



Safety Monitoring in the Age of Big Data From Description to Intervention

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OUTLINE

- ▶ Background
- ▶ Automatic Safety Data Gathering in ATM: ASMT
- ▶ Examples of ASMT use
- ▶ Main issues of automatic safety data gathering
- ▶ Lessons learnt
- ▶ Conclusions and next steps

BACKGROUND: THE RESEARCH QUESTIONS

- ▶ WHAT is the potential contribution of automatic safety data to safety monitoring?
- ▶ HOW can we integrate ASDG into the SMS?
- ▶ HOW can we analyse ASDG data?

“

What can 30.000 STCA tell us on safety?

”



BACKGROUND: OUR EXPERIENCE

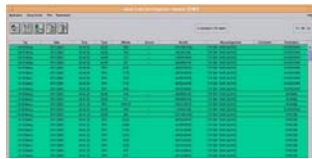
- ▶ DBL has been working on ASDG projects since 2004
- ▶ Monitoring of safety events in RTS and OPS (ENAV 2004-07)
 - » Definition of a roadmap for ASMT operational introduction
- ▶ ASMT design review (EUROCONTROL 2009)
 - » Software reverse engineering
 - » Production of OPSCON guidance
- ▶ Development of the ASMT training package (EUROCONTROL 2010)
- ▶ Support to ANSPs for data analysis (EUROCONTROL 2011)
 - » Current: Italy, Lithuania, Romania
- ▶ Analysis of disturbances propagation in SESAR scenario (SESAR JU 2011)



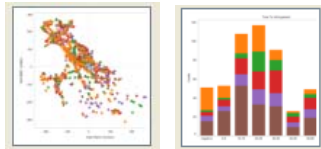
ASDG IN ATM: ASMT

EUROCONTROL since late 90s has been developing a tool for automatic collection and analysis of large sets of safety data

ASMT – Automatic Safety Monitoring Tool

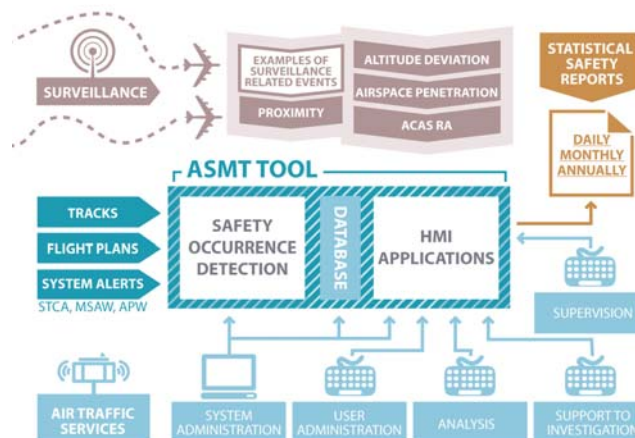


- ▶ Collects and processes radar tracks, flight plans and ATC alerts
- ▶ Detects safety events
- ▶ Collects data for statistical analyses



ASDG IN ATM: ASMT

- ▶ Event types: losses of sep, STCA, ACAS-RA, Airspace Infringements, APW, and...



ASDG IN ATM: ASMT

Data recorded by ASMT:

- ▶ Radar track data
- ▶ Flight plan data
- ▶ For concerned aircraft
- ▶ For vicinity aircraft

Example:

- ▶ Position (X, Y, FL)
- ▶ Date and time
- ▶ Start and end time
- ▶ Closest Point of Approach details
- ▶ Rate of Closure
- ▶ Risk of Collision (ESARR2)
- ▶ Duration



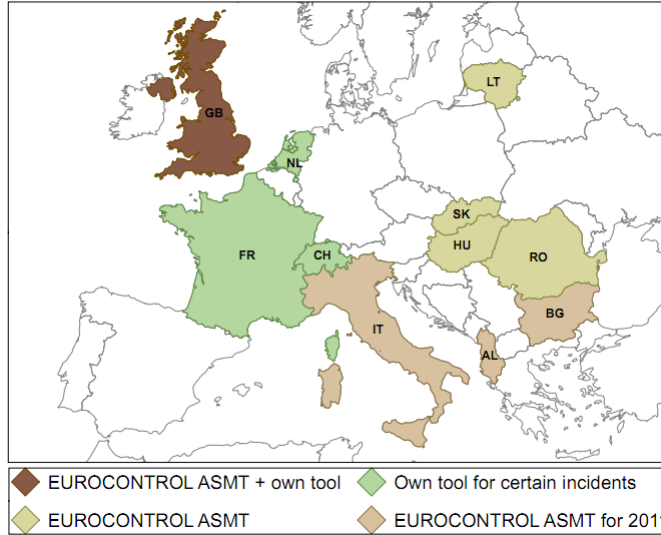
ASDG IN ATM: ASMT

History of ASMT

- ▶ ASMT project born in 1996 in EUROCONTROL Experimental Centre (EEC)
- ▶ Initial development by EEC supported by Maastricht UAC, driven by Maastricht UAC requirements
- ▶ First version installed in MUAC in 1999
- ▶ New releases in MUAC in 2001, 2003, 2007
- ▶ Since 2004 ASMT managed by EUROCONTROL HQ
- ▶ Installed in 6 states [see Performance Review Report 2010]



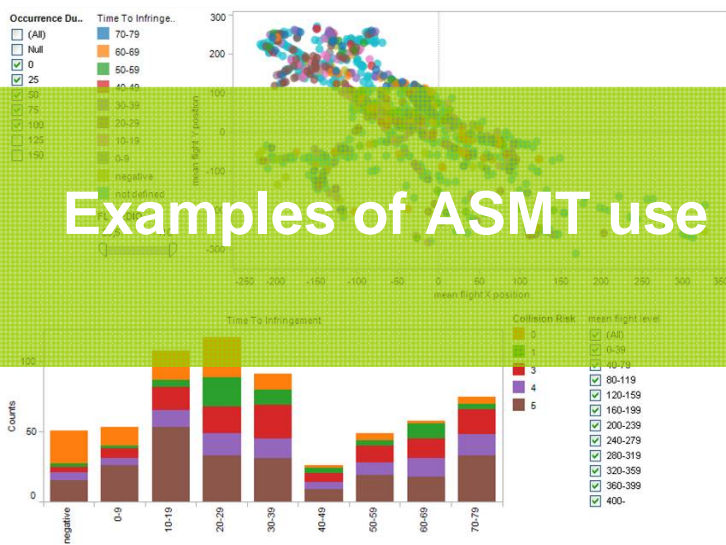
ASDG IN ATM: ASMT



DEEP BLUE srl

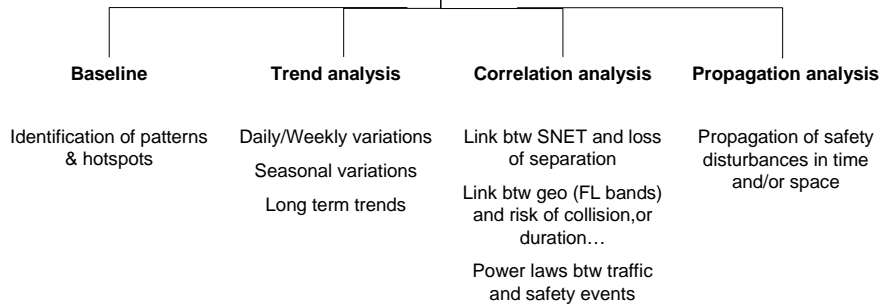
[Performance Review Report 2010]

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EXAMPLES OF ASMT USE

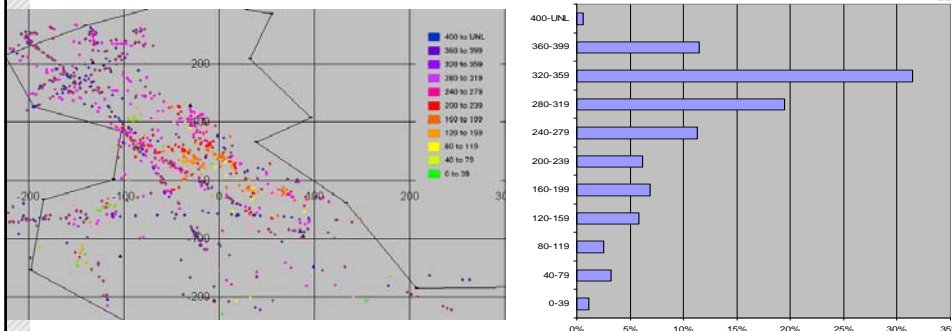
ASMT for Safety Monitoring



EXAMPLES OF ASMT USE

Baseline analysis:

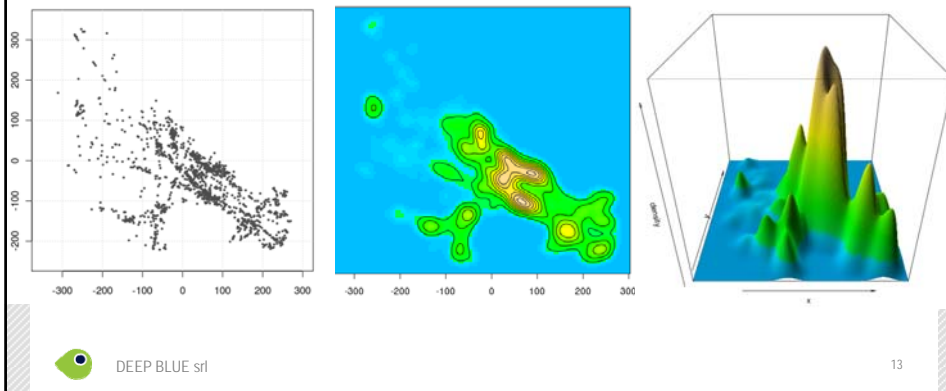
- ▶ Distribution by FL bands
- ▶ Distribution by Risk of Collision
- ▶ Distribution by Rate of Closure
- ▶ ...



EXAMPLES OF ASMT USE

Baseline analysis:

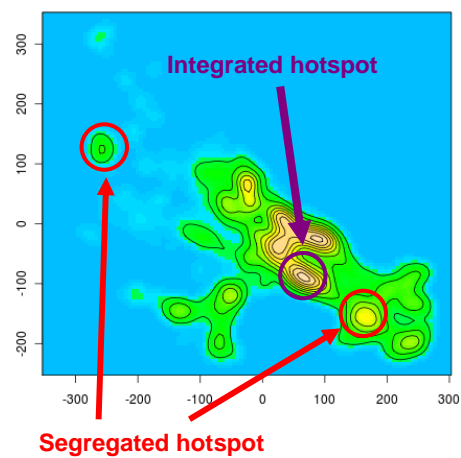
- Identification of hotspots, with scatterplots or density maps



EXAMPLES OF ASMT USE

Characterisation by magnitude & topology:

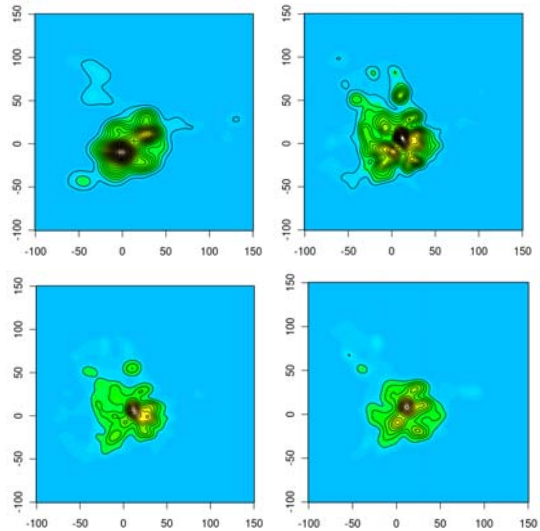
- Segregated hotspots as areas of sudden safety degradation...
...or areas in which degradation is effectively contained?



EXAMPLES OF ASMT USE

Trend analysis:

- ▶ Daily



EXAMPLES OF ASMT USE

Trend analysis:

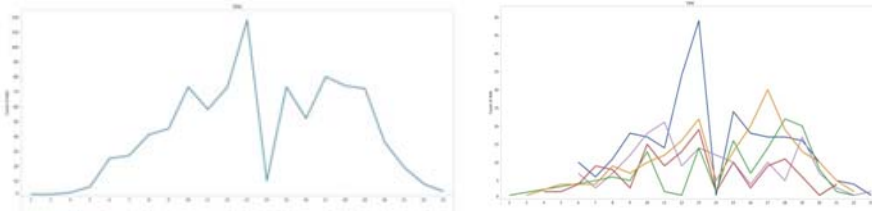
- ▶ Weekly



EXAMPLES OF ASMT USE

Trend analysis:

- ▶ Yearly



EXAMPLES OF ASMT USE

Correlation analysis:

- ▶ Link btw FL bands and risk of collision

	FL	0 ÷ 79	80 ÷ 159	160 ÷ 239	240 ÷ 319	320 ÷ 399
Risk of Collision						
15		3%	5%	2%	6%	8%
12 - 14		13%	14%	10%	17%	21%
10 - 11		10%	11%	9%	15%	26%
8 - 9		15%	14%	14%	16%	15%
6 - 7		12%	12%	8%	11%	8%
3 - 5		13%	14%	14%	11%	4%
1 - 2		17%	14%	19%	12%	8%
0		17%	16%	24%	12%	10%
Total Number of losses of separation		30	58	95	49	59

EXAMPLES OF ASMT USE

Correlation analysis:

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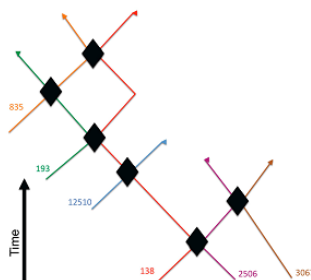
70%



EXAMPLES OF ASMT USE

Propagation analysis:

- ▶ Capability of **local optimisation** measured via network analysis
- ▶ The nodes of the network are the aircraft, which have been involved in at least one STCA
- ▶ Two nodes (aircraft) are linked if they were involved together in at least one STCA



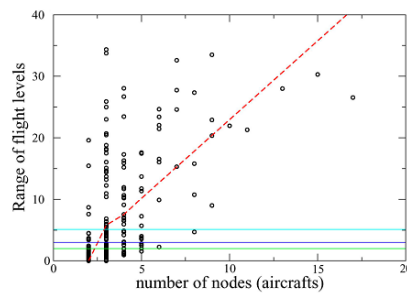
EXAMPLES OF ASMT USE

Propagation analysis:

- ▶ Distribution of cluster size with more than 2 aircraft

Size	3	4	5	6	7	8	9	10	11	13	15	17
Freq.	94	32	17	8	4	4	4	1	1	1	1	1

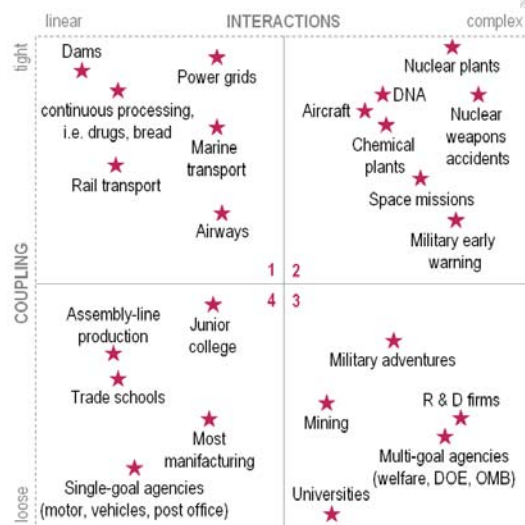
- ▶ No correlation between average FL and number of nodes
- ▶ Correlation btw Delta FL and number of nodes



EXAMPLES OF ASMT USE

Propagation analysis:

- ▶ Taxonomy of sectors from low to high [coupling/complexity]
 - » High Coupling if STCA is followed by other STCA
 - » High Complexity if network is complex



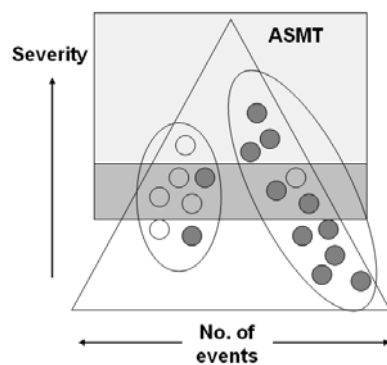
Main issues & Lessons learnt



LESSONS LEARNT

Advantages of Automatic Safety Data Gathering:

- ▶ Exhaustive data gathering
- ▶ Measuring frequency of low severity events
- ▶ Remove some of the biases of manual reporting: quantitative threshold



MAIN ISSUES OF ASDG

Main issues:

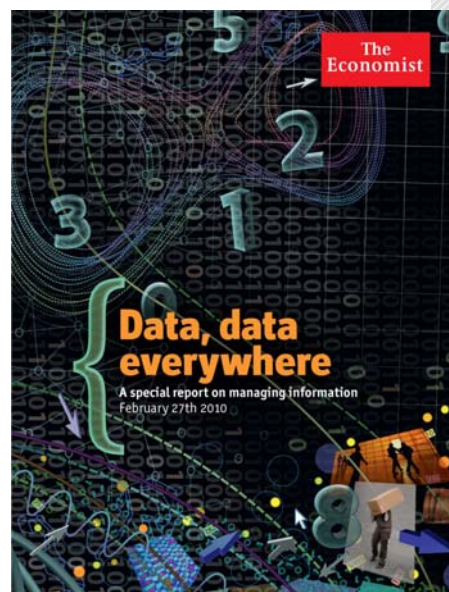
- ▶ Integration with local ATC system: may hamper data quality
- ▶ Organizational issues: need to protect ASMT data from “undesired uses”
- ▶ Require change of paradigm in safety management: risk of information without knowledge
- ▶ Data quality: noisy data sets
 - » Losses of separation: 800 in ECAC, previous experience tells 1200 per year for medium/large ACC.
 - » STCA and ACAS-RA: thousands per month



MAIN ISSUES OF ASDG

Common to many domains, not only ATM

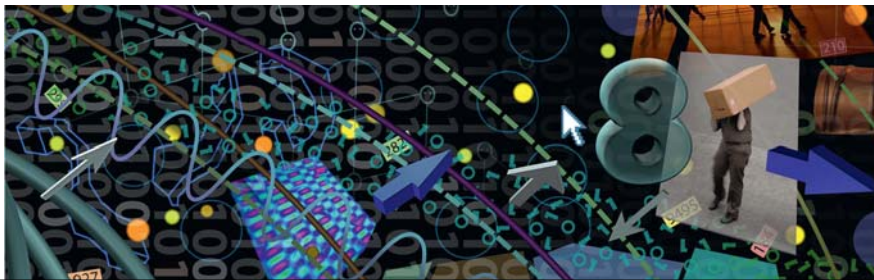
“ *Big data open new possibilities but requires paradigm shift* ”



LESSONS LEARNT

Lessons learnt: Data quality is the key issue

- ▶ Integration with local ATC system is critical
- ▶ Data complexity is the major issue for effective use and interpretation



LESSONS LEARNT

Data complexity: Interpretation by combination of three perspectives

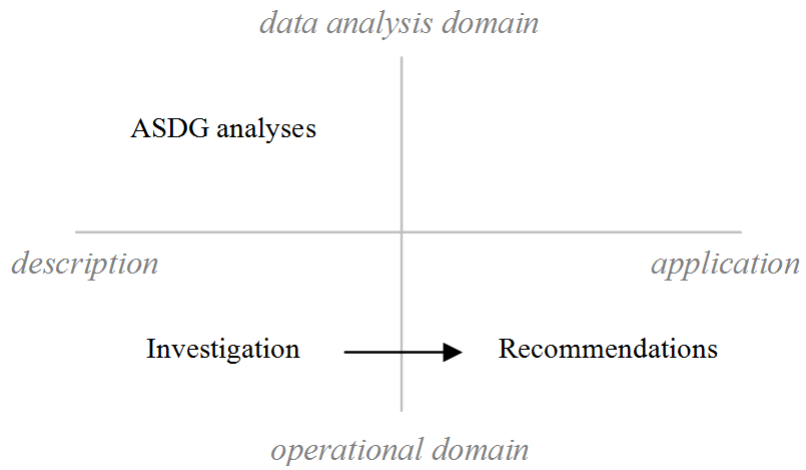
- ▶ Data Analysis perspective:
 - » driven by **analysis methods and techniques**
 - » it aims at a **statistical characterization** of the data set under analysis.
- ▶ Operational perspective:
 - » to interpret analysis results with OPS and Safety expertise.
- ▶ Information Visualization perspective:
 - » the ability to visualize information in ways people can use it with efficiency and effectiveness
 - » visually enforcing the "right comparisons":

Compared to what? [Graphical representations] answer directly by visually enforcing comparisons of changes, of the differences among objects.

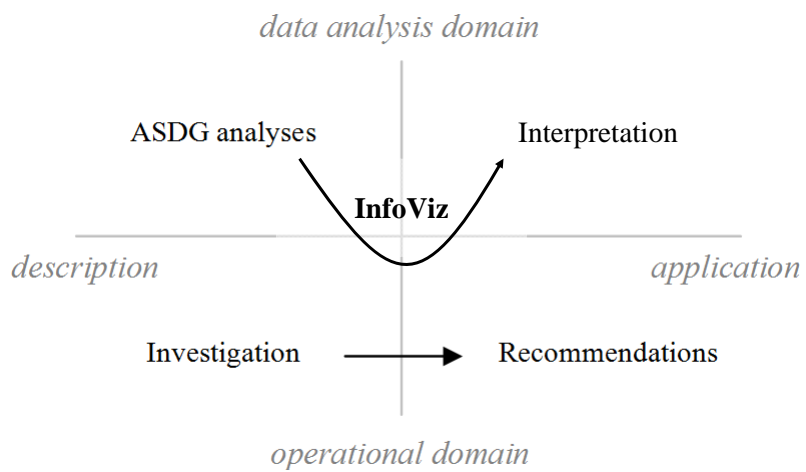
[E. Tufte]



LESSONS LEARNT



LESSONS LEARNT



LESSONS LEARNT

	Analysis	Operational	InfoViz
▶ Data gathering	75%	25%	
▶ Validation	25%	75%	
▶ Data analysis	100%		
▶ Info Visualization	25%		75%
▶ Intepretation	10%	80%	10%

LESSONS LEARNT

	Analysis	Operational	InfoViz
▶ Data gathering	75%	DATA	
▶ Validation	25%	↓	
▶ Data analysis	100%	INFORMATION	
▶ Info Visualization	25%	↓	75%
▶ Intepretation	10%	KNOWLEDGE	10%

CONCLUSIONS & NEXT STEPS

Conclusions:

- ▶ Very rich source of knowledge
- ▶ Data complexity demands an *equal complexity* of expertises
- ▶ Complementary to voluntary reporting, but can also require it as a pre-condition

Next steps:

- ▶ Correlation study btw different safety proxies (see also APF)
- ▶ Parallel validation: quantitative and operational
- ▶ Studies of propagation in SESAR scenario: performance and safety



THANKS FOR YOUR ATTENTION
QUESTIONS?

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