

EUROCONTROL Central Flow Management Unit

ATFM section

Use of Free Software in European Air Traffic Flow Management

Wet 12:20 Unt 13:2

Δ0

Is LFEES FMP

RFL	IOBT				
220	12:10	12:19E	I	12:19	N N
220	12:10	12:19E	I	12:19	N N
180	12:05	12:20E	I	12:12	N N
180	12:10	12:19E	S	12:19	N N
180	12:10	12:19E	S	12:19	N N
180	12:05	12:20E	I	12:20	N N
270	11:50	12:10E	I	12:10	N N
210	11:45	12:05E	I	12:05	N N
270	11:50	12:10E	I	12:10	N N
190	11:50	11:55E	S	11:55	N N
210	11:45	12:05E	I	12:08	N N

10 15/01/2002

Objective of this presentation

- FOSDEM = Free and Open Source Software Developers European Meeting
- Is Eurocontrol developing Free Software ? NO !
- So, why this presentation?
 - => See how free SW is used in mission critical applications
 - ◆ (show that free SW has some mission critical references)
 - => See why Eurocontrol/CFMU has chosen to use (some) free software instead of proprietary
 - => See how an organisation like Eurocontrol is participating to the free software community

Presentation Plan

- What is Eurocontrol/CFMU ?
- Description of 2 CFMU mission critical applications
 - IFPS: flight plan processing and correction for whole of Europe
 - ETFMS: flow management for whole of Europe
- Demo of ETFMS
- Usage of free software:
 - Where used ?
 - Why choosing free software ?

- Eurocontrol :
 - European Organisation for the Safety of Air Navigation
 - International organisation, 35 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, ...
 - 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

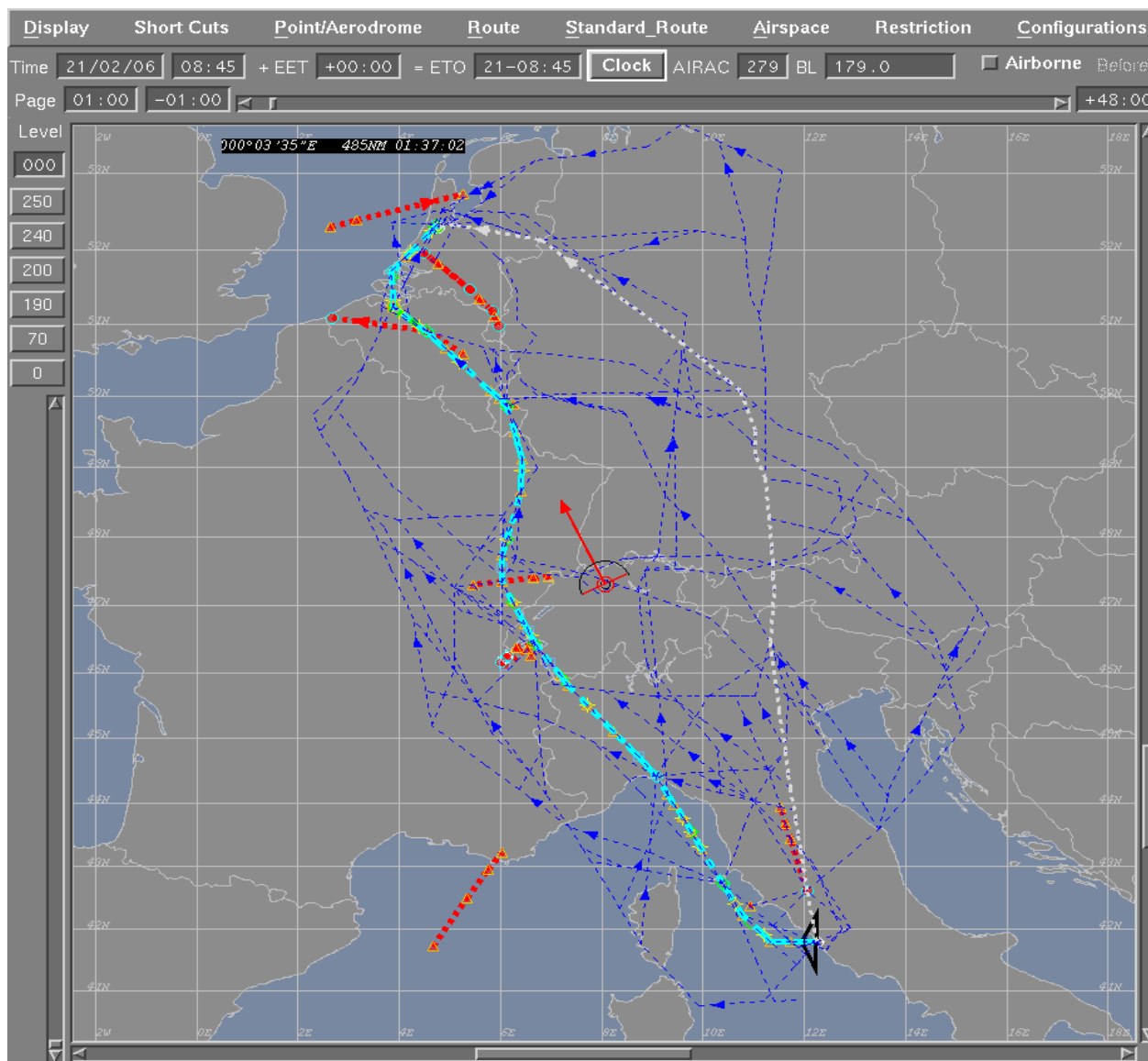
ETFMS & IFPS

- Around 1.5 million SLOC
- Initially developed (from 1991 onwards) in Ada83, now in Ada95, will switch to Ada05
- Reliability requirements:
 - If IFPS down: no flight plan processing over Europe !
 - If ETFMS down : many people will sleep in aerodromes !
 - Hp-ux pa-risc servers in switch over configuration, duplicated LANs, contingency systems, ...
- Performance requirements
 - ETFMS handles about 2 millions messages per day (e.g. radar tracks). Sometimes implies complex processing (e.g. recompute a flight route)

ETFMS Main Functions (demo)

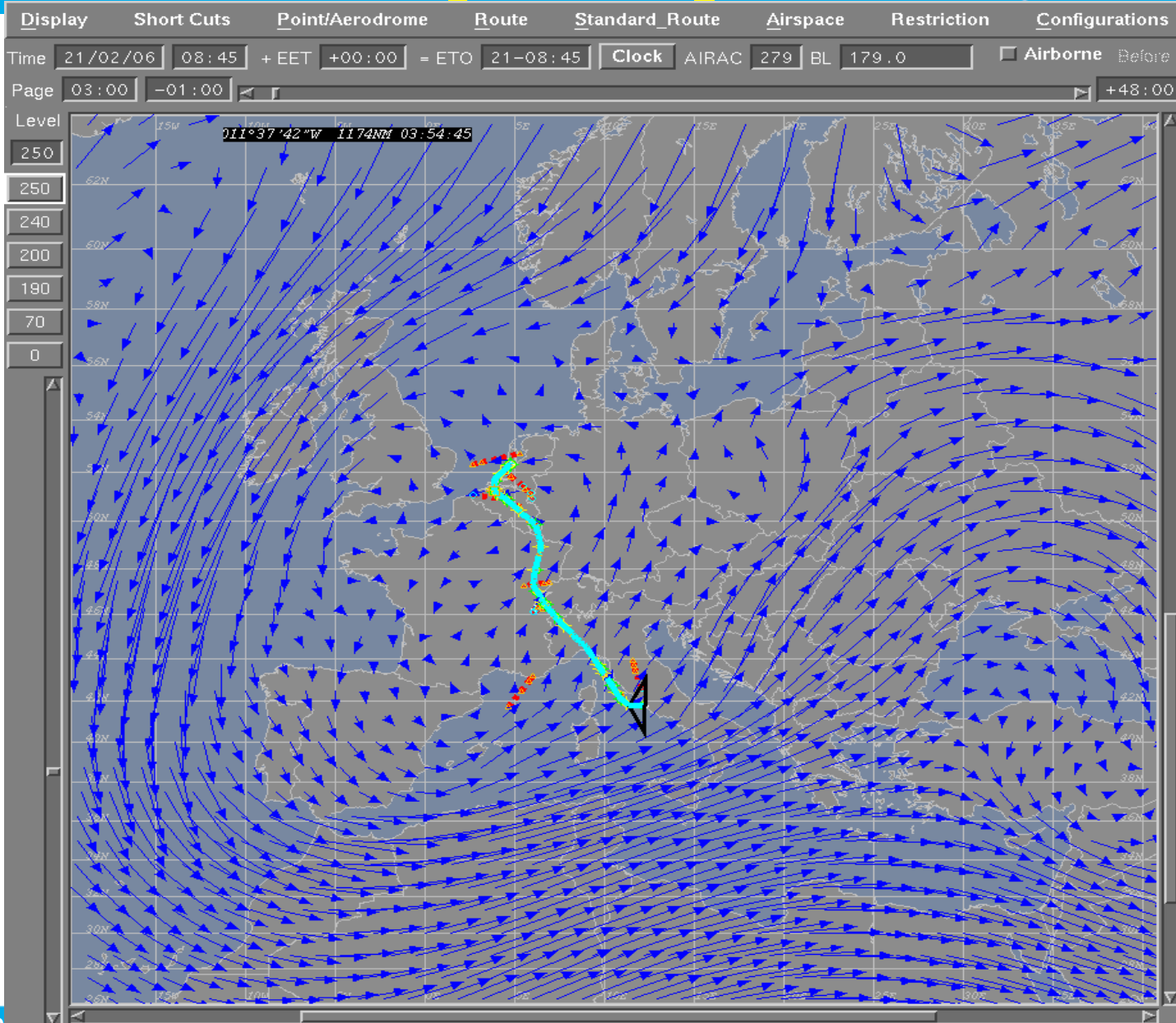
- Calculation of flight 4D trajectories
- Calculation of traffic counts and traffic load + monitoring
- Create/Update/Execute ATFM measures
 - Optimise sector configurations
 - Re-routing of flights
 - Allocation of flight departure times (take-off slots)
 - Handle exceptional situations (fog, snow,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

2D Trajectory & alternate routes

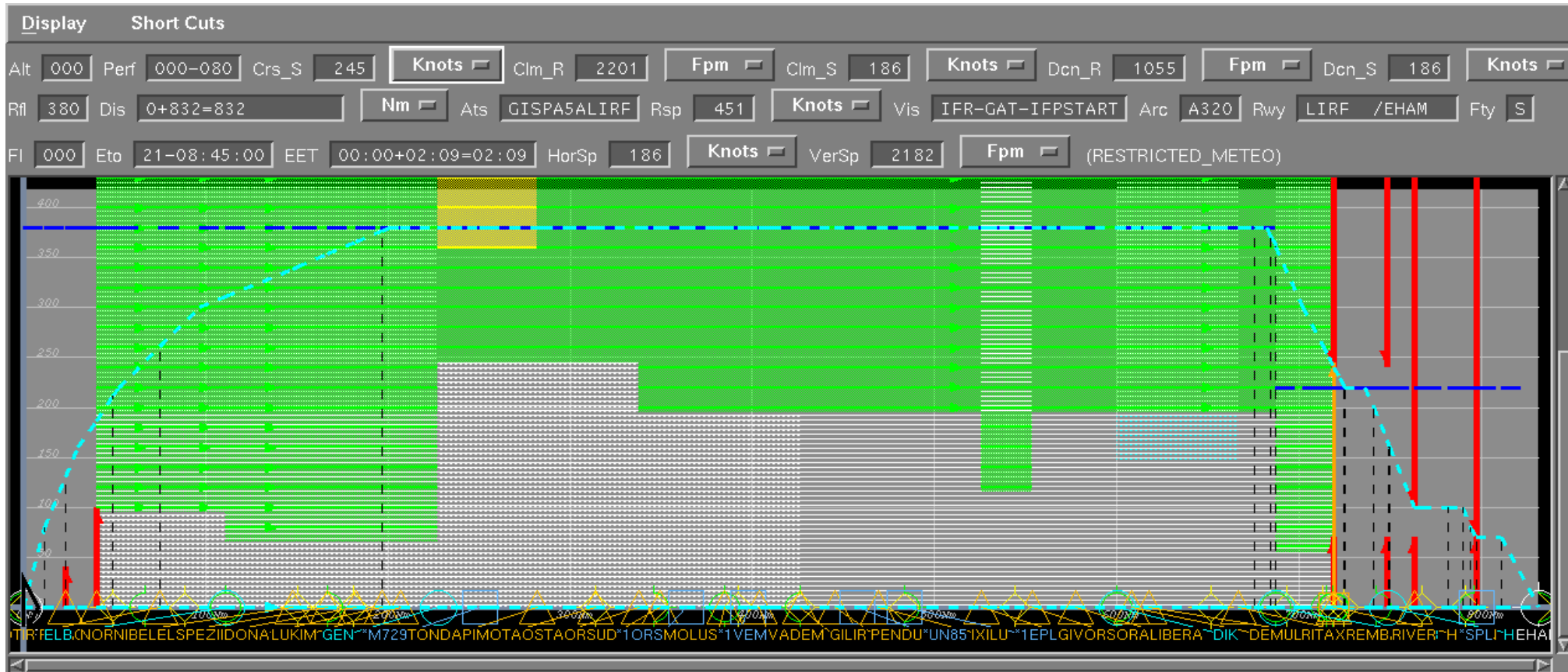


EUROCONTROL

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

Display Tools

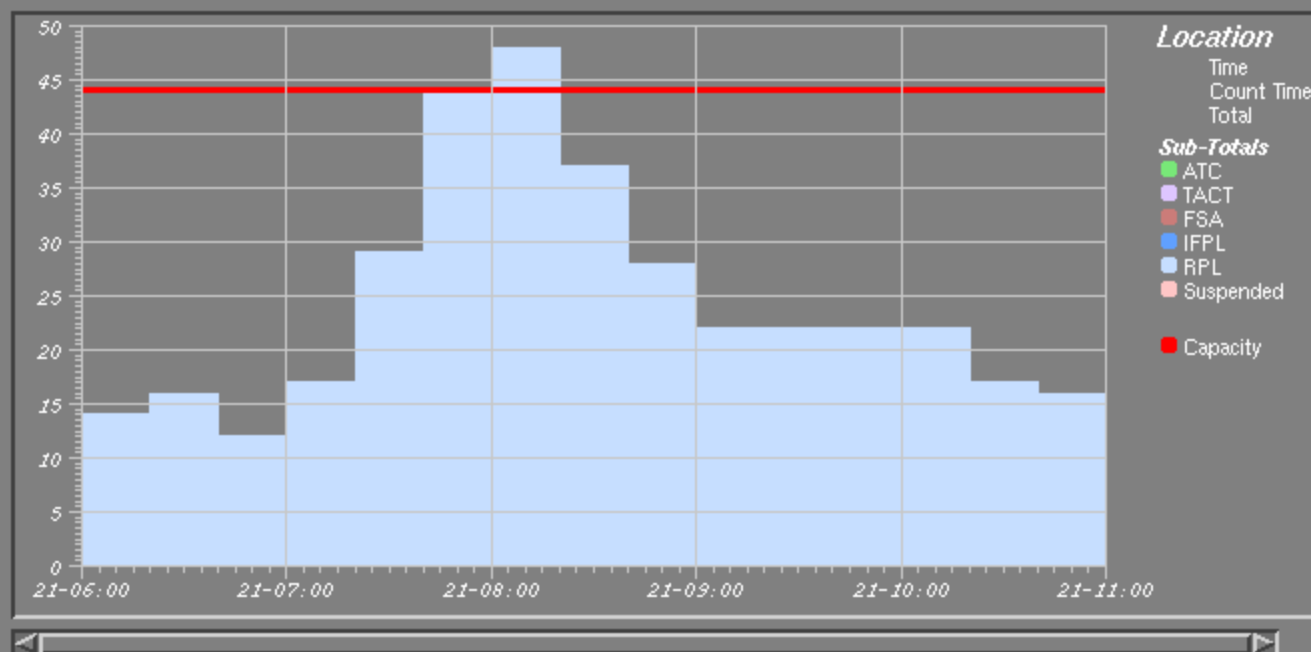
Flights / Hour every 20 min (Demand) departing from Aerodrome LIRF between 21-06:00 and 21-11:40. Last Updated: 21-00:00

Time	Tot	Cap	Act	(Atc)
21-06:00	14	44	0	0
21-06:20	16	44	0	0
21-06:40	12	44	0	0
21-07:00	17	44	0	0
21-07:20	29	44	0	0
21-07:40	44	44	0	0
21-08:00	48	44	0	0
21-08:20	37	44	0	0
21-08:40	28	44	0	0
21-09:00	22	44	0	0
21-09:20	22	44	0	0
21-09:40	22	44	0	0
21-10:00	22	44	0	0
21-10:20	17	44	0	0
21-10:40	16	44	0	0

Display Scale Activations

Flights / Hour every 20 min departing from Aerodrome LIRF between 21-06:00 and 21-11:40. Last Updated: 21-00:00

Count Type: **Demand**

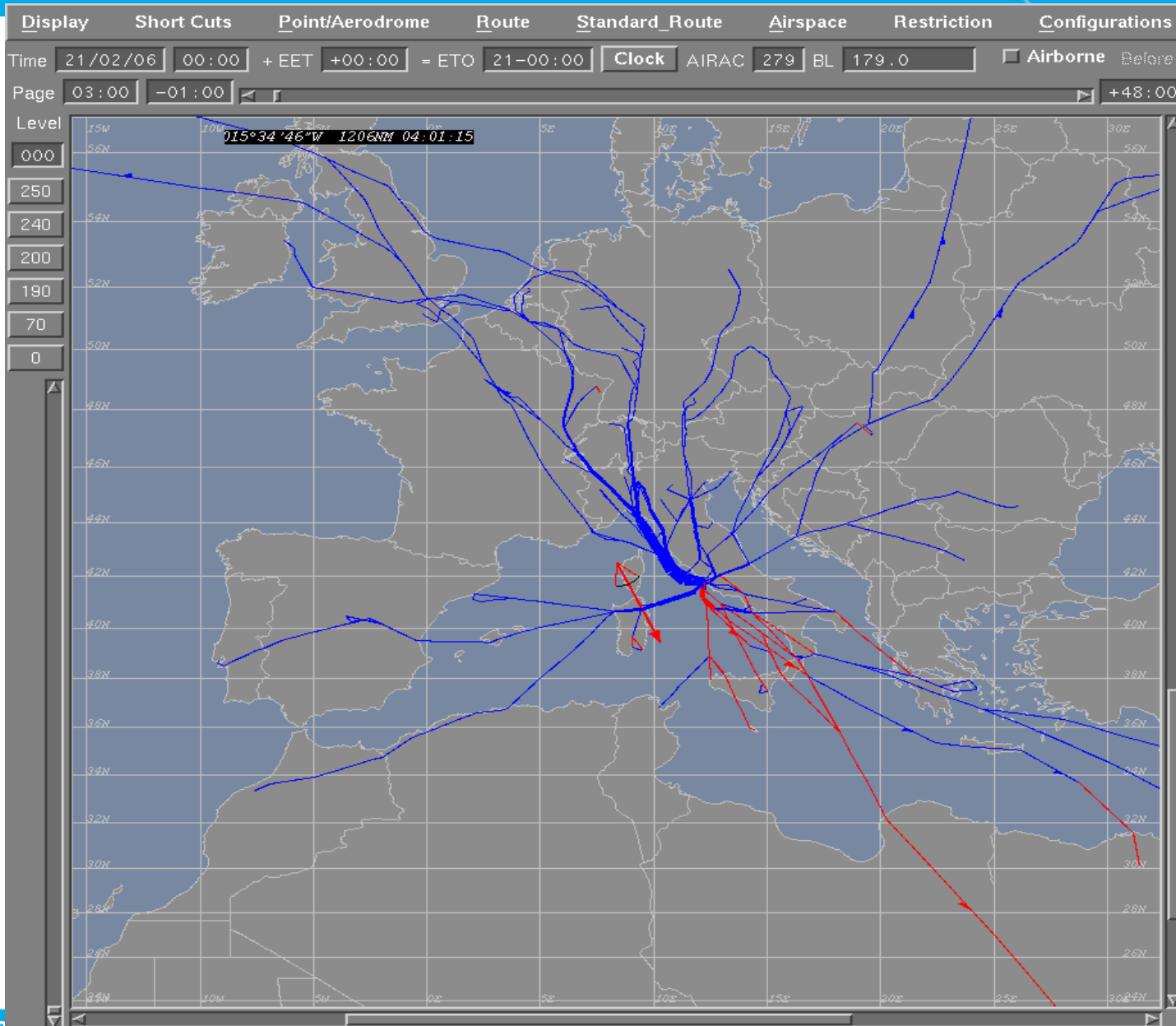


Query ... Counts on Flows Flight Lis

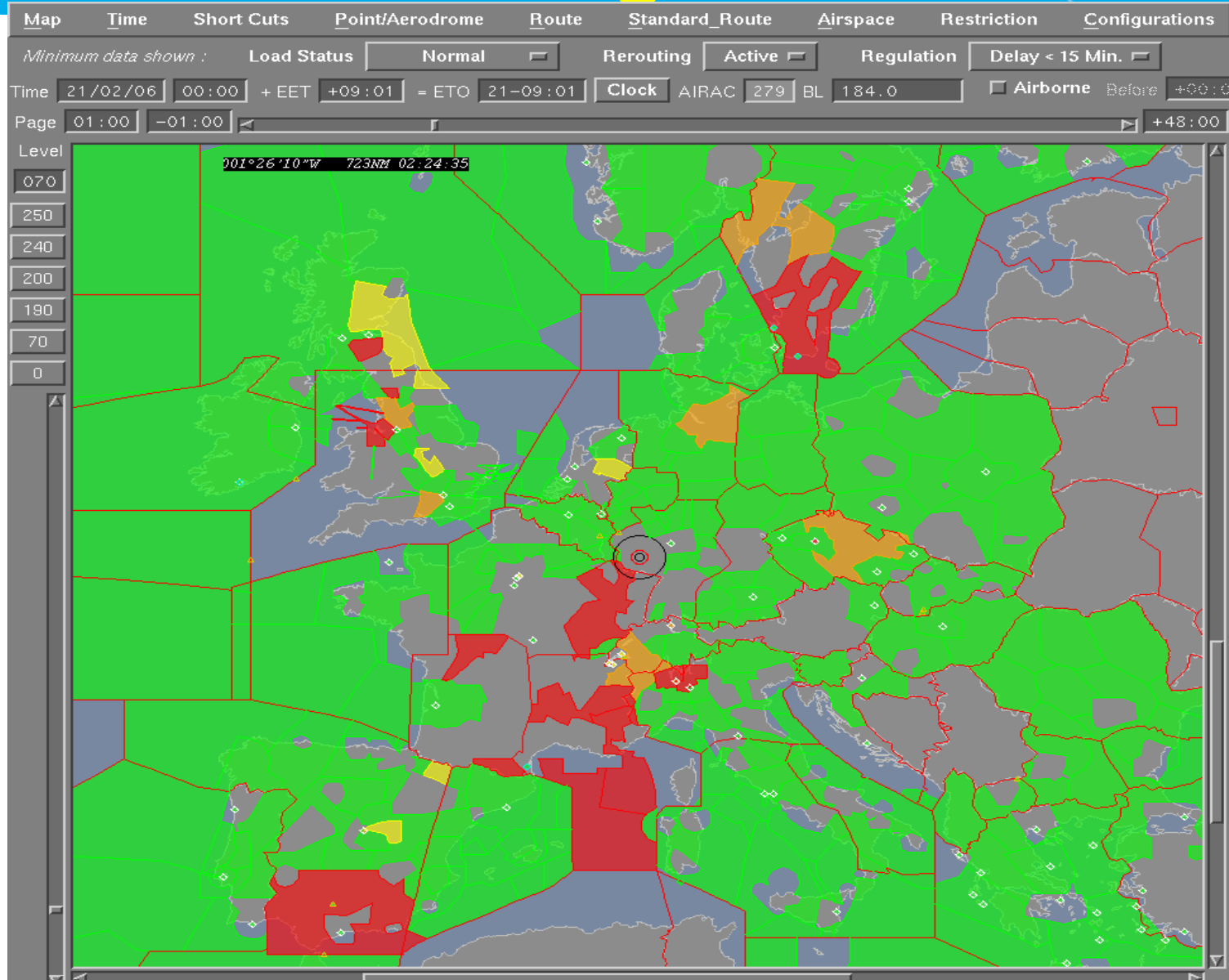
Query ... Counts Counts on Flows Flight List



Counts on routes



Monitoring threshold



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
Airborne Monitoring (FAM)

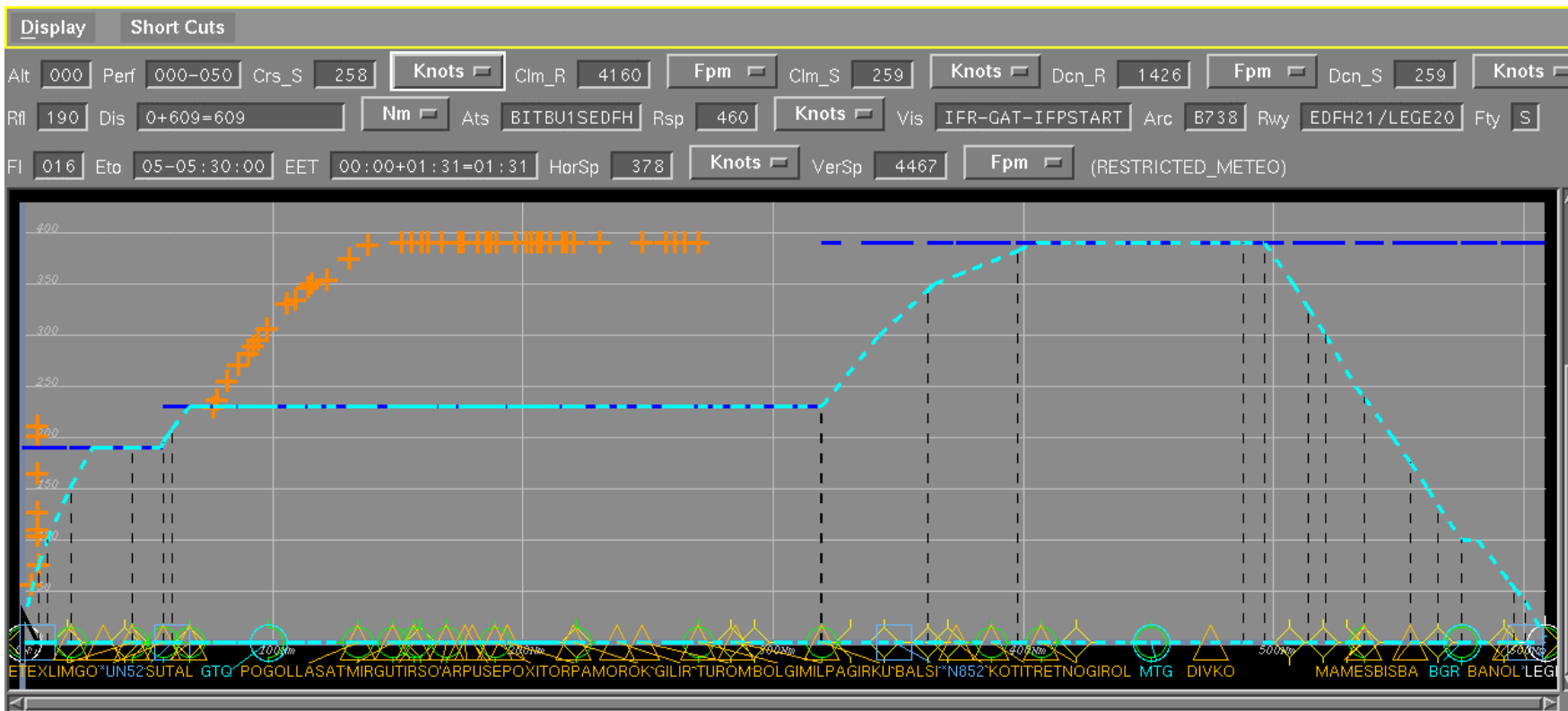
111

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 LTBAARR	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	
LHBP05M LHBPARR	09:20	12:00			22.7 Min
OTHER			35	Flights	
LKPR05M 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 LTBAARR	12:40	17:00			9.7 Min
AERODROME CAPACITY			60	Flights	

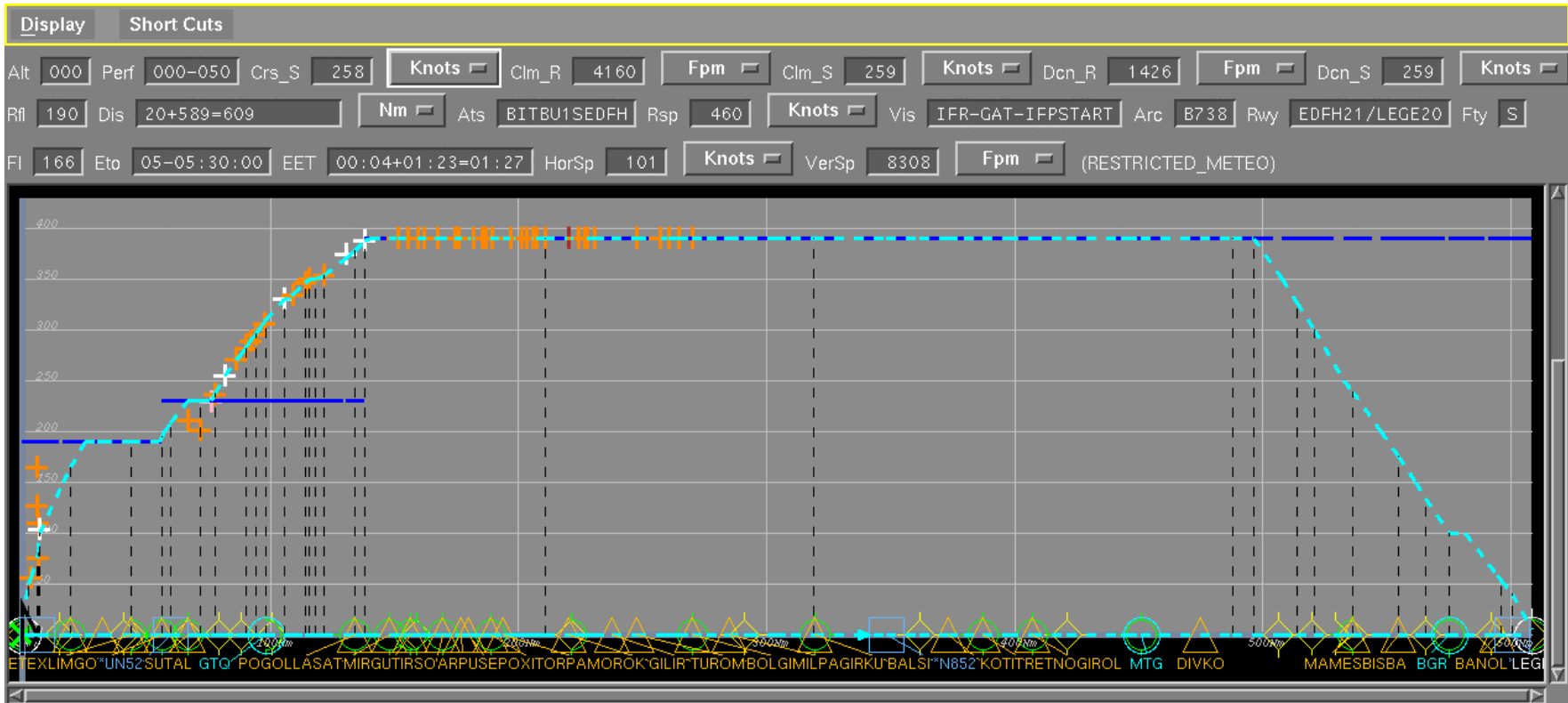
Query ...



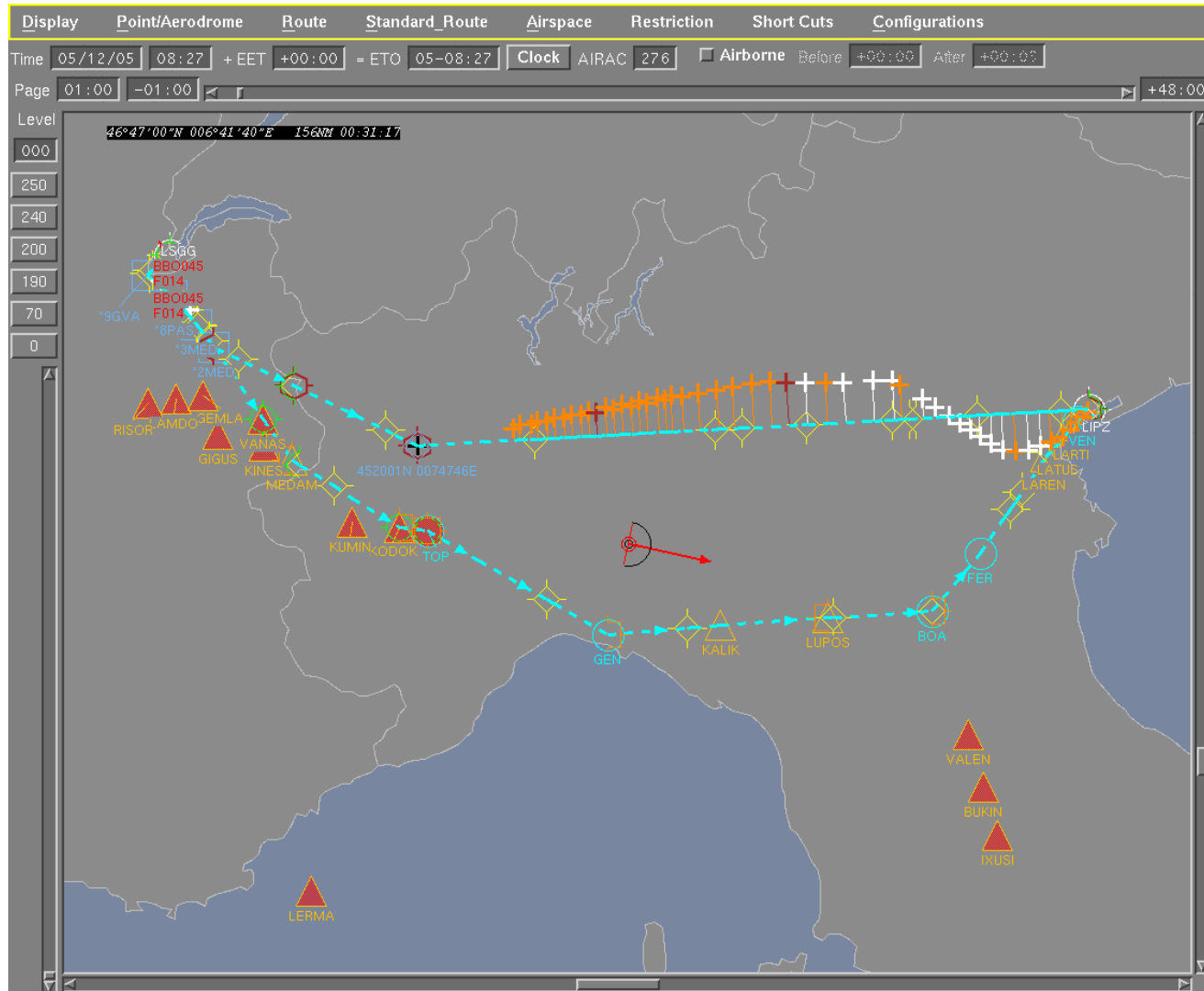
Difference Plots <> Plan



Recomputed with Plots



Plots Lateral deviation recompute



Usage of Free Software

■ 5 phases

- 1990 No free software at all
- 1991->1996 Ultra limited usage of some tools, in development only
- 1996->1999 Usage of some tools for non-critical support activities in operations
- 2001 Some free software started to be used in the heart of mission critical activities
- 2002-> 2006 Free software usage increased significantly in mission critical activities. Some main items are still proprietary (OS, database)

■ Future phases ?

Initial phase: no free software at all

- Development started in 1990: only proprietary software:
 - Proprietary OS
 - Proprietary database
 - Proprietary compiler
 - Proprietary development environment (including a not so nice editor), ...
- Why no free software ?
 - free software not that visible/known/...,
 - option to use free software even not discussed

1991 -> 1996 : ultra limited usage

- In 1991: emacs introduced as a better editor alternative
- But a lot of resistance to free software:
 - Emacs: ok for development but not ok even for viewing log files on the operational servers
- Main concerns/fear/uncertainty/doubts:
 - ◆ Who takes the responsibility of this software ?
 - ◆ What about support ?
 - ◆ Free software = free as in free beer = no money = no value = poor quality
 - ◆ ...

1996->1999: limited usage for support

- Gradual introduction in development of more tools
 - More GNU tools (grep, sed, ...) are used
 - Buy GNU deluxe distribution
- Some of these GNU tools used in operation support
 - Only for non critical support activities (for example, viewing/editing big log files with emacs)
 - But no discussion about free software for critical activities
- In 1999: the vendor of the proprietary compiler:
 - announces the Ada83 compiler will become obsolete and support will stop
 - proposes Ada 95 compiler based on new technology

2000 : evaluation of compilers

- => decision is taken to evaluate various Ada95 compilers by porting ETFMS to these compilers
- Main criterias:
 - Quality of the compiler (development tools/point of view)
 - Quality of the generated code & run-time
 - Quality of the support
 - Cost was a **secondary** criterion: quality first !
- One free alternative (GNAT, part of gcc compiler collection) was included in the set of possible options
 - GNAT considered because a company (AdaCoreTechnology) provides support !

2000 : GNAT is selected

- GNAT evaluation results on hp-ux pa-risc were:
 - Good front end
 - Very good development environment (gnatmake, source based compilation model, ...)
 - Pa-risc gcc back-end of medium quality (performance wise)
 - Gdb : poor quality
 - GNAT quality in total acceptable, comparable to proprietary.
 - what has really made the difference: the quality of the support
- What is usually planned for software once selected:
 - Buy software (“initial license cost”)
 - Afterwards, pay for (professional) yearly support

2000 : enhancement contract

- GNAT:
 - professional support available (\$\$\$)
 - but no need to pay license fees
- Management accepted to invest the planned license cost in increasing the quality, expecting ROI.
- Contract signed with ACT to improve various aspects:
 - Improve code generation and run-time
 - Improve gdb
 - Have the compiler inserts a lot more checks in the generated code, helping to find bugs during development & testing

2001 : GNAT compiled code is OPS

- March 2001:
 - ETFMS & IFPS mission critical systems compiled with GNAT using a free Ada run-time are operational
 - => free software+mission critical is now an acceptable combination at CFMU
- Enhancement contract has given very good results
 - in particular, the additional checks provides a big added value
 - => some more investment done for other enhancements to GNAT, with objective to further increase the quality of the application

2002-2006 : use more free software

- More usages of free software in operational software
 - XmlAda (Xml parser), Gtk/GtkAda used to develop some new screens, POLYORB (Ada CORBA ORB), AWS (Ada Web Server)
- 2003: invest limited effort to study porting ETFMS on GNU Linux
 - Objective was to study and produce a report about remaining work/difficulties to solve
 - But in the limited effort, ETFMS was ported and tested (you have seen a demo on a GNU Linux laptop !)
 - Valgrind (memcheck/callgrind) used for additional checking and optimisation of ETFMS & IFPS (valgrind on Linux better than Purify/Quantify on hp-ux pa-risc)

- End 2004: call for tender to study/prototype a code rule checker for customized code verification.
- Call for Tender allows the result of study/prototype to be released under GPL, if both Eurocontrol and the winning tenderer agree.
- => AdaLog company was selected
 - Development of AdaControl on top of GNAT Asis (ASIS = library to access Ada Semantic Information)
 - Resulted in a code rule checker available under GPL
 - Used by other companies
 - Some improvements paid by other companies after that

Eurocontrol non-CFMU Free SW use

- ARTAS: a radar tracker used in many countries in Europe will switch to GNU-Linux-x86
- CFMU acquired some specialized air traffic messaging systems running on GNU-Linux-x86
- Maastricht Eurocontrol Air Traffic Control Centre will soon have various GNU-Linux based systems operational:
 - Simulator
 - Fallback System

Future ?

- CFMU is busy studying the platform that will replace the current HP-UX pa-risc platform
- GNU-Linux considered as an attractive option
- Here again, a major choice factor will be the quality:
 - Technical quality (for development, for operations)
 - Support aspect is very important
 - High availability aspects is critical

Conclusion

- Eurocontrol/CFMU is a significant reference for use of free software in mission critical activities.
- Free software development model is compatible with mission critical activities.
 - For this, free software must have a high level of support/services (free beer not ok for mission critical !)
 - Free software can be developed under call for tender
 - It results in higher total quality:
 - ◆ help of the community and/or other companies sharing costs and benefits
 - ◆ Open source simplifies problem identification, ...

end

■ QUESTIONS ?