Report on 7th EUROCONTROL Innovative Research Workshop

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Presented at
ENRI International Workshop on ATM/CNS
March 2009, Tokyo, Japan

Brief history of the workshop

- Held each year in December at EUROCONTROL Experimental Centre, France
- Now on 7th in the series
- Started as a forum for PhD students with around 40 participants
- 2008 saw:
  - 230 participants
  - >40 papers
  - a dozen exhibits

Highlighted papers

- This presentation introduces a handful of papers that (arguably) represent the state of the art in their subjects[1]:
  - Man-machine interaction, collaboration and automation
  - ASAS
  - Economics
  - + environment and future communications
- There are some recurrent themes

[1]to be discussed ... over a cocktail!

References

- All full papers and presentations available on the website:

  inoworkshop.eurocontrol.fr

- Also a couple of videos
- All slides in this presentation used with agreement

Man-machine interaction, collaboration and automation

Highlighted paper: *Concept, Content, Containers and Controls for 3D in 2D Planar Displays for ATC (Wong et al, Interaction Design Centre, Middlesex University)*

- New display and interaction techniques
  - Used readily available devices used to explore new possibilities
- Rather than using 3D for a spatial-perspective view, support perception of important invariant functional relationships or key dimensions of cognitive work
  - Example: energy management

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D3.1 Review: Alternate Display Technologies

Middlesex University

- **To consider how alternative and advance display technologies could influence how the ATC task is performed under SESAR**
- **Any future display should assist controllers, pilots …**
  - Recognise deceptive situations and compensate for human limitations in perception, attention and memory
  - Discover conflicts and better SA
- **Goggles - projected, shutters**
- **Glasses - blue/red anaglyph**
- **Lenticular, autostereoscopic displays**
- **Gaze-Contingent Displays**
- **Multi-touch interaction, iPhone - Mitsuibishi MERL**
- **Gestural interaction**
- **'Imagineer' future interface => Un-tethered, and un-encumbered spatial and proprioceptive displays, interaction with chorded gestures**
  - At the moment, this may still be too far ahead.

3D-in-2D Display Project History:
ARToolkit Prototypes

Reach-in-and-grab

Stack manager

Operational Concepts 1:
Exploit 3D as Multi-dimensional Info rather than Spatial-Perspective Views

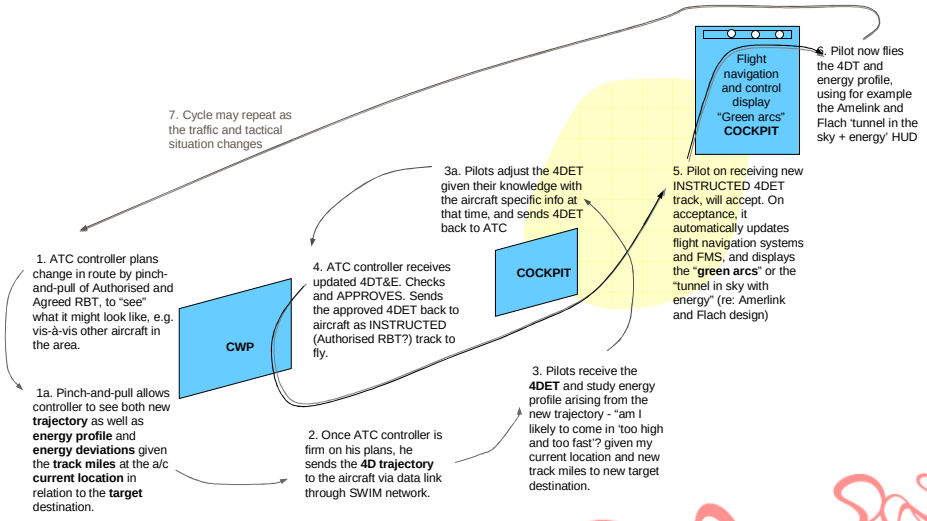
- **Often 3D used in aviation domain refers to spatial perspective views (e.g. the use of VR)**
  - This is a limiting concept as we try to mimic the real world airspace and its limitations, rather than creating powerful new affordances
- **Instead, displays should support perception of important invariant functional relationships or key dimensions of cognitive work**
  - Off-load intensive mental computations onto the visual representations that a pilot or controller can use to plan, execute and adapt
  - E.g. Energy profiles rather than a flight path

Pinch-and-Pull supported by Malleable 3D Tubes, Rings for 4DET, and the Energy Profile display

4DT => 4DET

4D-Energy Trajectory (4DET) Re-planning:

An Example of how Controller-Pilot coordination might occur



Man-machine interaction, collaboration and automation

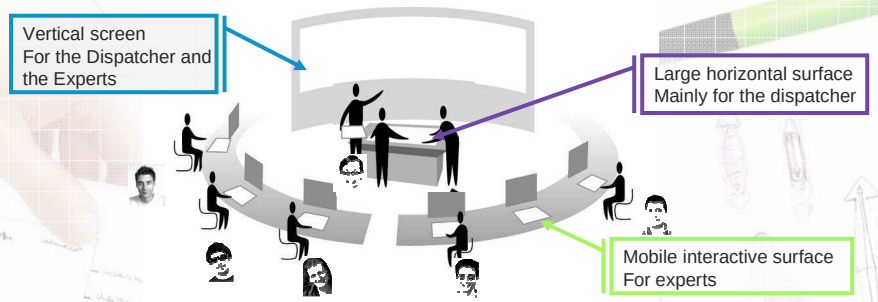
Highlighted paper: *MAMMI: Exploring Collaborative Workspaces for Air Traffic Controllers in the Scope of SESAR (Vales et al, Intuilab, Thales, Intactile, ENAC)*

- Collaboration is a word that tends to be over-used
- MAMMI looked at both workflow and physical interaction
  - Focussed on roles of multi/meta sector planner and tactical controller
    - Object of the collaboration is Reference Business Trajectory
    - Key enabler is SWIM

MAMMI Workspace

Global situation awareness

Real-time collaboration

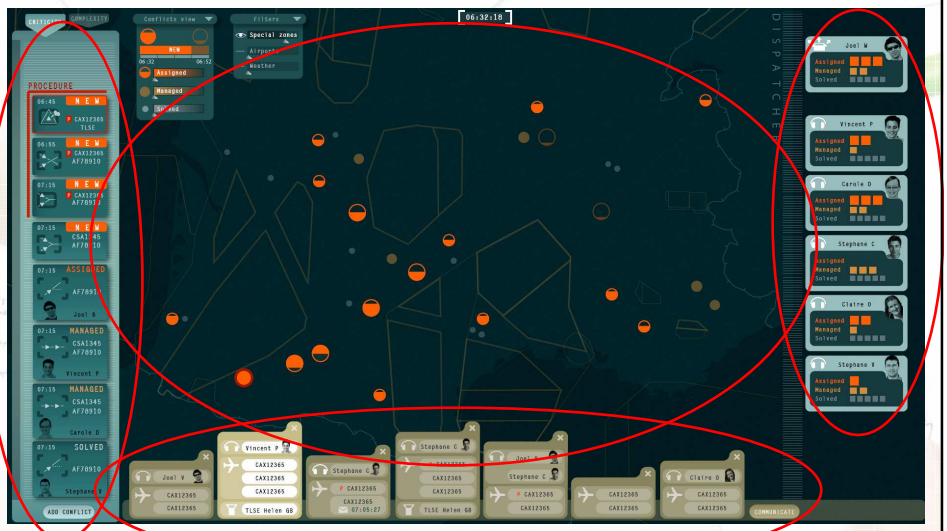


Mobility

Direct voice communication

Informal collaboration

HMI solution overview for the dispatcher



Example of multitouch interaction

MAMMI: a study in collaboration

- Collaborative workflow and interfaces need to be designed hand-in-hand
- Scenarios have been developed for cabin emergencies, weather, deviations, conflicts
- Linked into SESAR operational concepts

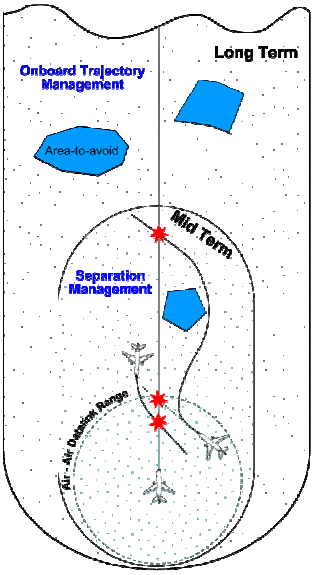
Autonomous Separation Assistance Systems (ASAS)

Highlighted paper: *Airborne System for Self-Separation in a Trajectory-Based Airspace* *(Casek et al, iFly/Honeywell)*

- Important since it engages a major avionics manufacturer
- iFly avionics architecture integrates:
  - SWIM
  - mid-term conflict detection
  - long-term zone avoidance

Situation Awareness

Honeywell



Areas of interest:

- Long Term Awareness Zone(LTAZ) – relevant for Trajectory Management (optimization)
- Mid Term Awareness Zone(MTAZ) – used for Separation Management
- Air–Air Data link Range – additional state-based Conflict Detection

A3 Airborne System Architecture Overview

Honeywell

Information Management

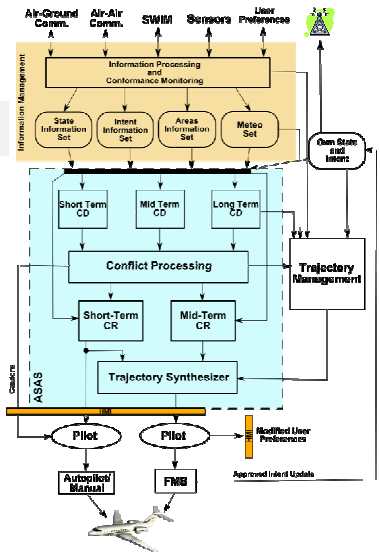
- Shields communications details
- Collect and process required data

Separation & Trajectory Management

- Situation Assessment
- Resolution Advisories

Human Machine Interface

- Situation Awareness
- Flight changes advisories



Autonomous Separation Assistance Systems (ASAS)

Highlighted paper: *Simulated Collision Risk of an Uncoordinated Airborne Self-Separation Concept of Operation* *(Blom et al, iFly/NLR)*

- Safety is a prime concern, particularly if there is no coordination e.g. exchange of intent data.
  - Priority rules do apply
- Collision risk modelled using TOPAZ methodology

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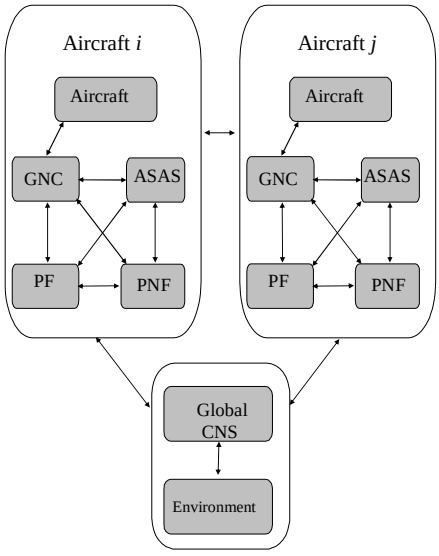
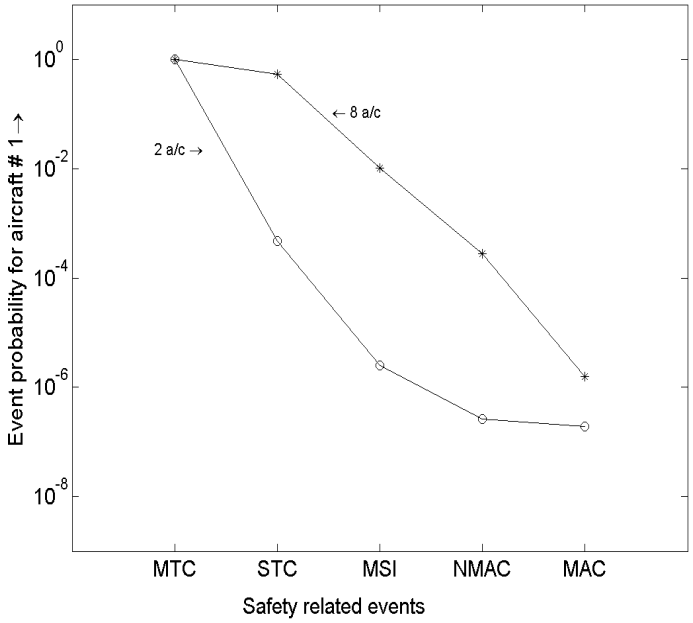
Multi Agent model



iFly

Two-aircraft vs. eight-aircraft encounter.



Conclusions

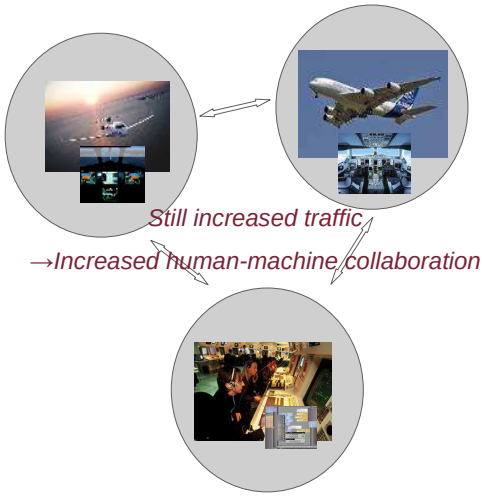
- **We identified novel behaviour, which emerges from the combined dynamical interactions of Joint Cognitive Systems (or Multi Agent System), and which has not shown before for AMFF**
- **Solving conflicts one by one in free flight, falls short in safely accommodating high en route traffic demand.**
- **Follow-up work on risk assessment:**
  - **Include ACAS, etc. in simulation model**
  - **Consider other free flight/ASAS based operations**
  - **Improve modeling and novel simulation speed-up**
  - **Validation of assessed risk level**

Autonomous Separation Assistance Systems (ASAS)

Highlighted paper: *A Socio-Cognitive Descriptive Modelling Approach to Represent Authority Distribution*
(Straussberger et al, Eurisco, LORIA, Dassault)

- Who is responsible between ground and air has long been an issue for ASAS
- The PAUSA project developed a model specifically to look at authority sharing in ATM including human and machine actors

Changing authority concepts

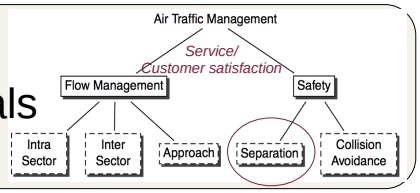


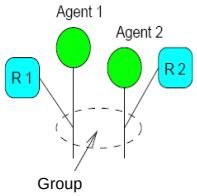
TOMORROW

- Human remains in the loop, but future operational concepts contain a new dimension of « Who does what and when »
- ATCO is no longer single point of cognition to ensure stability, flexibility, and consistency
- Dynamic variations of distributions and structures of a given authority

The organizational modeling

⇨Identify goals





⇨Identify agents

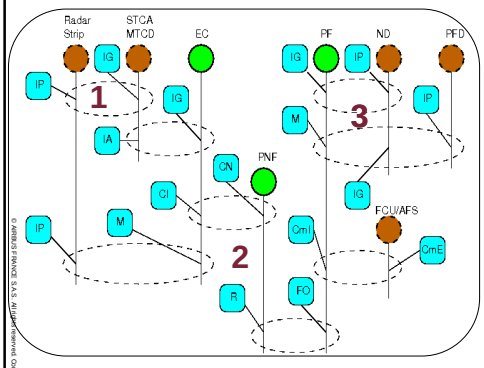
Airside Agents (A380, A321, Falcon9000)		Groundside Agents	
Human	Machine	Human	Machine
• Pilot Flying (in role of First Officer) • Pilot Non Flying (in role of Captain) • Flight Dispatcher	• FMS • Navigation Display (+CDTI), • ACAS/TCAS (AP- TCAS), • ECAM, • RMP, • PFD, • FCU	• Planning Controller • Executive Controller • Approach Controller (EXE) • Approach Controller (PLE) • Sequencer	• STCA (Short Term Conflict Alert) • ERATO • AMAN (Approach Manager)

⇨Identify roles

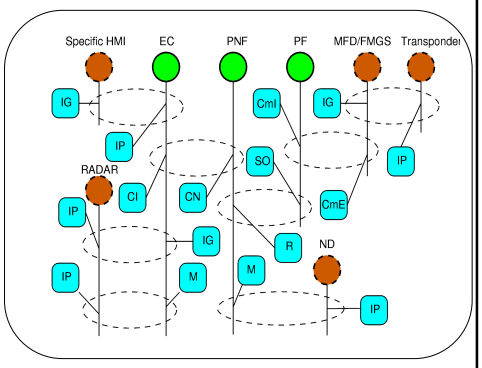
Abbreviations	Role
IP	Information Provider
IG	Information Gatherer
IA	Information Analyzer
R	Relayer
M	Monitor
FO	Flying Operator
CmI	Command Initiator
CmE	Command Executer
CI	Clearance Initiator
CN	Clearance Negotiator
SO	Spacing Operator

An ASAS Example

Separation today



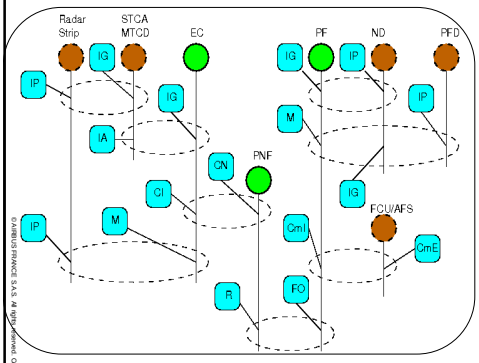
S&M Target selection



1 EC(IG) uses information provided by RADAR and by conflicts detected by MTCD or STCA.
To solve conflicts, EC issues clearances to aircraft, aircraft executes clearances.
2 PNF(CN) communicates with ground and relays to PF(CmI) who transforms clearance in command by FCU(CmE).
3 PF monitors through ND(IP) and PFD(IP).

An ASAS Example

Separation today



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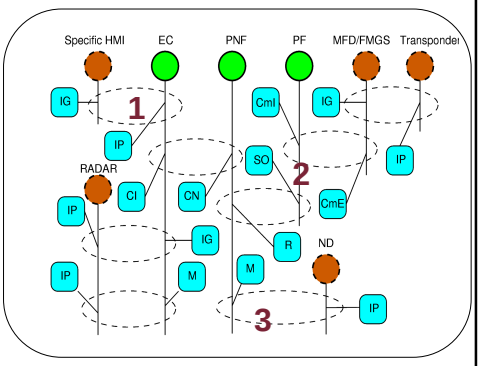
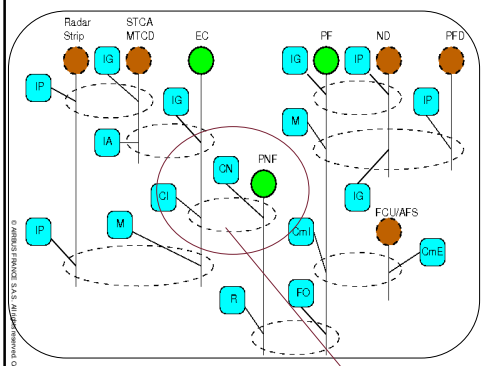


1 EC(IG) issues clearance to PNF(CN) that indicates target aircraft and confirms action on Specific HMI(IG)
2 PF (CN) operates autopilpt to follow target and sends command to FMGS.
3 FMGS manages separation with other aircraft using the information on target's transponder, PNF monitors execution of maneuver.

An ASAS Example

Separation today



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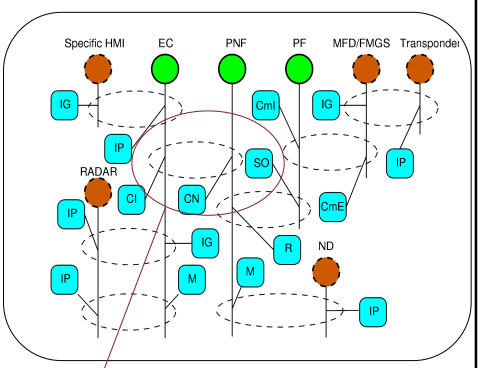
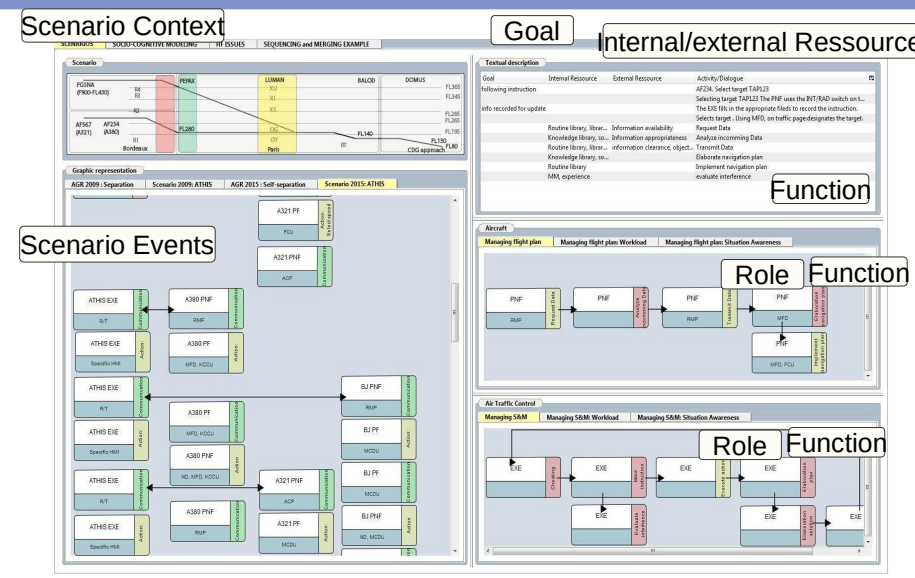


authority delegation function

A practical support: The PAUSA - Tool (Prototype)



Economics

Highlighted paper: *Dynamic Cost Indexing (Cook et al, University of Westminster)*

- Calculating delays in terms of value rather than time (ATFM delays cost > 1.3bn Euros)
  - Passenger costs of delay to the airline
  - Aircraft crewing
  - Aircraft maintenance
- Reactionary effects ('knock-on' network costs)
- Emissions – charging and impacts

- Crew cost example ...

Crew – marginal delay costs

- Considered cross-section of AO payment schemes, pilot & cabin crew salaries (2008)
- Pilots' salaries increase by size of aircraft
- Cabin crew salaries vary less
  - numbers driven by maximum number of seats available
  - used ICAO 2006 fleet data, over 4000 aircraft, unusual configurations excluded
- Annual block/flight duty hours, sectors flown and overnight stopovers used to derive time-based rates
- On-costs (e.g. pension contributions) included
  - since calculating cost to airline; these averaged 20-40%

Crew – marginal delay costs

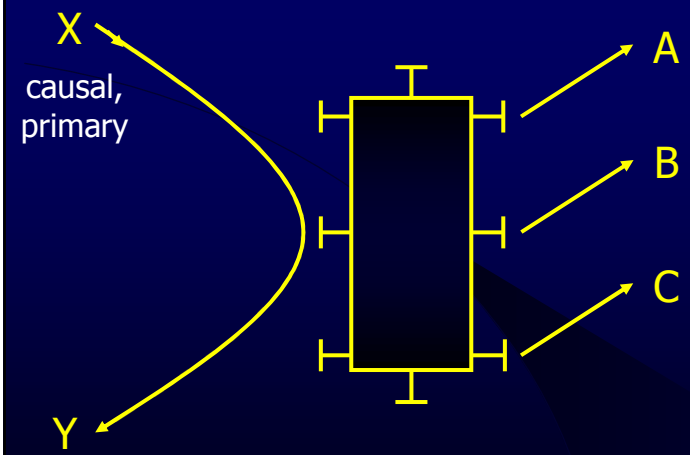
- Low cost scenario
  - for certain delays, e.g. under 'flying/block pay' or 'sector pay' mechanisms, it is possible that no extra payment will be made as a result of a delay (value thus set at zero)
- Base cost scenario
  - 'proxy' payment rates calculated, taking into account typical working hours, plus constraints of 28-day and annual flight & duty hours limited by Regulation (EC) 1899
- High cost scenario
  - overtime rates & a/c configuration for full-service carrier
- In the prototype tool (TDD 8.0)
  - user can mix and match, e.g. allocate low cost scenario for at-gate phase, and base cost scenario for airborne phase

Total, marginal crew costs by scenario

Aircraft	Low	Base	High
B737-300	0	8.1	16.9
B737-400	0	7.8	17.0
B737-500	0	7.6	16.5
B737-800	0	8.6	18.6
B757-200	0	8.6	17.2
B767-300ER	0	12.2	33.0
B747-400	0	15.9	43.0
A319	0	7.0	14.5
A320	0	7.4	15.4
A321	0	7.4	15.4
ATR42-300	0	5.4	11.0
ATR72-200	0	5.8	12.4

(Per-aircraft, per-minute costs in Euros. On-costs included. At-gate/airborne.)

Reactionary multipliers



Emissions – charging and impacts

CO_2 (please see dedicated report)

- •warming effect; proportional to fuel burn; altitude-independent
- •Kyoto Protocol (domestic aviation in national emission targets)
- •EU ETS: extending to aviation 2012; gate-to-gate fuel burn
- •legislation currently: all AOs operating to/from EU surrender permits

NOX (NO & NO_2: please see dedicated report)

- •warming effect (⇧O3); cooling effect (⇩CH4)
- •current regulation: certif new aircraft engines; limits LTO emissions
- •unregulated above 3000 ft; Commission developing policy by 2009
- •probably to operate parallel to inclusion aviation CO2 in EU ETS
- •lower cruise can increase NOx but reduce climate impact …

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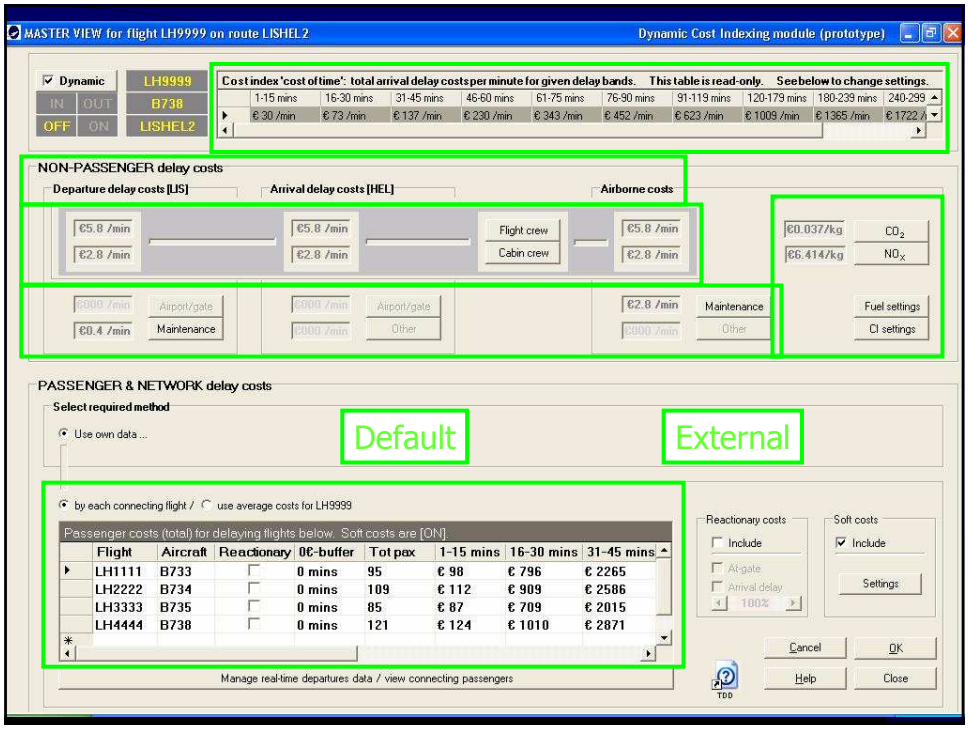
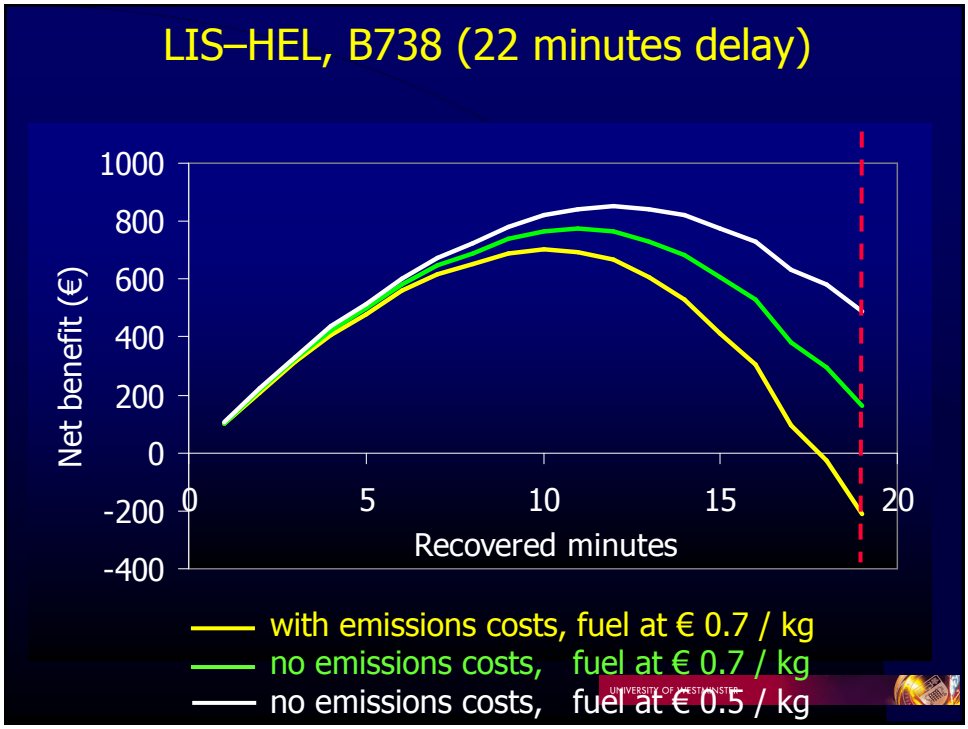


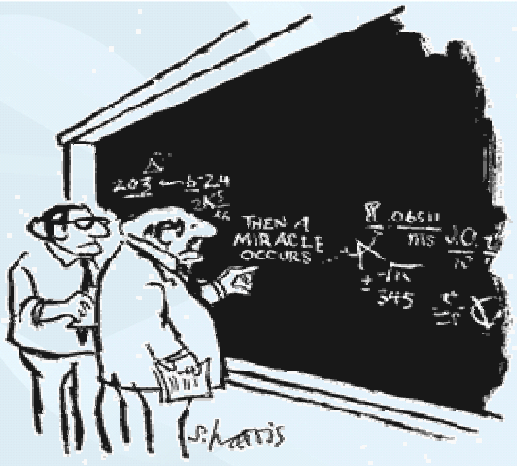


Economics

Highlighted paper: *A Market-Based Mechanism to Assign Priorities Amongst Flights* *(Ranieri et al, University of Trieste)*

- Where resources (airspace, airports) are capacity-constrained (planned demand > available capacity) delay is generally imposed without regard to the nature of different flights
- SESAR requires that airspace users will be fully involved in the process of demand and capacity balancing
  - UDPP, User-Driven Prioritisation Process, works at tactical level to manage unforeseen shortfalls

UDPP?



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

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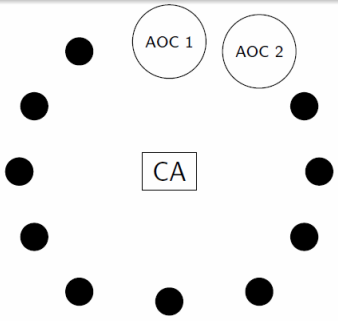
The Use of Combinatorial Auctions to Sequence Flights

Our proposal

A possible implementation of UDPP is based on an **iterative combinatorial auction** according to which:

- A Central Authority (**CA**) iteratively determines price of resources according to the current excess of demand;
- Airlines decide for each flight if it is preferable to acquire resources at the current market price or accept the delay;



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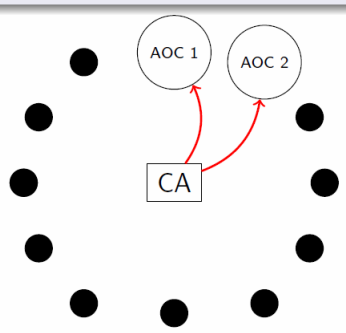

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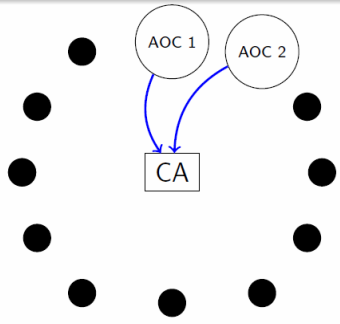

Simulation of implementation

		Slot Trading PayOff		$Cost^{MM}_{delay}$	$Cost^{FCFS}_{delay}$	Diff.
09.00	AZA1558	0	0	0	0	0
09.06	ADH61V	0	0	-18	-18	0
09.12	MAH421	0	0	-18	-18	0
09.18	KRP61T	0	0	0	0	0
09.24	HLX51H	0	0	0	0	0
09.30	USA715	0	0	0	0	0
09.36	BAW2583	-453.6	+413.9	0	-108	+68.3
09.42	SNB444	-413.9	+340.3	-36	-144	+34.4
09.48	AZA1472	-340.3	+255.3	-54	-162	+23
09.54	EZY5264	-255.3	+69.7	-68	-272	+18.4
10.00	DAL151	0	0	-180	-180	0
10.06	AUA2UD	-69.7	+453.6	-310	-10	+83.9
10.12	CSA735	0	0	-162	-162	0
10.18						

Departing traffic from LIPZ on 07/08/2008 09:00-10:18.
Unitary costs of delay provided by [Cook et al.2004].
All figures in Euro.

Market-based mechanisms

- This mechanism shows several positive features:
  - it is distributed
  - it starts from the well accepted FCFS solution
  - it looks for an improved solution to the FCFS allocation
  - everybody is better-off
  - it is incentive compatible
- ... At least it's a start!

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A brief mention of environment

Mentioned in my overview:

- A couple of papers that describe storm tracking and forecasting techniques that appear especially interesting for application to 4D trajectory planning
- Atmospherics, including a paper on computation and effects of dust ingestion, potentially of increasing concern due to changing desert configurations

Future communications

- A breakout workshop was held to discuss future communication strategies and options
- Based on work done between Europe and the US
  - Good convergence in some areas (airport surface)
  - Work ongoing in other (continental datalink: L-Band non-interfering solution)
  - New work on design for next generation satellite systems to meet ATM requirements

Conclusion

- This has been a rapid and incomplete overview of the 7th INO Workshop held last December
- The workshop exposed many new ideas, often specifically targeted at new concepts such as SESAR
- Proceedings and presentations are available at

  inoworkshop.eurocontrol.fr