



FDM Decoding and Data Analysis

Techniques and lessons learnt from SafeClouds.eu

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- 2/ FDM Data Sourcing
- 3/ Unstable Approach Case Study



1/ PROJECT OVERVIEW

1/ SafeClouds.eu* Project Overview

Partners, Scope, Use Cases

- Funded by European Commission
- Goes until Sep. 2019
- Aircraft covered:
 - A319/20/21/30/40
 - B737
 - 17 dataframes



SmartRunway



Unstable Approach



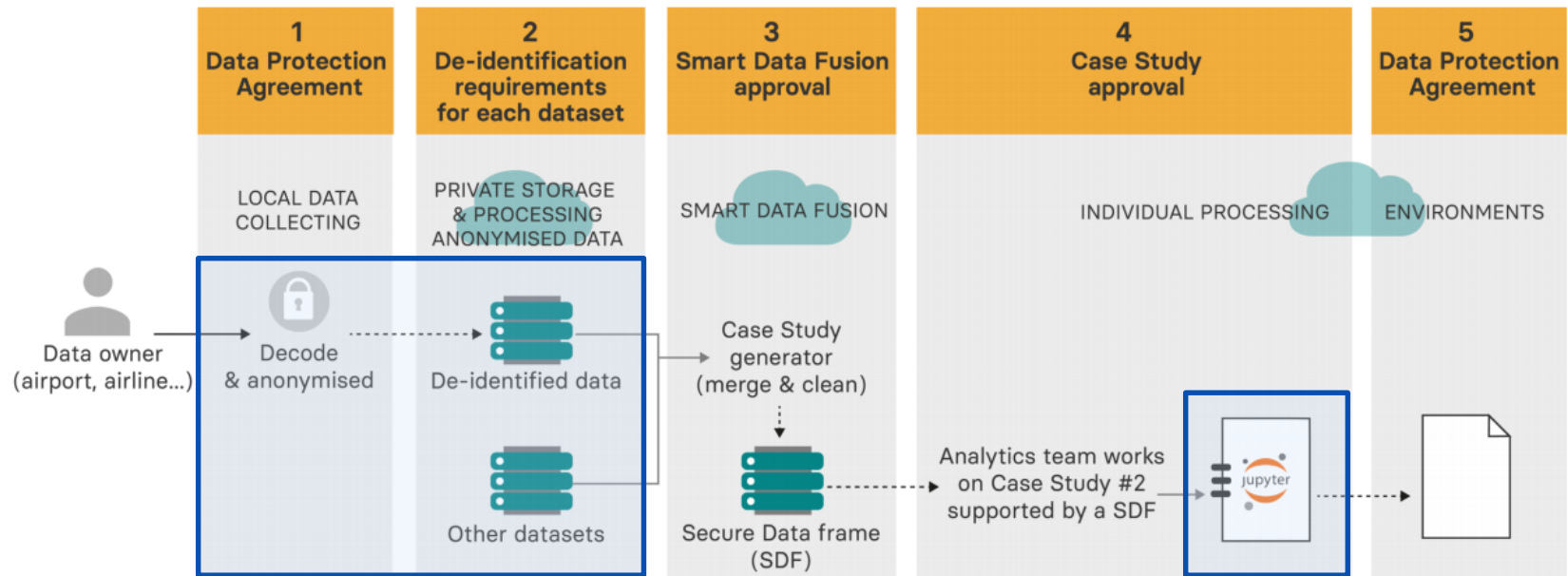
Ground Proximity



Airprox

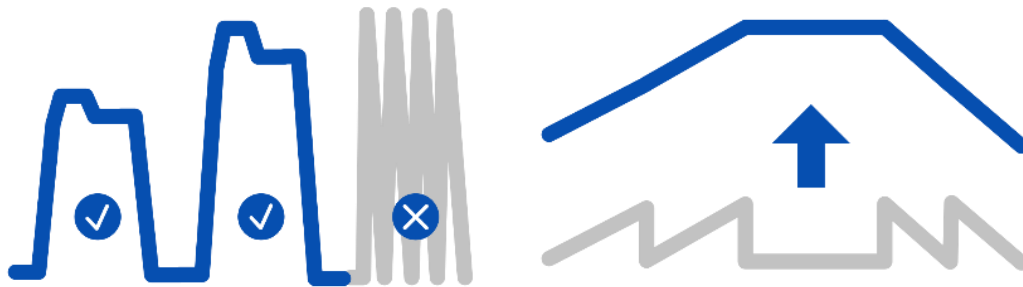
1/ SafeClouds.eu Project Overview

Infrastructure



source: Innaxis





2/ FDM DATA SOURCING

2/ FDM Data Sourcing

Local Node FDM Data Processing



Splitting



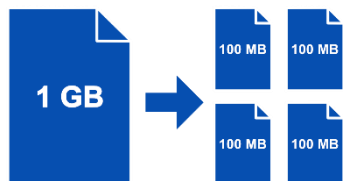
Versatile

Splits recordings
from all vendors



Selective

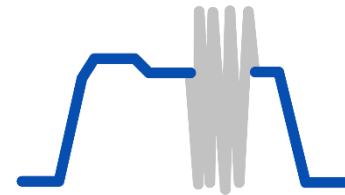
Rejects invalid
blocks of data



Efficient

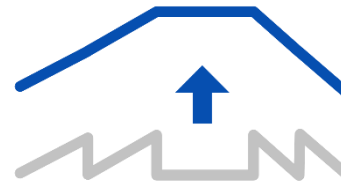
Digests large files
efficiently + fast

Decoding



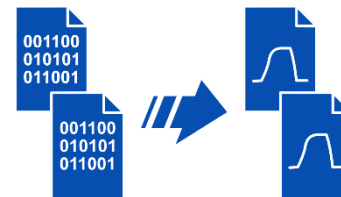
Robust

Rejects invalid
values



Smart

Repairs signals
on-the-fly



Fast

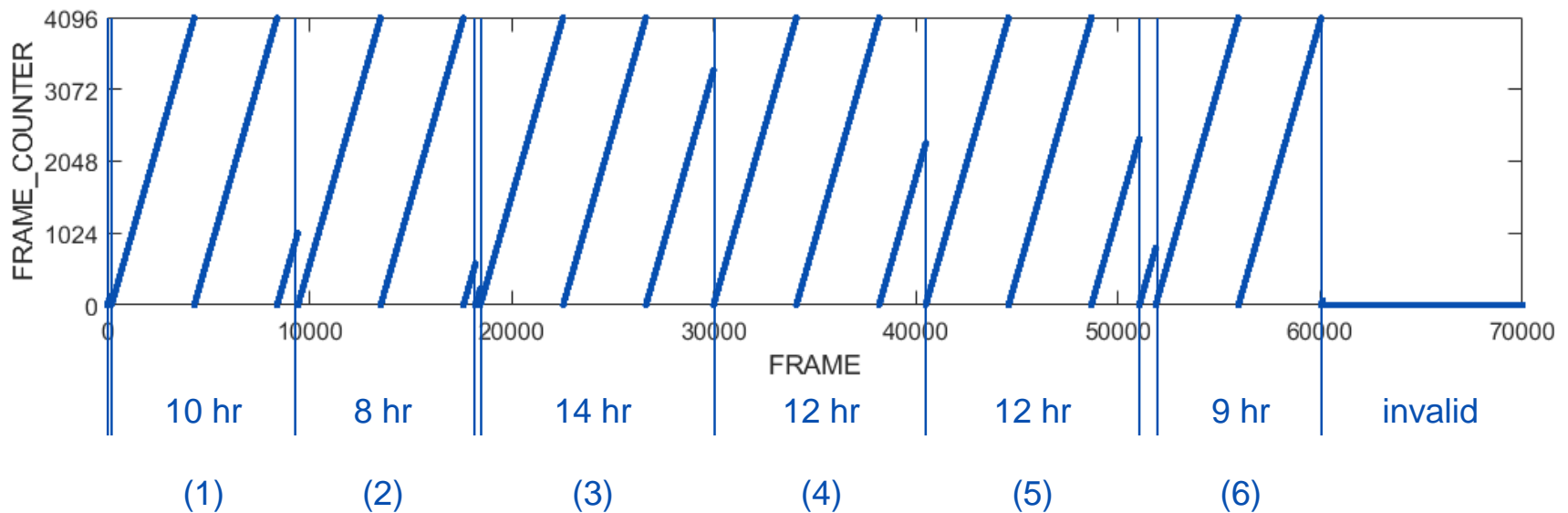
Takes less than
2 sec per flight

2/ FDM Data Sourcing

Raw QAR/DAR File Splitting

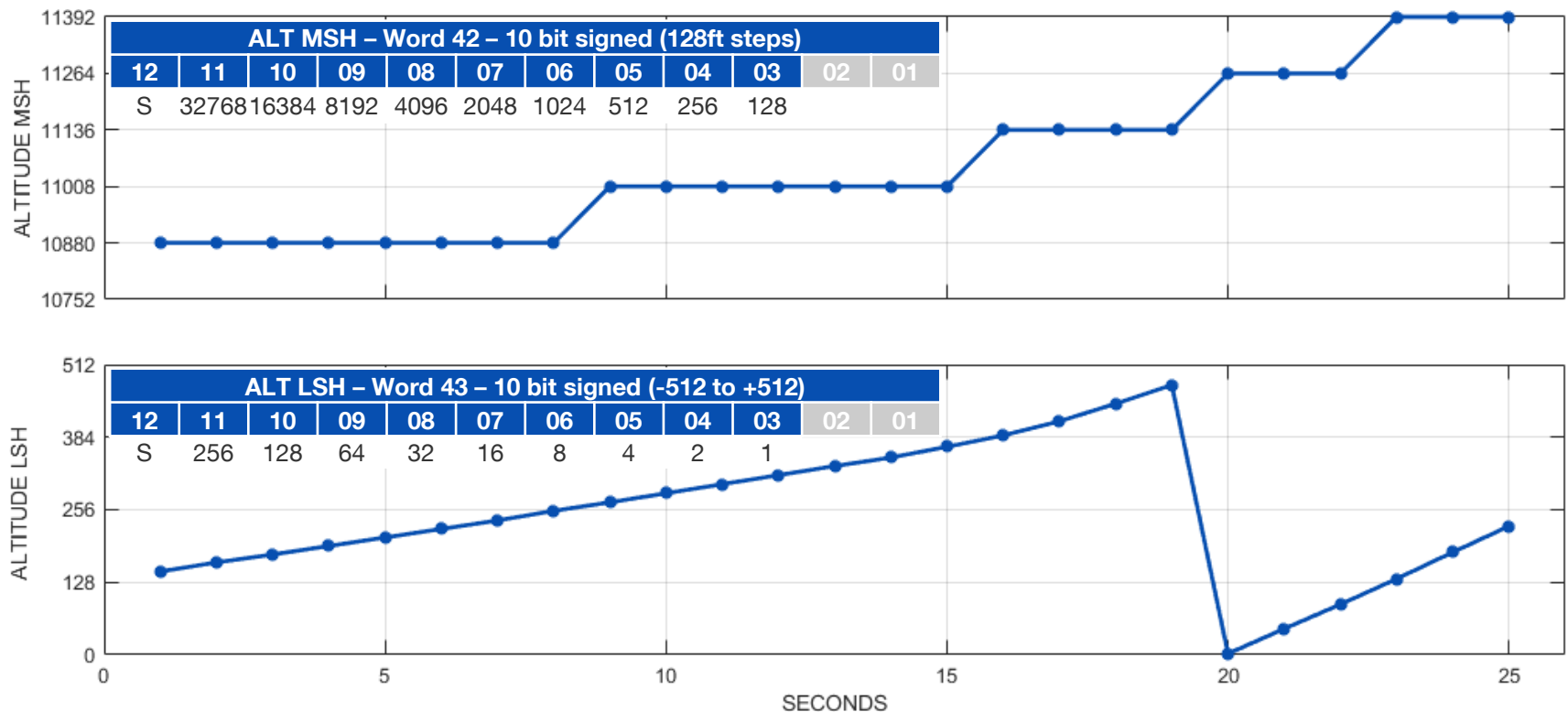


Example: Long Range Aircraft DAR Memory Dump (1.6 GB)
Splitting time: 6 seconds @ 2.5 GHz + Virtual Drive
Max memory: 3 GB



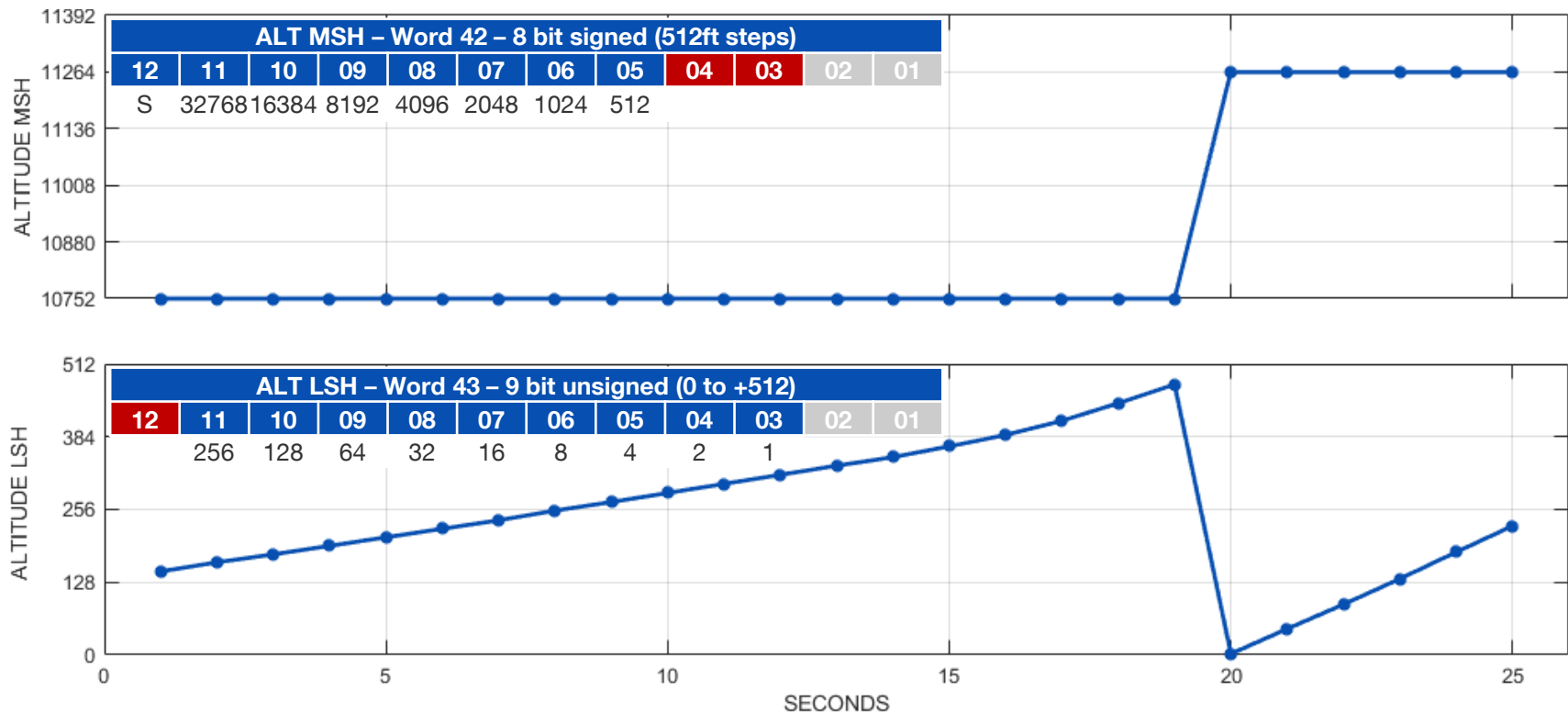
2/ FDM Data Sourcing

Raw QAR/DAR File Decoding (ARINC717)



2/ FDM Data Sourcing

Raw QAR/DAR File Decoding (ARINC717)



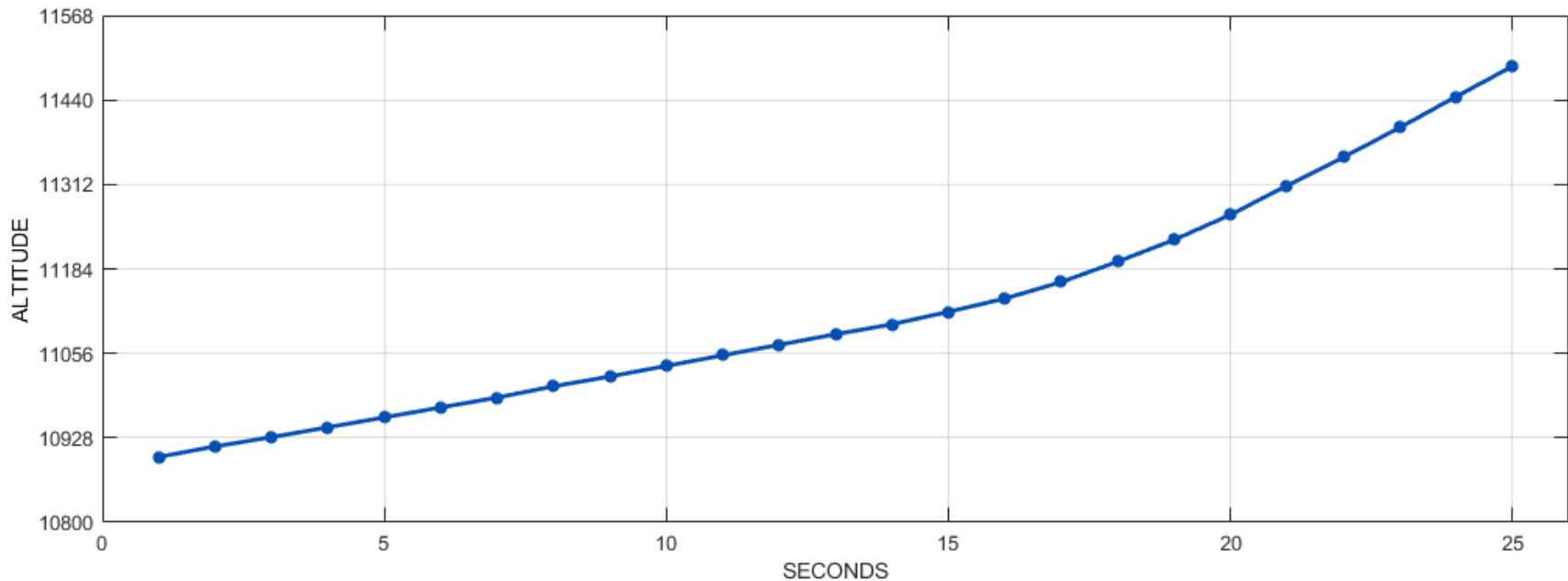
2/ FDM Data Sourcing

Raw QAR/DAR File Decoding (ARINC717)



$(MSH \& 0xff0) \ll 0x1ff \mid (LSH \& 0xefc) \gg 2$

12	11	10	09	08	07	06	05	11	10	09	08	07	06	05	04	03
S	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1



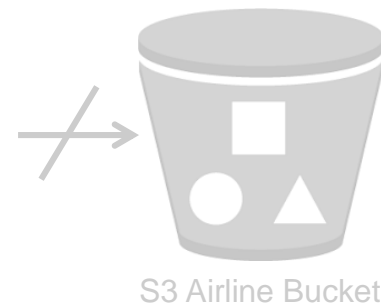
2/ FDM Data Sourcing

Deidentified Merging with METAR



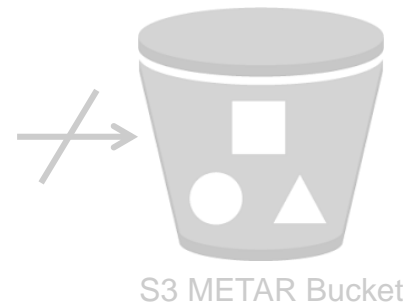
FDM

#	DATE	TIME	AIRPORT	CALLSIGN	...
1000	2019/4/1	10:20:42	EDDM	ABC123	...
1016	2019/4/1	10:20:43	EDDM	ABC123	...
1032	2019/4/1	10:20:44	EDDM	ABC123	...
1048	2019/4/1	10:20:45	EDDM	ABC123	...
...



METAR

#	DATE	TIME	AIRPORT	REPORT
42	2019/4/1	10:00	EDDM	11010KT ...
43	2019/4/1	10:15	EDDM	14007KT ...
44	2019/4/2	10:00	EDDM	12008KT ...
45	2019/4/2	10:15	EDDM	12006KT ...
...



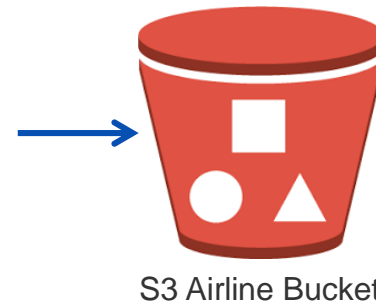
2/ FDM Data Sourcing

Deidentified Merging with METAR



FDM

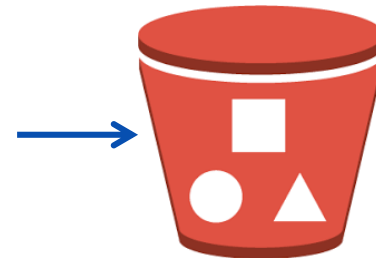
#	DATE	TIME	AIRPORT	CALLSIGN	...
1000	0fc08e7df	10:20:42	EDDM	61768db8	...
1016	0fc08e7df	10:20:43	EDDM	61768db8	...
1032	0fc08e7df	10:20:44	EDDM	61768db8	...
1048	0fc08e7df	10:20:45	EDDM	61768db8	...
...



irreversible SHA1 + salt hashing

METAR

#	DATE	TIME	AIRPORT	REPORT
42	0fc08e7df	10:00	EDDM	11010KT ...
43	0fc08e7df	10:15	EDDM	14007KT ...
44	a40d5c50	10:00	EDDM	12008KT ...
45	a40d5c50	10:15	EDDM	12006KT ...
...

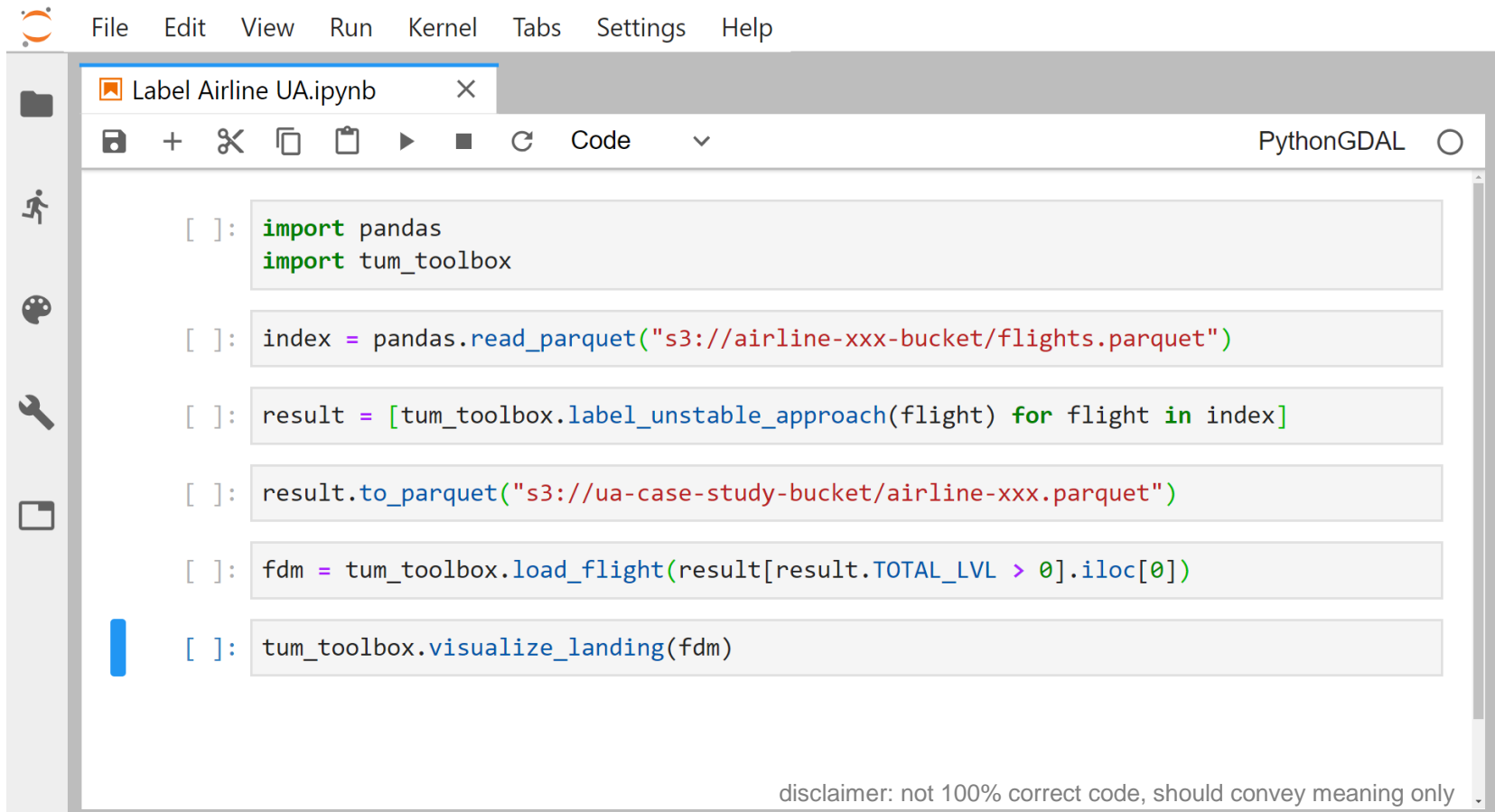




3/ UNSTABLE APPROACH CASE STUDY

3/ Unstable Approach Case Study

Working in the Analytics Sandbox



The screenshot shows the Analytics Sandbox interface. At the top, there is a menu bar with options: File, Edit, View, Run, Kernel, Tabs, Settings, and Help. Below the menu bar is a toolbar with icons for saving, adding, deleting, copying, pasting, running, and refreshing. The main area displays a Jupyter Notebook with the following code:

```
[ ]: import pandas
import tum_toolbox

[ ]: index = pandas.read_parquet("s3://airline-xxx-bucket/flights.parquet")

[ ]: result = [tum_toolbox.label_unstable_approach(flight) for flight in index]

[ ]: result.to_parquet("s3://ua-case-study-bucket/airline-xxx.parquet")

[ ]: fdm = tum_toolbox.load_flight(result[result.TOTAL_LVL > 0].iloc[0])

[ ]: tum_toolbox.visualize_landing(fdm)
```

At the bottom right of the notebook, there is a disclaimer: "disclaimer: not 100% correct code, should convey meaning only".

3/ Unstable Approach Case Study

Unstable Approach Criteria



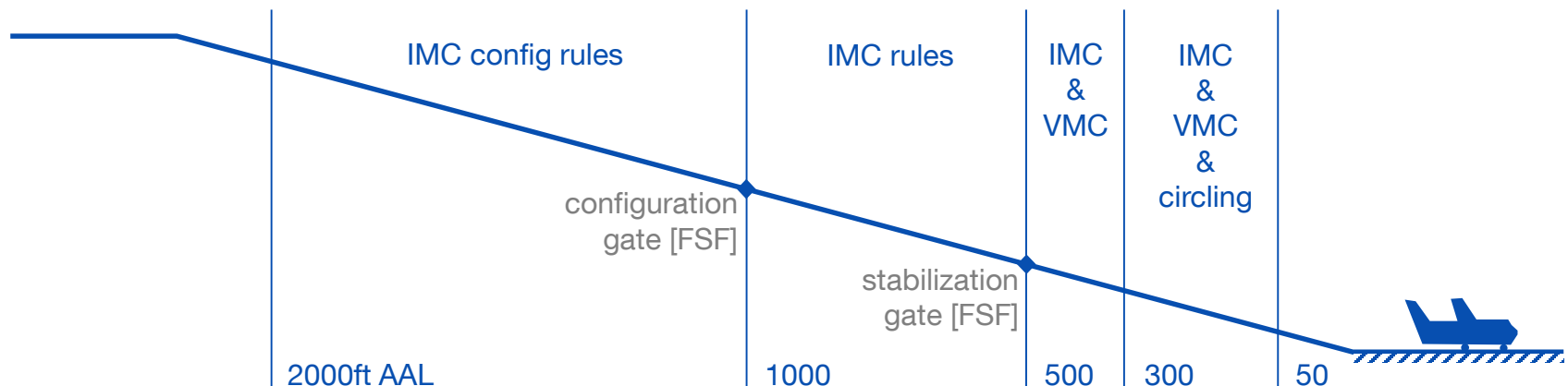
Landing is considered a **LOW severity UA** if common rules are violated:

2000-1000ft SPD BRK > 1500ft, GEAR DN > 1500ft, FLAP FULL > 1200ft

1000-500ft $-02 < \Delta V_{app} < 15$, $-1000 < V_{VS}$, $|\Phi| < 15^\circ$, $|\delta_{LLZ}| < 1^\circ$, $|\delta_{GS}| < 1^\circ$

500-50ft $-01 < \Delta V_{app} < 10$, $-1000 < V_{VS}$, $|\Phi| < 10^\circ$, $|\delta_{LLZ}| < 1^\circ$, $|\delta_{GS}| < 1^\circ$

1000-50ft $N_1 < N_{1,min,aircraft}$, e.g. 40%



3/ Unstable Approach Case Study

Unstable Approach Criteria



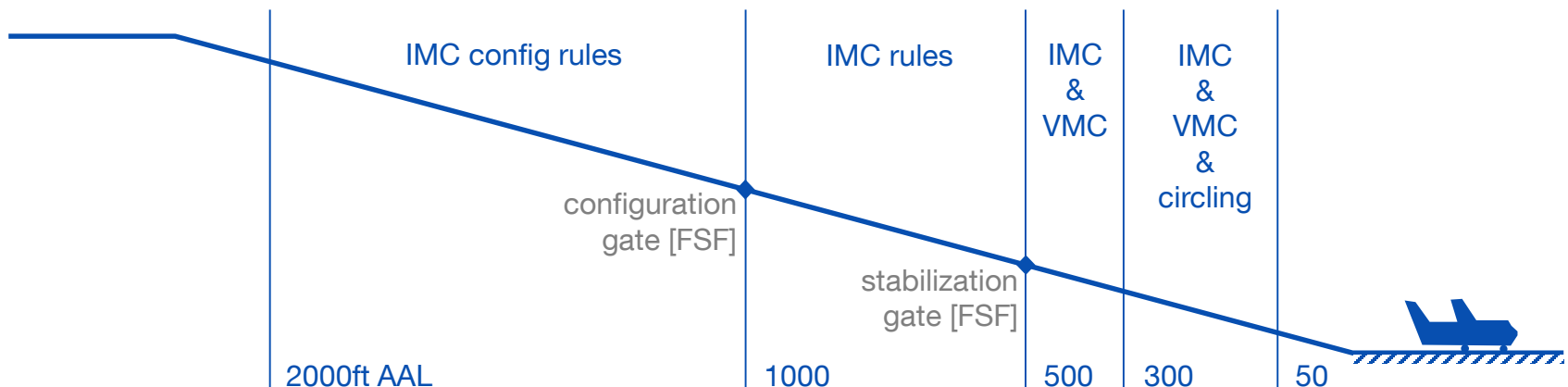
Landing is considered a **MEDIUM severity UA** if common rules are violated:

2000-1000ft SPD BRK > 1500ft, GEAR DN > 1500ft, FLAP FULL > 1200ft

1000-500ft $-05 < \Delta V_{app} < 20$, $-1100 < V_{VS}$, $|\Phi| < 17^\circ$, $|\delta_{LLZ}| < 2^\circ$, $|\delta_{GS}| < 2^\circ$

500-50ft $-03 < \Delta V_{app} < 15$, $-1100 < V_{VS}$, $|\Phi| < 12^\circ$, $|\delta_{LLZ}| < 2^\circ$, $|\delta_{GS}| < 2^\circ$

1000-50ft $N_1 < N_{1,min,aircraft}$, e.g. 35%



3/ Unstable Approach Case Study

Unstable Approach Criteria



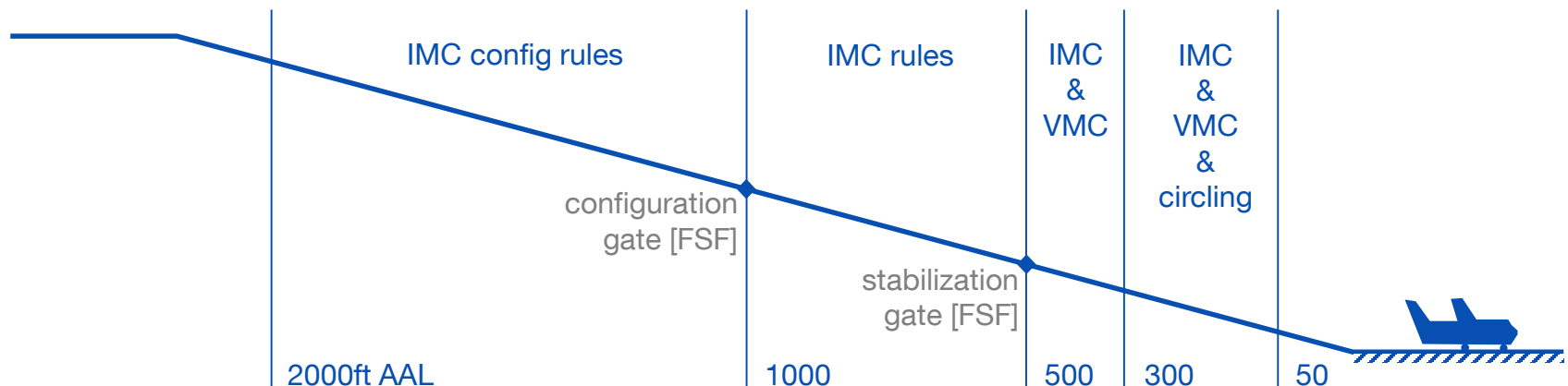
Landing is considered a **HIGH severity UA** if common rules are violated:

2000-1000ft SPD BRK > 1000ft, GEAR DN > 1000ft, FLAP FULL > 700ft

1000-500ft $-10 < \Delta V_{app} < 30$, $-1200 < V_{VS}$, $|\Phi| < 20^\circ$, $|\delta_{LLZ}| < 3^\circ$, $|\delta_{GS}| < 3^\circ$

500-50ft $-05 < \Delta V_{app} < 20$, $-1200 < V_{VS}$, $|\Phi| < 15^\circ$, $|\delta_{LLZ}| < 3^\circ$, $|\delta_{GS}| < 3^\circ$

1000-50ft $N_1 < N_{1,min,aircraft}$, e.g. 30%



3/ Unstable Approach Case Study

Deployment of Algorithms



- Python code
 - can only access one flight at a time
 - must not have any side effects
 - cannot access other files
 - is deployed via GIT repository
- Deployed to Spark cluster
 - 1 master node @ 4 cores, 8GB memory
 - 4 worker nodes @ 8 cores, 32 GB memory
 - 2 executors per node
- Inspects **300,000 flights in 4 hours**

3/ Unstable Approach Case Study

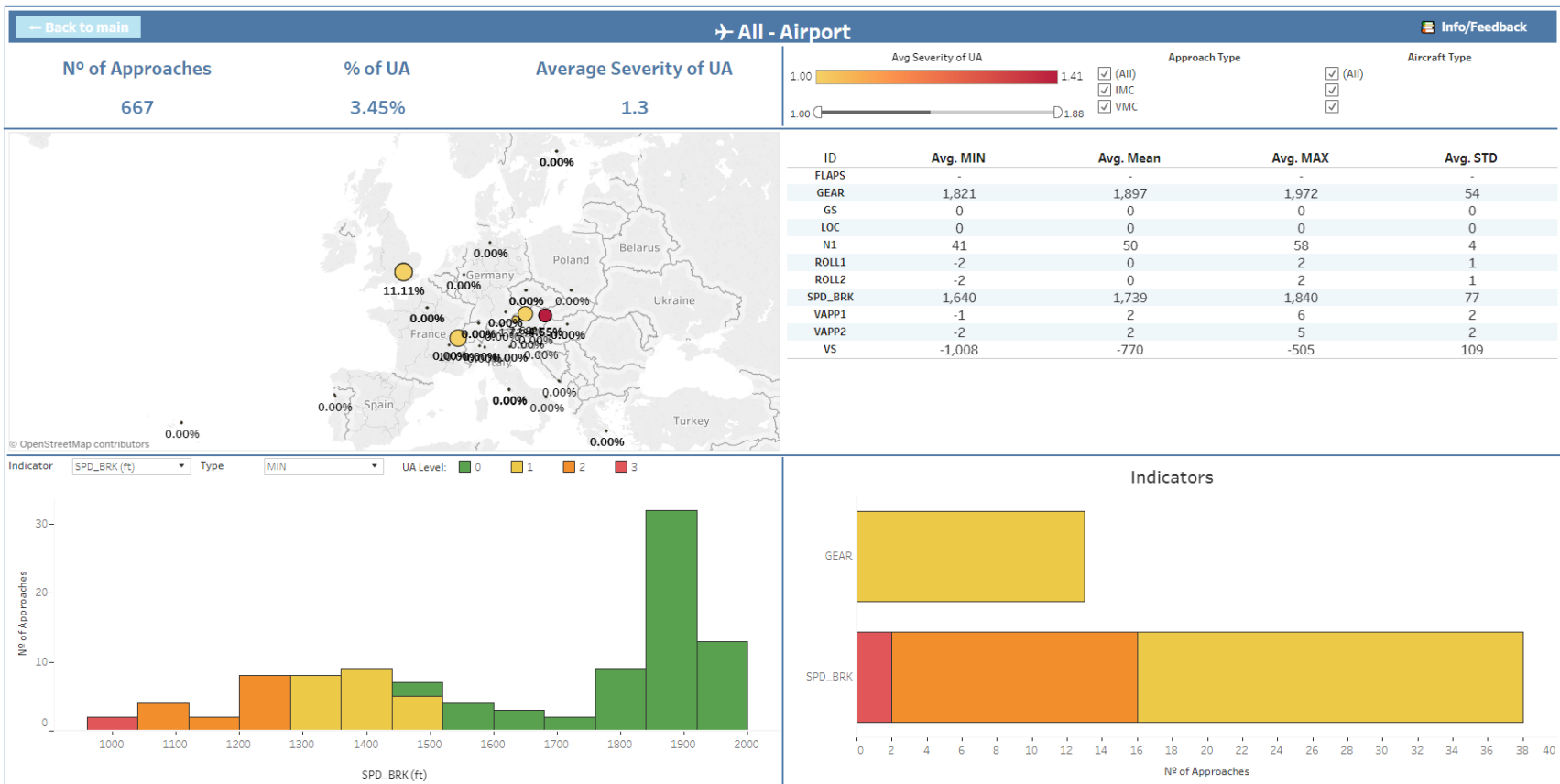
Findings



tbd

3/ Unstable Approach Case Study

Visualization of Results in Tableau



Summary

1/ SafeClouds.eu Project Overview

- We manage the full pipeline from raw QAR/DAR files to the analytics
- We protect airline data all the way and keep it de-identified

2/ FDM Data Sourcing

- We can split and decode ARINC717 files fast and with high quality
- We combine FDM data with other sources by irreversible hashing

3/ Unstable Approach Case Study

- We research 500k landings for UA and CFIT precursors
- We provide interactive dashboards for the results



now open to questions and discussion

THANK YOU



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