Wake vortex severity assessment – a core element of the safety case

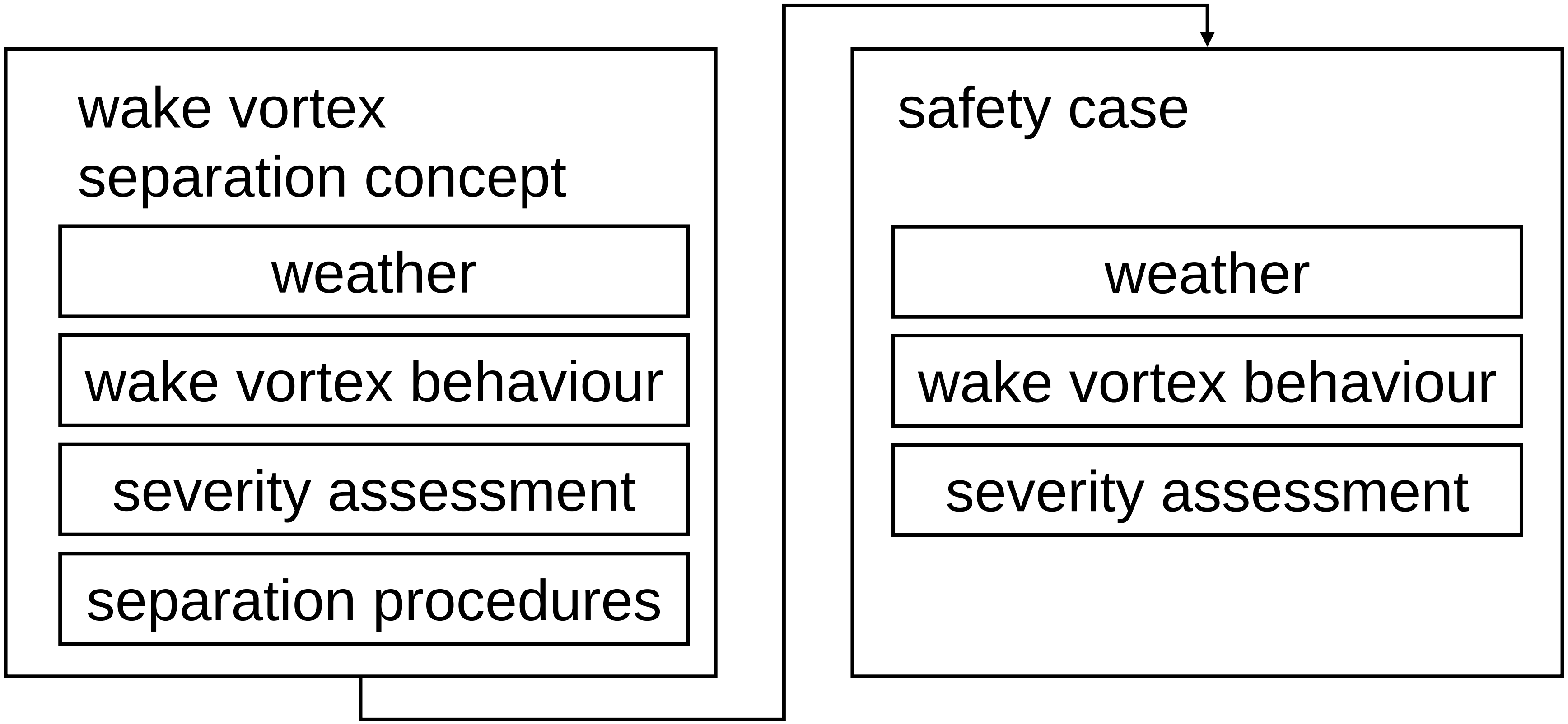
German Aerospace Center DLR

Carsten Schwarz, Klaus-Uwe Hahn - Institute of Flight Systems

Frank Holzäpfel, Thomas Gerz - Institute of Atmospheric Physics

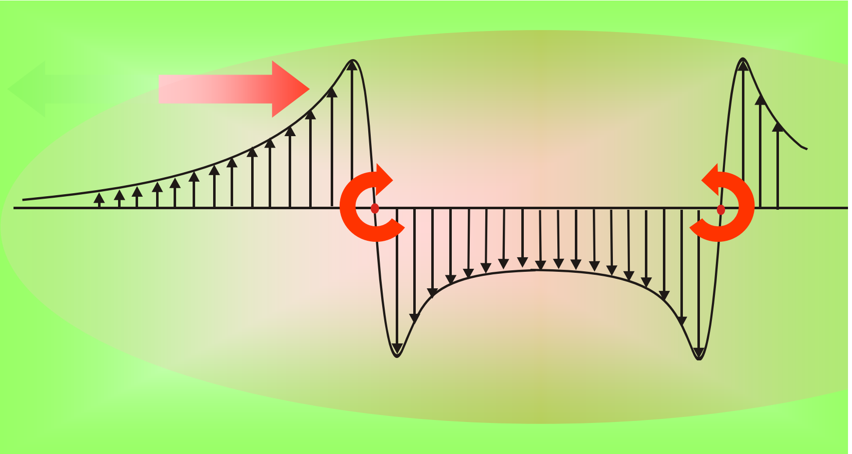
DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Wake vortex separations
Severity assessment and safety case



Wake vortex severity assessment

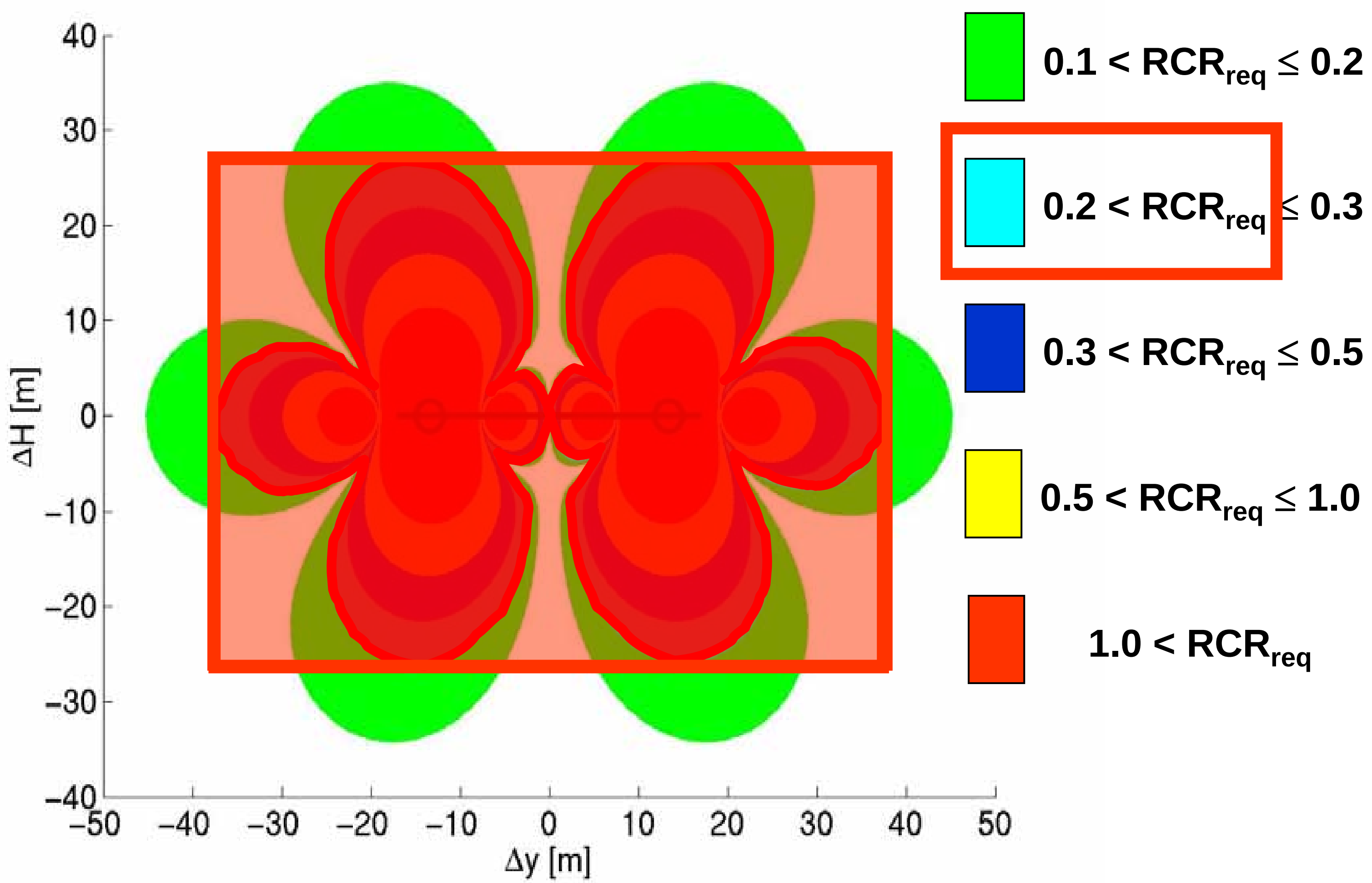
- „How close can one get to a wake vortex?“



- Open question:
  assessment of wake vortex encounters
  in terms of severity (incident classes) and risk (safety objectives unclear)

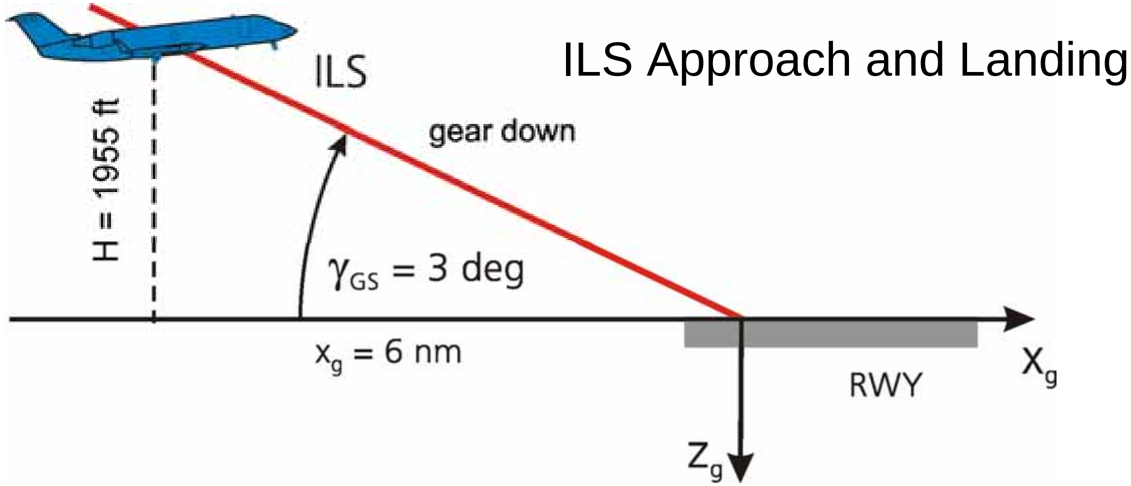
- DLR approach:
  safe and undisturbed operations possible outside the hazard area

Simplified hazard area (SHA)
Definition



Hazard area concept validation

Manually controlled approach

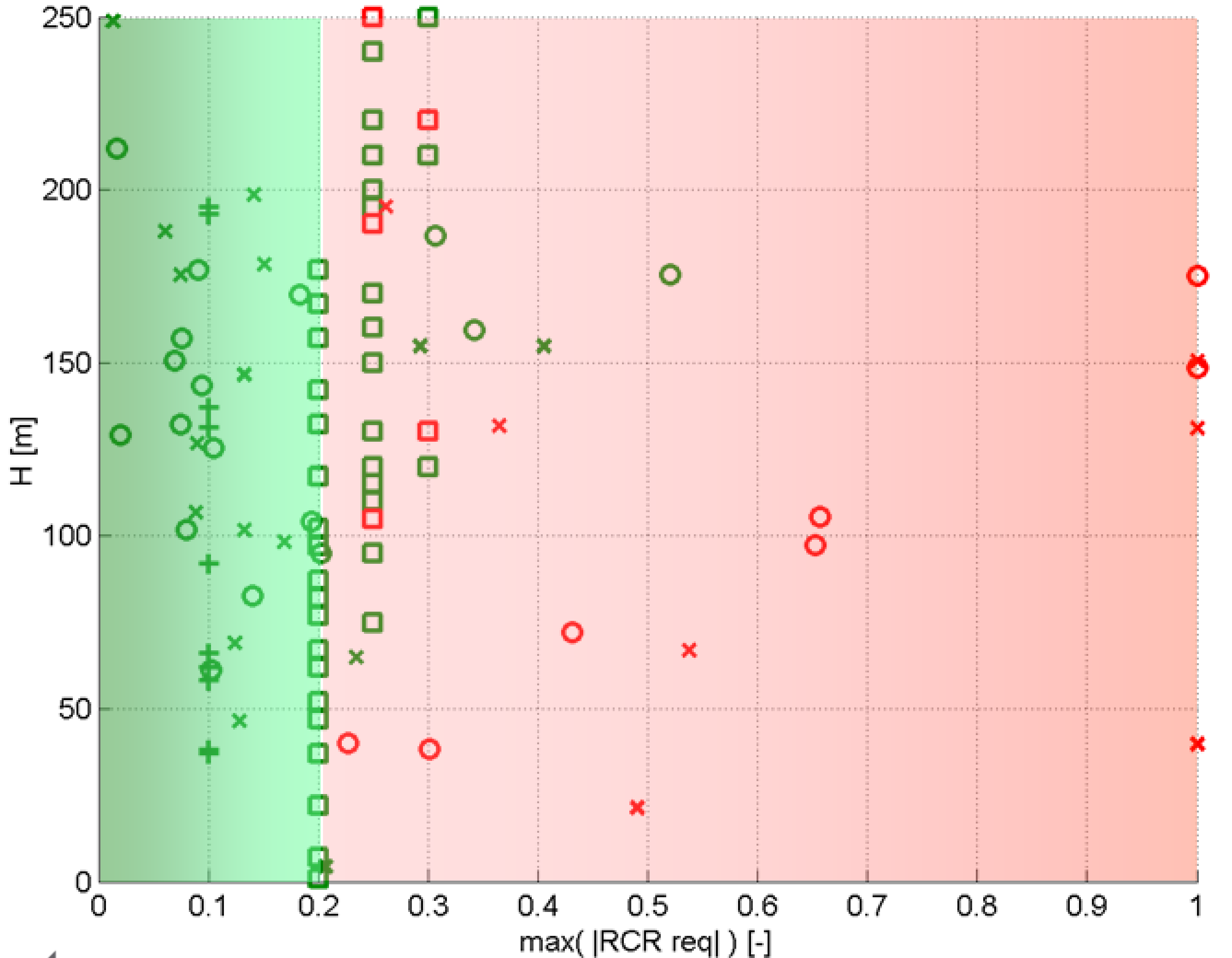


ATTAS fixed base Simulator

Full Flight Simulator
ZFB Berlin/ TU Berlin

ATTAS In-Flight Simulator

Hazard area limit results



acceptable (95)

unaccetable (19)

Severity criteria
State of the art

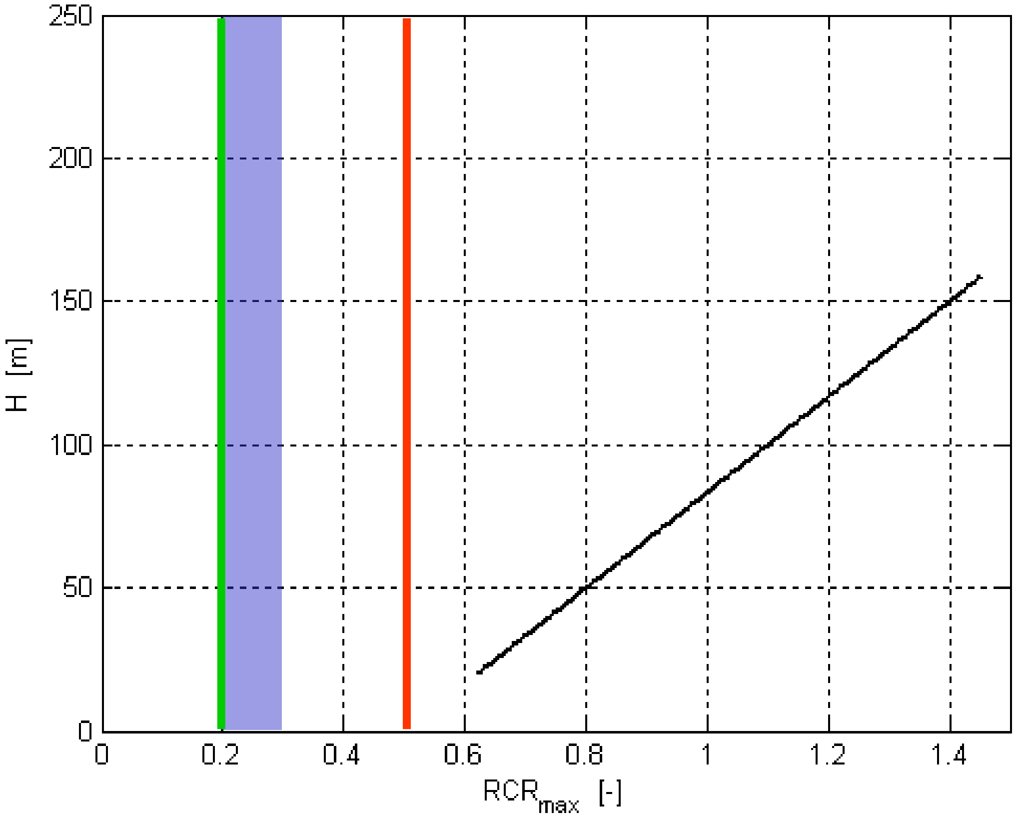
$RCR < 0.5 + 0.006 \cdot H_{RCRmax}$

RCR < 0.5

RCR < 0.2-0.3

RCR < 0.2
(based on DLR wake vortex projects “Wirbelschleppe I+II”)

- CREDOS (EU FP 6) severity criteria under development
- WakeNet3-Europe (EU FP 7) task group “safety assessment”
- RECAT/ SESAR JU



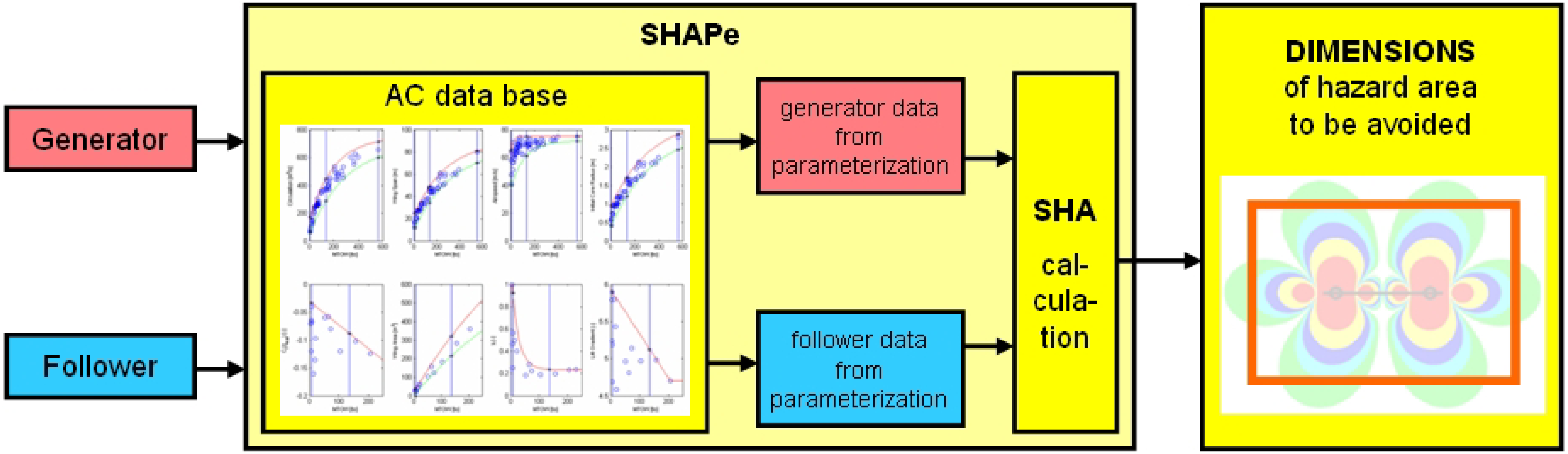
no commonly accepted severity criteria available

Simplified Hazard Area Prediction (SHAPe)

all relevant wake vortex parameters parameterized based on MTOW

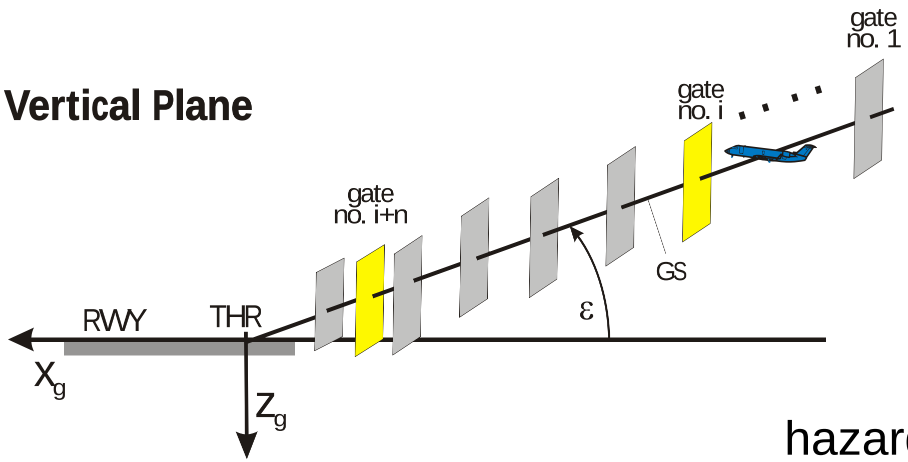
determination of hazard area depending on vortex age and RCR

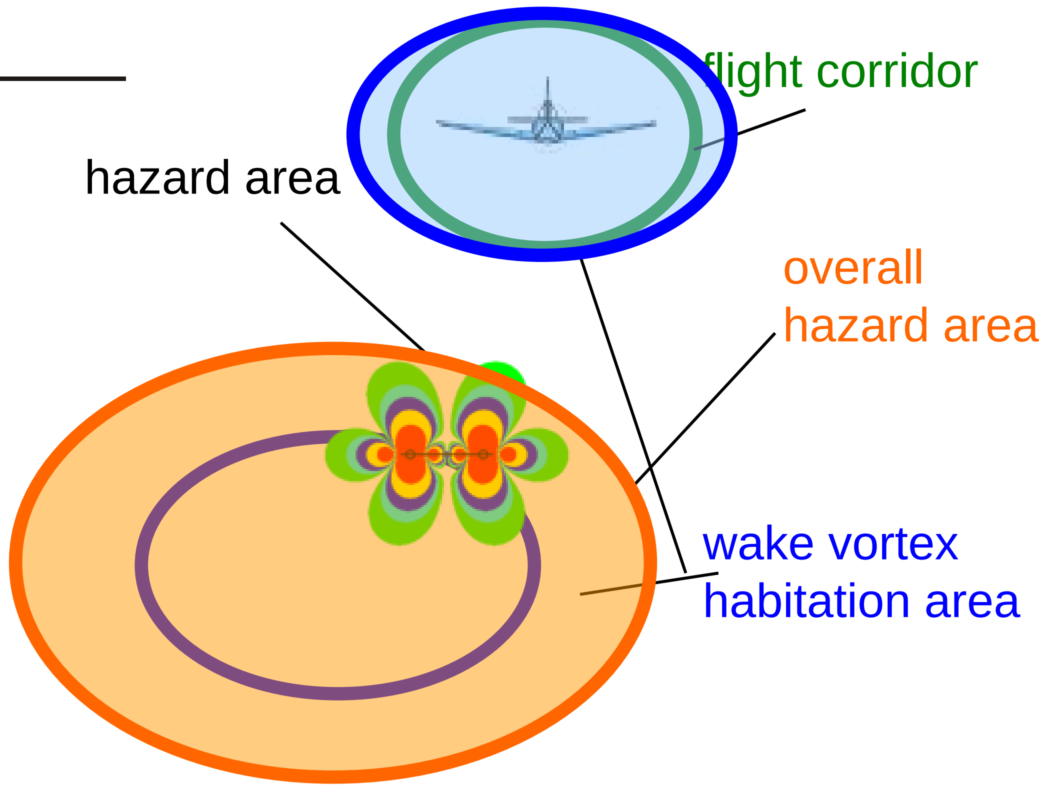
using worst case parameter combinations



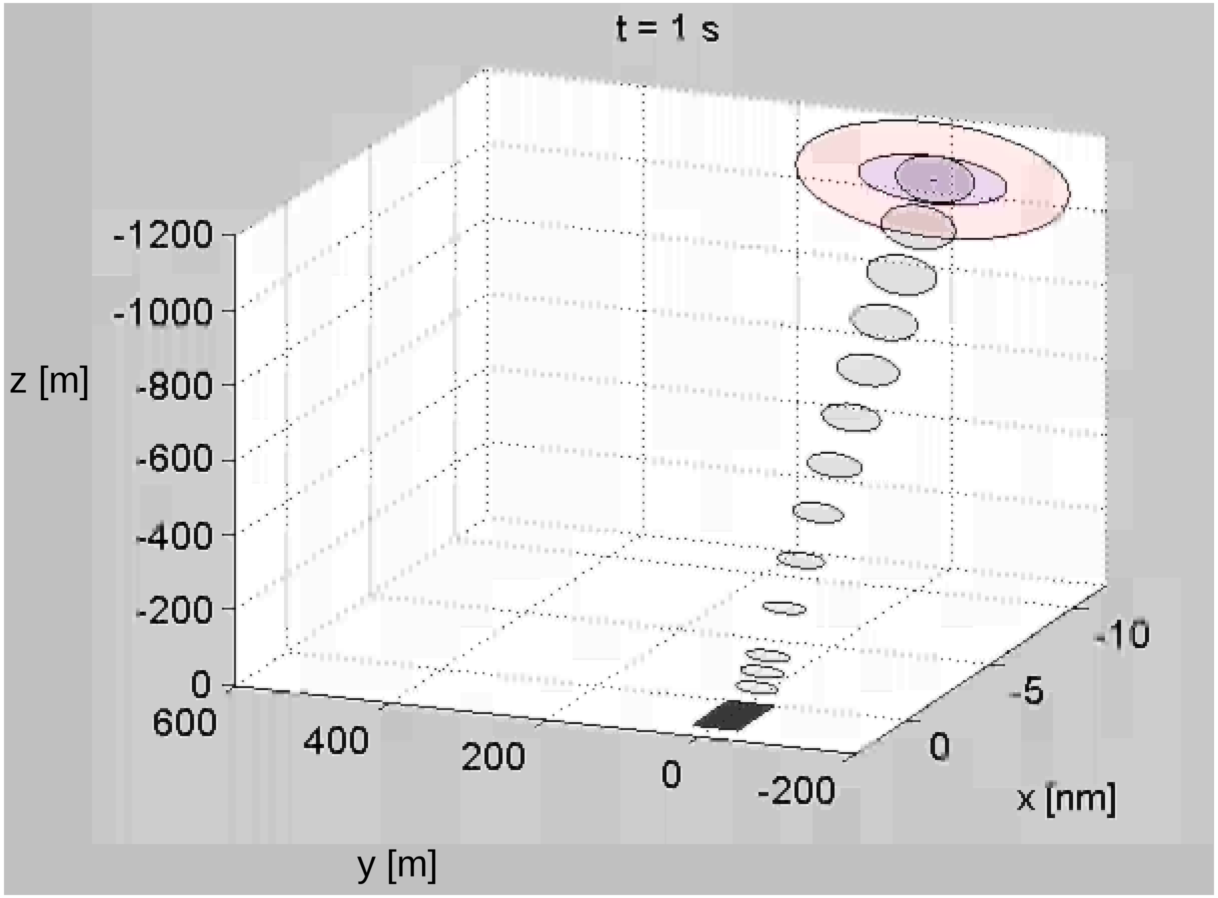
➜ **size of hazard area for any (generic) aircraft pairing/ any classes**

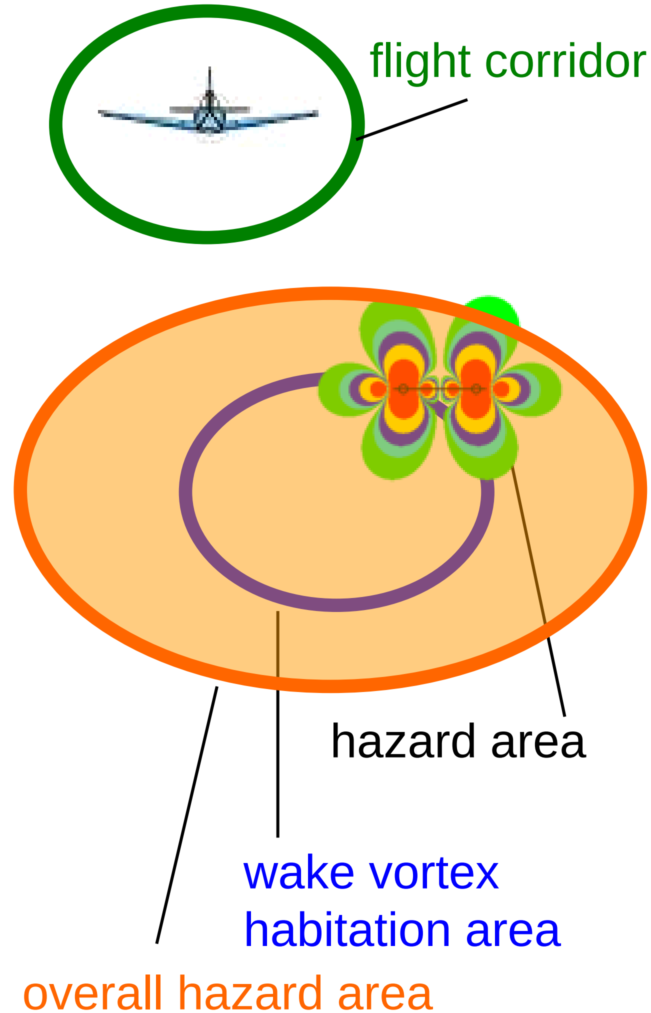
Dynamic wake vortex separations





Dynamic wake vortex separations





‘medium‘ behind ‘heavy‘:
- cross wind 3 m/s
- weak turbulence

Wake vortex advisory system

Wake-Vortex Prediction and Monitoring System (WSVBS)

WSVBS

- weather (SODAR/RASS USA & NOWVIV)
- flight path deviations (FLIP)
- wake vortex behaviour (P2P)
- severity assessment (SHAPe)
- separation FRA procedures (STG, MSR, MSL, ICAO)

LIDAR monitoring

Wake Vortex Prediction and Monitoring System (WSVBS)

functionality demonstrated at Frankfurt airport 66 days (2006/ 2007)

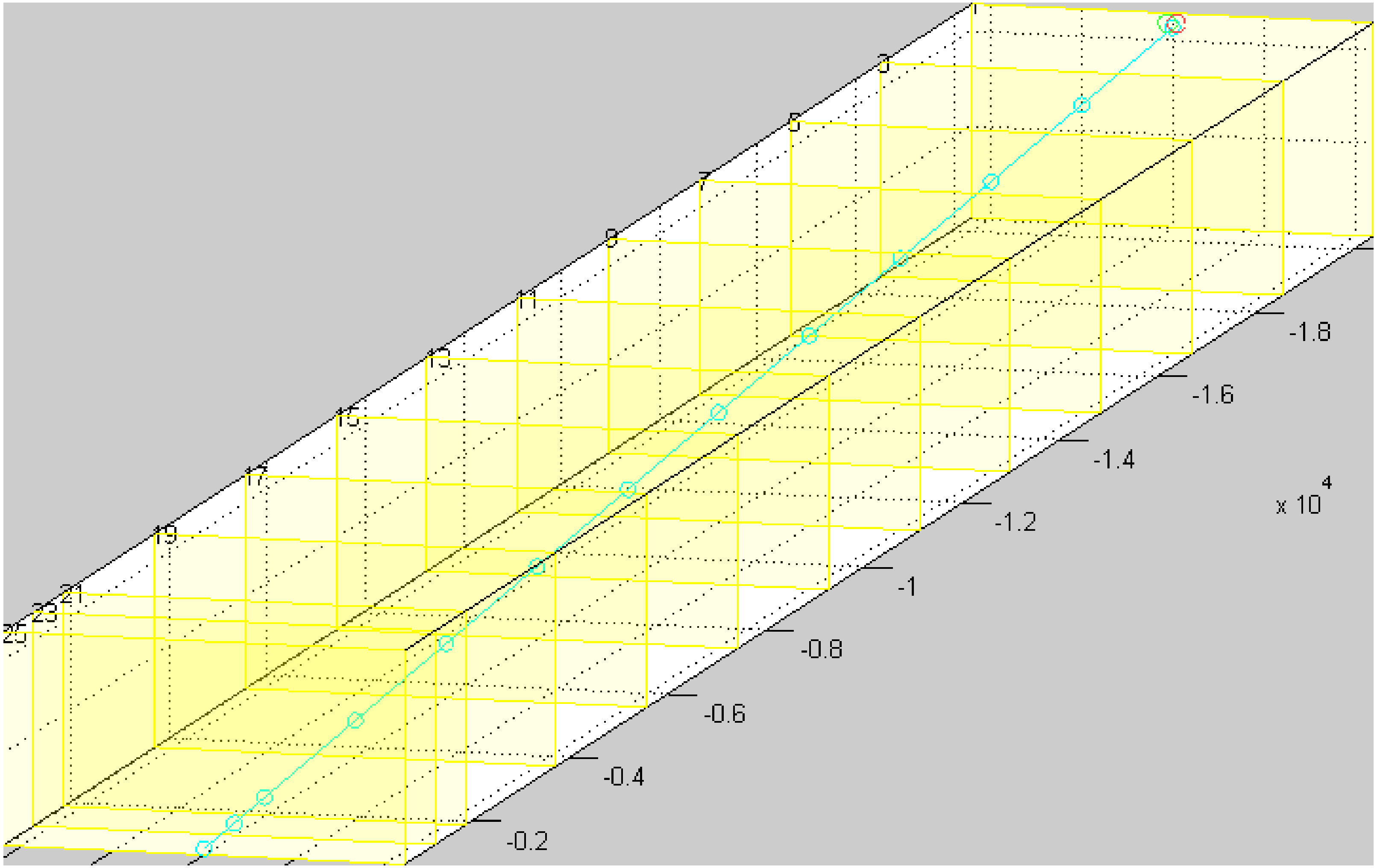
- Prediction horizon > 45 min, update every 10 min - no forecast breakdowns
- Predicts established (FRA) procedures - potential use 75% of the time, potential capacity gain 3 - 4 % (fast-time simulations FRA procedures)
- Can also predict individual separation times
- LIDAR as safety net monitors crucial altitudes - no warnings from the LIDAR
- Procedures and display well accepted by controllers

Risk analysis tool WakeScene

WakeScene

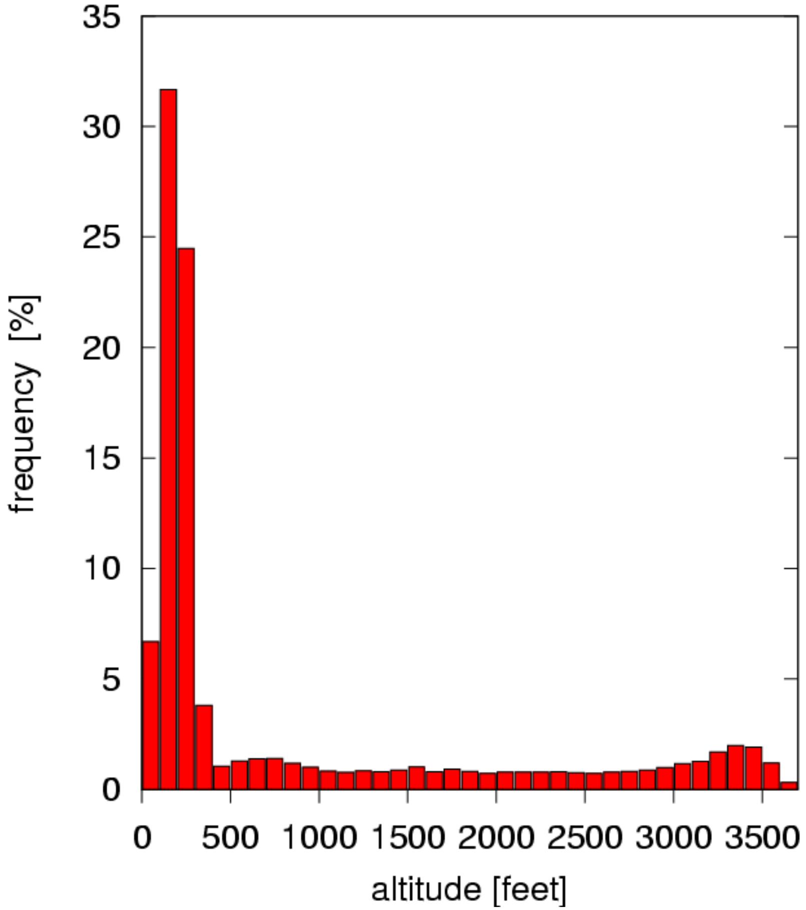
- weather (meteo data: measured/ model)
- aircraft trajectory model
- wake vortex behaviour (P2P)
- hazard area penetration (SHAPe)

Risk analysis tool WakeScene
3D Evolution



Risk analysis tool WakeScene
Results

100 000 approaches, leader B747, follower A320/ VFW614,
5 NM separation, full meteo, D2P



63% of closest approaches below 300 ft

Wake vortex severity assessment/ Elements of the safety case: Conclusions

Severity assessment

- Simplified hazard area concept SHA developed and validated for near-parallel encounters based on simulator and in-flight simulation data
- Hazard area prediction method SHAPe developed and applied in WSVBS and WakeScene
- No commonly accepted severity criteria available

Wake Vortex Prediction and Monitoring System (*German: WSVBS*)

- functionality successfully demonstrated at Frankfurt airport
- well accepted by controllers

Risk analysis tool WakeScene

- integrated MC simulation of WVs from FAF to threshold
- sub-models validated

  [Holzäpfel et al., Aerospace Science & Technology 2009 Issue 1]