SURV_TOPD	12	(* début de descente *)
SURV_MINUTE_STABLE (-1)	2	(* toutes les minutes, pour chaque avion stable *)
SURV_MINUTE_CLIMB (-1)	4	(* idem en montée *)
SURV_MINUTE_DESC (-1)	5	(* idem en descente *)
SURV_RVSM	45	(* niveau RVSM demandé *)
COORD_IN_STABLE (-8)	12	(* coordination en entrée de secteur, avions stable *)
COORD_IN_CLIMB (-8)	17	(* idem en montée *)
COORD_IN_DESC (-8)	17	(* idem en descente *)
COORD_OUT_STABLE (-4)	6	(* coordination en sortie de secteur *)
COORD_OUT_CLIMB (-4)	11	(* idem en montée *)
COORD_OUT_DESC (-4)	11	(* idem en descente *)
COORD_IN_INTER_STABLE	10	(* poids sup. en cas de coordination inter-centres *)
COORD_IN_INTER_CLIMB	10	(* idem en montée *)
COORD_IN_INTER_DESC	10	
COORD_OUT_INTER_STABLE	10	
COORD_OUT_INTER_CLIMB	10	
COORD_OUT_INTER_DESC	10	

Annexe B : CAPAN simulation parameters

- The table below shows the list of tasks affected by data-link :

Description of the Task	Execution time (sec)		
	Baseline		Data-link
First call from an aircraft entering the airspace of a new ACC.	EC 12"	-8"	EC 4"
First call from an aircraft entering another sector of the same ACC	EC 9"	-5"	EC 4"
Report of an aircraft on reaching a specified level	EC 6"	-	EC 6"
R/T Instructions to change SSR code	EC 6"	-2"	EC 4"
R/T Instruction to an aircraft to comply with a new planning clearance (Level change, start of descent, new stack level clearance)	EC 7"	-5"	EC 2"
Last R/T message to an aircraft leaving an ATC sector.	EC 6"	-4"	EC 2"

- The table below shows the main CAPAN simulation results :

	Baseline	25% Fleet Equipped	50% Fleet Equipped	75% Fleet Equipped	100% Fleet Equipped
Reduction of Total Executive Controller Workloads	-	-7%	-15%	22%	-29%