Reducing rate of false FDM events

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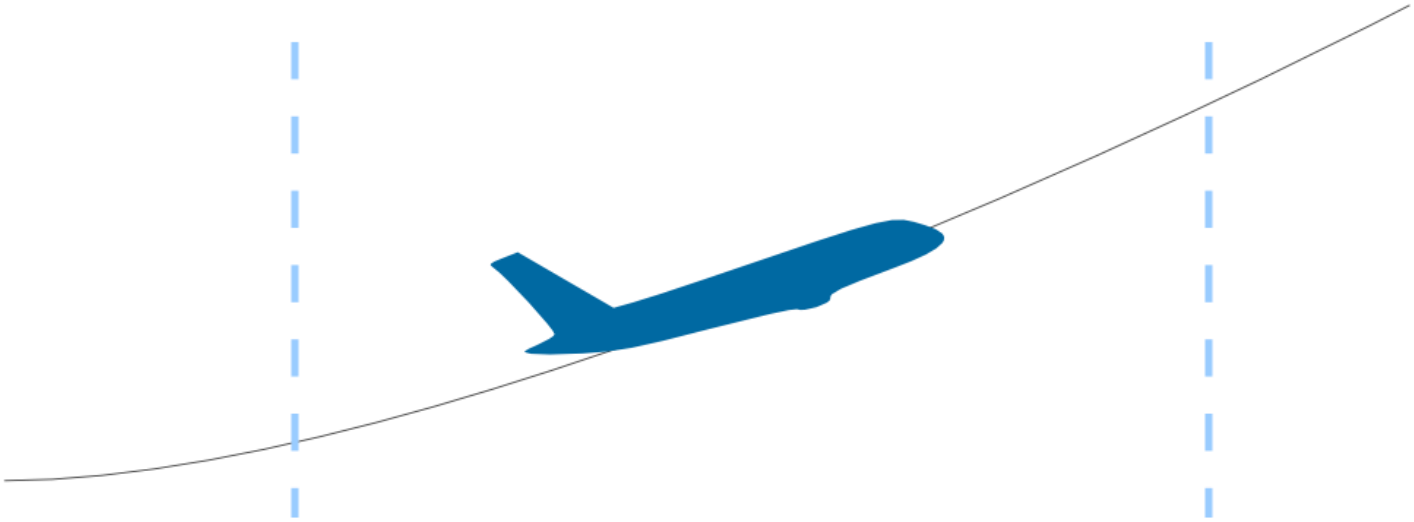

SAFRAN Sagem

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Context of this project

➔ Internal algorithms refactoring at Air France

- Current observation : difficulties to have reliable statistics which are representative of the reality
- Complete re-engineering of FDM procedures in progress

➔ What is Svetlana ?

- E.U. – Russian project with Sagem (2010-2012): Improving flight data analysis with new techniques such as data-mining
- One of the topic of the project was the improvement of existing FDM process

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n ACPO-GA-2010-265940 SVETLANA.

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Context of this project

➔ Air France – Sagem collaboration within Svetlana

- Sharing of skills:

operational FDM experience + software expertise

- Improve analysis results quality as well as reusability
- Promote documented procedures
- Validate a workflow for high quality procedures development

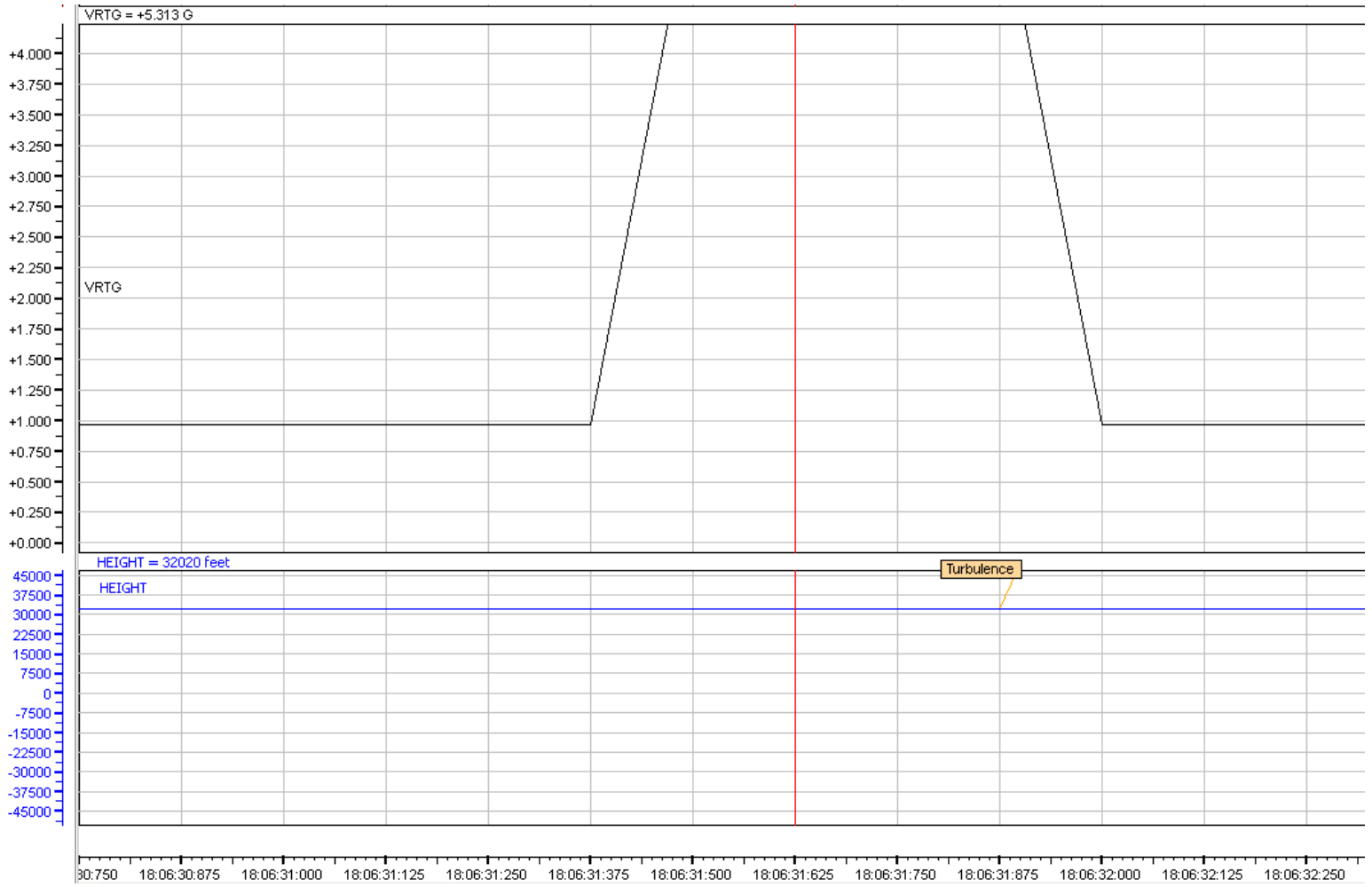
Summary

1) Understanding the causes of false events
2) Detecting and correcting invalid parameters
3) Using parameter invalidity information
4) Results for Air France fleet
5) Conclusion

Understanding the causes of false events

Examples

False “SevereTurbulence” (VRTG involved)



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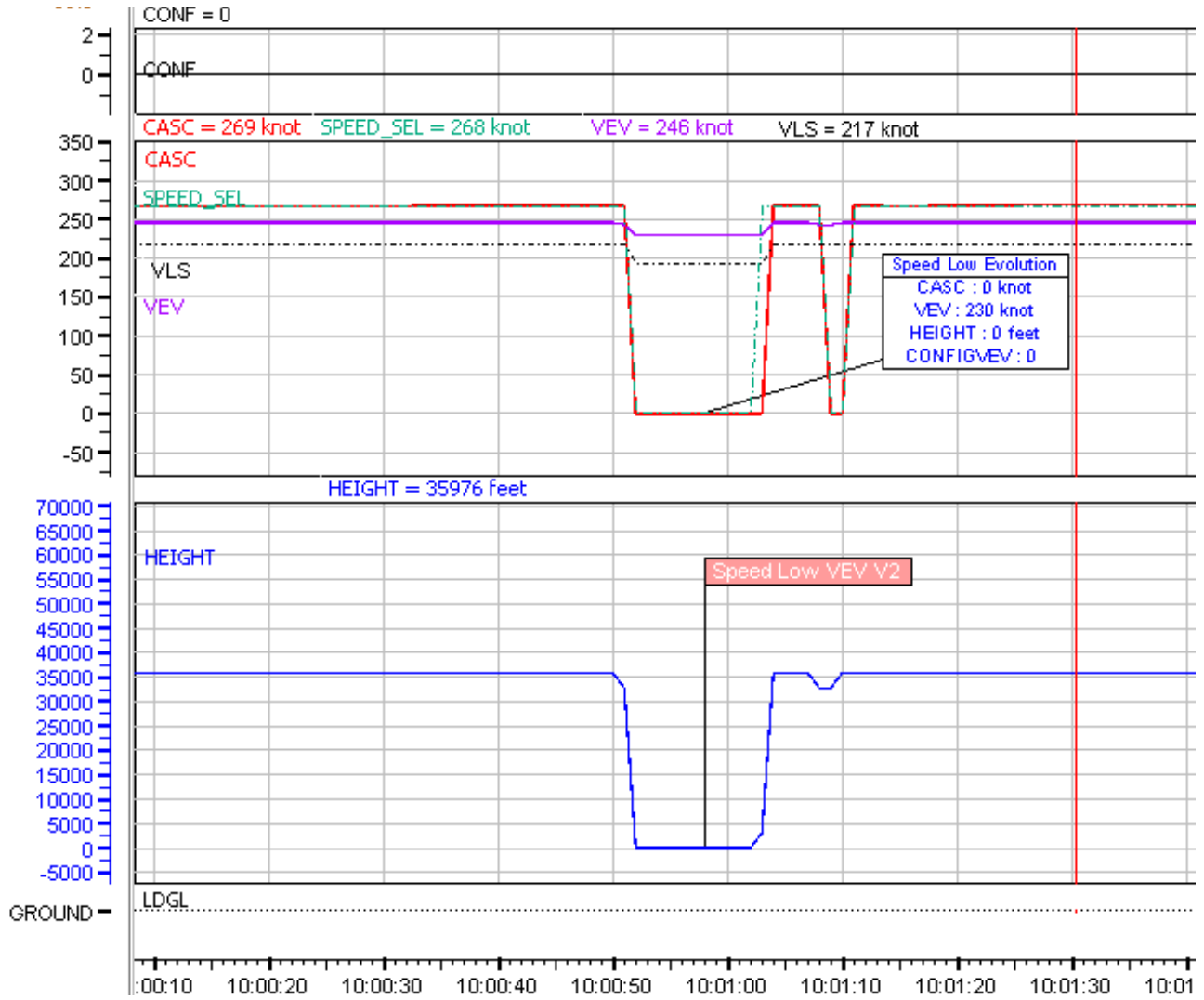
False “Speed low” (CAS involved)



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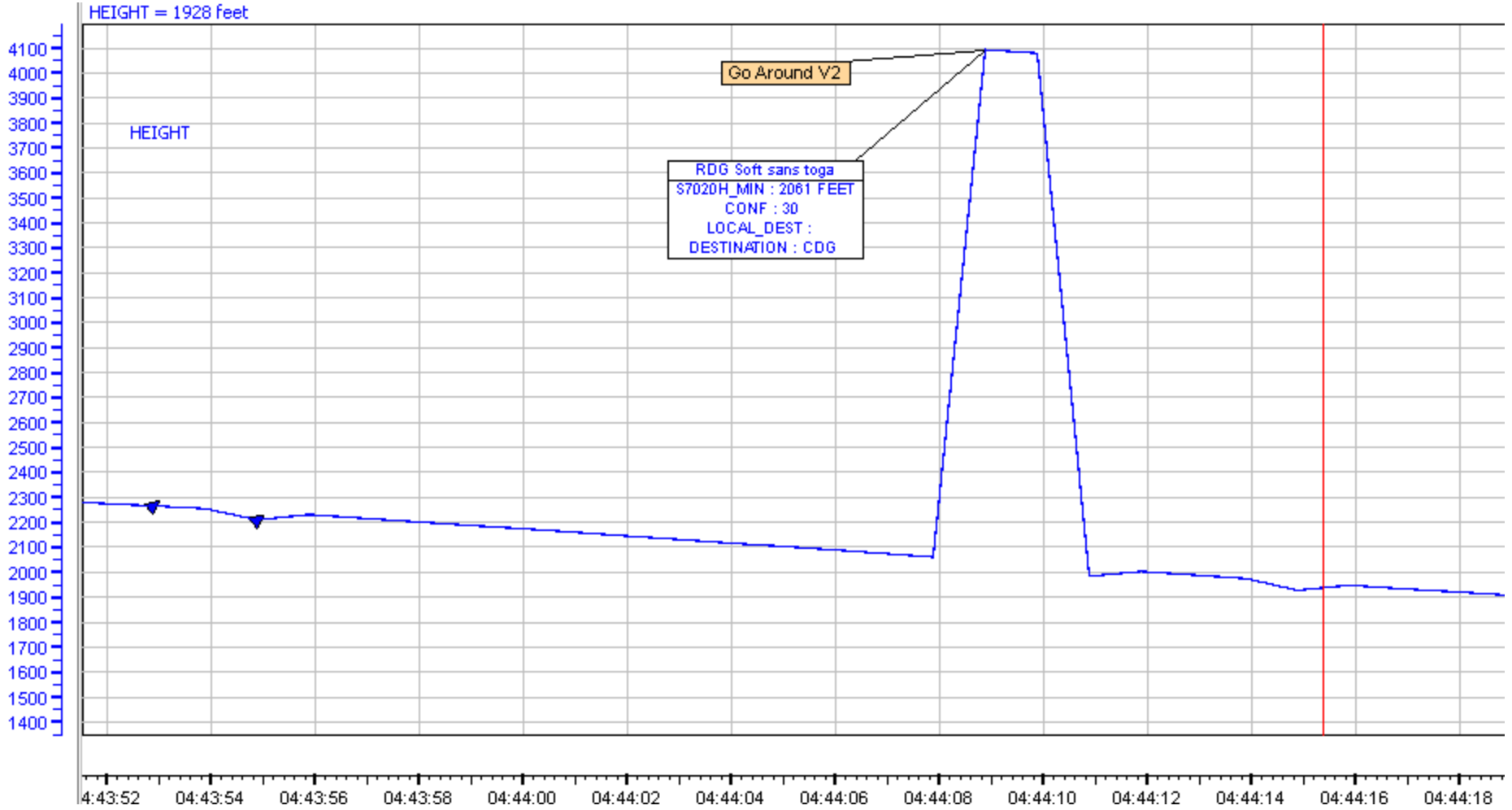
False “Go around” (ALT STD involved)



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Identification of responsibilities in false event detection

"A chain is only as strong as its weakest link"

Weak detection algorithm

- If the algorithm is too dependant on a single parameter, or not covering enough from possible situations, it will fail in any unexpected situation
- Will not be developed in this presentation, but is also part of the project

Bad input data

- Input data can be noisy, which often cause a simple algorithm to fail
- Two approaches
  - filter data in each event algorithm
  - filter data once and for all

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Detecting and correcting invalid parameters

Theory

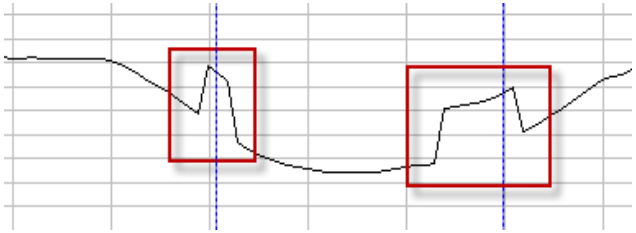
Looking for patterns

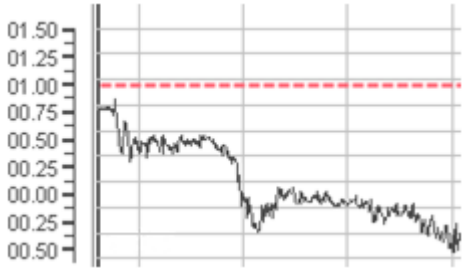
Air speed

Altitude

Vertical acceleration

Roll





- ➔ Peaks, isolated or grouped
- ➔ Value gaps
- ➔ Parameter out of normal range

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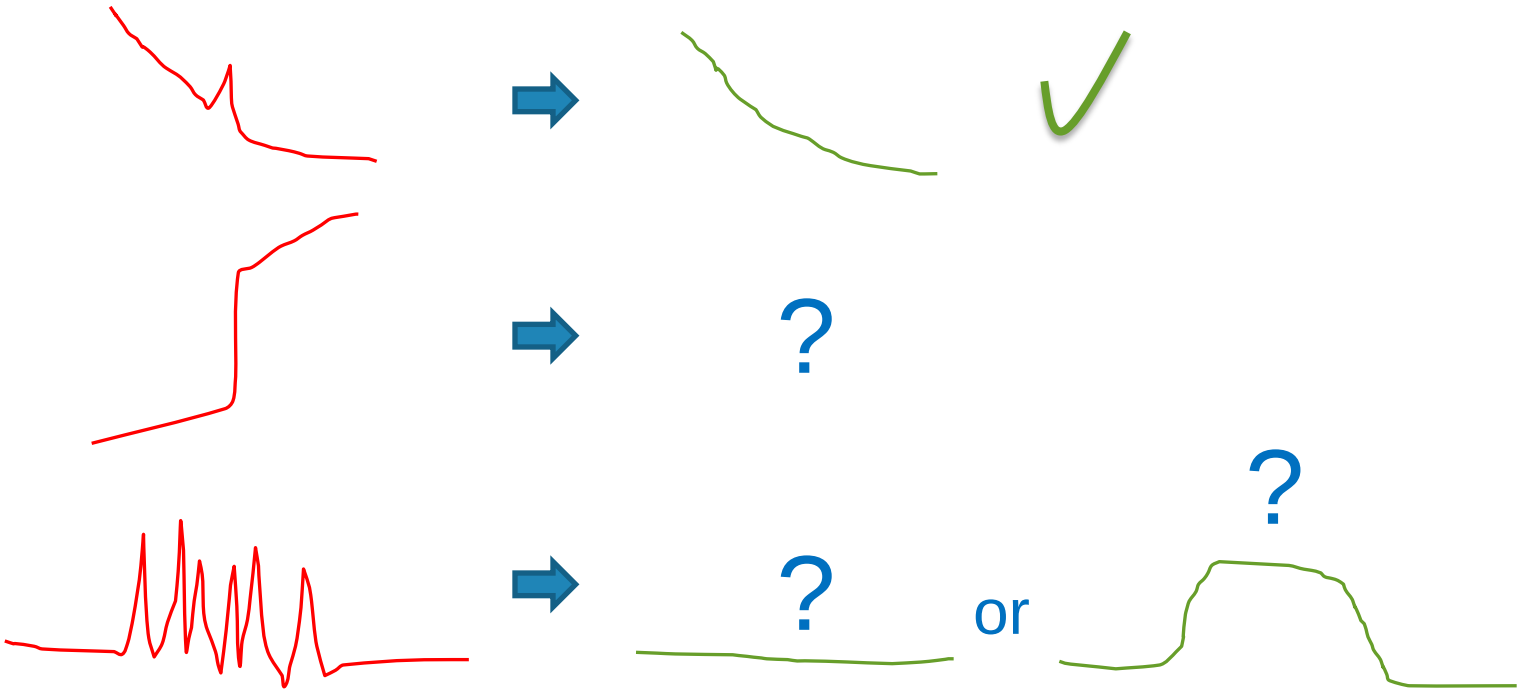
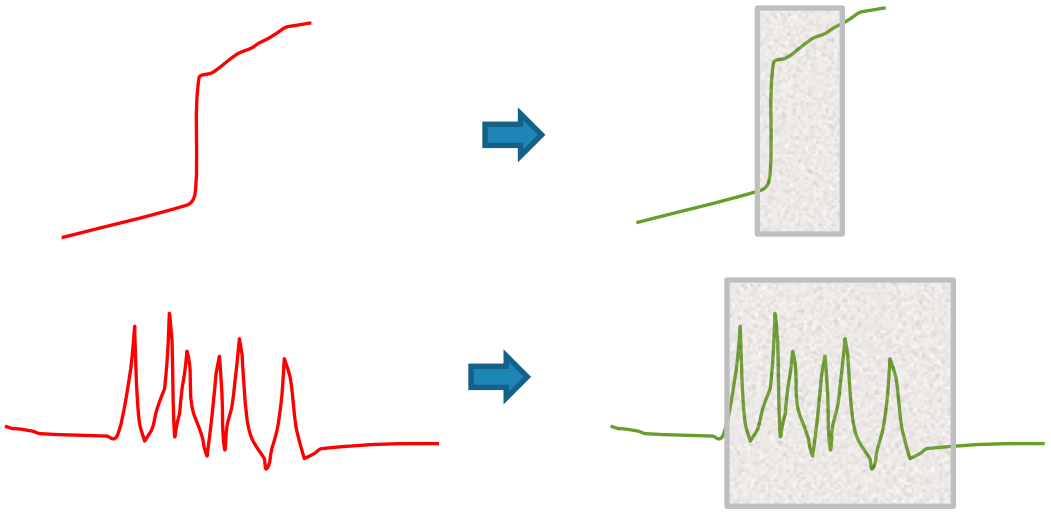
Correction is not enough



- ➔ It is often not possible or not reasonable to correct the parameter value.
- ➔ We cannot honestly tell that a parameter is “corrected” if we are not confident in the correction that has been applied

Parameter invalidation

➔ When no correction is possible, the parameter should be **invalidated**



➔ What an invalidation means:

"This parameter **should not be used** during this period, because it was not possible to correct it with a sufficient level of confidence. "

➔ Need to attach a boolean "validity" parameter to each parameter we want to monitor

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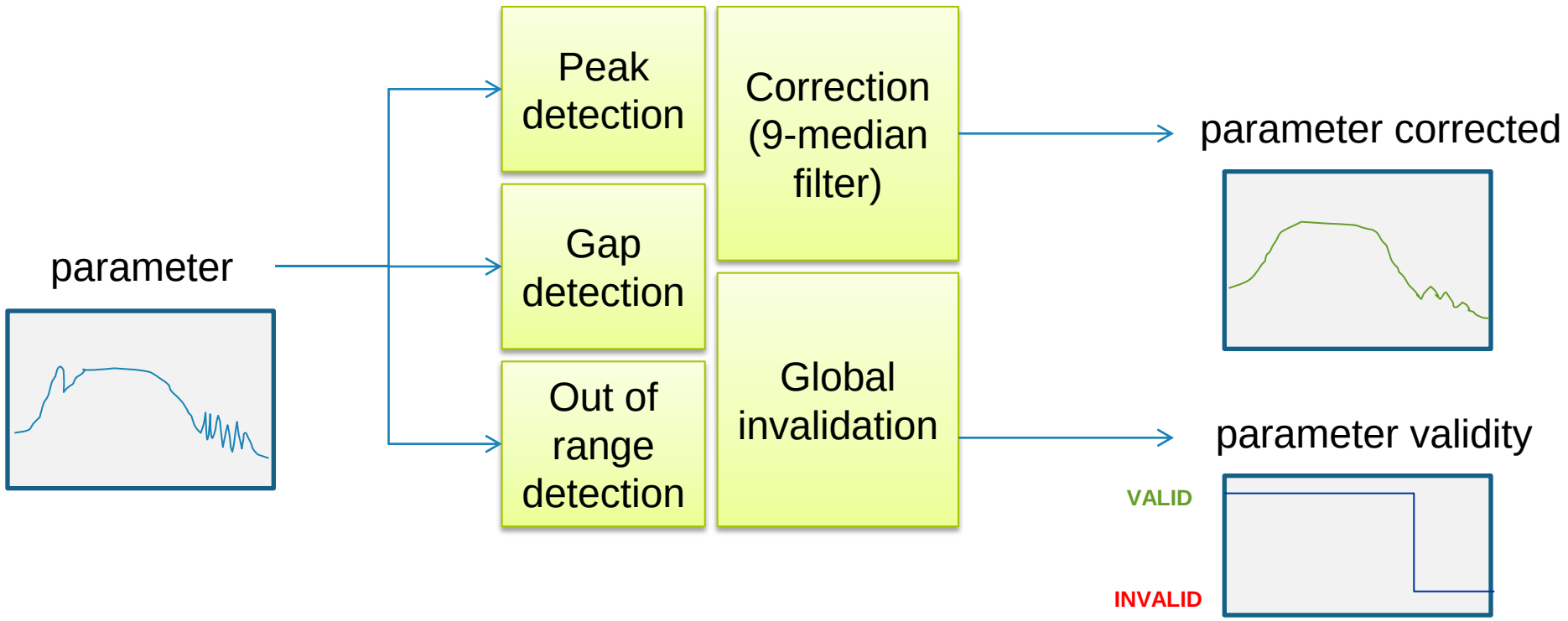
Implementation



Median Filter

➔ Input 9 elements

5	9	3	1000	15	11	7	17	13

➔ Sort

3	5	7	9	11	13	15	17	1000

➔ Result is the element in median position

				11				

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Using parameter invalidity information

In practice

Impact on existing algorithms

➔ **Any algorithm** can start using parameter invalidation and correction by introducing a **simple test** on parameter invalidation

BEFORE

```
IF ( CAS > limit ) THEN
    EVENTV(…)
ENDIF
```

AFTER

```
IF ( CAS_VALID ) THEN
    IF ( CAS_CORRECTED > limit ) THEN
        EVENTV(…)
    ENDIF
ENDIF
```

➔ But this could also be used in other powerful ways

- Behave in degraded mode if one of the parameters needed for the computation is invalid
- Use it for additional parameter computation
- Anything else you could imagine that uses PARAM_VALID and PARAM_CORRECTED !

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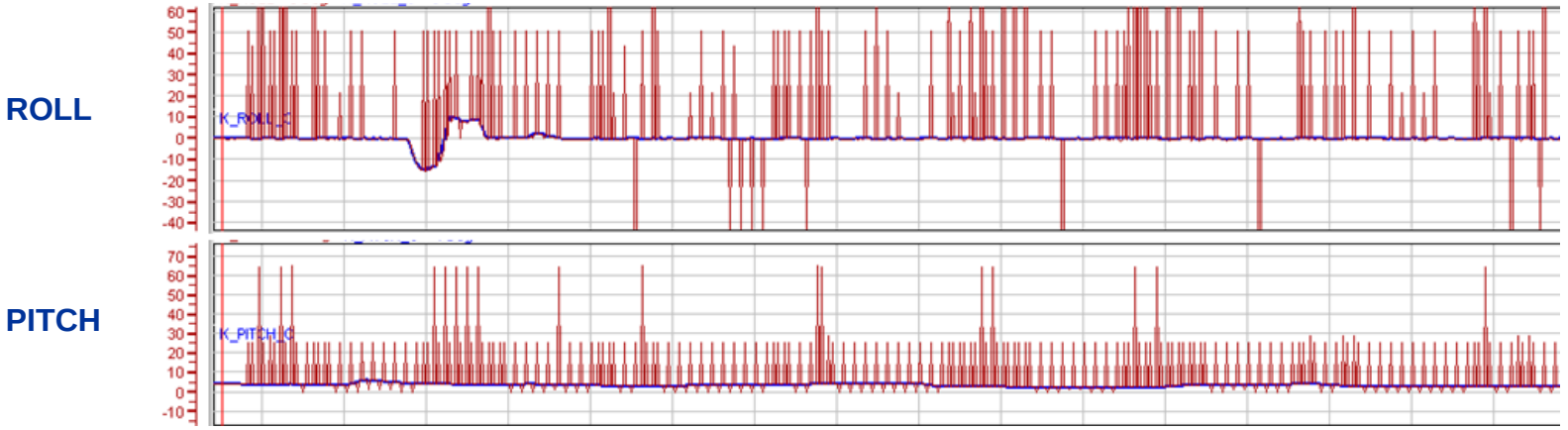
The invalidation paradox

➔ If we stop here, we're still missing something…



Chances are strong that this flight doesn't raise any event about parameter PITCH or ROLL as it's quite always invalid ! Yet this flight deserves to be seen.

➔ Need a **maintenance event** that monitors the **invalidity ratio** on the whole flight, for each parameter which goes through invalidation & correction algorithms.

```
cas_invalidity_ratio = TOTAL_INVALID_SAMPLES / TOTAL_SAMPLES
IF ( cas_invalidity_ratio > 0.25) THEN
    EVENTV(…)
ENDIF
```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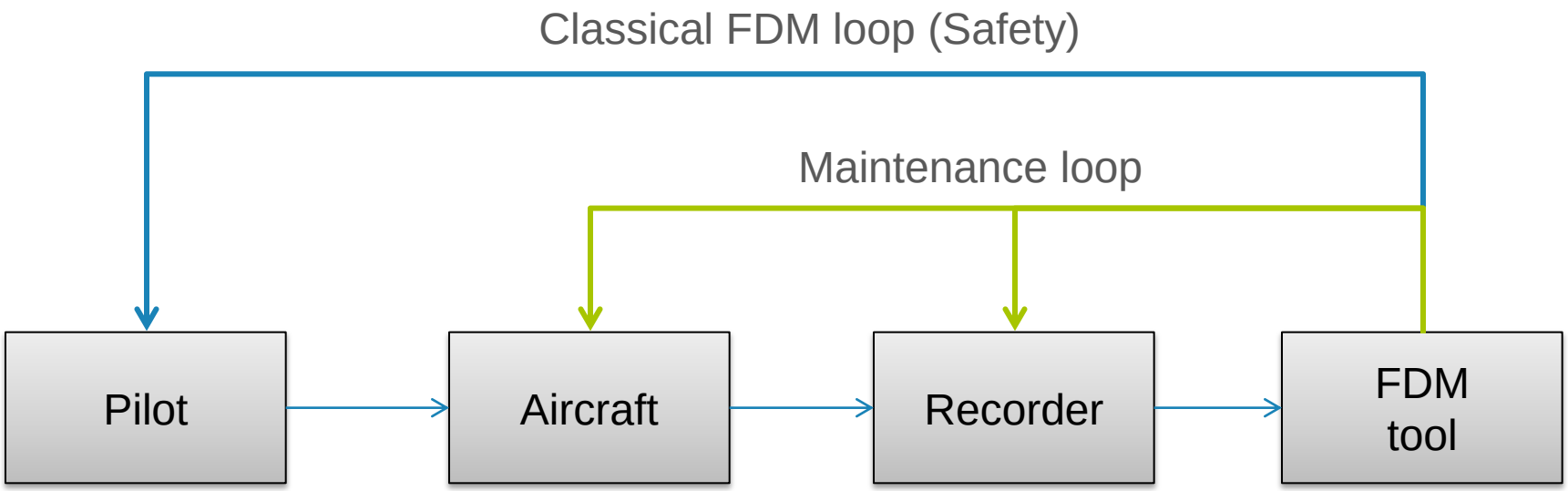
Improving FDM workflow

➔ Having this new **maintenance oriented event** on parameter validity reinforces the **maintenance retroaction loop** of the FDM process



Results on Air France fleet (B747 & A340)

Earnings

Overview of Air France fleet

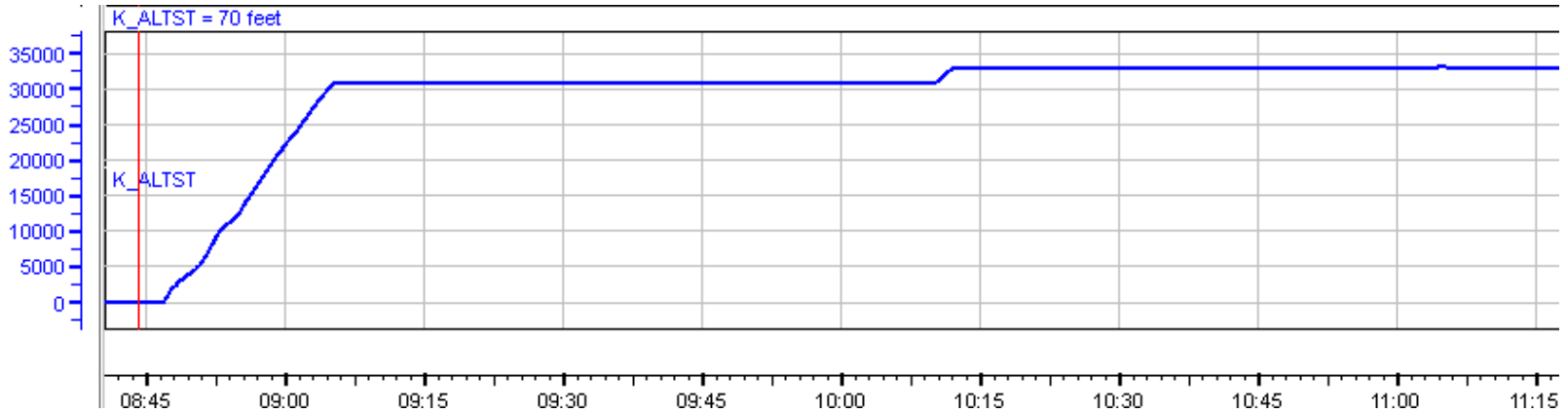
➔ AF Fleet

- 256 aircrafts
- 820 flights per day

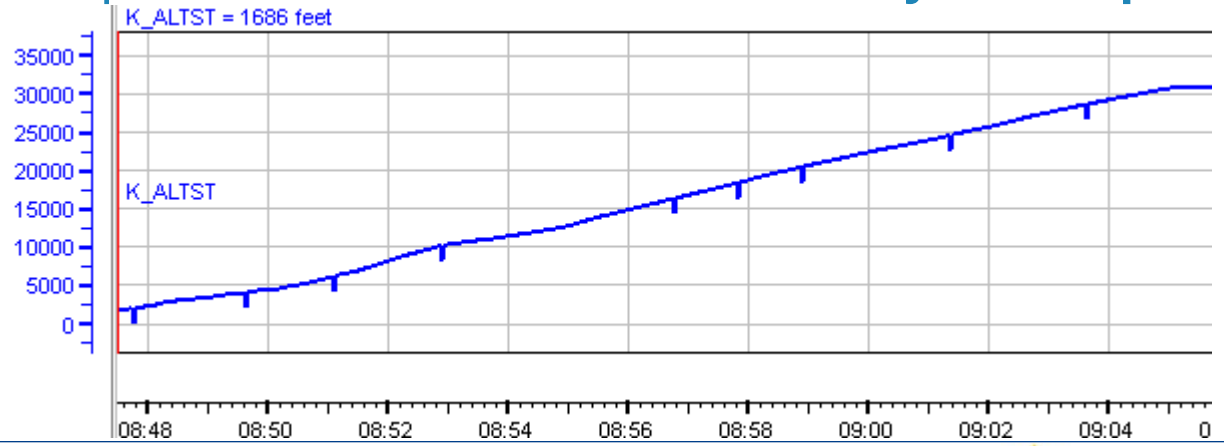
Fleet	Aircraft Number	Flight / year
A320	146	240 162
A330	15	10 353
A340	13	7 141
A380	8	3 786
B747	10	4 772
B777	64	32 226

« Shift » definition

➔ Parameter apparently correct: **analysis possible with human eye**



➔ Zoom on this parameter show some shifts: **analysis not possible for IT system**



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Results for AF B747 fleet

- Replay of B747 flights for year 2011
- Non corrected and corrected parameter shift number measuring.
- Shift threshold :
  - CAS : 30kts
  - ALTST : 300ft
  - PITCH : 10
  - ROLL : 10

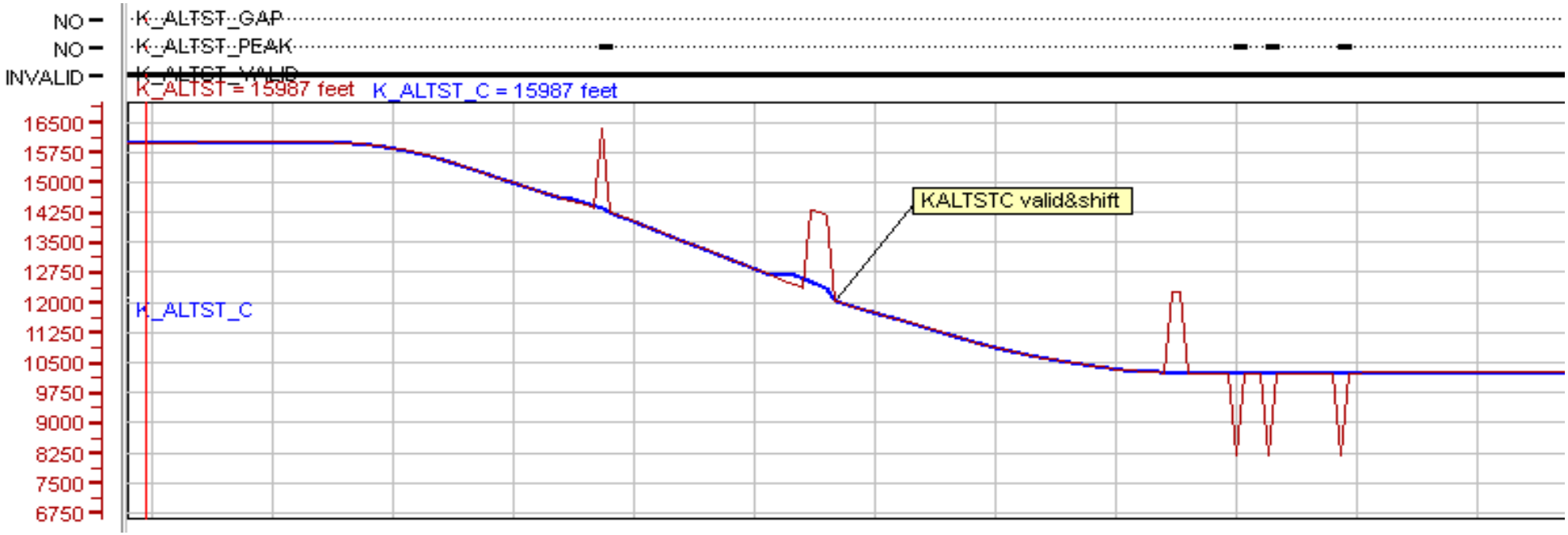
Parameter	Shift number on input param	Shift number on corrected param	%
CAS	38 797	45	99.9
ALTST	297 568	2 110	99.3
PITCH	1 086	57	94.8
ROLL	919	120	86.9

Results for AF A340 fleet

- Replay of A340 flights for year 2011
- Non corrected and corrected parameter shift number measuring.
- Shift threshold :
  - CAS : 30kts
  - ALTST : 300ft
  - PITCH : 10
  - ROLL : 10

Parameter	Shift number on input param	Shift number on corrected param	%
CAS	15 085	2 773	**81.6**
ALTST	127 198	1 682	**98.7**
PITCH	35 174	0	**100.0**
ROLL	36 644	83	**99.8**

Parameter correction with median filter



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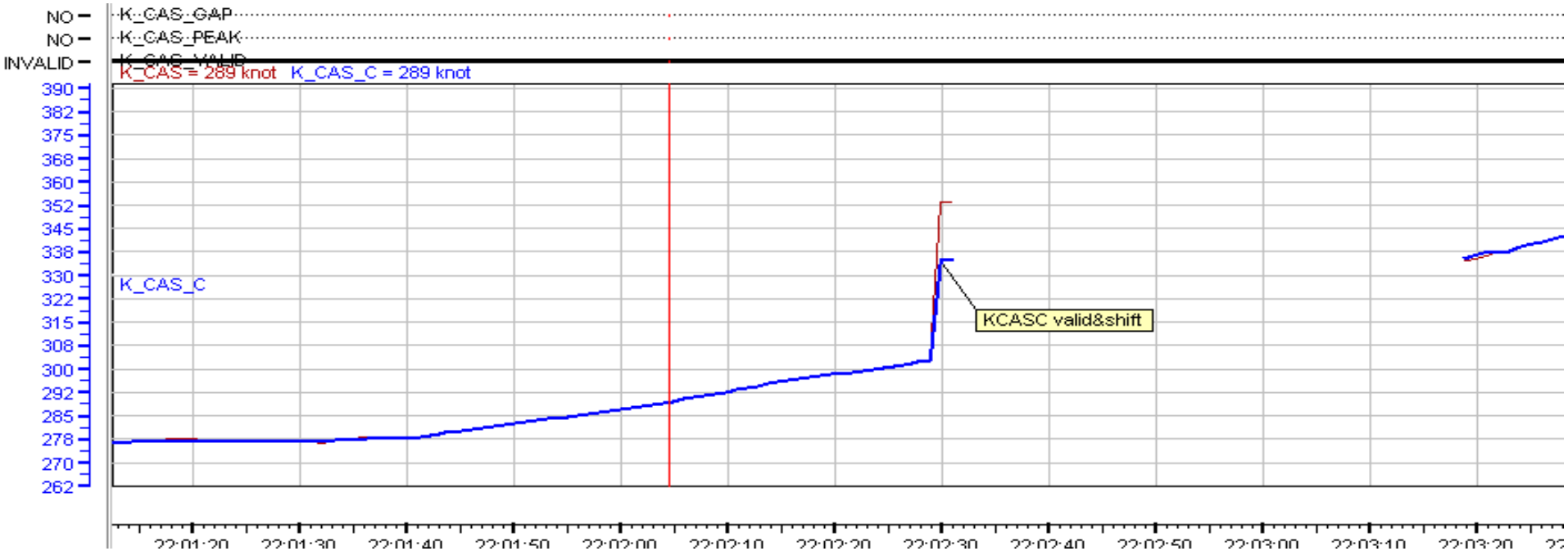
Gap detection not robust enough



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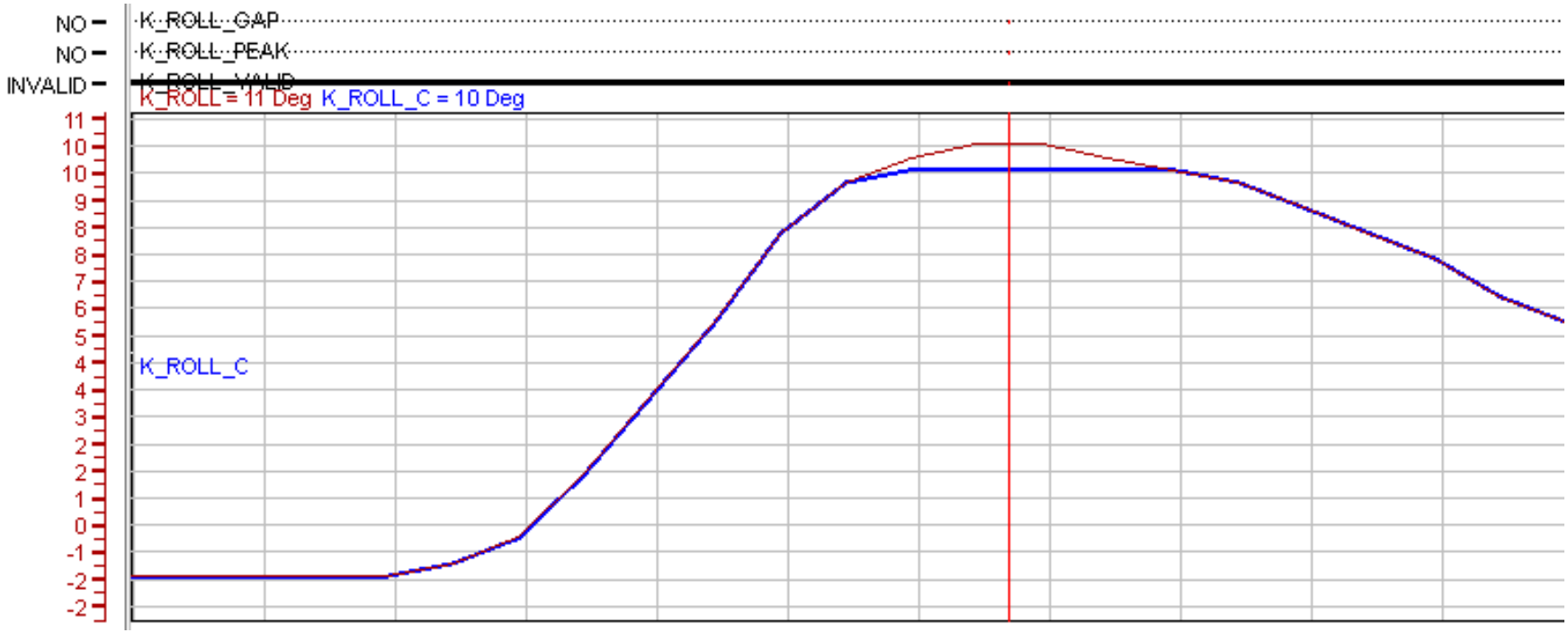
Median fliter clipping



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Conclusion

➔ **Successful** and very rich **cooperation** between two types of expertise

➔ A promising start, still some things to improve

- Dealing with the parameters which don't support well the 9-median filter (e.g. PITCH & ROLL) with adaptive median filter
- Retrofit of the whole event detection set to use parameter invalidity
- Improvement of some event detection algorithms
- Covering the whole event set

➔ Paves the way to a **common set of procedures** in the AGS

➔ This work also led to the development of a methodology