

The Influence of Uncertainties on TCSA

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Introduction

The CATS/ERCOS Simulator

Simulation Results

Conclusion and Future Work

What is TCSA ?

- Traffic Control Using Speed Adjustments
- Keep aircraft on their tracks
- and solve potential conflicts
- with little speed adjustments
- ⇒ Controllers are not disturbed
- ⇒ Adds an "independant" layer to the ATM system
- Was studied in the ERASMUS project

What is ERASMUS ?

- En Route Air traffic Soft Management Ultimate System
- Subliminal TCSA
- Scenarios were tested in real environments
- Check the controllers sensitivity to speed changes
- Check the controllers interaction with an automatic solver using speed adjustments
- Questions raised
 - Efficiency of TCSA ?
 - Interaction with Controllers (Controllers might break resolutions) ?
 - Interaction with pilots (how much time is needed) ?
- Experiments performed using ERCOS

Existing TCSA Algorithms :

- Mixed Integer Linear Programming
- GATech, LICIT
- Evolutionary Computation
- DSNA
- ...

Objective of the paper

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- Different hypotheses on process update

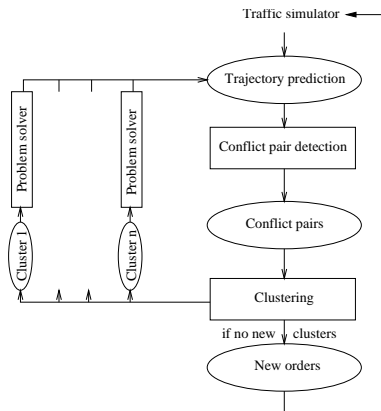
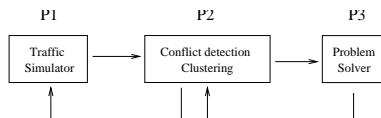
What is CATS ?

- Complete Air Traffic Simulator
- Fast time simulator
- Real data flight plans
- Tabulated Model (BADA)
- timesteps
- Uncertainties can be used

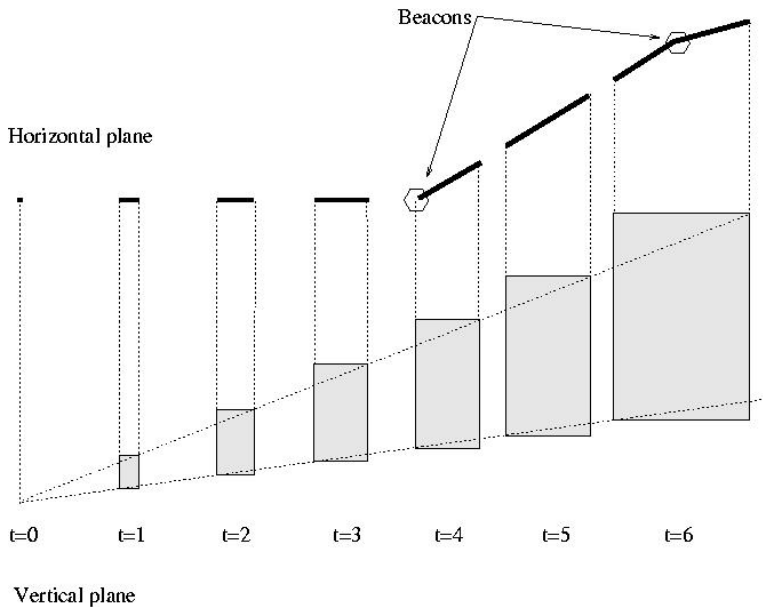
What is ERCOS ?

- En-Route Conflicts Optimized Solver
- Detects conflicts on a prediction Time Window (20 Minutes)
- Builds clusters (transitive closure of pairwise conflicts)
- Solves Conflicts
- Checks that maneuvers do not create new conflicts
- Applies resolutions that start before the next detection
- Moves on to the next Detection process (every 3 to 5 minutes)

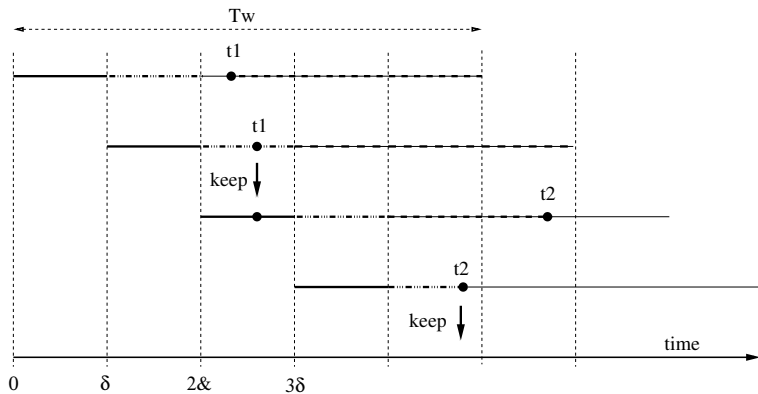
What is ERCOS ?



ERCOS : Uncertainty modeling



ERCOS : Maneuver decision time

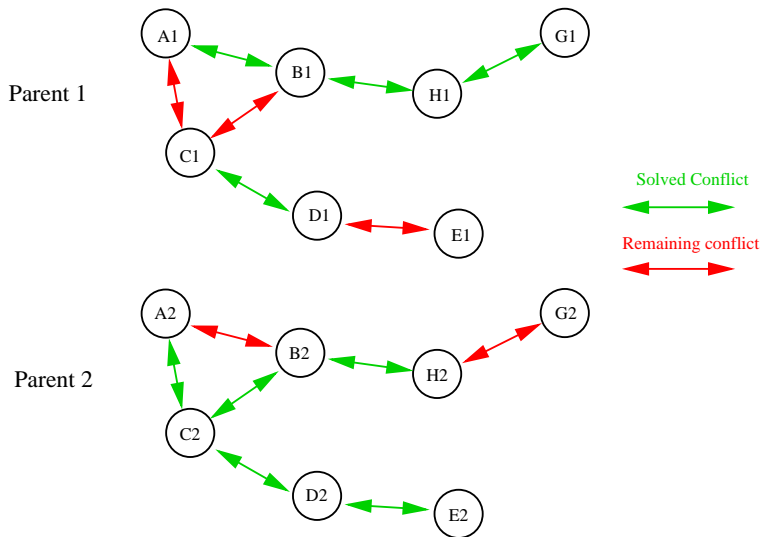


ERCOS : Fitness function

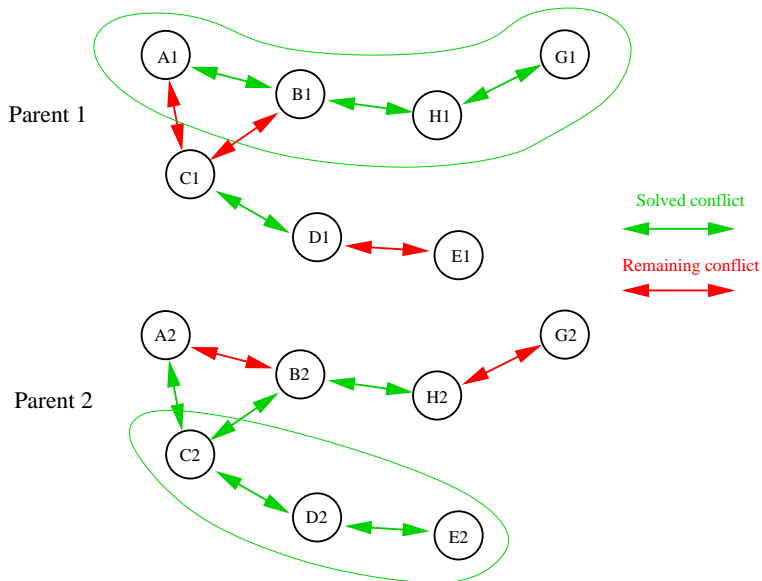
$$F = \frac{n - \sum_{i=1}^n \left(\frac{\delta_i}{\delta_{max}} \right)}{1 + n_{rc}}$$

where n is the number of aircraft and n_{rc} is the number of remaining conflicts.

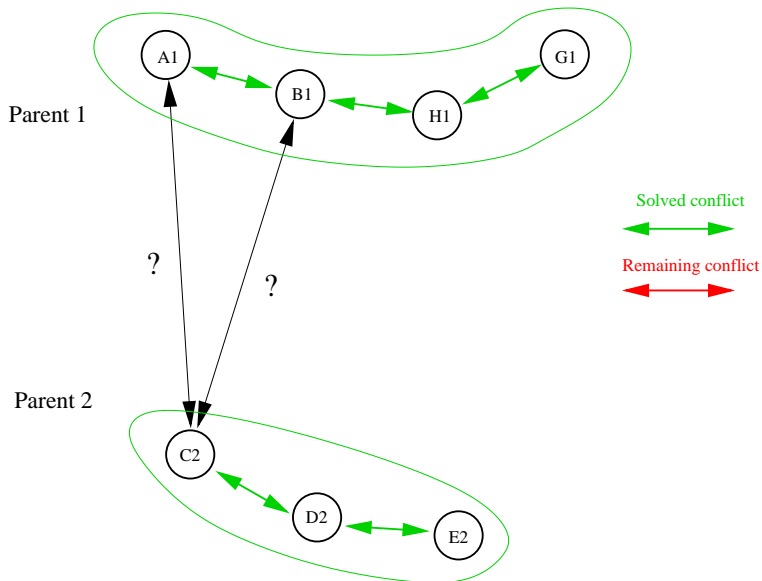
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ERCOs : Crossover operator



Simulation context

- busy day of traffic (July 17th 2010)
- French upper airspace (above FL195)
- 8870 flights
- 2305 conflicts are detected
- Mean time of flights : 57 minutes
- Mean travelled distance : 394 nautical miles.

Simulation Results ($\delta = 3\text{minutes}$)

horiz uncert	vert uncert	speed range	remaining conf(leveled)	% rem confs	man aircraft	% of acft man	nb of mans	nb man per acft
0	0	[-15 15]	78 (69)	3%	1889	21%	2397	0.27
0	0	[-10 10]	82 (72)	4%	1940	22%	2428	0.27
0	0	[-5 5]	144 (131)	6%	2102	24%	2605	0.29
2	10	[-5 5]	173 (142)	7%	3609	41%	5023	0.57
2	30	[-5 5]	191 (143)	8%	4663	53%	7093	0.80
5	10	[-5 5]	347 (244)	15%	5224	59%	8658	0.98
5	30	[-5 5]	392 (279)	17%	6194	70%	11447	1.29
10	10	[-5 5]	872 (612)	38%	6971	79%	14808	1.67
10	30	[-5 5]	1019 (663)	44%	7445	84%	16952	1.91

Simulation Results ($\delta = 5 \text{ minutes}$)

horiz uncert	vert uncert	speed range	remaining conf(leveled)	% rem confs	man aircraft	% of acft man	nb of mans	nb man per acft
0	0	[-15 15]	100 (84)	4%	2026	21%	2634	0.3
0	0	[-10 10]	107 (89)	5%	2057	23%	2700	0.3
0	0	[-5 5]	205 (166)	9%	2349	26%	3060	0.34
2	10	[-5 5]	251 (204)	11%	4162	47%	6058	0.68
2	30	[-5 5]	334 (232)	14%	5284	60%	8258	0.93
5	10	[-5 5]	517 (359)	22%	5773	65%	9688	1.09
5	30	[-5 5]	591 (386)	26%	6544	74%	11995	1.35
10	10	[-5 5]	1150 (801)	50%	7133	80%	14428	1.62
10	30	[-5 5]	1410 (935)	61%	7593	86%	16675	1.88

Conclusion

- TCSA very efficient with a good TP in the $[-5 \ 5]$ speed range
- Uncertainties increase
 - the number of remaining conflicts
 - the number of maneuvers
- Update frequency can limit the impact of uncertainties

Future work

- Some uncertainties are not taken into account (Pilots intents)
- Integrate FMS RTA capabilities in the modeling
- How to prevent controllers from "breaking" solutions
- Model the fuel cost in the optimized criteria
- CSP modeling