an update on

WakeNet2-Europe

Bram Elsenaar

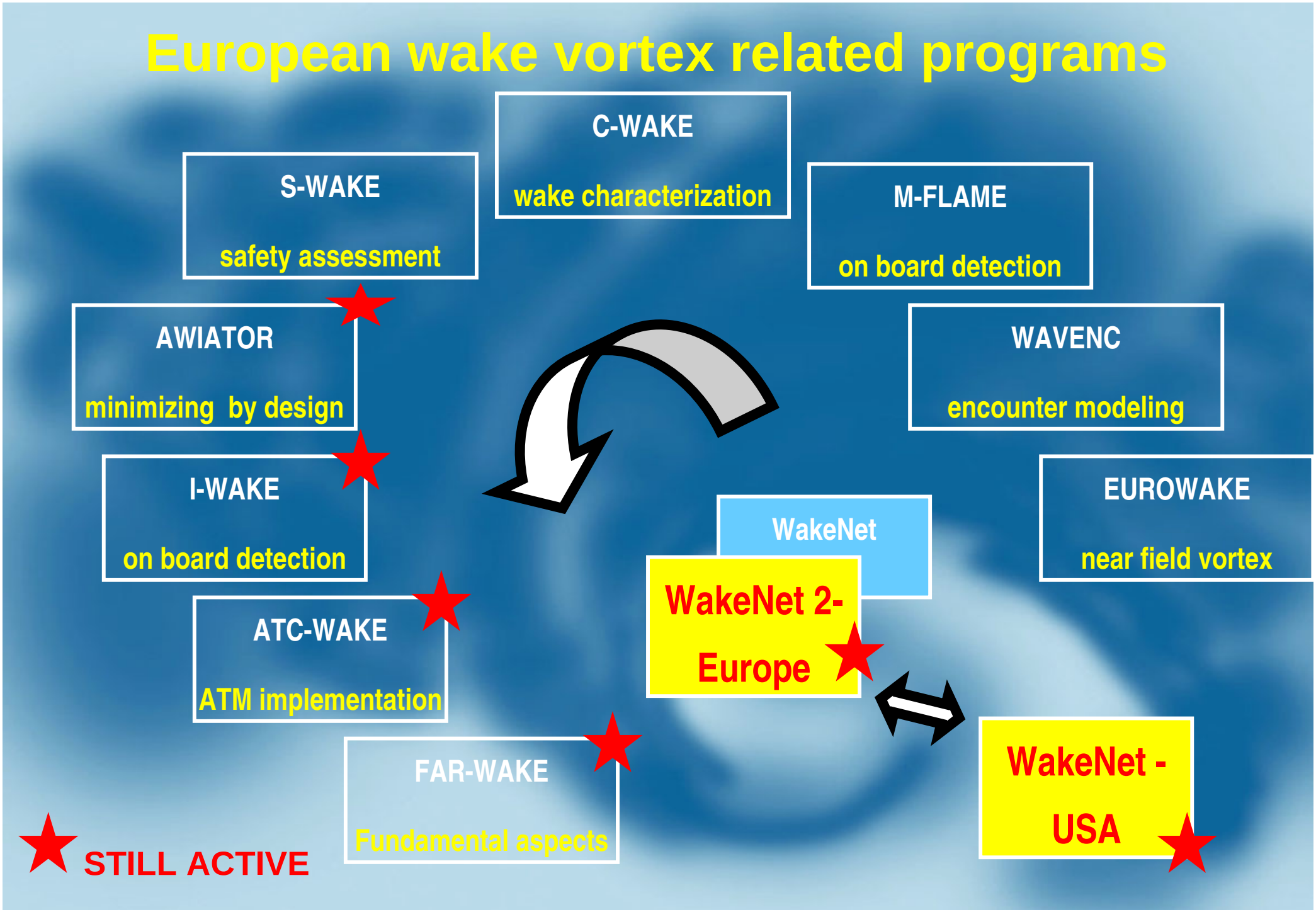
Coordinator of this European network

Mission Statement

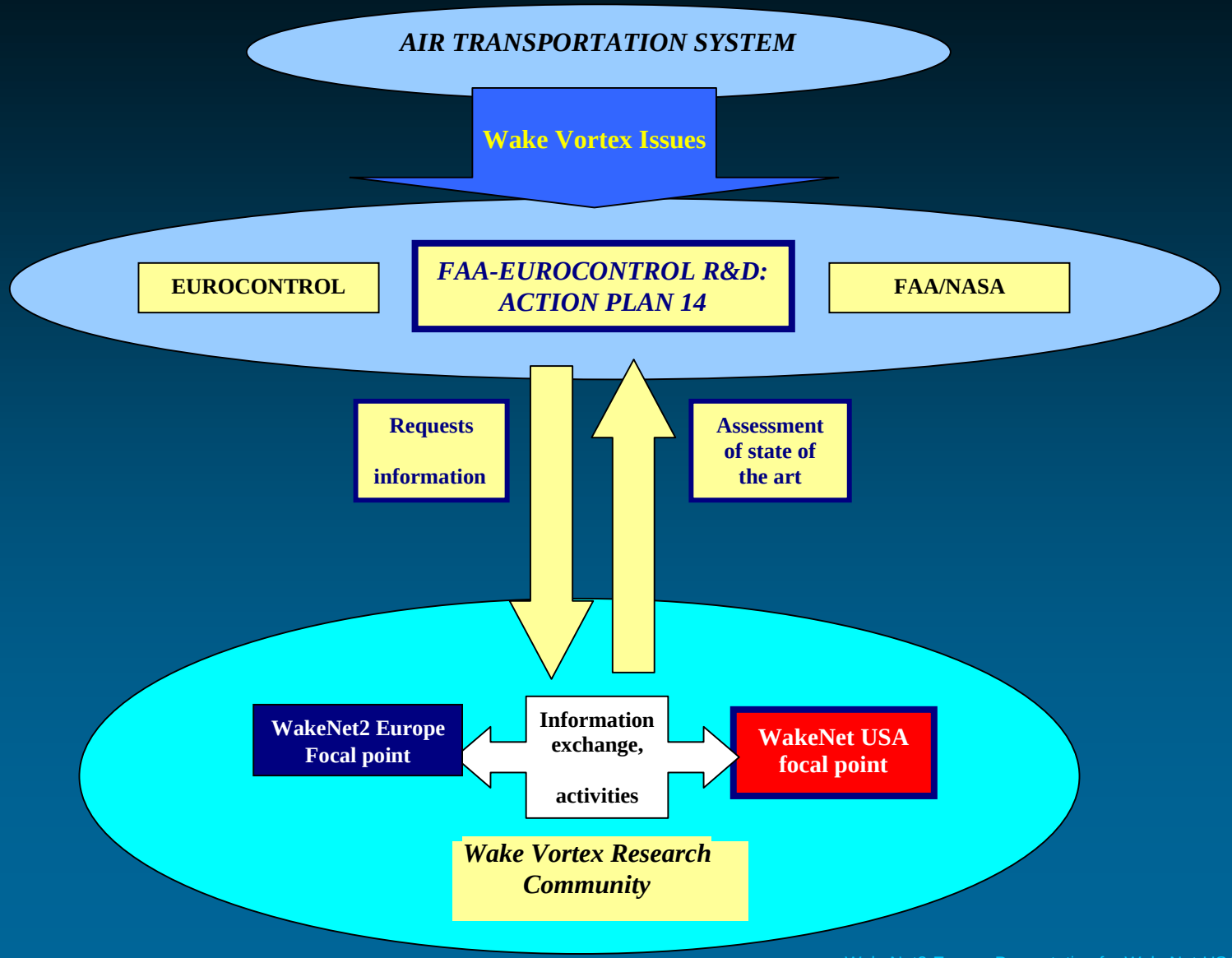
WakeNet2-Europe will:

- **promote multidisciplinary contacts and information exchange between specialists active in the field of wake turbulence and end-users of this knowledge in the operational airport environment**
- **enable the development of a shared view on research needed to address the existing and foreseeable safety and capacity related problems caused by wake turbulence**

European wake vortex related programs



Relation with FAA-Eurocontrol Action Plan 14



WakeNet2-Europe partners

- NLR (co-ordinator)
- IFALPA (Vereinigung Cockpit)
- DLR
- THALES-AVIONICS
- DFS
- UCL
- NATS En-route Ltd
- EUROCONTROL
- AIRBUS (dep co-ordinator)
- UK MetOffice
- QinetiQ
- ONERA

Way of working

- **WakeNet2 does not do research itself but connects those that do the research and those that need the answers:**

research  **operations**

- **7 ‘Working Groups’ to assess ‘state of the art’ and to make recommendations for the future**
- **10 ‘Links’ to establish contacts with specific groups**
- **3 Workshops during its three years existence**
- **Internet site (www.cert.fr/projets/WakeNet2-Europe)**
- **support to FAA / EUROCONTROL Action Plan 14 on Wake Vortices**
- **Periodic reporting, reviews and recommendations**

Activities (1)

- **WakeNet2-Europe Workshops**
  - Data bases of operational wake data and risk assessment methodologies (NATS)
    - November 2003, London Heathrow, UK
  - Capacity gains as function of weather and weather prediction capabilities (DFS)
    - December 2004, Langen, Germany
  - Prospects of improved wake vortex regulations (EUROCONTROL)
    - planned for fall 2005

Activities (2)

- **Working Group Workshops:**
  - WG2 *(Feb04)*
    - *"On the Relevance and Treatment of EDR for Aircraft Wake Vortex Problems"*
  - WG5 *(May04)*:
    - *"Wake Vortex Effects: Aircraft Responses and Pilot Perception"*
  - WakeNet-USA (with active WN2E participation; Apr04)
    - *"The Prediction of Wake Vortices In-Ground Effect in an Operational Context"*
  - WG7 (Feb05)
    - *"Wake vortex alleviation"*

Activities (3)

- **Link with US**
  - Intensive contacts and exchange of information; mutual participation in meetings and workshops
  - WakeNet-USA and WakeNet2-Europe are somewhat complementary (more business/ATM-system implementation oriented versus more research oriented)
  - Important stimulus for activities
- **Action Plan 14 (FAA-EUROCONTROL co-operation)**
  - Important focus point tuned to implementation
  - Puts EUROCONTROL (and FAA) into the role of ‘prime stakeholder’

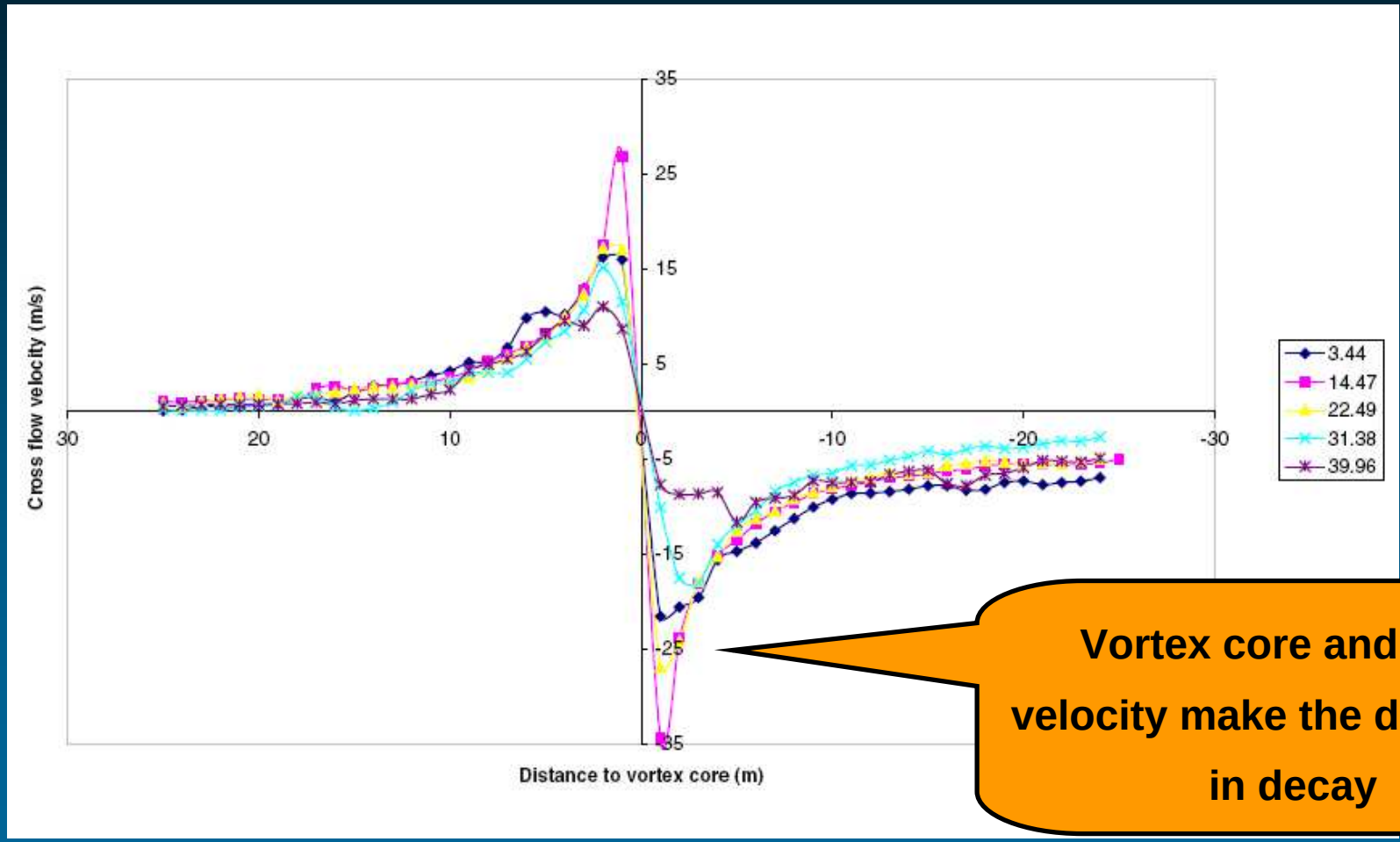
Activities (4)

- **Mid Term Review meeting:**
  - Passed successfully November 29 2004 in Langen, Germany
  - Reviewers comments:
    - Very positive
    - Work on wake vortex road map
    - More involvement ATC required

> The group is standing on a huge pile of knowledge overlooking the jungle of question marks
>
> **Comment from Michael Kraft (DFS), Reviewer**

- **Research Outlook**
  - Work started to define future research needs

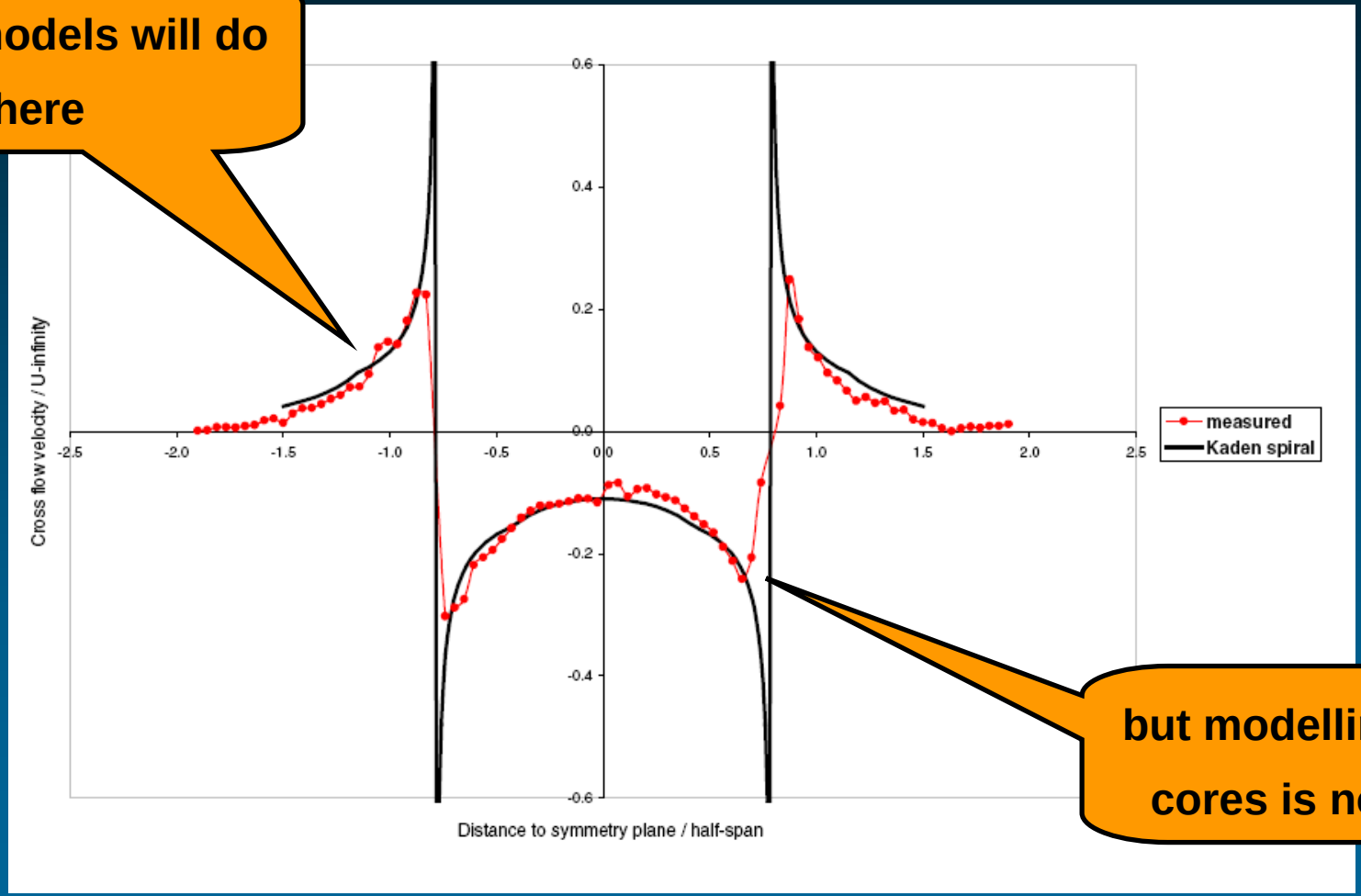
Typical cross flow velocities in a wake vortex (MEMPHIS Case 1107, AIRBUS 300)



Vortex core and peak velocity make the difference in decay

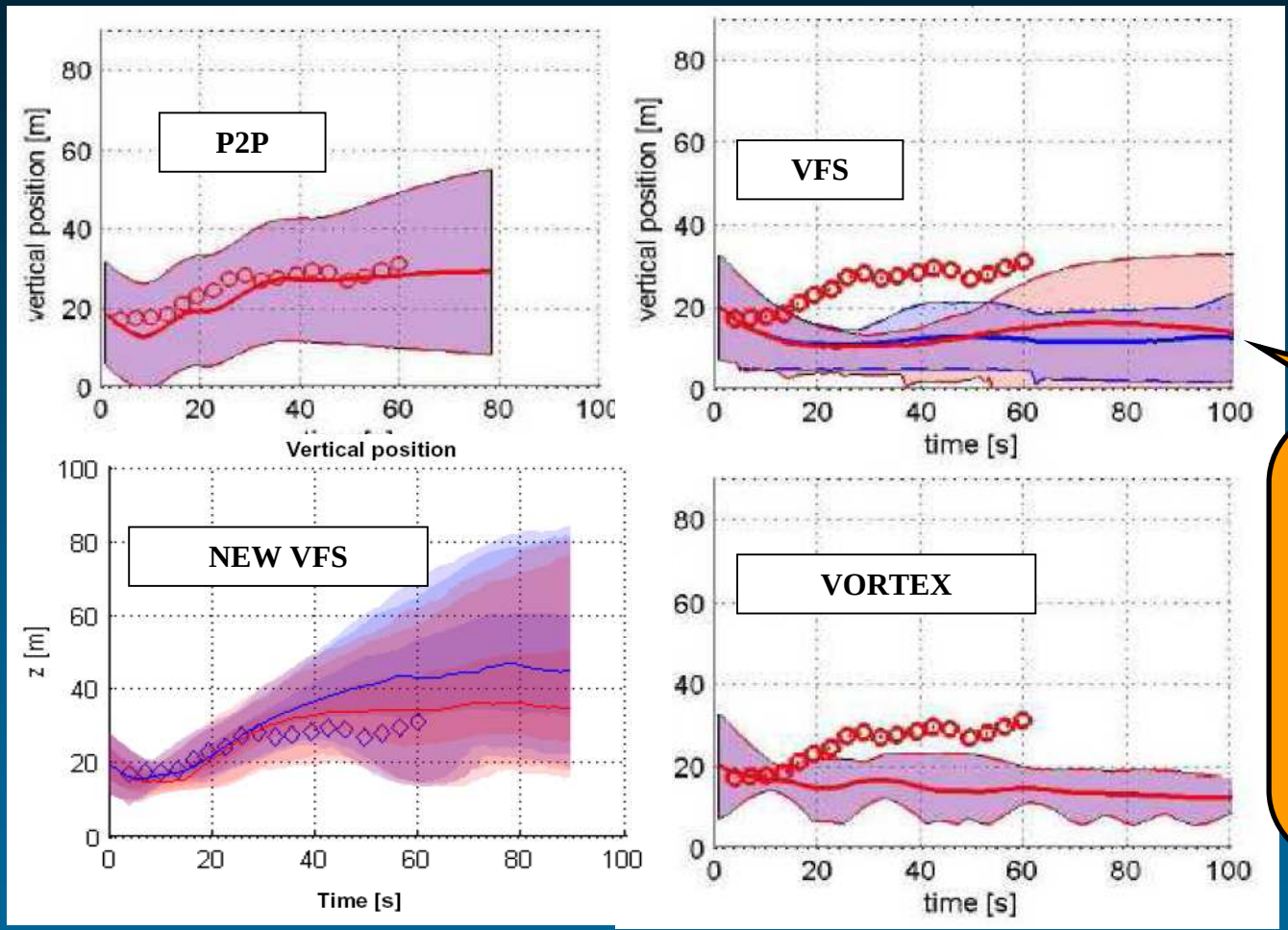
Simple approximation with Kaden Vortex solely based on aircraft characteristics (same case as before; analysis by Elsenaar)

Simple models will do here



but modelling vortex cores is not trivial

Comparison of prediction methods for wakes in ground effect: MEMPHIS case 1518, weak winds, stratification (from WN-USA / WN2-Europe Ground Effect Workshop)



. . . better modelling of wakes in ground effect might help but needs more validation !

Accurate atmospheric measurements are essential: WTR – Wind Temperature Radar as installed at FraPort

Manufacturer: Scintec AG, Tübingen, Germany

Combination of Doppler-Radar for clear air measurements and Radio Acoustic Sound System (RASS) for measurements in bad weather

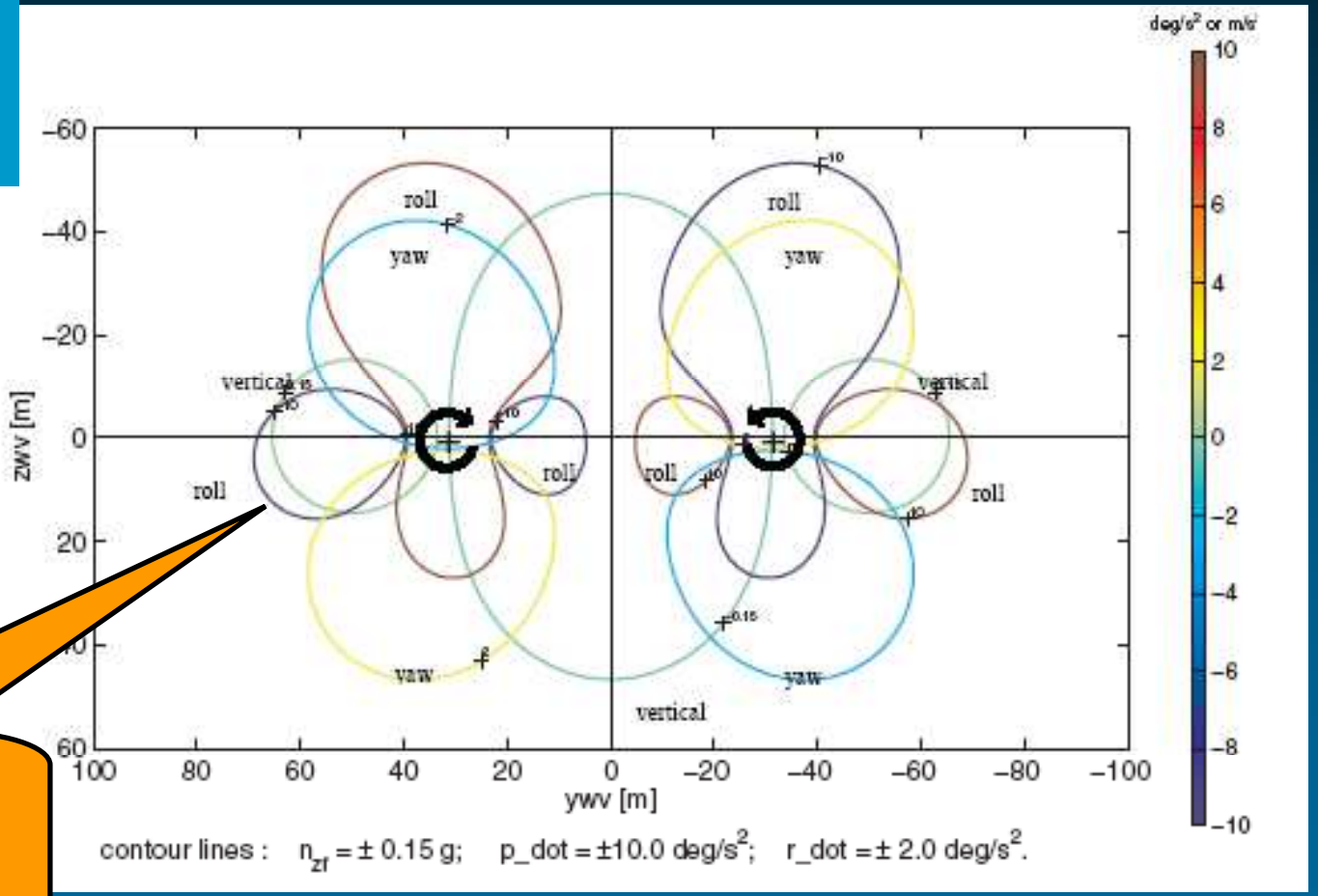
- Measurement of wind (from 100m to 1500m altitude) with a precision of 0.5 m/s
- and temperature (from 100m to 1000m altitude) with a precision of 0.5°C /100m

Areas with dominating roll, yaw, and vertical accelerations (VFW614 behind VLTA)
S-Wake Study by Luckner (Airbus)

separation 5 Nm

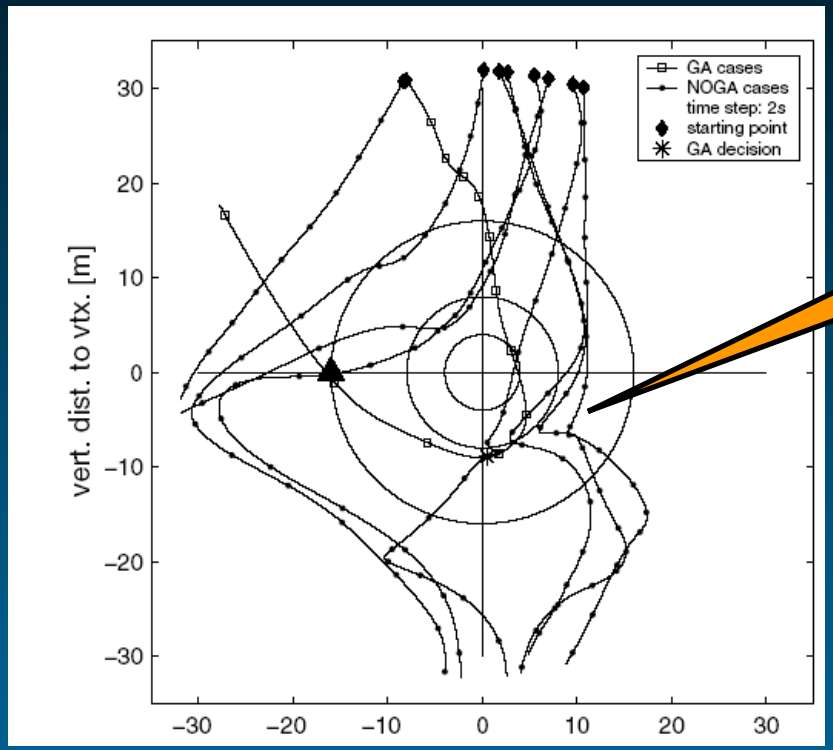
Winckelmans / Sarpkaya model

app. 80 % decay



Vortex core detail might matter here !

Aircraft motion in wake encounter from flight simulation studies (S-Wake results, AIRBUS)



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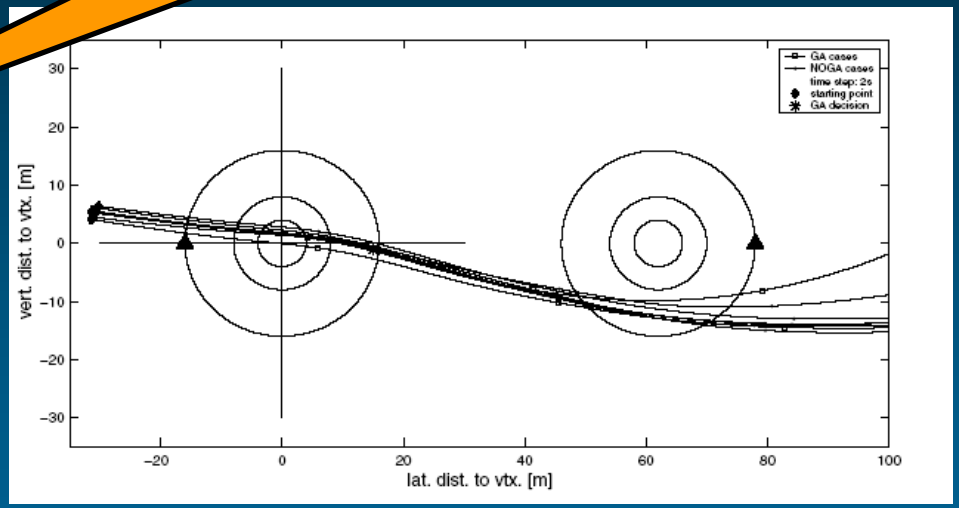
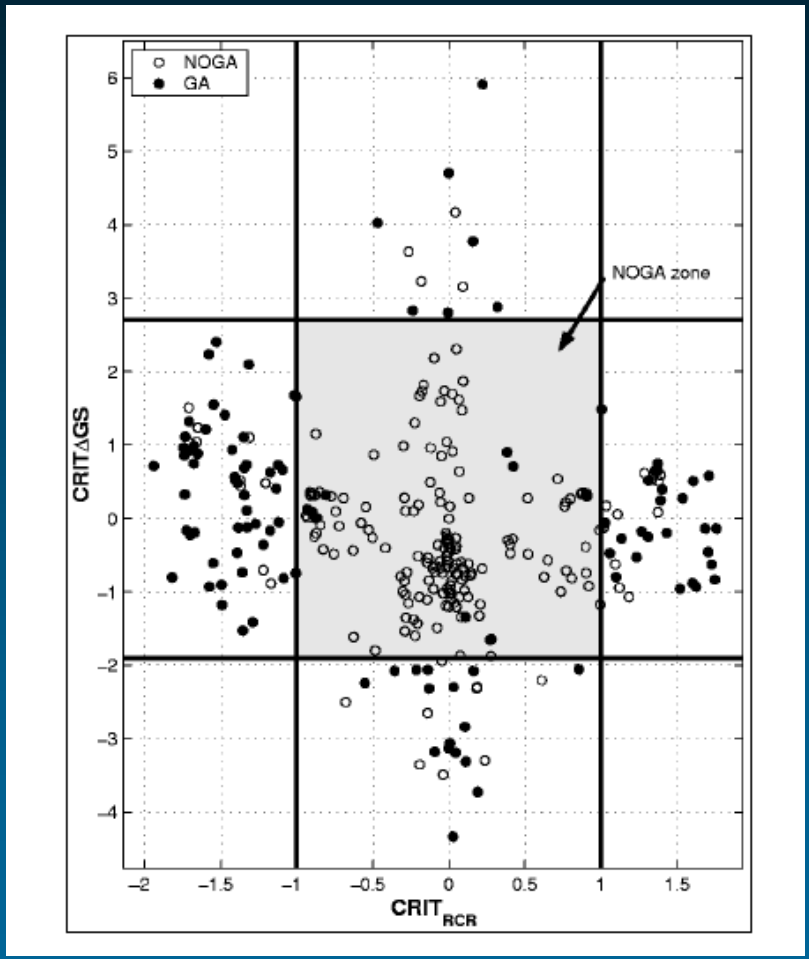


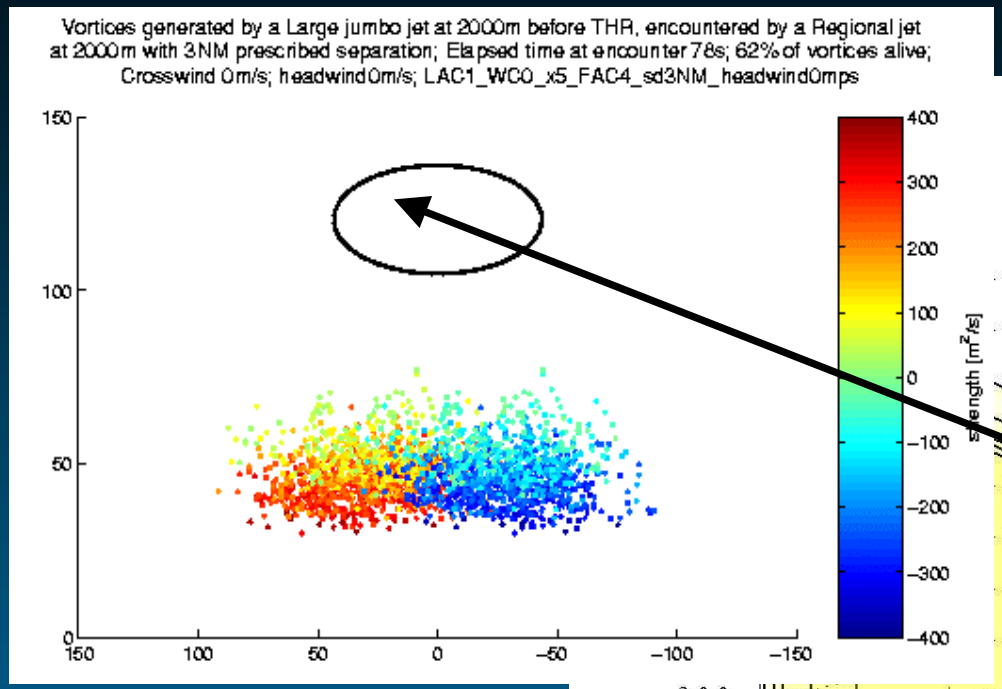
slow intercept from above (vertical intercept is 2 deg.)

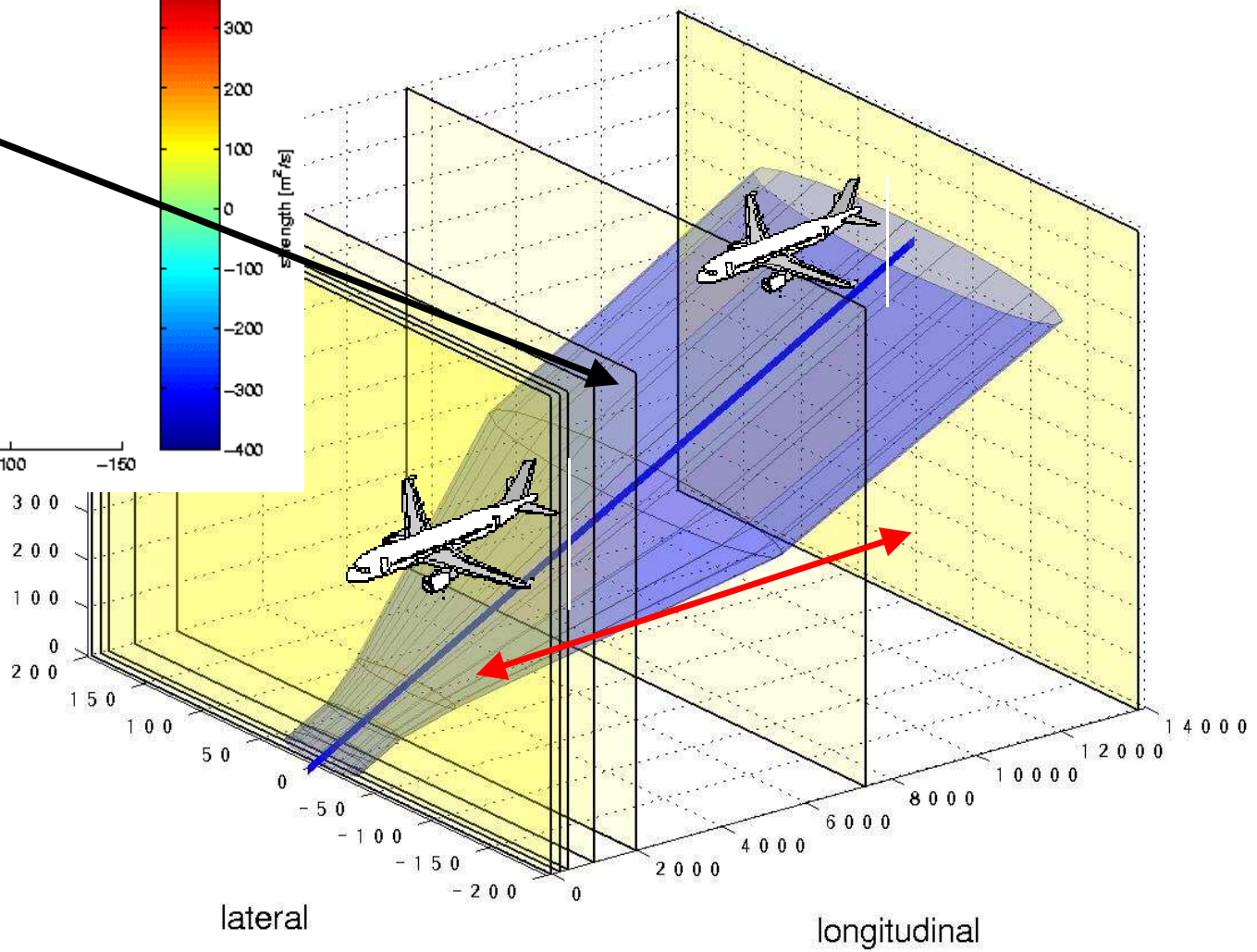
quick intercept from aside (horizontal intercept angle is 20 deg.)

“Combined Roll-Control Ratio and Vertical Acceleration” criterion for Go-Around decision (S-Wake flight simulator results, AIRBUS)

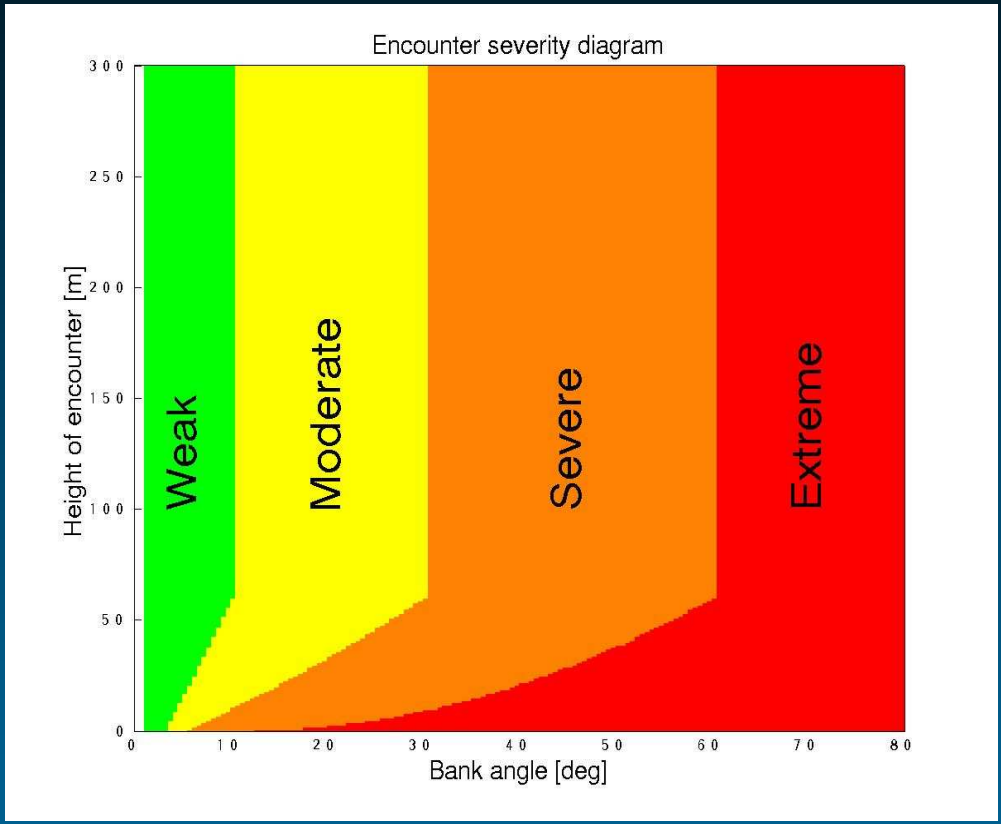


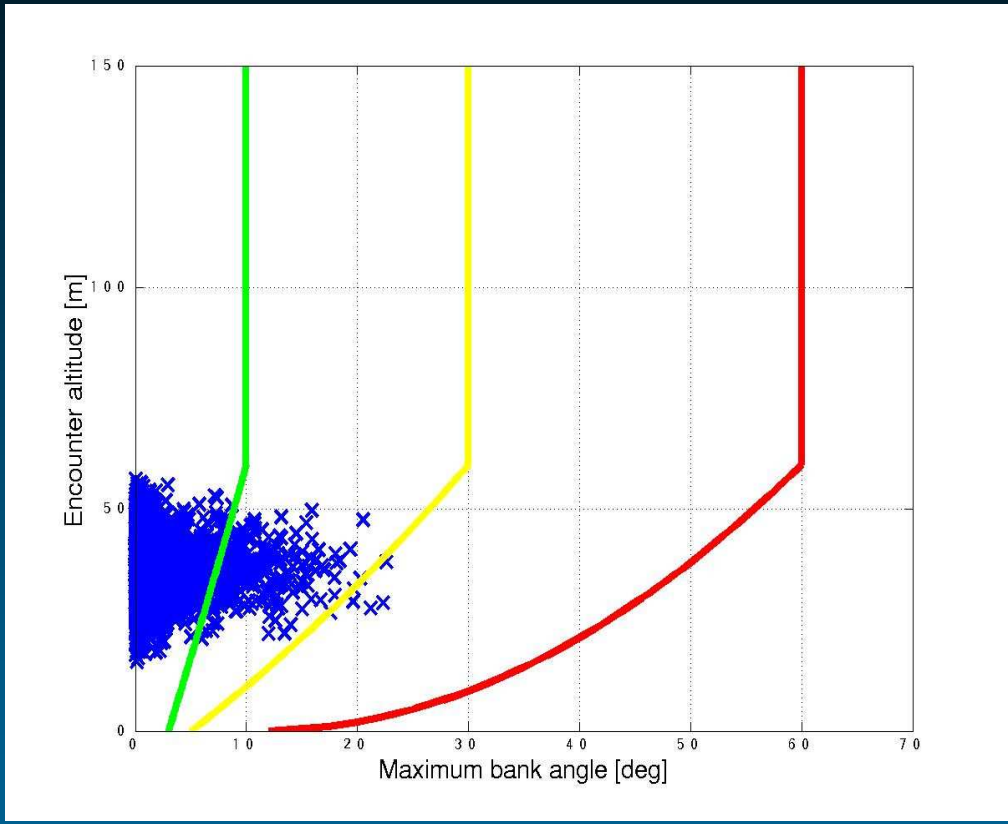
Probabilistic Wake Vortex Evolution Modelling (S-Wake, WAVIR, NLR)





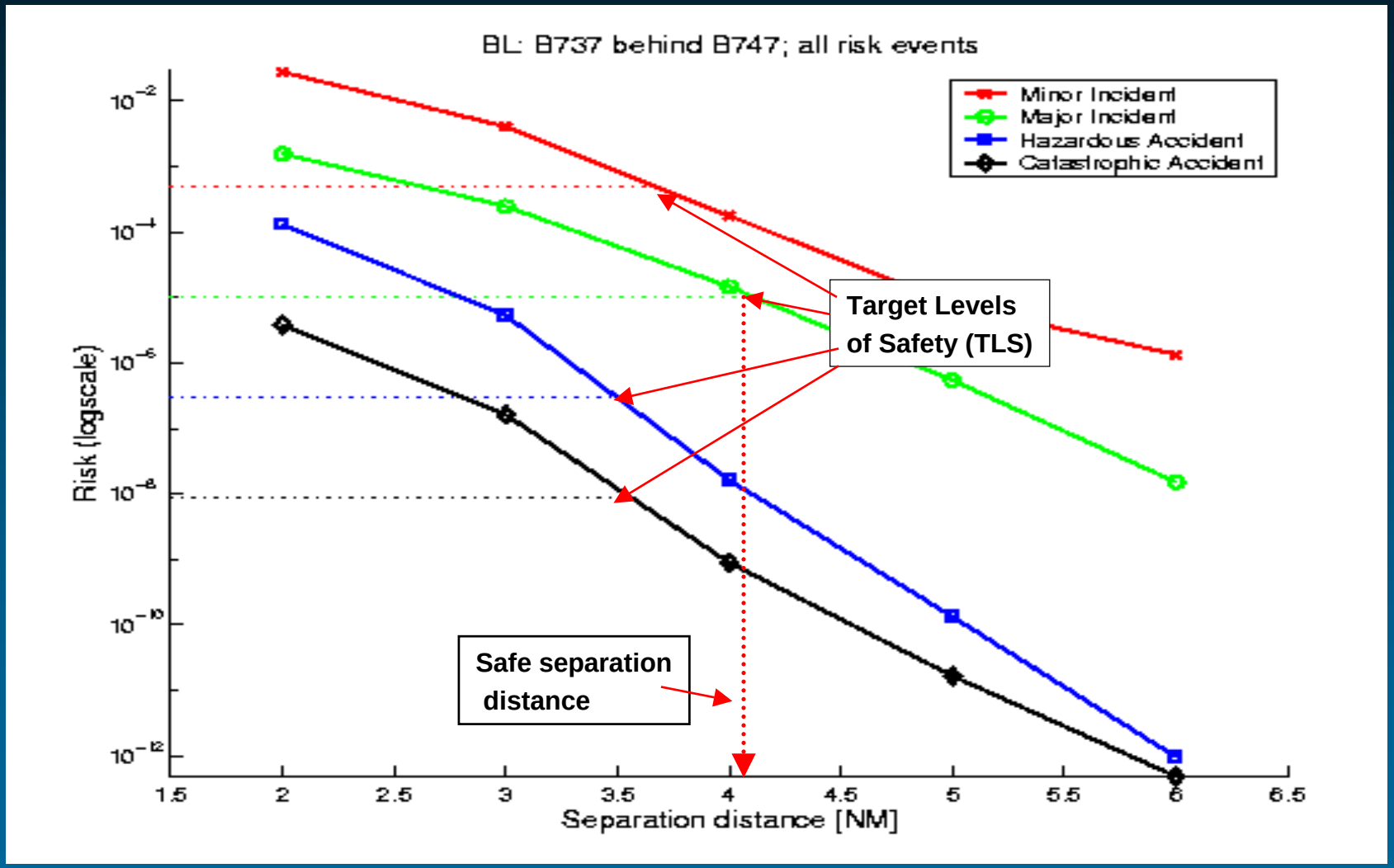
Encounter severity classification
Results from WAVIR Monte Carlo type simulations (S-Wake, NLR)





Bank angle versus loss of height / encounter altitude is used as *wake encounter* severity metric

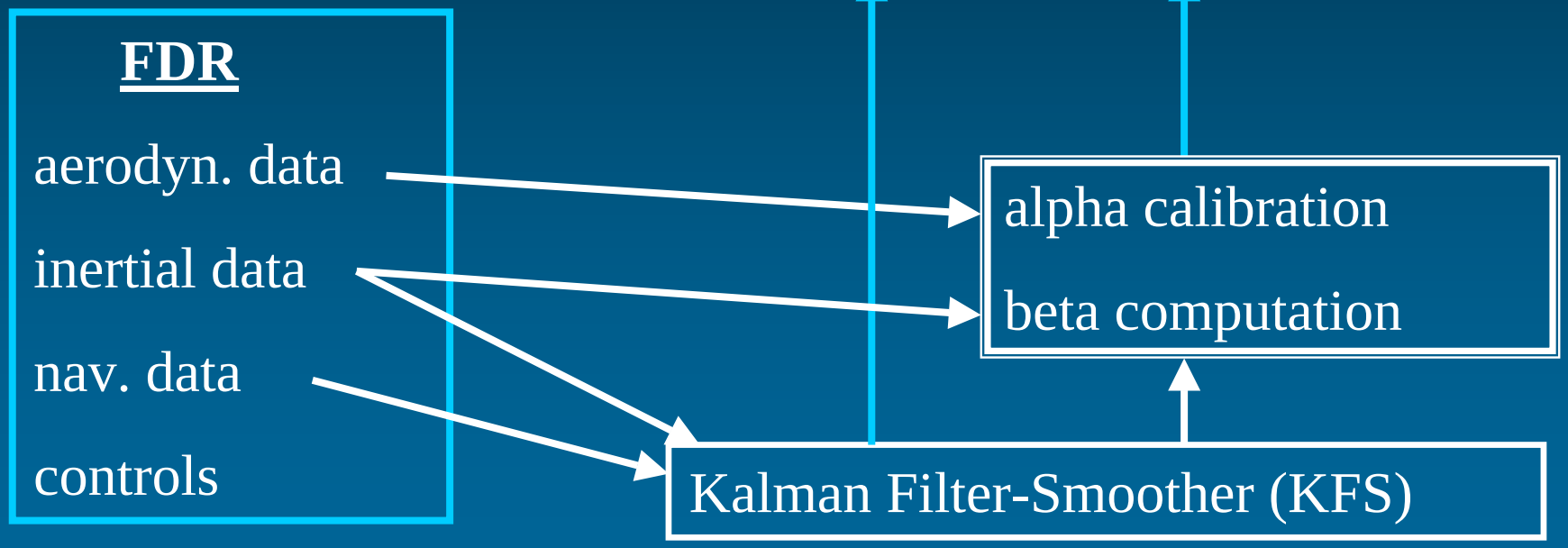
Example of risk assessment for a B737 behind a B747 in ‘average’ weather conditions (S-wake, WAVIR, NLR)



NLR – VORTEX: automated encounter detection from Flight Data Recordings

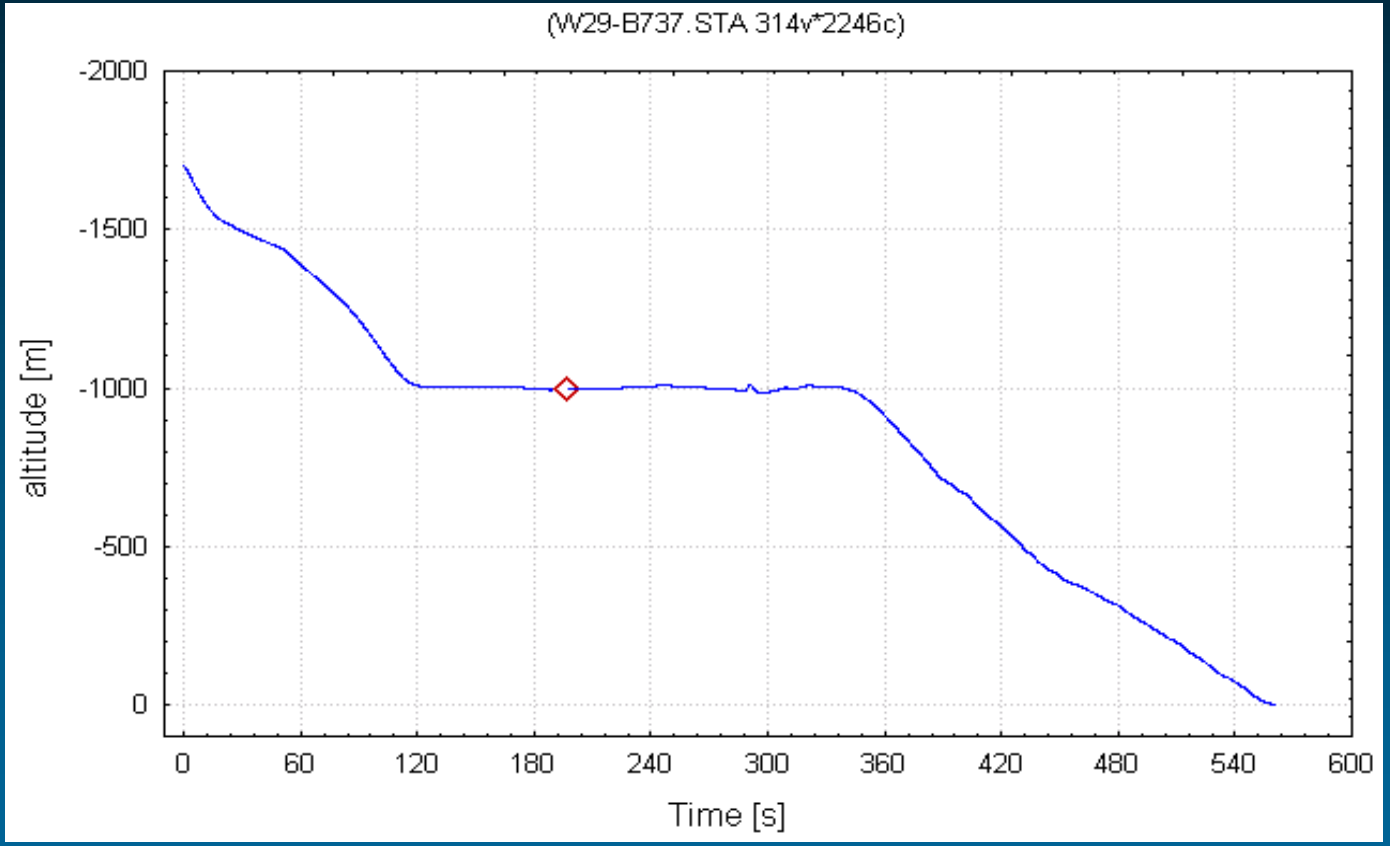
processes involved in determining the wind vector V_g

$$\vec{V}_g = \vec{V}_{inertial} - \vec{V}_{aero}$$



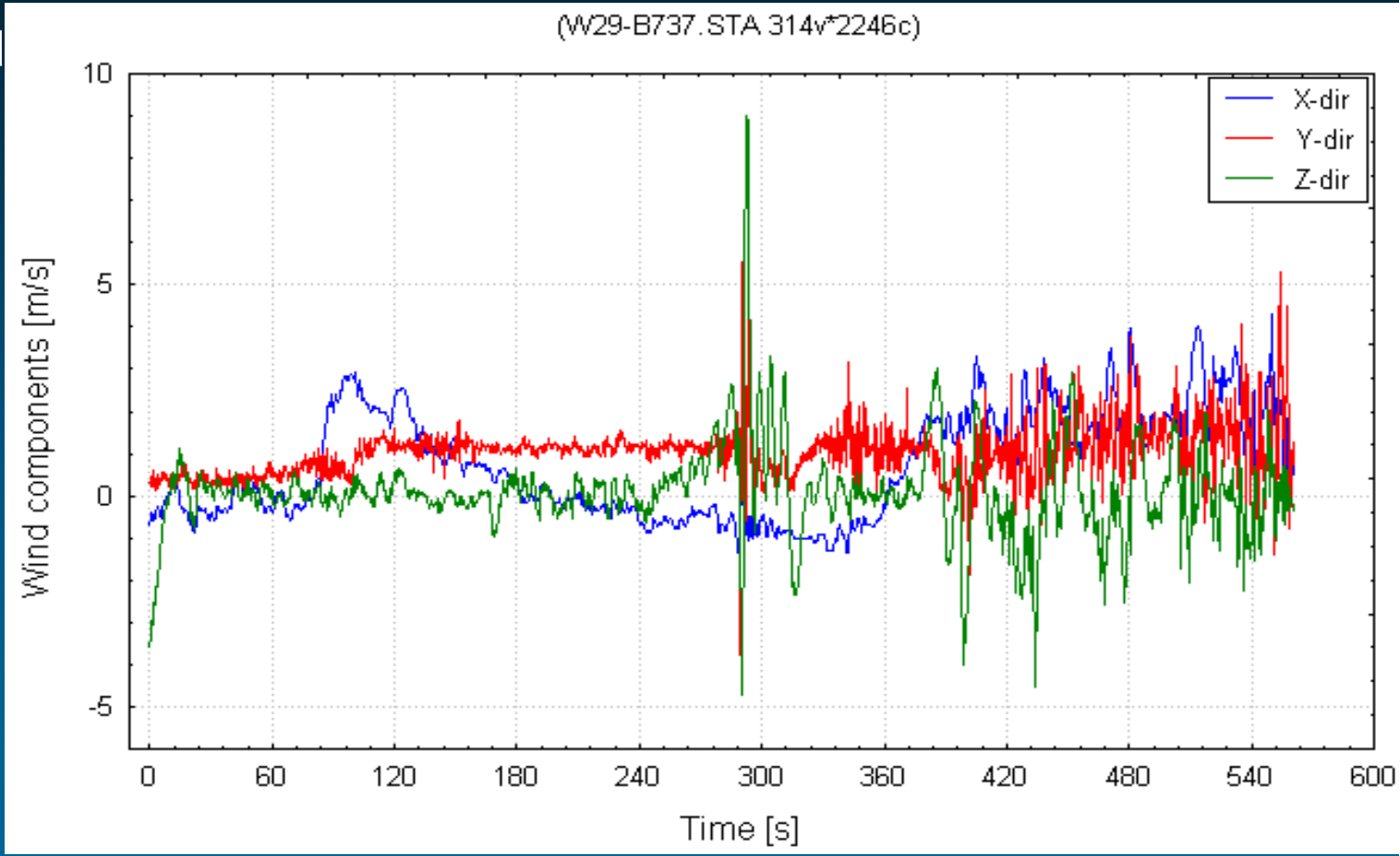
Example
B737 landing approach altitude

- **Possible WVE occurred midway at 3000 ft**



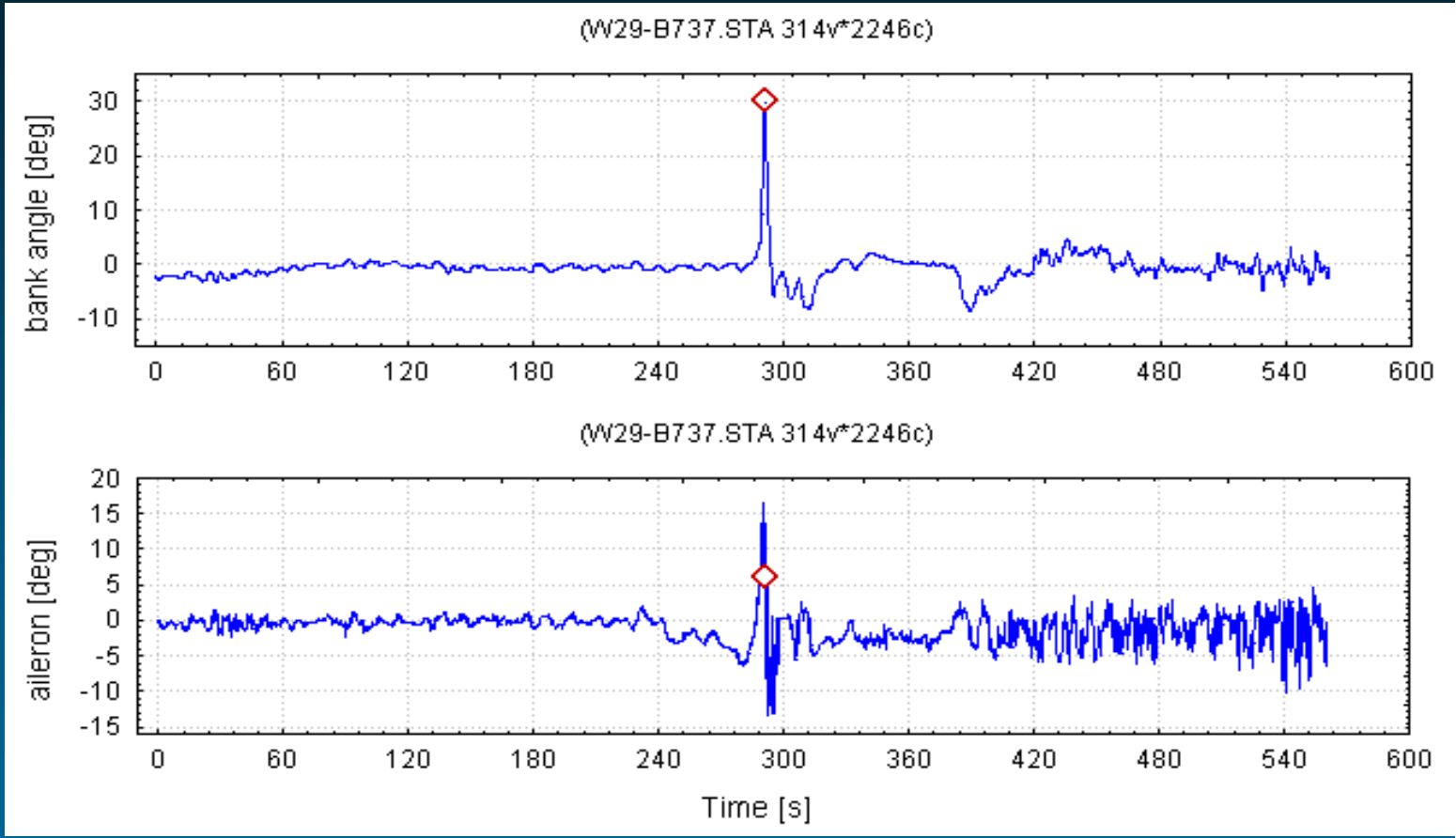
Example
wind components

- **Peak in crosswind component**
- **Peak in vertical wind component**

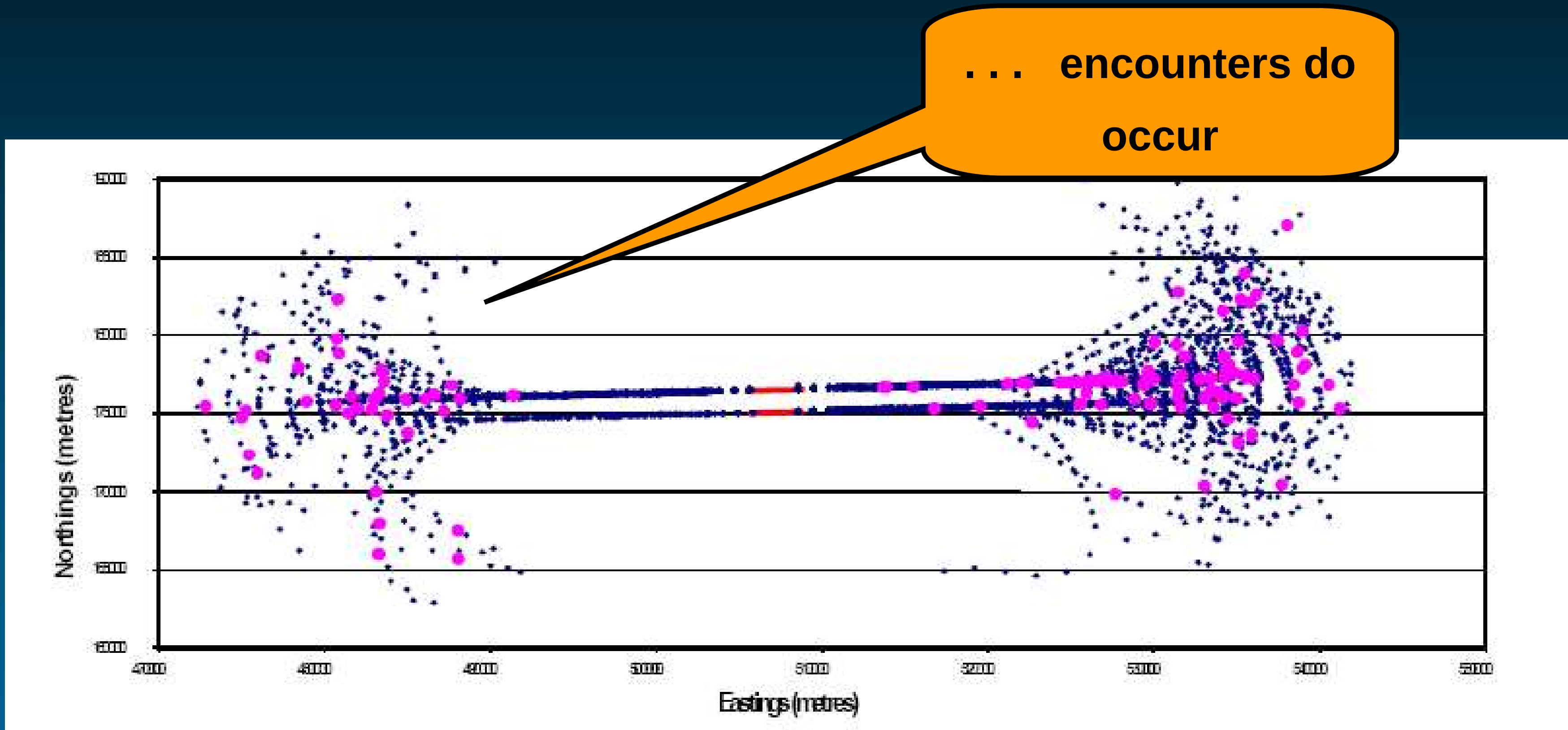


Example
roll motion: bank and aileron

- **One single peak both in roll and aileron**
- **Bank angle disturbance about +30 deg!**



London Heathrow: detected wake vortex encounters from NLR VORTEX FDR analysis (from S-Wake Study NATS / NLR)



Violet dots are detected (likely) encounters; Blue dots are radar trackings from the flight path's of detected encounters

A first shot on ‘Research recommendations’ (1)

- **Establish sensitivities of encounter modelling for details of the wake vortex and refine wake characterisation if required (e.g. decay)**
- **Improve modelling for wakes in ground effect and its validation**
- **Push weather prediction to its limits, using the most up-to-date and numerical weather forecast and validation with quality field measurements**
- **Investigate (follower A/C class dependent !) hazard definition**

A first shot on ‘Research recommendations’ (2)

- **Improve and validate automated encounter reporting from FDR analysis**
- **Establish ‘current practice’ as (Airport dependent?) ‘base line’**
- **Organise ‘peer reviews’ to establish shortfalls in wake vortex safety assessment**
- **Agree on a safety assessment methodology (who ?)**

To think about:

It is likely easier to construct a safe system than to rigorously prove that the system is safe.

Jens Konopka, DFS, Langen 2004

If ‘uncertainty is piled upon uncertainty’, the outcome will be worse than today; probabilistic modelling, respecting all details and including proper validation, is the only promising answer.

Bram Elsenaar, to be discussed

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T H A N K Y O U

for more information see the WebSite

http://wwwe.onecert.fr/projets/WakeNet2-Europe