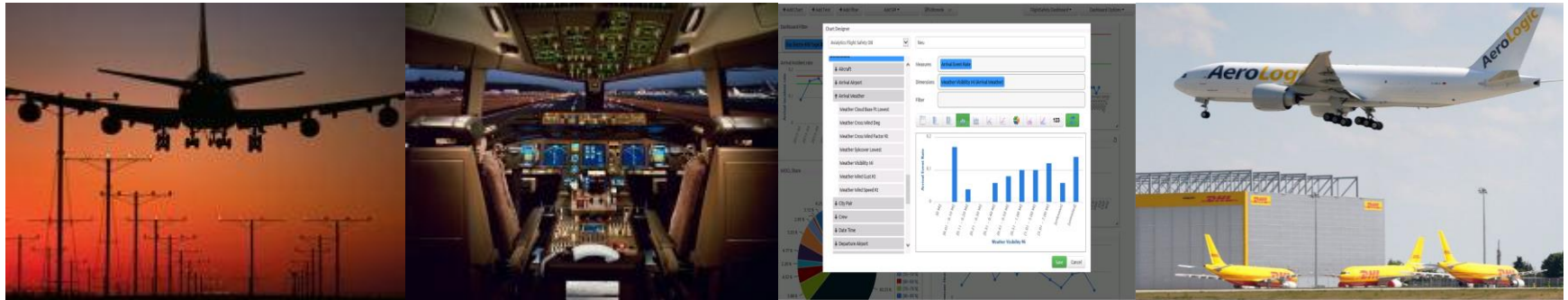


Big Data for flight safety and accident investigation

Evolving safety data into actionable insights



Safety and Accident
Investigation Centre

ANZSASI2017

9-11 June, Wellington, NZ

Dr. Björn Hennig





- Björn Hennig
- Pilot 1989 (St. Augustine, FL), privat flying St. Pete Air, KSPG
- PhD Operations Research Karlsruhe Institute of Technology (KIT), Germany
- Cranfield University, UK: Safety and Accident Investigation, MSc started 2015
- Performance and Safety Architect @ avialytics GmbH - FRA
- Aviation Experience: Airbus, Lufthansa, DHL, Aerologic, ACG ...



... An ACTF [IATA Accident Classification Task Force] study revealed that of the approximately 1,000 accidents over the last decade, accident reports were available for only around 300 of them. And of those, many had room for improvement. ...

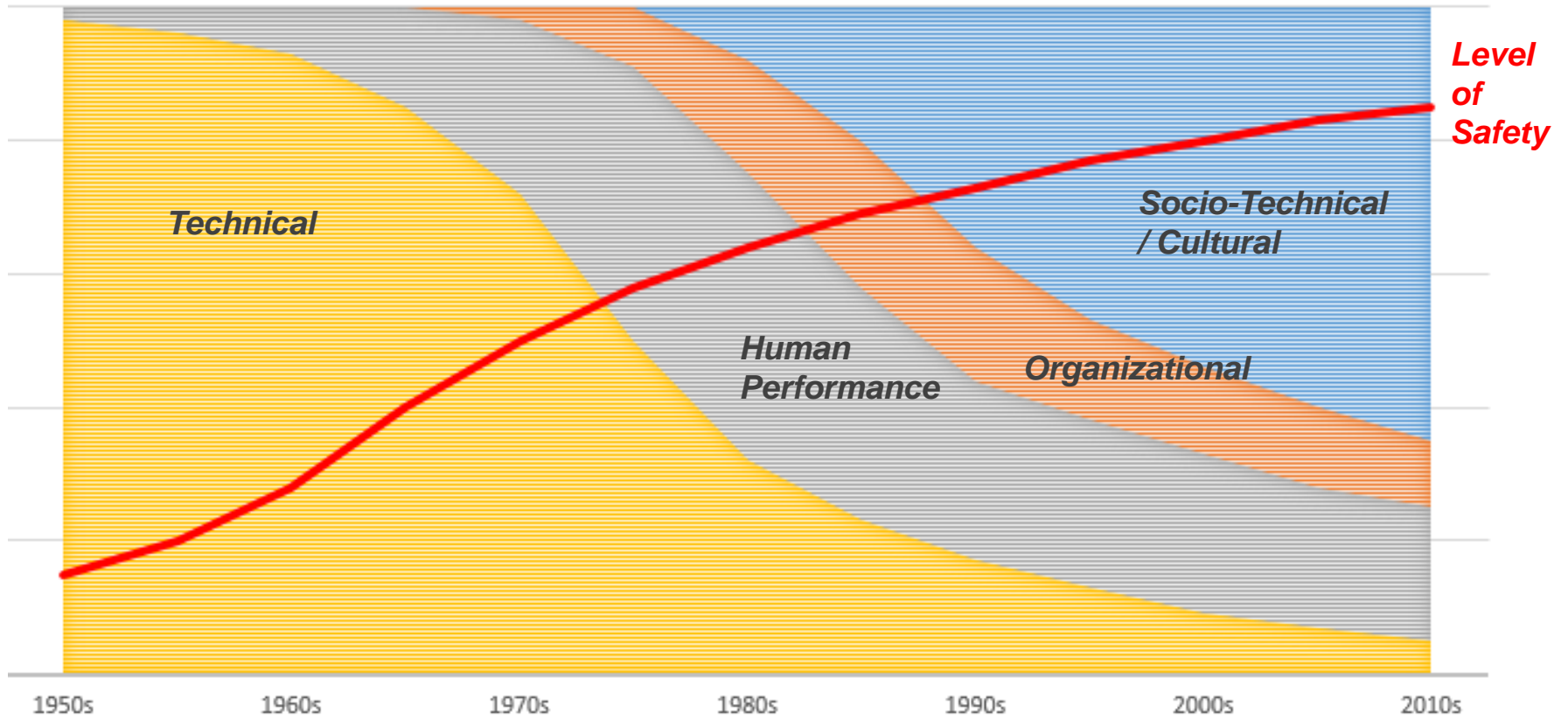
... Accidents are so rare that many states are challenged to maintain the necessary expertise. ...

... to address safety issues with greater speed. Safety is complex. Solutions to problems or changes to the way we do things need to be well thought out. ...

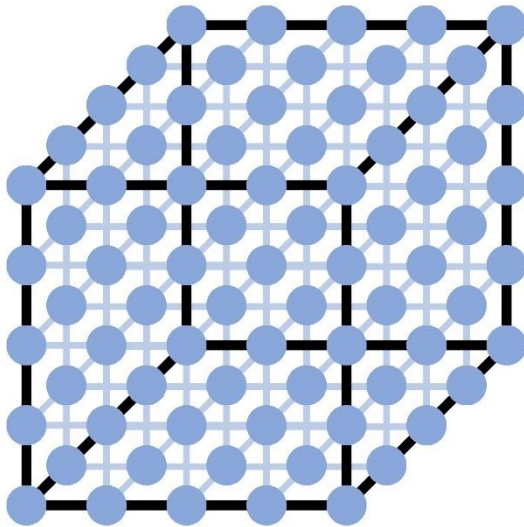


**Alexandre de Juniac (IATA President and CEO)
at the IATA Safety and Flights Ops Conference
Seoul, 24 April 2017**

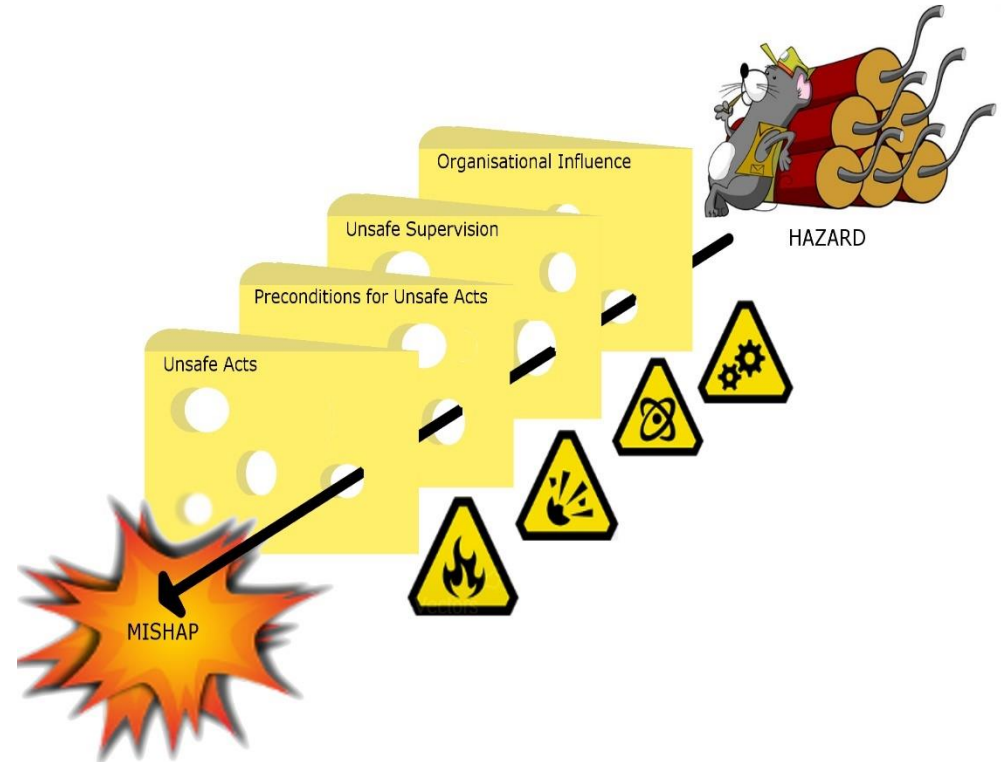
Safety and Accident Investigation - Implications



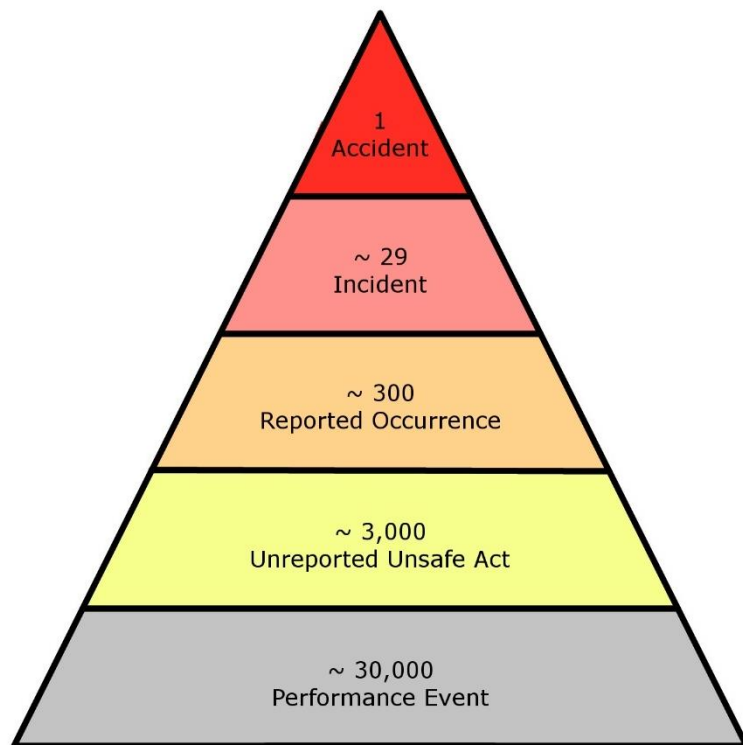
6σ



Zero-Error



Defence / Barrier Approach



Safety Management



- Biases, Heuristics?
- Premature closure?
- Decision Support?
- Objective: *Prevention*

Accident Investigation

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NOAA's National Weather Service
Aviation Weather Center



Simulator Protocol




Lufthansa Systems
NetLine/Crew



InfoBOX ODS/DWH




Data Retrieval & Capture Agents

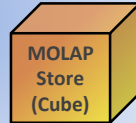


discretization


Repository



Flight Safety Data Mart (FS DM)



MOLAP Store (Cube)



CPM / LDM



ACARS

Big Data Example 1: Roster Robustness



Severity: Recovery Timezones	Recovery hours (Rest, off, hotel)	Block hours	Circadian Low (Minutes)	Duty-Type						
> 4	> 4	> 8	> 120	VAC->Flight OFF->Flight	Low	Moderate	High	High	Extreme	Extreme
+ 4	-4	+ 8	- 61 to 120		Minimum	Moderate	Moderate	High	High	Extreme
+ 3	-3	+ 6 or 7	- 31 to 60		Minimum	Moderate	Moderate	Moderate	High	High
+ 2	- 2	+ 4 or 5	- 16 to 30	STBY->Flight	Minimum	Low	Moderate	Moderate	Moderate	High
+ 1	- 1	+ 1 to 3	- 15		Minimum	Minimum	Minimum	Low	Low	Moderate
Timeliness: (ahead of STD)					1 week +	48 - 167 hours	24 - 47 hours	12-23 hours	6-11 hours	< 6 hours

| Aerologic |

| Roster Robustness Index |
72.34%

| General stability Index |
87.23%

05 | Extreme

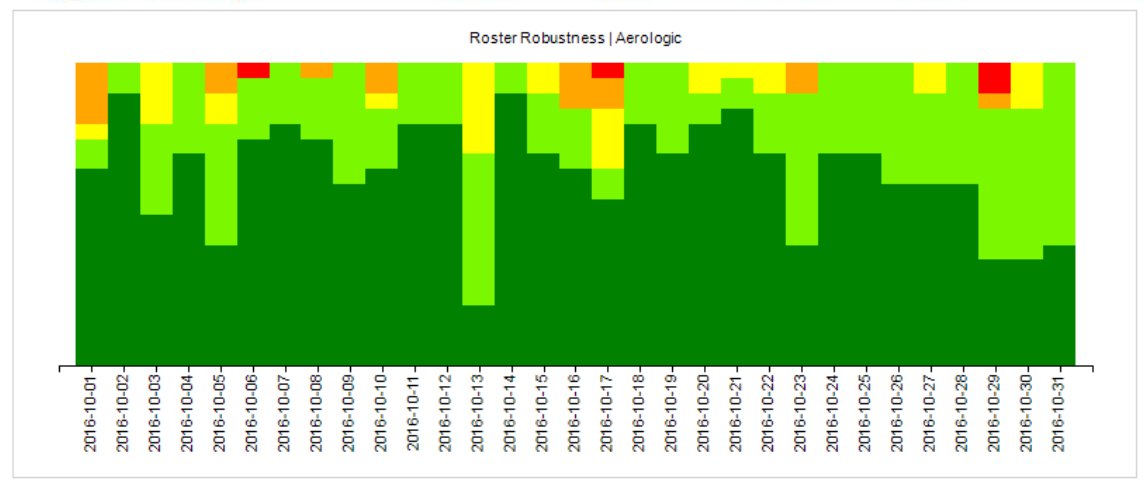
04 | High

03 | Moderate

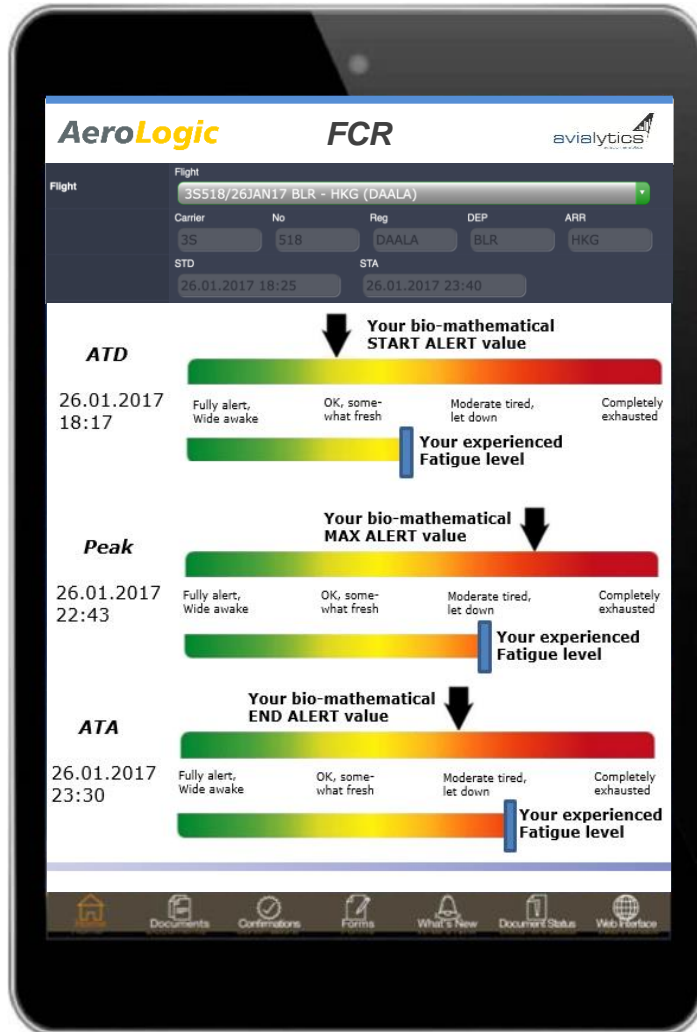
02 | Low

01 | Minimum

12/14/2016 5:53:38 PM
USER: AEROLOGIC\TRalthaus



Big Data Example 2: (Bio mathematical ?) Fatigue

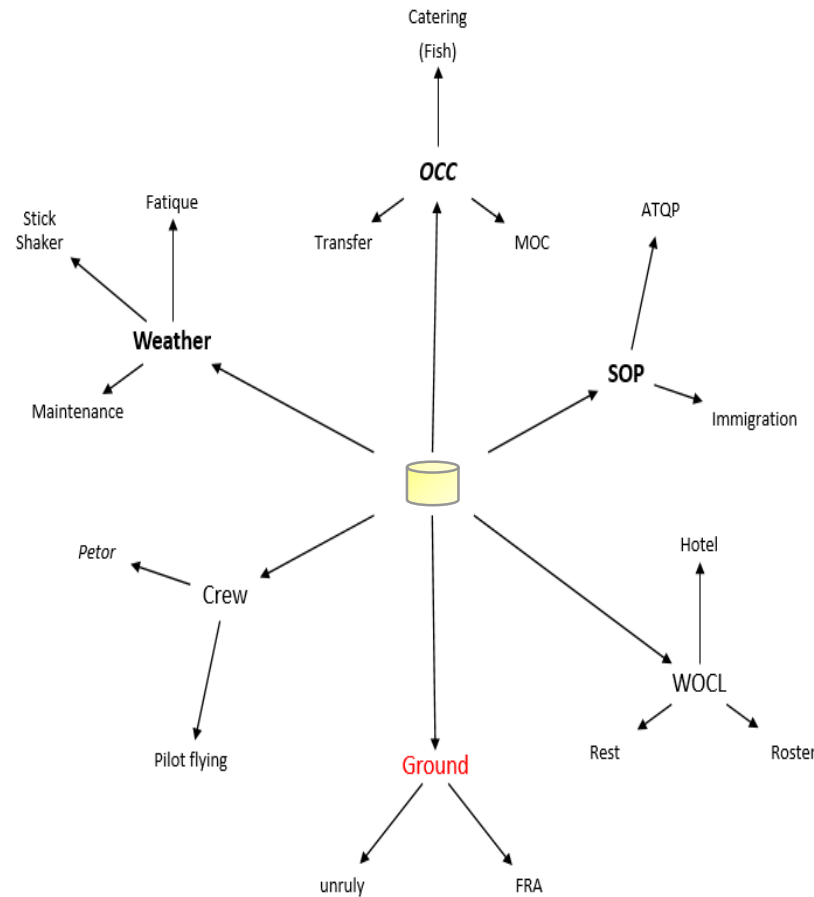


- Bio mathematical Fatigue Calculations (ALERT, SAFE, CARE ...)
- Vs. Experienced Fatigue
- Provide Reference to Crew?
- Monitor via Wearables?

Big Data Example 3: Text Mining (eDiscovery)



- Boeing 777 Fleet
 - Bird Strike
 - Fatigue
 - Crew Rest
 - Commander Discretion
 - Safety Occurrence
 - Other
 - Airbus 320 Fleet
 - Bird Strike
 - Fatigue
 - Crew Rest
 - Commander Discretion
 - Safety Occurrence
 - Other
 - Embrear
 - Bird Strike
 - Fatigue
 - Crew Rest
 - Commander Discretion
 - Safety Occurrence
 - Other
 - Ground
 - Ground Ops
 - Occurrence
 - E-Mails
 - Tech Docs
 - Other
 - Maintenance
 - Occurrence
 - E-Mails
 - Tech Docs
 - Other
 - Flight Safety
 - SOP
 - Pre-Flight
 - Flight
 - Taxi Out
 - Take Off
 - Departure
 - Cruise
 - Arrival
 - Landing
 - Taxi In
 - Post-Flight



Weight	Theme
100	Weather
97	Fatigue
97	Crew
82	ORD
82	Catering
81	APROX
80	Birdstrike
75	Water
72	Maintenance
71	Pilot tube
70	TCAS
70	Crew rest
60	Fish
58	Jump Seater
55	Ash
55	FRA
54	Aileron
50	Pilot flying
48	DAGBL
48	Stick Shaker
42	Scheduled Mainenance
42	WOCL
40	Beer
39	Attorney
39	EICAS
39	Safety pilot
34	###
34	Incident
20	FDM
15	Stabilizer
10	ACARS

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Flight Safety Box – Flight List



AeroLogic

FlightList Safety Performance Indicators Dashboard Administration

09.03.2014 16:26

16:26 UTC

0.1.5177.23774



Date	Flight	Reg	DEP	RWY	ARR	RWY	STD	STA	ATD Delay	ABN	LND	ATA Delay	FDM Events	FDM Identifier	Occ. Report	Weather	Gate Keeper	Hard Landing	Unstable Approach	Fatigue	Comment
01 Jan 2014																					
☒			DXB	30R		26L	07:50	14:25	07:44	08:00	14:11	14:19	5			☁			⚠		
Next Day: 01.01.2014																					
☒			DXB	12R		26L	07:50	14:25	07:29	07:49	14:01	14:10	1		+	☁		⚠			
Next Day: 01.01.2014																					
☒			LEJ	26L		25R	03:10	04:25	03:11	03:24	04:32	04:41	1		+	☁					
☒			HKG	07R		26L	09:45	22:00	10:21	10:30	22:35	22:43	4		+	☁			⚠		
									36												43
Next Day: 01.01.2014																					
☒			BLR	09		08R	06:40	16:15	06:30	06:54	15:50	15:54	3			☁			⚠		
Next Day: 01.01.2014																					
☒			FRA	18		28R	07:00	16:15	07:36	08:04	16:51	17:01	2			☁					
									36												46
Next Day: 01.01.2014																					
☒			LAX	25L		07L	01:35	12:40	01:34	01:48	12:03	12:13	1			☁		⚠			
Next Day: 01.01.2014																					
☒			HKG	07R		08R	09:45	22:00	09:52	10:23	22:01	22:07	1			☁					
Next Day: 01.01.2014																					
☒			ORD	28R		25L	18:15	23:05	17:42	17:56	22:05	22:10	2			☁					
Next Day: 01.01.2014																					
☒			DXB	30R		08R	07:50	14:25	07:20	07:47	13:49	13:55	3			☁		⚠	⚠		

Flight No	Owner	Type	Reg	DEP	ARR	STD	STA
		77F		HKG			

General **FDM** Occurrence Weather Multileg Gate Keeper Metric Assessment

- Unstable Approach at or below 1000ft
- Reduced flap landing
- Low Fuel on Landing
- High rate of descent (<500ft)**

High rate of descent (<500ft)

Invalidate Reason for invalidation

Name Approach: High rate of descent (<500ft)

Save changes

Occurrence Reports No connected Safety Reports available

FDM Event Date: 17.01.2014 10:20

Event type: Flight Path

Event value / unit: -1072.000000 Feet per Minute

Reference: Sink Rate - max (below 500ft) Reference Min/Max Range: -5000 1000

Event context: AIRSPEED=166.6, PITCH=U 3.0, RALT=56.0

Flight Safety Box – Multileg



AeroLogic

FlightList Safety Performance Indicators Dashboard Administration

09.03.2014 17:11

17:11 UTC

0.1.5177.23774



Crew	
Count	3
Complement	CP CP FO
Dead Head	0
Add Pers	1
Crew Rest	-
TO Rank	SFO
LD Rank	SFO
Dutytime	- [xx:xx]
FlightTime	12:05 [xx:xx]

Aircraft	
Registration	[text]
DOW	141450
MTOW	347451
MZFW	248115
EZFW	241419
TOW	??
ZFWMAC	26.000000
LDW	245619
PayLoad	99769

Information	
GCD	4786
Autolanding	NO
Autothrottle	YES
Traning	??

Flight Safety Box – Metric



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FlightList Safety Performance Indicators Dashboard Administration

09.03.2014 17:11
17:11 UTC
0.1.5177.23774

avialytics
AEROLOGIC/BHennig

Flight No	Owner	Type	Reg	DEP	ARR	STD	STA
		77F		HKG			

← Back to FlightList

General FDM Occurrence Weather Multileg Gate Keeper **Metric** Assessment

Base Measure:

Granularity:

Filter:

Metric Group

Aircraft

Crew

Crew

Flight

Flight

Flight

Flight

Flight

Route

Route

Route

Departure Event Rate
Unstable Approach
Departure Event
FDM Event Rate Major
FDM Event Rate Critical
FDM Event Rate
Departure Event Major
Departure Event Critical
Departure Event Rate
Arrival Event Major
FlightTime Duration [601 +]
Departure Airport HKG
Arrival Airport LEJ
City Pair HKG - LEJ



20134
All flights: 0,02695595
Departure Airport HKG: 0,0180722892

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Data Analytics – Pay Load



Pay Load Window of Circadian Low Crew Complement

Date Time

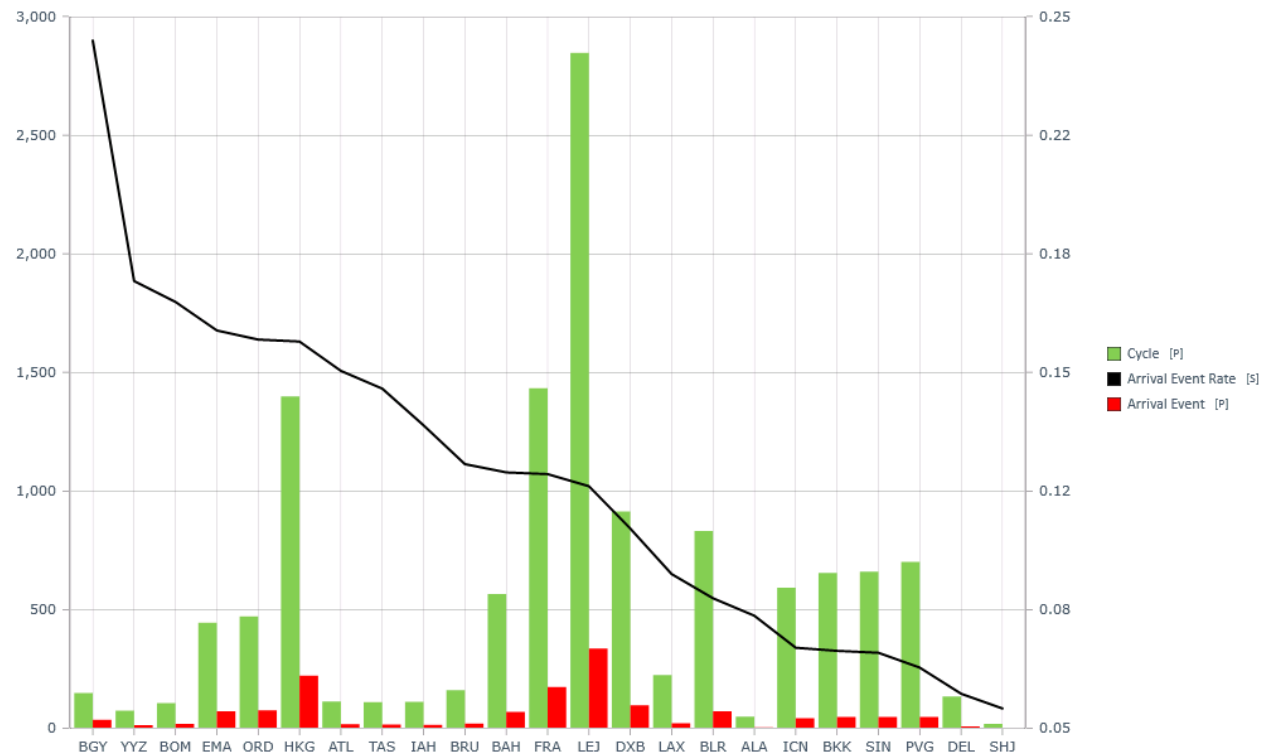
2012

2013

2014

Unknown

	Cycle	Arrival Event Rate	Arrival Event
BGY	148	24.32%	36
YYZ	74	17.57%	13
BOM	106	16.98%	18
EMA	445	16.18%	72
ORD	471	15.92%	75
HKG	1399	15.87%	222
ATL	113	15.04%	17
TAS	110	14.55%	16



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Book1 - Excel

TABLE TOOLS

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW DATA MINING ANALYZE DESIGN

Analyze Key Detect Fill From Forecast Highlight Scenario Prediction Shopping FlightSafety/MDDB Help
Influencers Categories Example Exceptions Analysis Calculator Basket Analysis (localhost) Connection Help

Table Analysis Tools

G9 : X ✓ ✎ TRUE

	A	B	C	D	E
1	ATD	DEP	ARR	WOCLShare	DEPWeigh
2	1/7/2012 15:53	LEJ	FRA	[None]	< 160
3	1/7/2012 15:53	LEJ	FRA	[None]	< 160
4	1/7/2012 15:53	LEJ	FRA	[None]	< 160
5	1/13/2012 17:27	LEJ	FRA	[None]	[180,200]
6	1/20/2012 17:28	LEJ	FRA	[None]	[160,180]
7	1/27/2012 17:20	LEJ	FRA	[None]	[200,220]
8	2/3/2012 17:34	LEJ	FRA	[None]	[180,200]
9	2/10/2012 17:30	LEJ	FRA	[None]	[180,200]
10	2/17/2012 17:32	LEJ	FRA	[None]	[180,200]
11	2/24/2012 17:02	LEJ	FRA	[None]	[200,220]
12	3/2/2012 17:48	LEJ	FRA	[None]	[160,180]
13	3/9/2012 17:22	LEJ	FRA	[None]	[180,200]
14	3/16/2012 17:31	LEJ	FRA	[None]	[180,200]
15	3/23/2012 17:19	LEJ	FRA	[None]	[180,200]
16	3/23/2012 17:19	LEJ	FRA	[None]	[180,200]
17	1/1/2012 2:47	ORD	LAX	[50-59 %]	[unknown]
18	1/6/2012 6:06	FRA	ORD	[None]	[240,260]
19	1/6/2012 6:06	FRA	ORD	[None]	[240,260]
20	1/6/2012 17:15	ORD	LAX	[None]	[160,180]
21	1/7/2012 16:05	FRA	ORD	[1 -9 %]	[240,260]
22	1/8/2012 3:23	ORD	LAX	[30-39 %]	[160,180]
23	1/13/2012 6:06	FRA	ORD	[None]	[220,240]
24	1/13/2012 17:11	ORD	LAX	[None]	[160,180]
25	1/14/2012 16:04	FRA	ORD	[None]	[240,260]

FRA - ORD FALSE [320+] False False

Sheet19 Prediction Report for HasHar Prediction Calculator for Ha Printable Calculator for Has

READY

SQL Server Data Mining - Prediction Calculator

Prediction Calculator

Microsoft SQL Server 2012

This tool detects the patterns that predict a specific value (the Target) of a column based on values in the other columns. The patterns are presented in a scorecard format that allows assigning scores based on the values of the other columns. The tool generates an analytic report of scores, which can be used to analyze the impact of misclassification costs. It may also generate an operational Prediction Calculator and a printer-ready sheet.

Column Selection

Target: HasHardLanding

Exactly: True

In range:

[Choose columns to be used for analysis](#)

Output Options

Operational Calculator Printer-ready Calculator

Run Close

Advanced Columns Selection

This task analyzes the data in the table columns to recommend columns for use in analysis. You can override this recommendation by manually choosing the columns below.

Choose columns to be used for analysis

- ATD
- DEP
- ARR
- WOCLShare
- DEPWeight
- CityPair
- HasFDMEvent
- ARRWeight

OK Cancel

	K	L	M
	BlockTripDuration	HasDepartureFDMEvent	HasArrivalFDMEvent
	[0,60]	False	True
	[0,60]	False	True
	[0,60]	False	True
	[241,360]	False	False
	[481,600]	False	False
	[241,360]	False	False
	[481,600]	False	False
	[241,360]	False	False
	[481,600]	False	False

Prediction Calculator Report for the 'True' state of 'HasHardLanding'

Specify the costs and profits associated with correctly and incorrectly predicting 'True'. These costs/profits are needed to compute the optimum score threshold for the calculator.

False Positive Cost	10
False Negative Cost	10
True Positive Profit	10
True Negative Profit	10

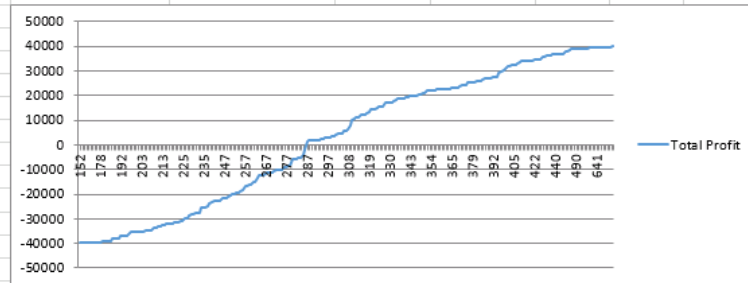
Suggested Threshold to maximize profit: 752

Score Breakdown

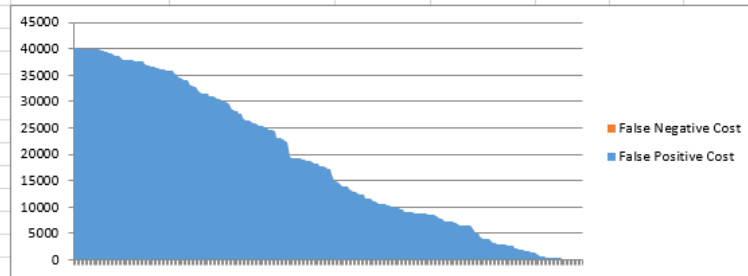
Individual scores for each state of each analysed column

Attribute	Value	Relative Impact
WOCLShare	[70-79 %]	489
ARR	YYZ	315
ARR	ORD	257
ARR	BRU	197
ARR	EMA	196
WOCLShare	[30-39 %]	165
ARR	HKG	161
ARRWeight	[220,240]	147
ARR	FRA	137
ARR	BGY	130
ARRWeight	[240,260]	119
WOCLShare	[None]	100
ARRWeight	[280,300]	100
WOCLShare	[80-89 %]	94
ARRWeight	[160,180]	94
ARRWeight	[200,220]	88
ARRWeight	[180,200]	85
ARRWeight	[320+]	85
ARR	LEJ	82
ARRWeight	[260,280]	77
WOCLShare	[10-19 %]	76
ARR	BLR	64
WOCLShare	[20-29 %]	64
ARRWeight	[300,320]	62
ARR	BOM	61
ARR	SIN	60
ARR	DXB	59
WOCLShare	[1-9 %]	58
ARR	BKK	56
ARR	IHF	55

Profit for various score thresholds



Cumulative misclassification cost for various score thresholds



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➤ Double Loop Learning:

- Deduct context and assumptions based on analytics
- Verify and create hypotheses
- Identify appropriate measures, actions and lessons learned
- Implement measures and actions in training and/or operations
- Trace measures in Flight Safety Analyzer
- Question and validate assumptions based on results
- Close control loop by adapting SPIs, proceedings and trainings

➤ Implications for Evidence-based Training:

- Creation of Evidence/Performance profiles based on training and operation
- Drill down SPIs and other facts to relevant level
- Proposal of individual/team based scenarios for facilitated instructional techniques
- Integration of simulator data, protocols and evaluation
- Measurement of results via SPI and FDM analytics
- Establish continues improvement process and learning (mentored)
- Proactive identification of future risks, threads and individual weaknesses (e.g. Information-Sharing und Benchmarking - ASIAS)

Thank you



Stay in touch!

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