



EUROCONTROL Central Flow Management Unit Engineering Division

Ada in Industry An Experience Report

Use of Ada in European Air Traffic Flow Management

10 15/01/2002

Presentation Plan

- What is Eurocontrol/CFMU ?
- Description of Ada Systems at Eurocontrol
 - 2 CFMU mission critical applications
 - ◆ IFPS: flight plan processing and correction for whole of Europe
 - ◆ ETFMS: flow management for whole of Europe
 - Other Ada usage at Eurocontrol
 - More details about ETFMS functionality
- Main interesting characteristics of Ada for CFMU
- Possibilities of collaboration between Eurocontrol/CFMU and Educational/Research community

- Eurocontrol :
 - European Organisation for the Safety of Air Navigation
 - International organisation, 38 member states
 - Primary objective: ensure a seamless pan-European Air Traffic Management system
- Multiple activities/directorates/...:
 - Coordination of big projects (e.g. RVSM)
 - Research Centre (Bretigny near Paris)
 - Maastricht ACC (Airspace Control Center)
 - Central Route Charge Office
 - Central Flow Management Unit (CFMU)
 -
- More info: www.eurocontrol.int

CFMU

- Established around 1990, fully operational in 1996
- Main responsibilities : flight plan processing & flow management
- Flight plan processing over whole of Europe (IFPS)
 - ◆ Aircraft Operators are sending flight plans to IFPS
 - ◆ Flight plans are verified, corrected if needed, redistributed to Airspace Control Centres, aerodromes, Aircraft Operators
- Flow management (ETFMS) Balancing demand and capacity:
 - ◆ First objective = safety. Avoid ATC overload
 - ◆ Second objective = optimise. Best use of ATC capacity, minimise delay
 - ◆ Guiding objective = equity/transparency between all airspace users
- Users :
 - ◆ Internal users (~ 200), External users (~ 3500), Public (~ ?)
 - ◆ For public applications, see <https://www.cfm.eucontrol.int/PUBPORTAL/gateway/spec/index.html>

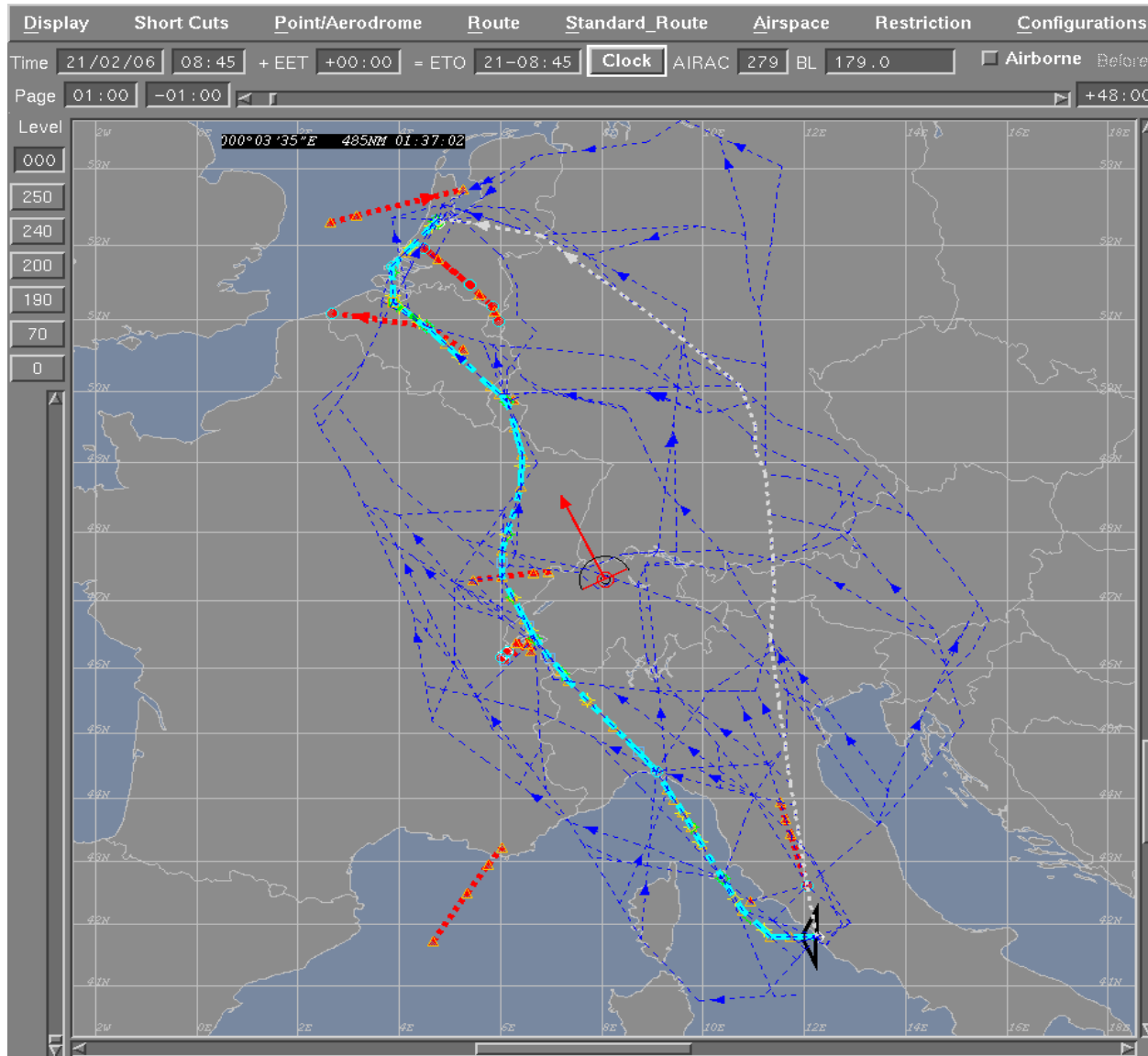
ETFMS & IFPS

- Around 1.5 million SLOC
- Initially developed (from 1991 onwards) in Ada83
 - Evolved to use Ada95 then Ada2005
- Reliability requirements:
 - If IFPS down: no flight plan processing over Europe !
 - If ETFMS down : many people will sleep in aerodromes !
 - Servers in switch over configuration, duplicated LANs, contingency systems, ...
 - ◆ Busy migrating from HP-UX PA-RISC to GNU/Linux Intel X86-64
- Performance requirements
 - ETFMS handles about 2 millions messages per day (e.g. radar tracks). Sometimes implies complex processing (e.g. recompute a flight route)
- Other Ada systems at Eurocontrol : ARTAS (Radar Tracker), FDPS (Flight Data Processing System), ...

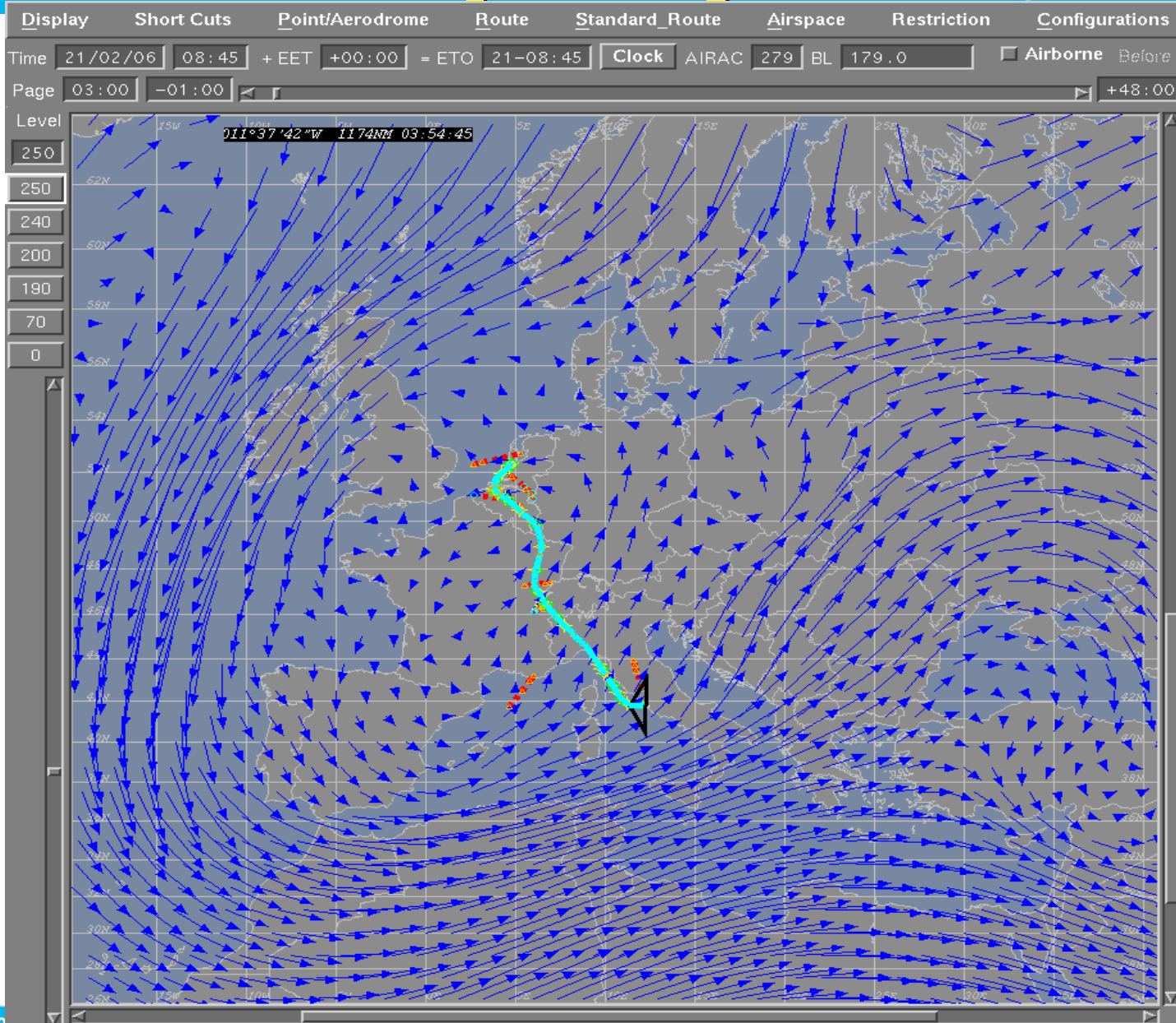
ETFMS Main Functions

- Calculation of flight 4D trajectories
- Calculation of traffic counts and traffic load + monitoring
- Create/Update/Execute ATCFM measures
 - Optimise sector configurations
 - Re-routing of flights
 - Allocation of flight departure times (take-off slots)
 - Handle exceptional situations (fog, snow, strike, ...)
- Flight non-departure detection/airborne deviation
- User interfaces for CFMU flow controllers, Airspace Control Centres, Aircraft Operators, ...
- Distribution of traffic data to other systems

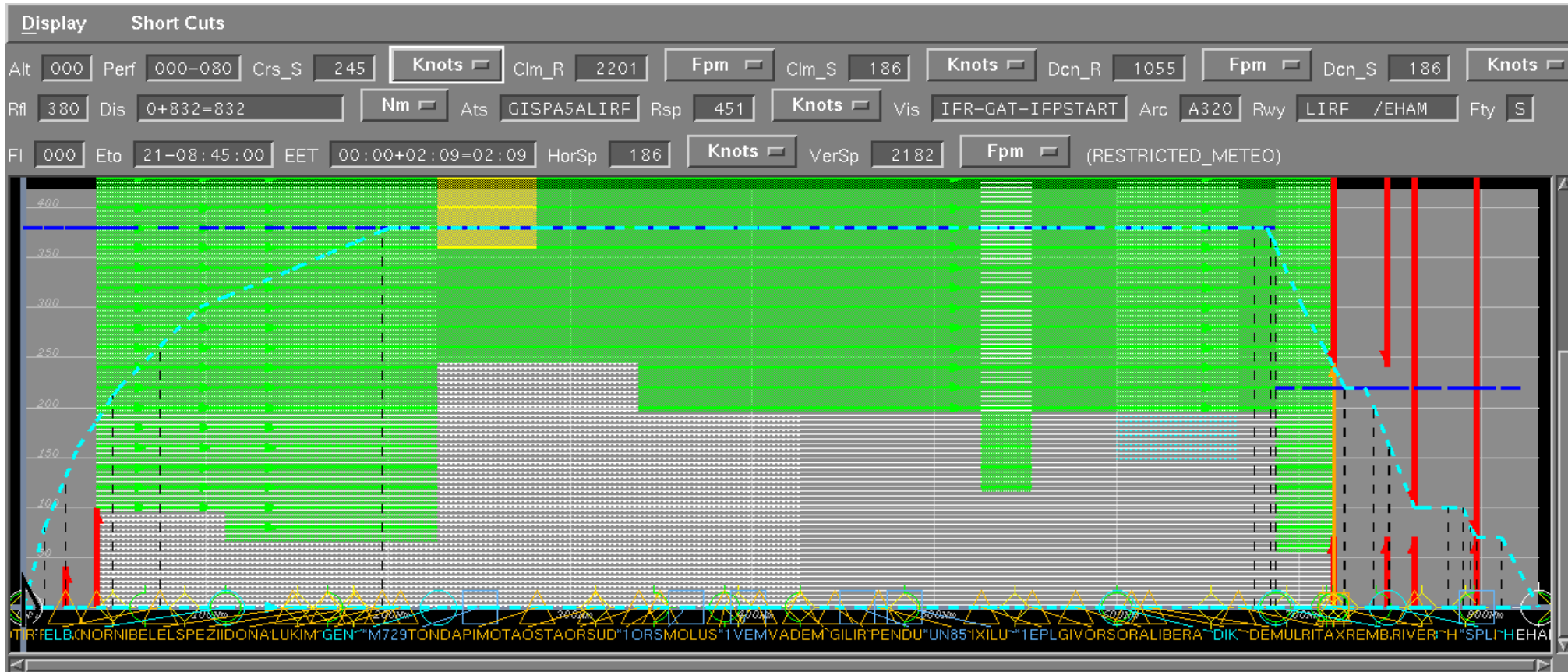
2D Trajectory & Alternate Routes



2D Trajectory: Wind



Vertical Trajectory & Constraints



Flight List

Display Tools Options Help

Flights (Demand) departing from Aerodrome LIRF between 21-00:00 and 23-00:40 .

Last Updated: 21-00:00
410 Flights. Total Delay: 0

ARCID	Aty	Adep	Ades	IOBT	LOBT	CTOT	ATOT	Cdm	Kind	Stat	RR	RFL	T.Over	M. Pen	Delay	XFR
			▼ D*	3												
			▷ DA*	1												
			▷ DT*	2												
			▼ E*	60												
			▼ EB*	8												
DAT3188	RJ1H	LIRF	EBBR	21-06:20					RPL			340	06:35			
AZA156	MD82	LIRF	EBBR	21-07:55					RPL			360	08:10			
VEX73T	B733	LIRF	EBBR	21-09:15					RPL			360	09:30			
DAT3178	RJ1H	LIRF	EBBR	21-11:35					RPL			340	11:50			
AZA16V	MD82	LIRF	EBBR	21-14:20					RPL			340	14:35			
BPA866	B752	LIRF	EBOS	21-14:30					RPL			340	14:45			
DAT3182	RJ1H	LIRF	EBBR	21-16:50					RPL			300	17:05			
AZA164	A320	LIRF	EBBR	21-20:15					RPL			340	20:30			
			▷ ED*	25												
			▷ EF*	1												
			▷ EG*	11												
			▷ EH*	8												
			▼ EI*	2												
EIN40R	A320	LIRF	EIDW	21-11:15					RPL			360	11:30			
EIN803	A320	LIRF	EICK	21-20:40					RPL			360	20:55			
			▷ EK*	1												
			▷ EL*	2												
			▷ EP*	2												
			▼ G*	1												
			▷ GM*	1												

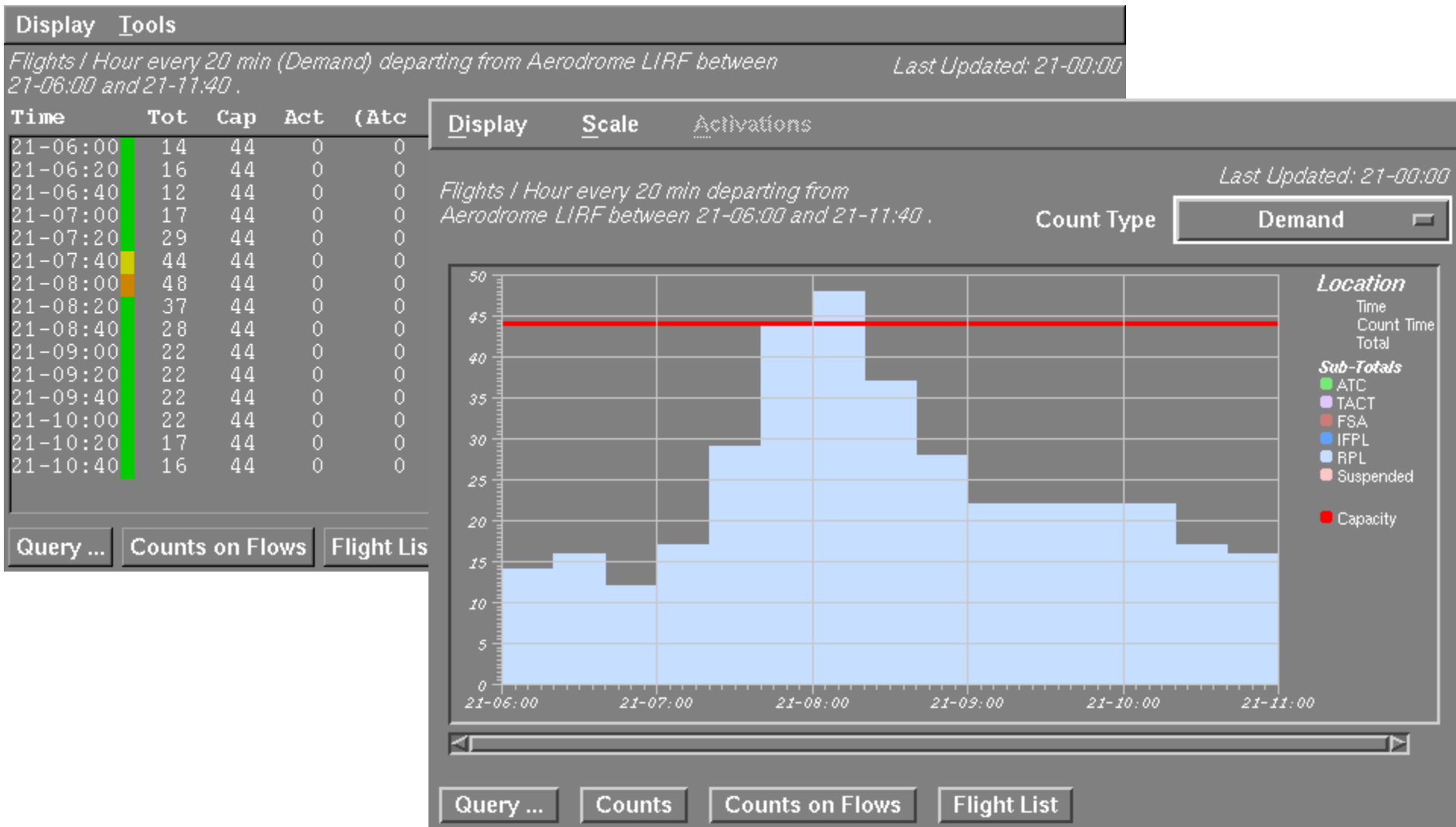
Location: [Query ...](#) [Counts](#) [Counts on Flows](#) [Load Display](#)

Flight: [Undo ...](#) [Data](#) [Regulation List](#) [Show Positions](#)

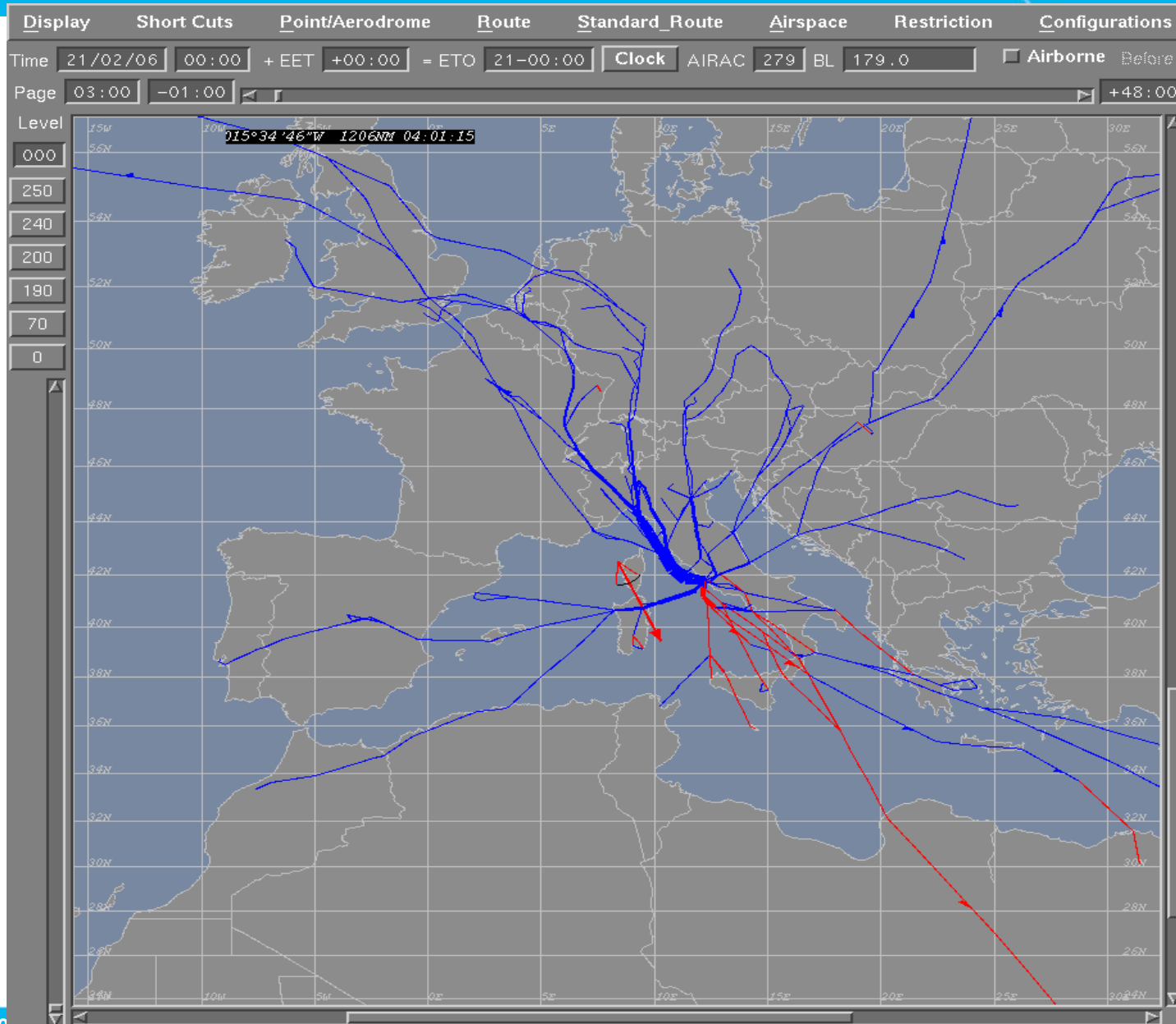
[Show Route](#) [What if](#) [Mail](#) [Query ...](#) [Op log](#)



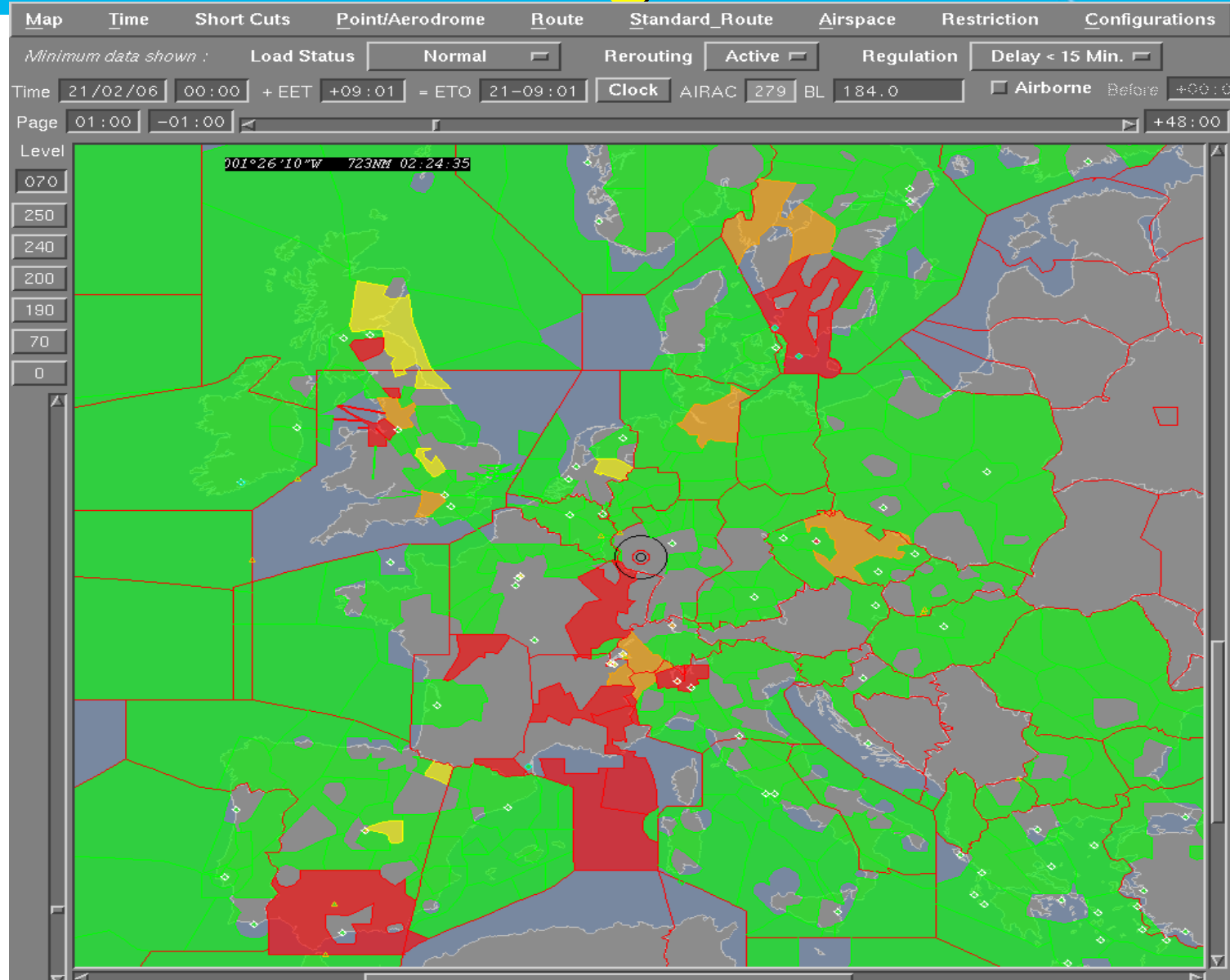
Counts



Counts on Routes



Monitoring Threshold



EUROCONTROL

Global ATFCM Situation Display

Display Tools Last Updated: 05-21:10

ATFCM Situation 05/12/05 00:00 24:00

25067 Flights

21538 Landed Flights 2464 Airborne Flights
1065 Expected Flights

17425 Min Delay (Average 0.7 Min)

7623 En Route 9802 Airports

199 Flights delayed above 30 Min

Delay Cause	Minutes
ACCIDENT/INCIDENT	0
DE-ICING	0
MILITARY ACTIVITY	0
SPECIAL EVENT	0
ATC STAFFING	0
ENVIRONMENTAL ISSUES	0
EQUIPMENT NON-ATC	0
ATC CAPACITY	6469
AERODROME CAPACITY	3538
ATC IND ACTION	0
OTHER	1567
ATC ROUTEINGS	66
ATC EQUIPMENT	3328
WEATHER	2459
IND ACTION NON-ATC	0

ATFM Slot Window Compliance

403 Departed too early
 555 Compliant
 186 Departed too late

Suspended Flights Reason

0 ATFM Measure

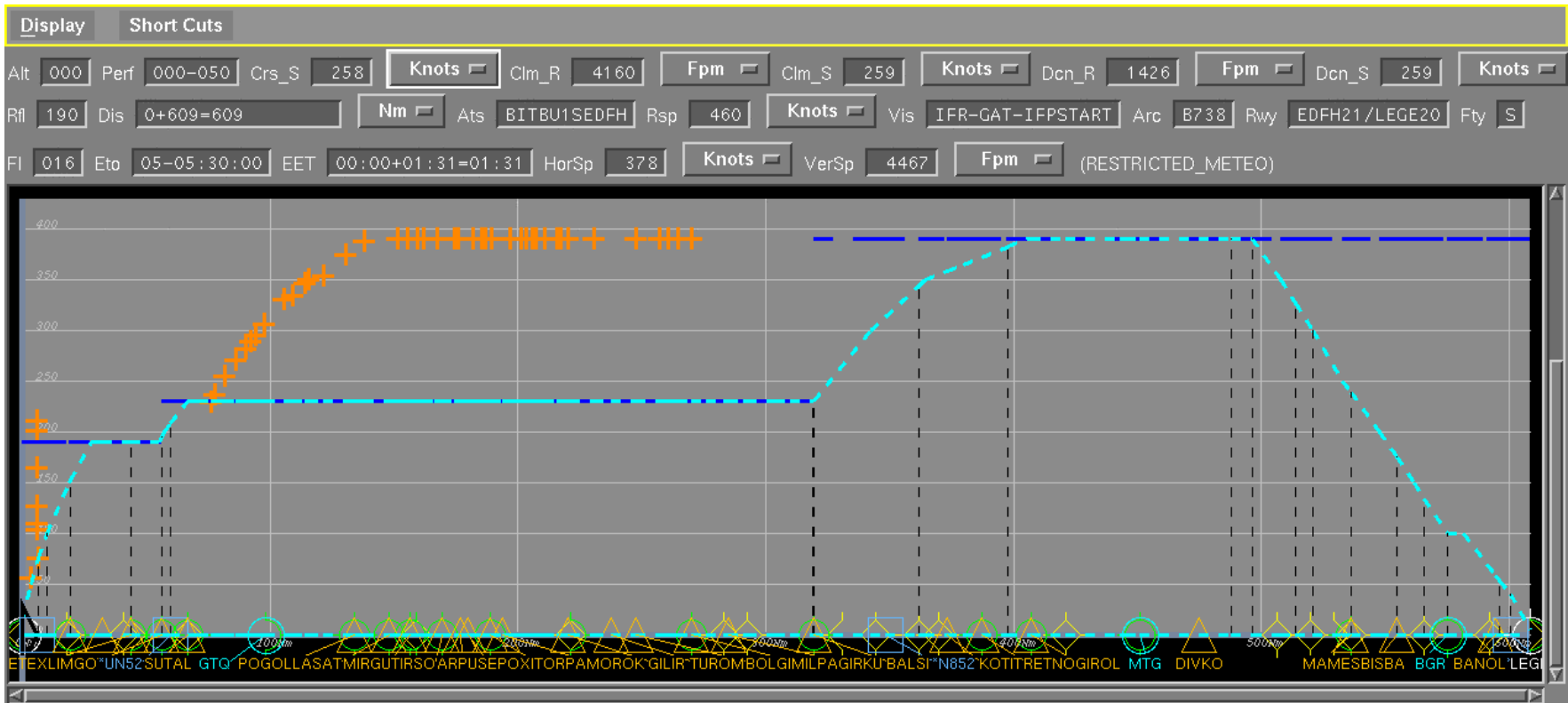
111 Airborne Monitoring (FAM)

Main Congestions	>30	>20	>10	<=10	Avg Delay
ES0305 ES03 05:00 13:00					22.7 Min
ATC CAPACITY				103 Flights	
LOWWA05M LOWWARR 06:20 09:20					45.8 Min
WEATHER				25 Flights	
ES0205 ES02 05:00 13:00					18.4 Min
ATC EQUIPMENT				60 Flights	
LTBAA05M LTBAAARR 08:00 11:00					35.2 Min
AERODROME CAPACITY				31 Flights	
ES0705 ES07 05:00 13:00					11.7 Min
ATC EQUIPMENT				84 Flights	
LEMDA05M LEMDARR 06:40 12:00					10.1 Min
ATC CAPACITY				93 Flights	
ESSAA05 ESSAARR 06:00 08:40					34.0 Min
ATC EQUIPMENT				24 Flights	
LHBPAA05M LHBPARR 09:20 12:00					22.7 Min
OTHER				35 Flights	
LKPRAA05 LKPRARR 08:40 11:00					19.3 Min
AERODROME CAPACITY				41 Flights	
LIMCA05M LIMCARR 05:40 12:00					15.6 Min
WEATHER				48 Flights	
ZGZ05M LECM2GZ 08:00 10:40					7.7 Min
ATC CAPACITY				92 Flights	
EG05X05 EG05XBCN 07:00 10:20					13.6 Min
ATC CAPACITY				51 Flights	
LHABLM05 LHABLM1 09:40 13:20					7.1 Min
ATC CAPACITY				97 Flights	
LTBAA05A LTBAAARR 12:40 17:00					9.7 Min
AERODROME CAPACITY				60 Flights	

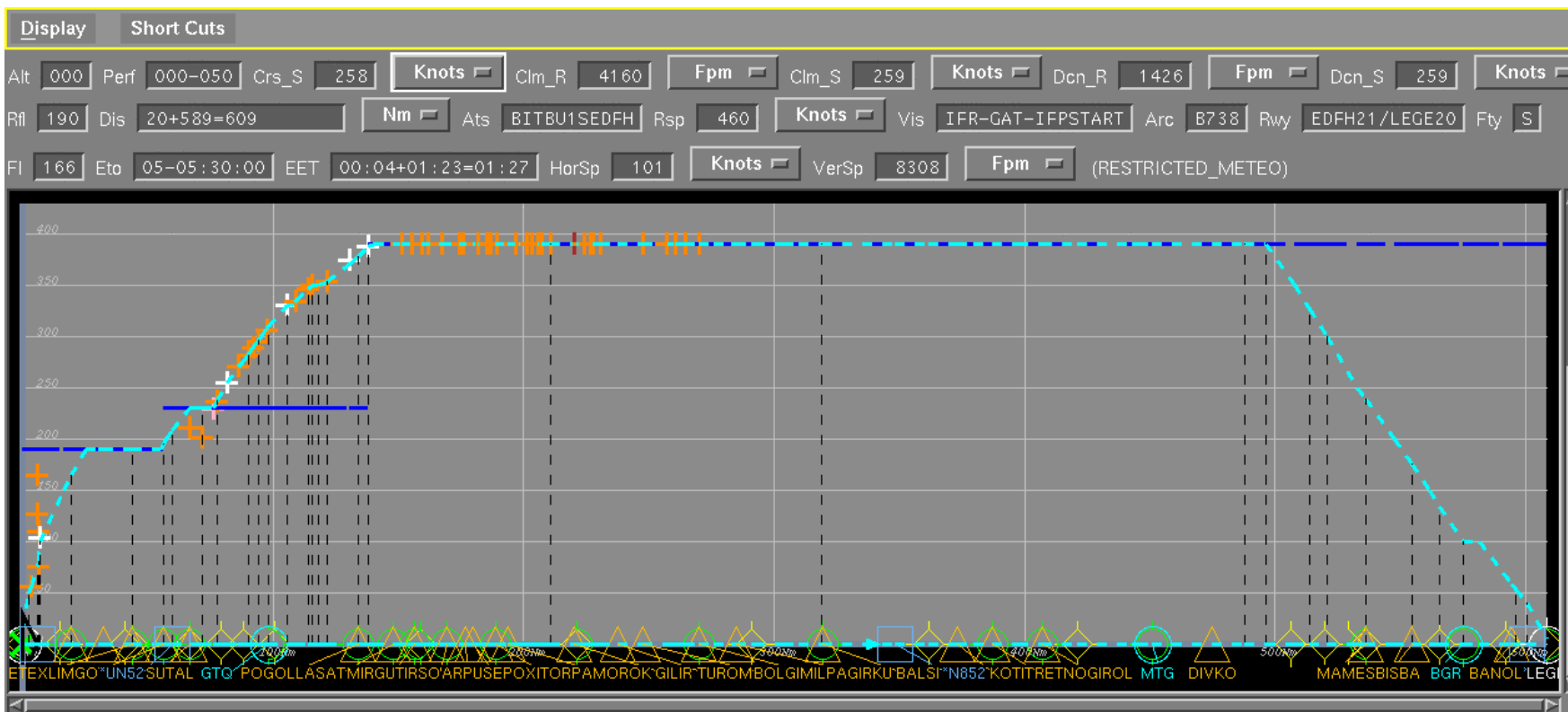
Query ...



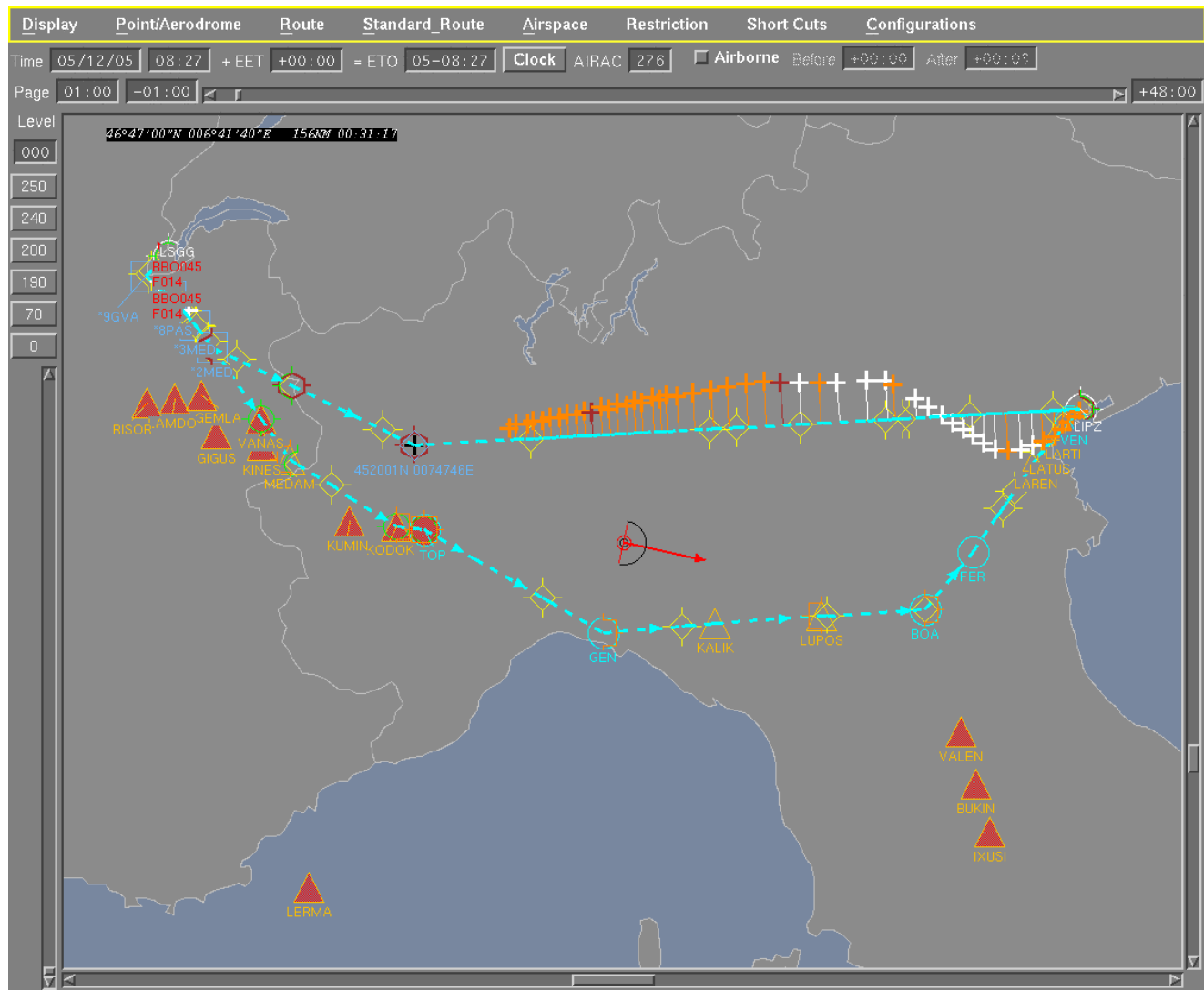
Difference Plots <> Plan



Recomputed with Plots



Plots Lateral Deviation Recompute



CFMU Applications Characteristics

- Big applications
- Long live applications: maintenance and heavy functional changes for 20 or more years.
- Sophisticated functionalities/algorithms/...
- Mission critical
- Performance requirements

=> Need for language (and tools) supporting these constraints

Ada Characteristics for CFMU

- General language and dev environment quality
 - Readability, absence of surprises and “dirty tricks”, no need for Makefile(s), ...
 - Language well defined (e.g. few “implementation defined”)
 - Orthogonality of concepts (e.g. type hierarchy and modularisation)
- Separation between specification (“spec”) and implementation (“body”)
- Expressiveness :
 - High level constructs (type system, OO, multi-threading supported by language, ...)
 - Allows code to be closer to domain instead of computer
 - ◆ Example: type Flight_Level is range 0 .. 999;

Ada Characteristics for CFMU

- Compile time/static verifications:
 - strong type checking
- Run-time checks :
 - Ada Reference Manual mandates a lot of runtime checks
 - These are part of the language => compiler can optimize the checks => reasonable performance impact (for CFMU : ~ 5 %)
- Overall effect:
 - Language and language tools are efficient programming assistants (“pair programming without buddy”)
 - Team made more efficient for evolution and maintenance of large and complex systems

“Super” Ada at CFMU

- Additional static or run-time checks
 - GNAT emits a bunch of extremely helpful warnings
 - Normalize_Scalars: standard Ada feature to assign an initial value to all scalars (if possible, an invalid value that will be detected with run-time checks)
 - At CFMU, we use Initialize_Scalars, a GNAT superset of Normalize_Scalars: more flexible, a lot more run-time checks
 - ◆ Too CPU consuming for operational usage at CFMU, so used only during testing and operational validations
 - ◆ Others are using Initialize_Scalars for fielded systems.
- AdaControl
 - Static code analysis tool (under GNU GPL)
 - Based on ASIS (standard API, allows to build code analysis tools independent of the compiler)
 - Verifies a user defined set of coding rules and absence of undesirable constructions

- Eurocontrol has a program to welcome students
 - For training/stage/...
 - and/or end of study work
- We have interesting subjects
 - Technical :
 - ◆ apply new techniques and/or enhance tools and/or study their behaviour/results on large applications
 - ◆ ...
 - Functional :
 - ◆ Optimisation heuristics
 - ◆ HMI ergonomomy
 - ◆ ...

Conclusion

The Ada language is one of the factors which has helped to build, maintain and enhance the CFMU mission critical sophisticated applications

QUESTIONS ?