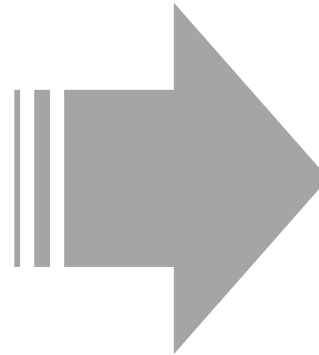


Bayesian techniques to quantify risk using flight data

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Tuesday 14th May 2019



Runway excursion
CFIT
LOC-I
Runway incursion
Airborne conflict



Background

Where can I get answers to:

- What is my airline's probability of a runway excursion?
 - 1 in 1000? 1 in 1,000,000,000?
- Where is my airline most likely to experience a runway veer-off?
 - Belfast City (BHD)
 - Dalaman (DLM)
 - Moscow Domodedovo (DME)
 - Edinburgh (EDI)
 - London Heathrow (LHR)

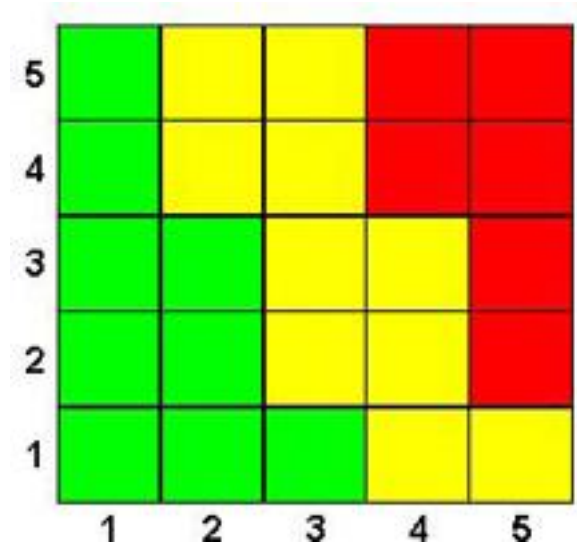


Quantifying risk in airline operations

Despite availability of data....

Most risk assessments rely on some form of subjective estimate of probability:

- "reasonably probable", "remote" etc
- A value is assigned (e.g. 1-5) for probability and consequence, which are then multiplied
- Result is a number, but not truly quantitative



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Previous work

Runway veer-off (landing only)

- Review of causal factors involved in runway veer-off accidents 1994 – 2014
- Prevalence of causal factors in routine operations
 - 310,000 Airbus A320 flights
 - 370 recorded parameters
 - 68 features from each landing
 - METAR and runway data added



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Bayes' theorem

- Widely used in risk management and decision making in other industries
 - Drug trials
 - Financial risk
 - Environmental risk
 - Search for AF447

$$p(VO | CF) = \frac{p(CF | VO) p(VO)}{p(CF)}$$

From accident
investigations

From accident
statistics

From flight
data, METAR
etc

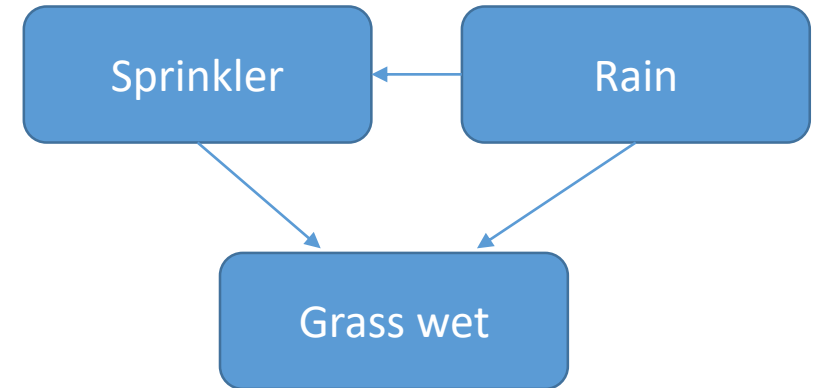
VO – veer-off

CF – causal factor

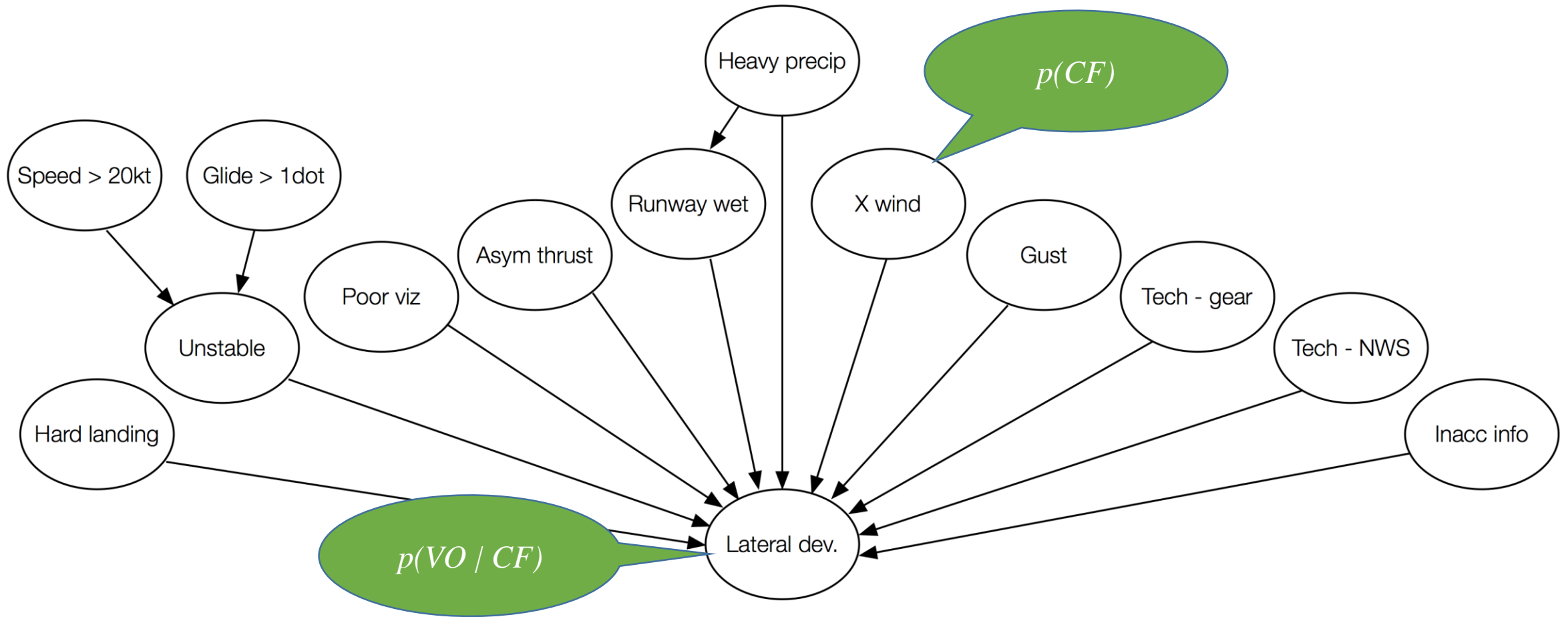


Bayesian networks

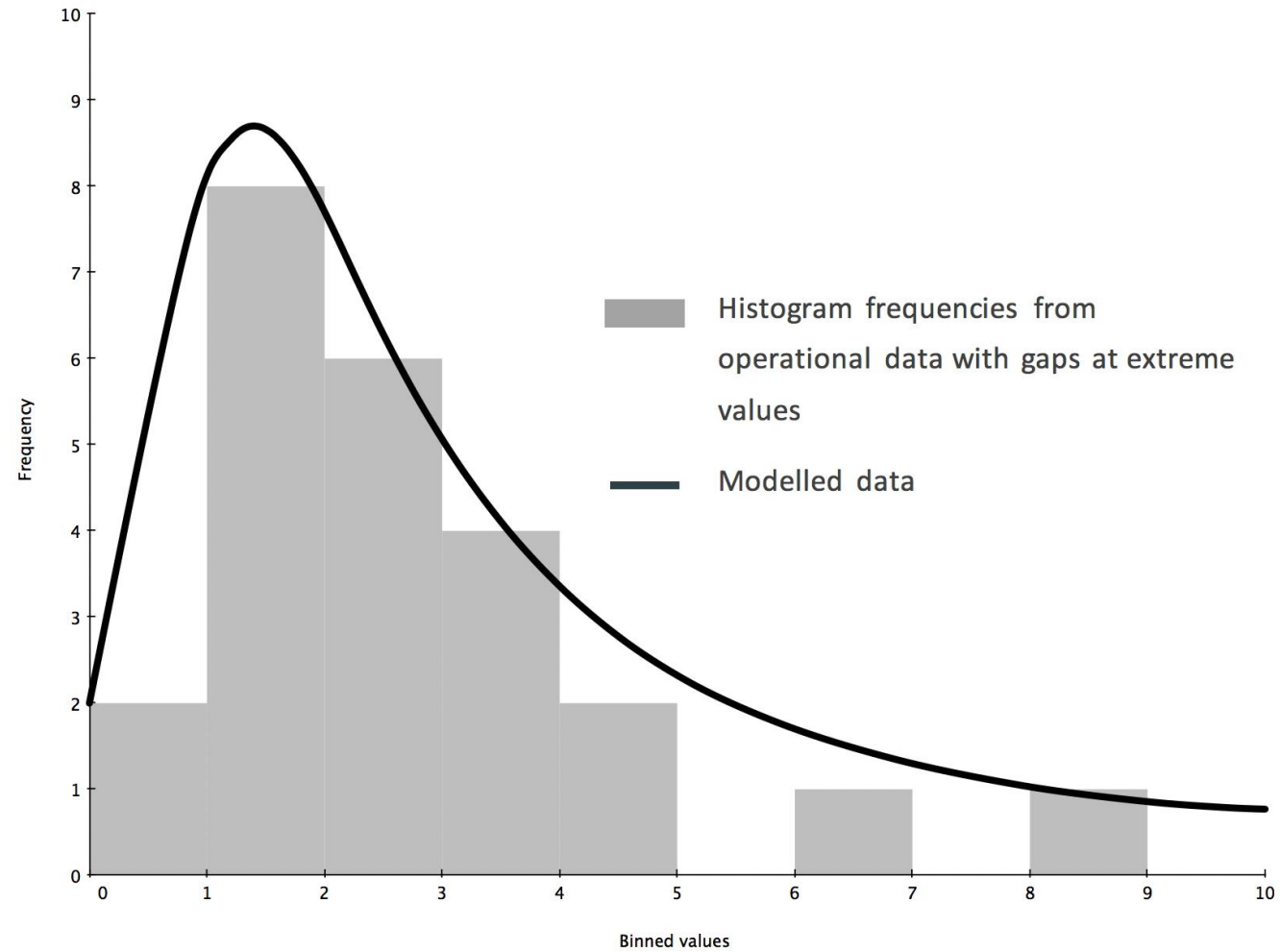
- Use Bayes theorem and represent the relationship between a set of variables
- Directed acyclic graphs (DAG)
- Relationships may be causal



Bayesian network for landing lateral deviation

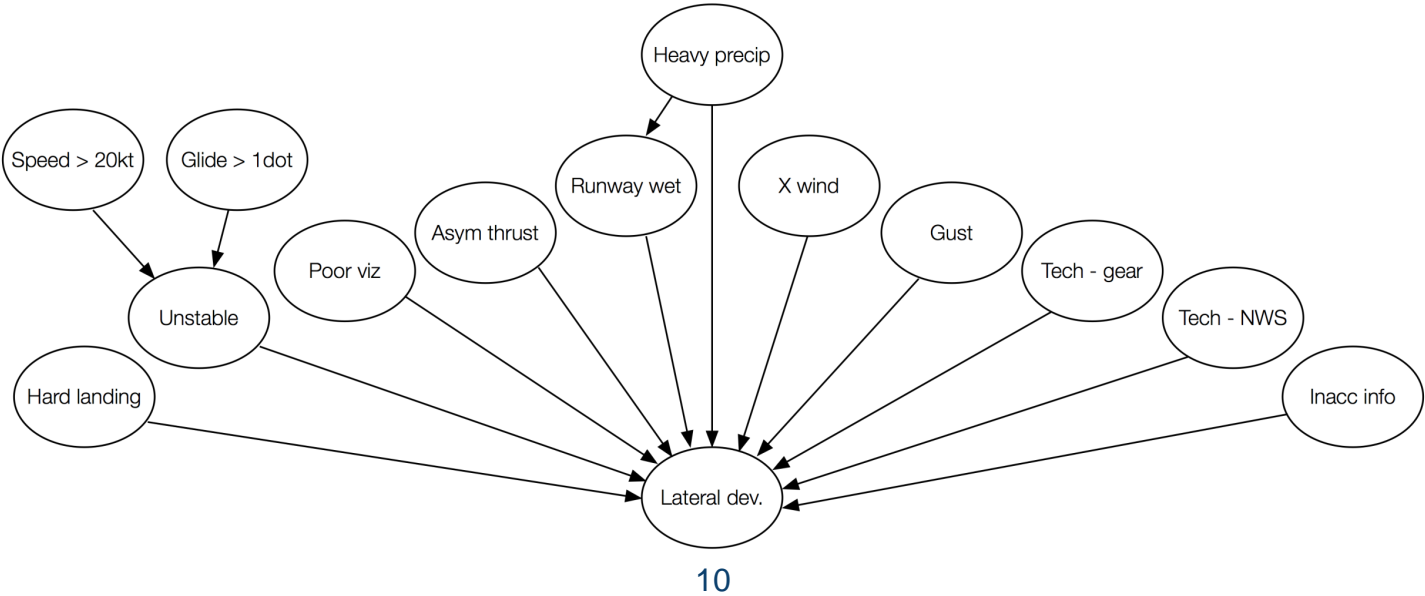


Modelling extreme values



Scenarios

Factors present	p(Lateral Deviation)	Increase
As modelled	2.88E-08	
Unstable	5.36E-08	86%
Unstable + Xwind	8.23E-08	185%
Unstable + Xwind + Gust + Wet	1.26E-07	338%



Comparing airports - results

Moscow Domodedovo (DME)	2.93E-08
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Belfast City (BHD)	2.78E-08
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Edinburgh (EDI)	2.65E-08
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London Heathrow (LHR)	2.52E-08
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Dalaman (DLM)	2.46E-08
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Application

Based on operational data e.g.:

- FDM results
- Weather forecasts
- Defect status

Pilots could receive a pre-departure risk assessment, thereby improving awareness and presenting an opportunity for mitigations to be decided.

Airfield briefings and categorisations.

Monitoring change over time.



Future work

- Apply method to other risks
- Use an alternative dataset with different aircraft types, other airports etc
- Expand to use risk controls in the Bayesian network in addition to causal factors
- Link to additional data sources



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Finally

AMC1 ORO.AOC.130 Flight data monitoring – aeroplanes

“(b) An FDM programme should allow an operator to:

- (1) identify areas of operational risk and quantify current safety margins;
- (2) identify and **quantify operational risks** by highlighting occurrences of non-standard, unusual or unsafe circumstances;
- (3) use the FDM information on the frequency of such occurrences, combined with an estimation of the level of severity, to assess the safety risks and to determine which may become unacceptable if the discovered trend continues;
- (4).....



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