

Machine Learning in FDM

Extracting new safety knowledge from FDM

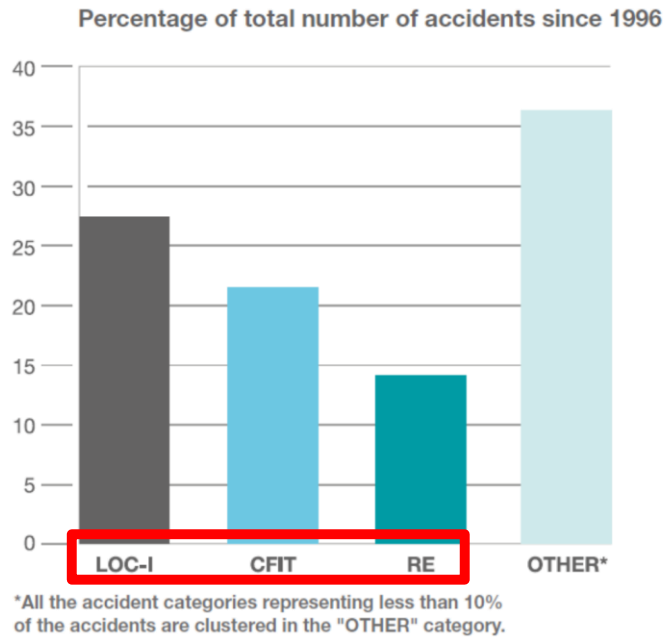
EASA Conference June 2017

Motivation



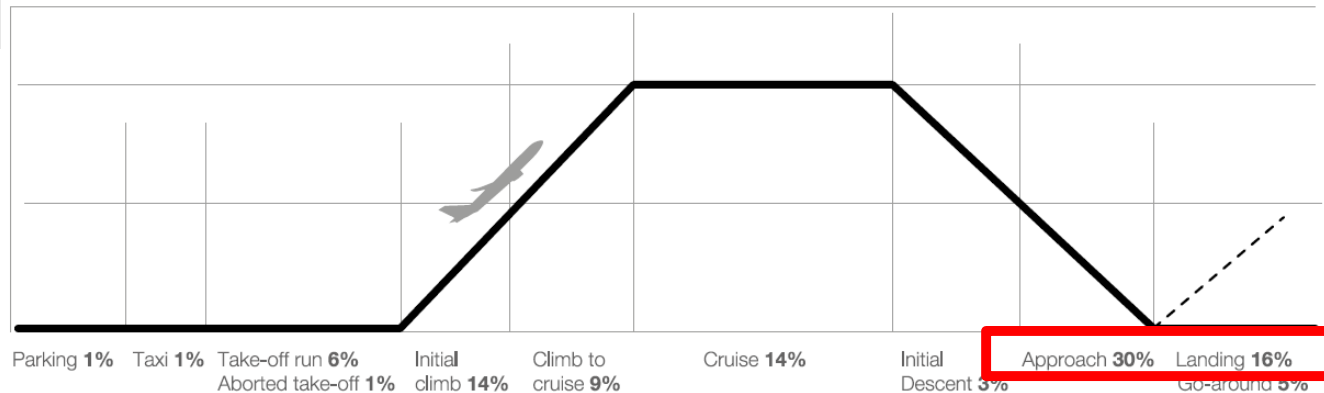
Safety driven approach

Fatal

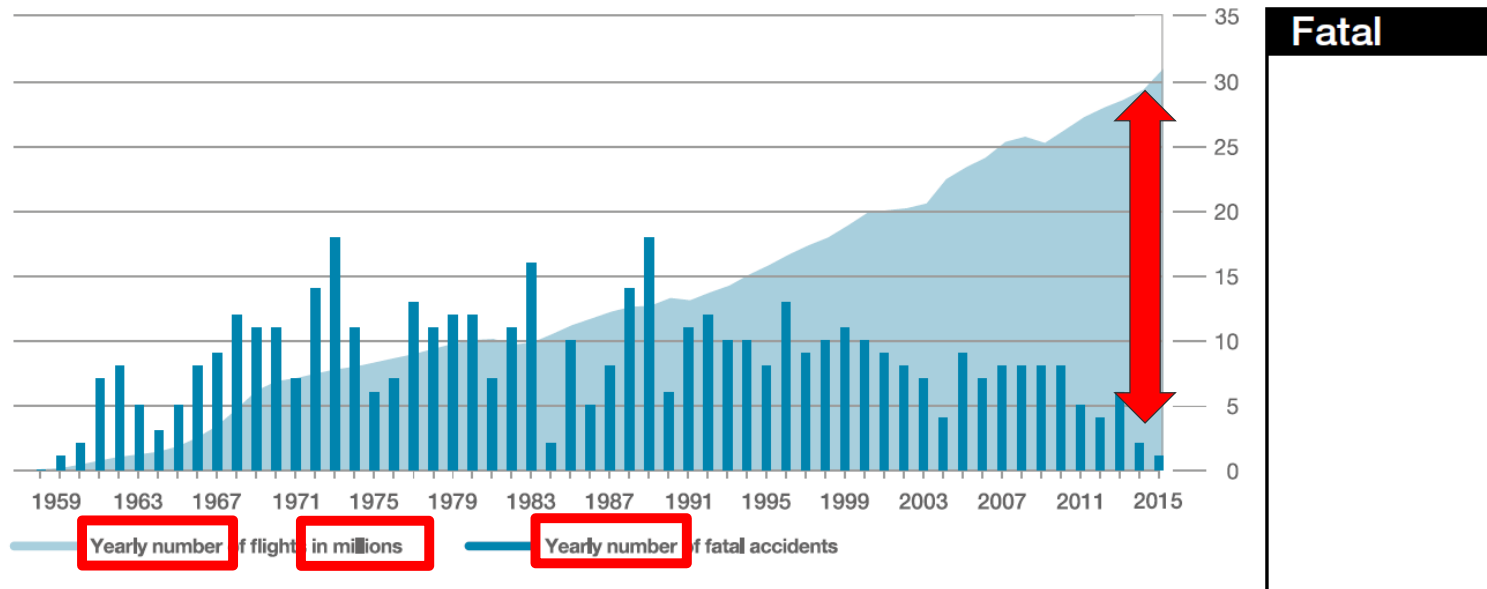


Source: Airbus:
A Statistical Analysis of
Commercial Aviation
Accidents 1958-2015

Fatal

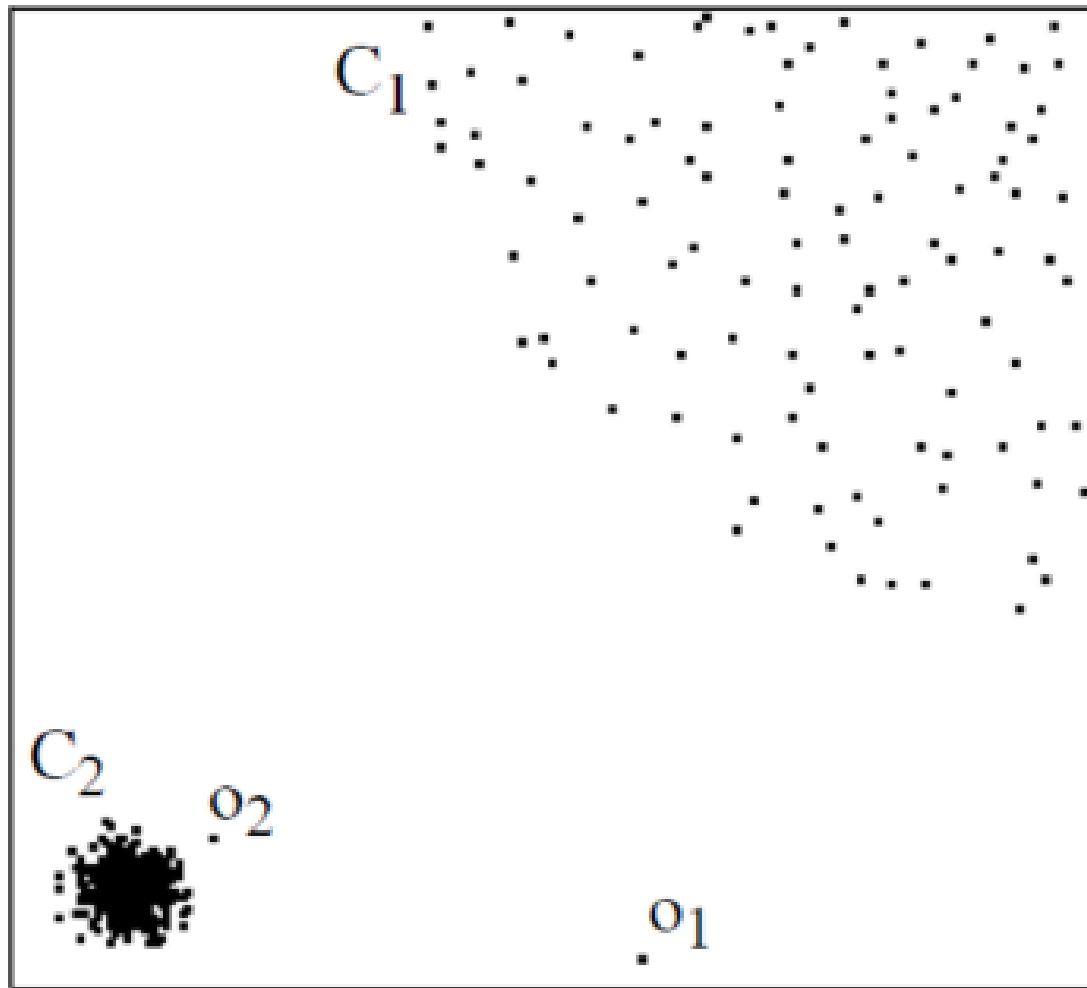


What to look for?

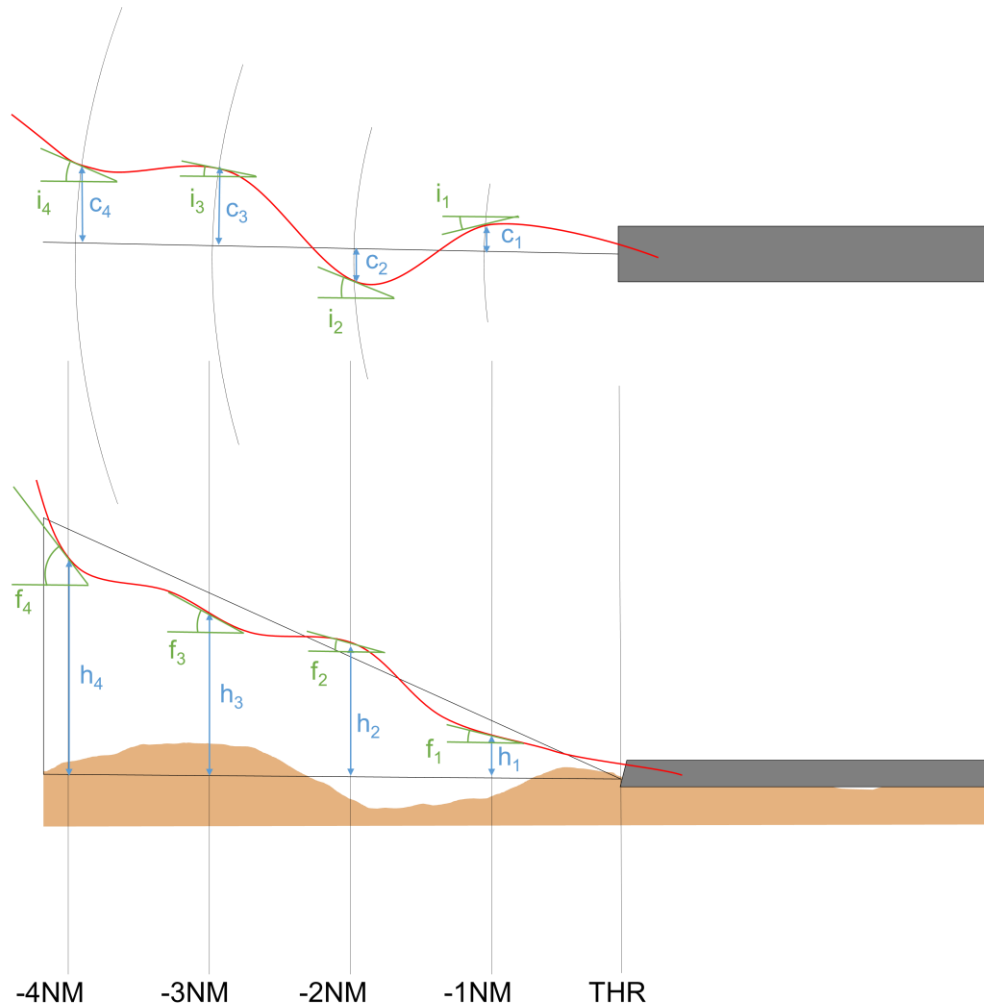


Hypothesis: The „normal“ or „average“ flight is safe. Outliers or „abnormal“ flights are potentially less safe.

Local Outlier Probability



Feature Space – 60 measurements for each approach



Data preparation

Flight Record	Flight Date (UTC)	Fleet	Takeoff Runway ID	Landing Runway ID	P335: Height above Threshold at 1 NM before Threshold (ft)
5426821 Mar 2013	A321, CF	FRA 07C BHX 15	359.407257080078	661.563659667969	958.945495605469
5426822 Mar 2013	A321, CF	BHX 15 FRA 07R	319.665588378906	668.171630859375	943.840209960938
5426823 Mar 2013	A321, CF	FRA 18 BUD 13R	341.948028564453	635.742614746094	954.005615234375
5426824 Mar 2013	A321, CF	BUD 13L FRA 25C	373.802886962891	722.822021484375	1122.65551757813

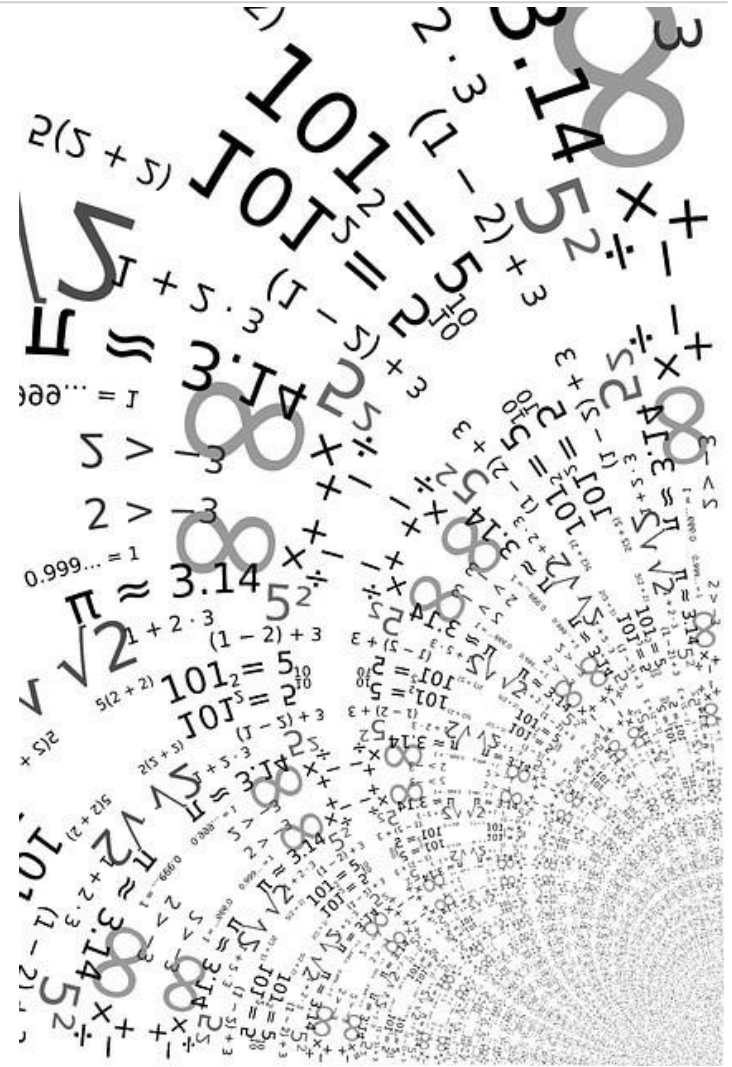
For preparation, the data was:

- Further de-identified
- Filtered for obvious data errors
- Standardized (mean = 0, SD = 1)

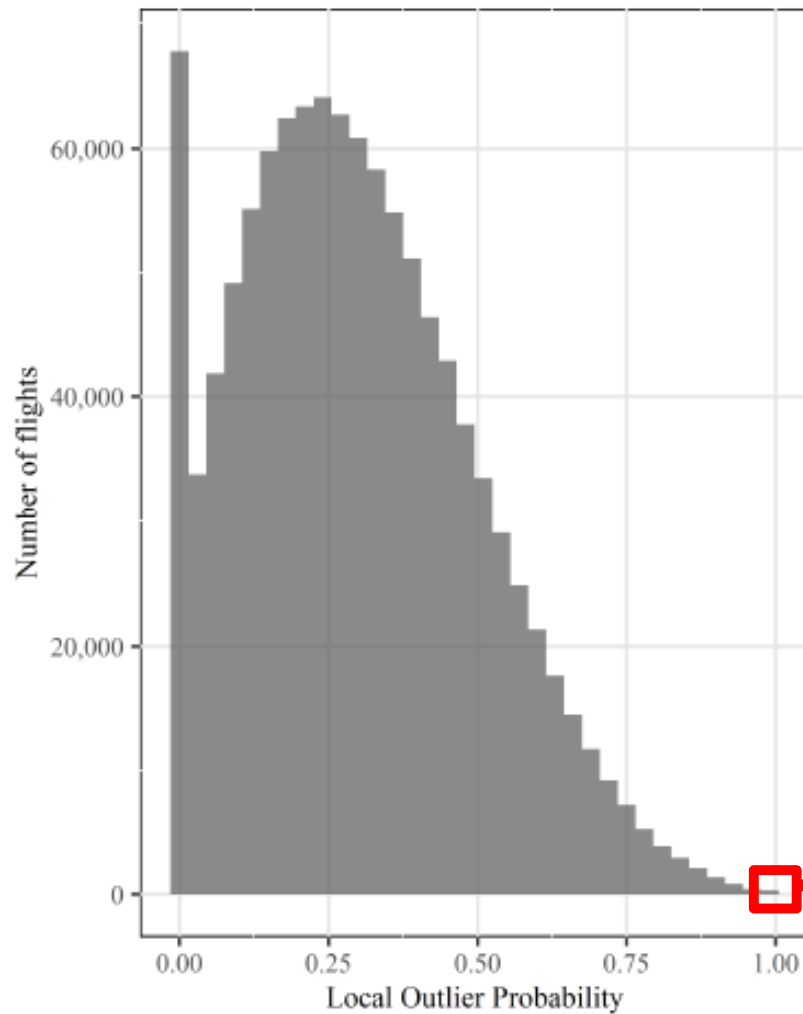
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ID=31712 -1.22350275032883 -0.349007783130655 -0.301402876398661 -0.639467185484248 -0.121575961614387 -0.218316612753149 -0.3805066030837
ID=144089 0.906106455163056 1.77319336350587 1.72985903769219 1.24161196597762 0.76872906813853 0.321336905632267 -0.127281095255215 -0.15
ID=70597 2.00302541573772 2.24055814261912 1.12496504385825 0.651976347070013 0.411025241716389 0.110825883340359 -1.21533510191475 -1.672
ID=847990 1.321308544375 -4.60498312920784 -5.83436519035633 -0.728549492091882 0.0448287706033649 0.00412220730526146 -0.0251291886714072
ID=1031588 -3.84057088011135 -0.0261192430995951 -0.151021809543952 0.211211794640853 0.113359543803654 0.0535232620616965 0.0885456272436
ID=510012 0.541781006388689 5.92390317378816 8.21326113285228 8.01683180518645 8.45791359017703 9.33605325964916 9.79020072797998 9.552767
ID=172303 -1.59109527773769 -0.676669311267654 -0.348452269103756 -0.182403416483242 -0.127855738585882 -0.110842353330528 -0.187716467287
```

„Number crunching“

- 60 data points per flight
- 1 million flights ($n = 10^6$)
- Algorithm performs n^2 calculations
- $10^6 \times 10^6 = 10^{12}$ calculations
- Cranfield University HPC
- 100 hours calculation time (on a single core)
- Result: one score between 0 and 1 per flight expressing the „outlierness“



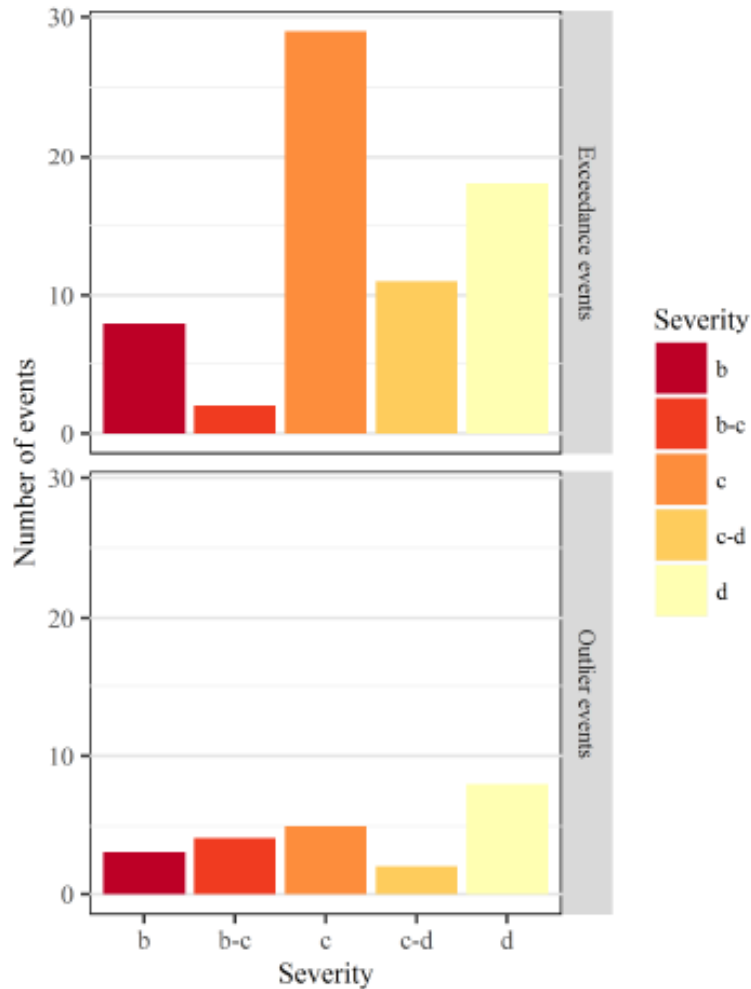
Distribution of outlieriness



Scores above 0.99 were translated into „pseudo-events“ and reviewed.

Approximately 75% were false positives.

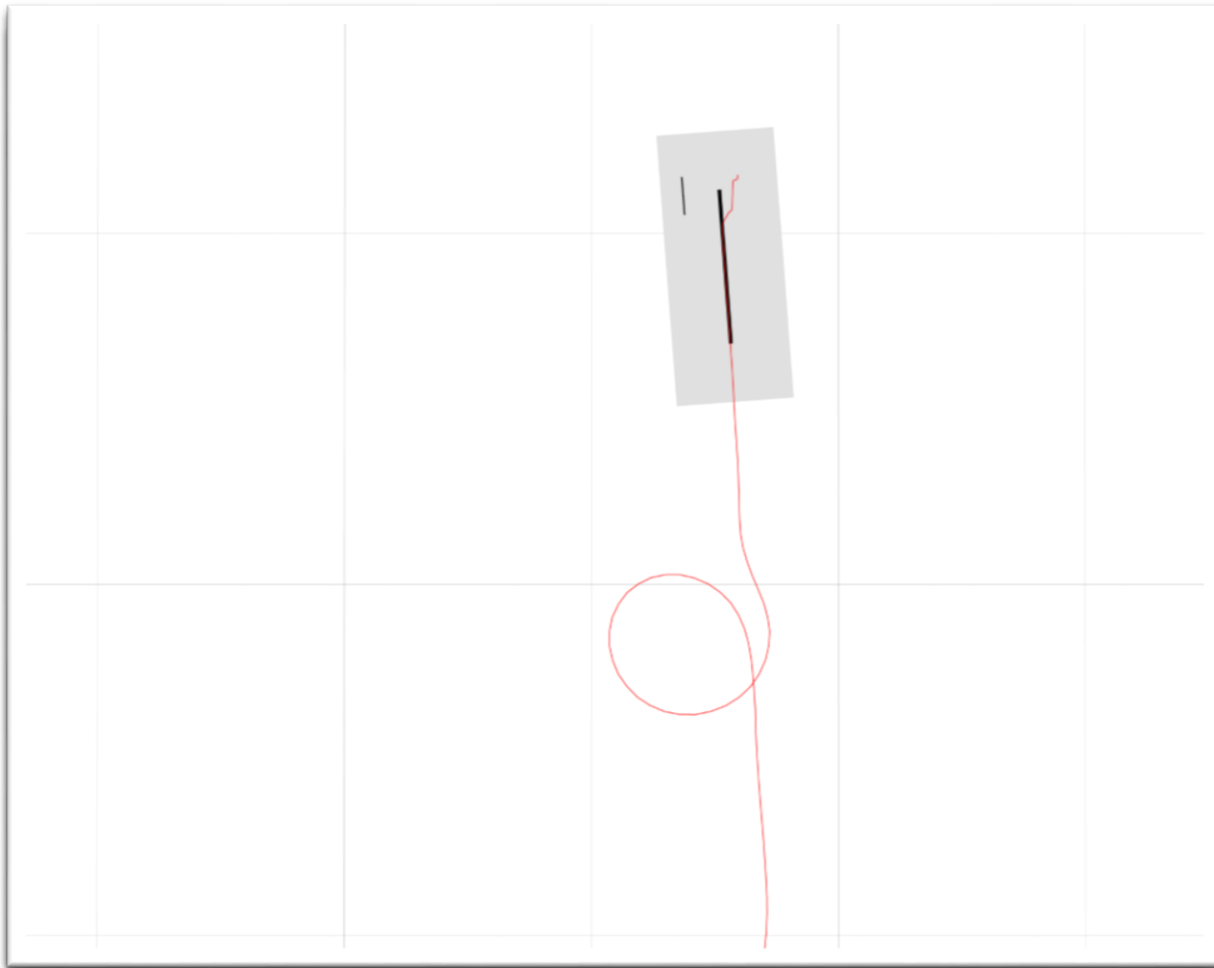
The „new“ events versus the „classic“ events



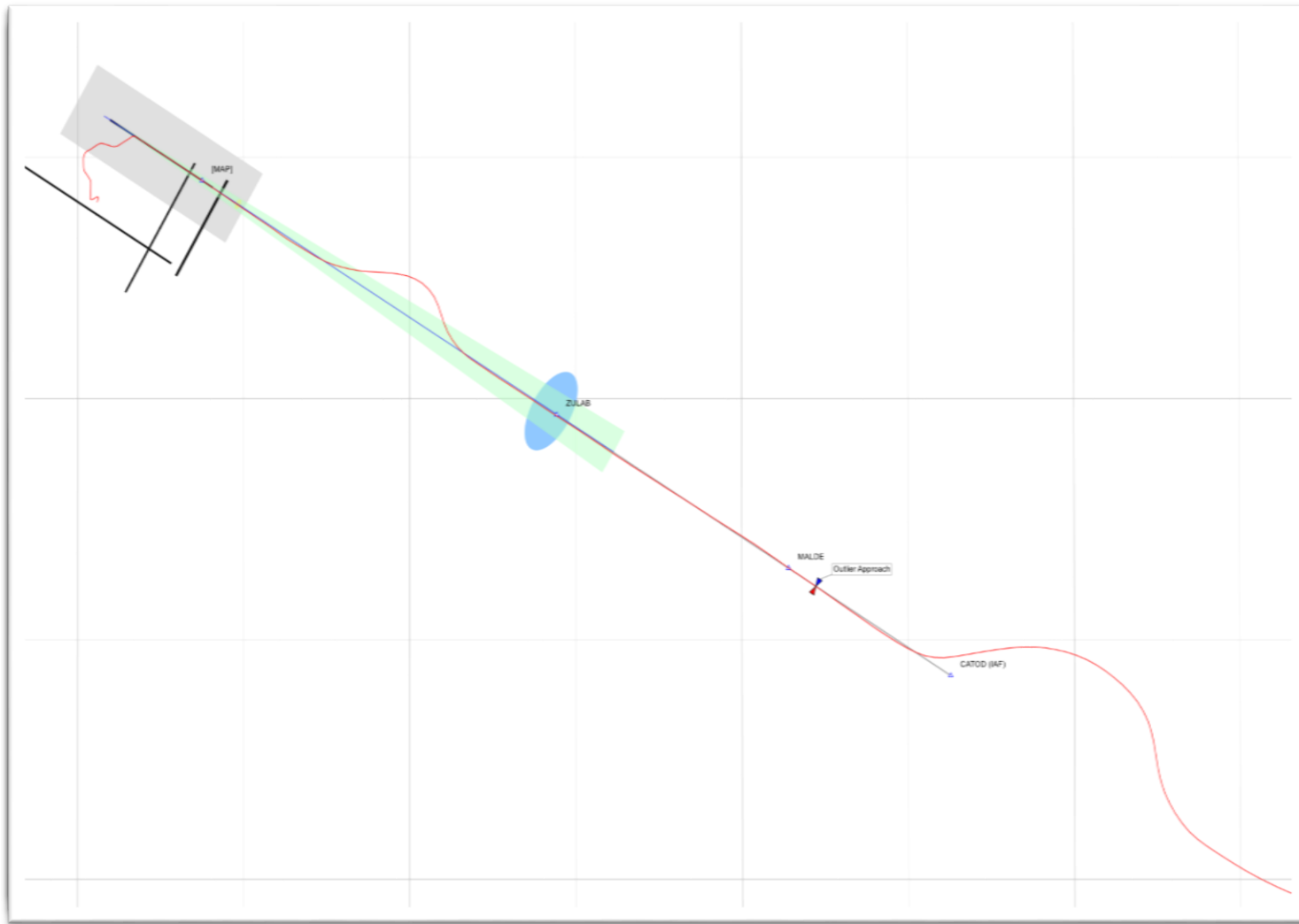
On comparison:

- Less events found (however, the cutoff at .99 is arbitrary)
- Most events previously unknown
- Many considered worth further investigation

An unexpected cluster



Another „failure of imagination“



One flight has no classic „High Severity“ event, but...

- Medium Severity Late Flap Extension
- Medium Severity Late Gear Extension
- Medium Severity GPWS: Glideslope
- Medium Severity Below Desired Glide Path on Approach
- Medium Severity Unstable Approach

The outlier technique “automatically aggregates” different types of events.

Conclusion

- “... it **reduces the failure of imagination** in FDM by detecting approach abnormalities for which no *exceedance event* existed.”

