R-WAKE

SESAR 2020 Exploratory Research Project

A Novel Framework to Assess the Wake Vortex Hazards Risk Supported by Aircraft in En-Route Operations

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R-WAKE

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Introduction

- Wake vortex issues in terminal maneuvering areas (TMA) are well known and have received a particular attention in the last decades
- In the en-route phase wake vortex encounters are unlikely and so far are still considered rare events
- Current separation standards might not be enough for protecting aircraft against WVE hazards while in other cases they might be over-conservative

Introduction

- Hazardous WVE en-route might become a serious issue:
  - forecast for higher volumes of traffic in certain areas
  - a more heterogeneous and diverse traffic fleet
  - new concepts of operation
  - more accurate navigation systems (reducing the dispersion of flight tracks)
  - new (or refined) standards leading to reduced separation minima between two aircraft

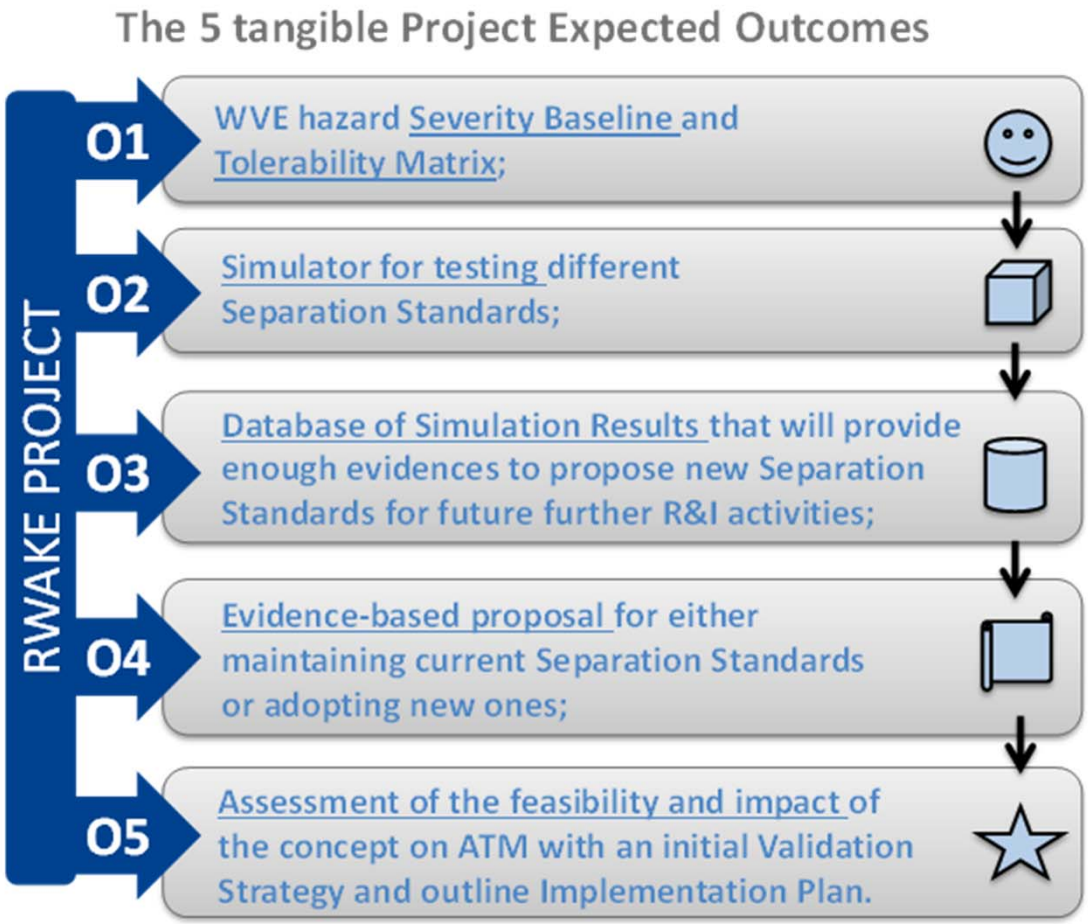
THE R-WAKE PROJECT

'What Separation Minima Reductions can be applied in specific and clearly defined operational conditions keeping the current safety level related to En-Route WVE hazards?'

R-WAKE = Simulation platform + Safety and robustness research methodology

THE R-WAKE PROJECT

Expected outcomes:



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STEP 1 – MICRO-ANALYSIS

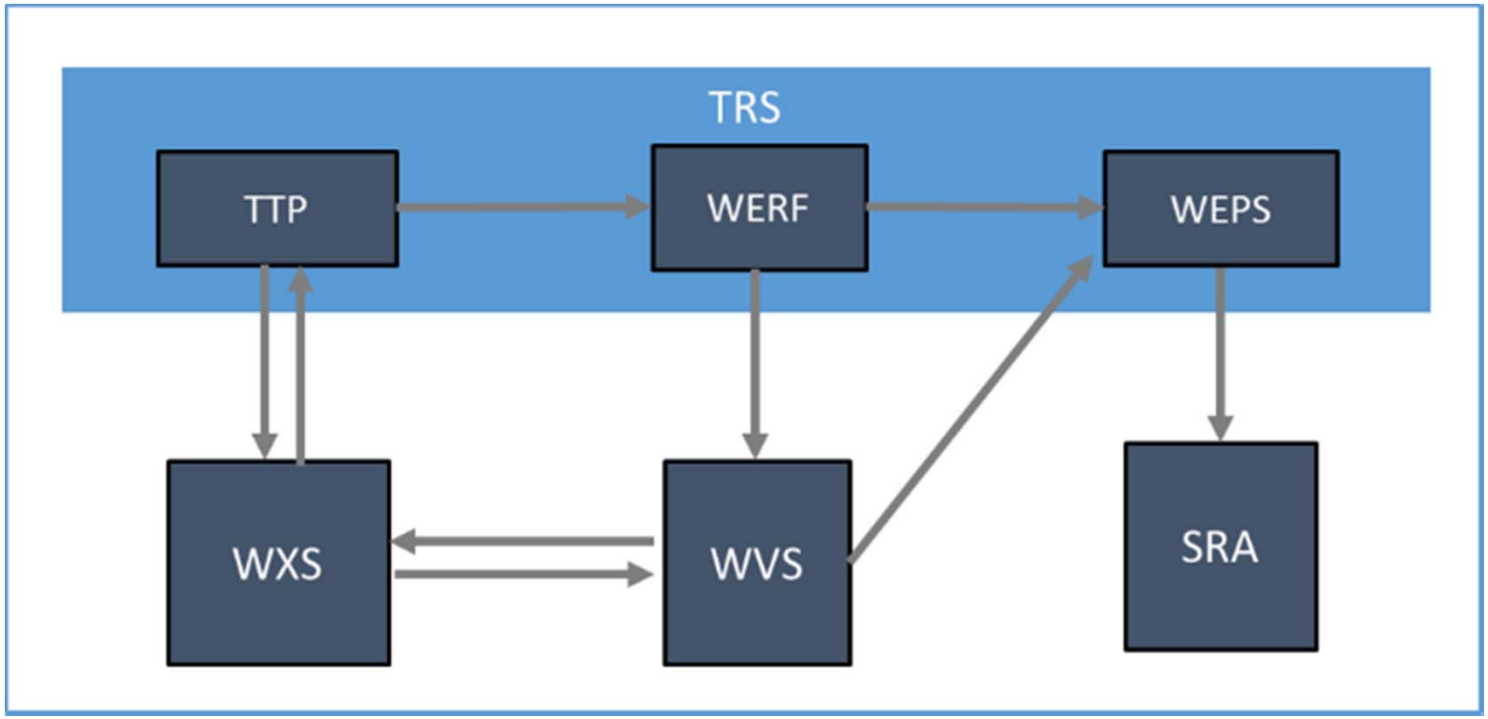
- The goal of the micro-scale simulations (or R-WAKE Step 1) is to generate the wake vortex safety baseline

- Used as input for the macro-analysis or Step 2

- Phases:
    1. Computation of the *vortex circulation*, generated by the generator aircraft and encountered by the follower aircraft.
    2. Computation of the aircraft upset experimented by the follower flight due to the vortex encounter.
    3. Assessment of the severity of the upset, based on expert knowledge.

THE R-WAKE PROJECT
STEP 2 – MACRO-ANALYSIS

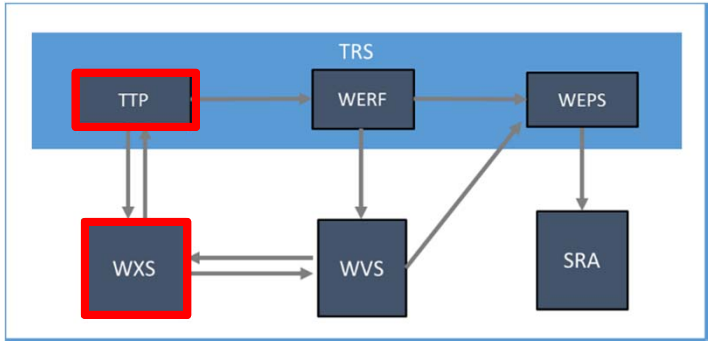
- Current and future traffic simulations
- New separation standards



THE R-WAKE PROJECT
STEP 2 – MACRO-ANALYSIS

- **Weather Simulator (WXS)**:
  - Provides historic weather data to the Traffic Simulator (TRS) and to the Wake Vortex Simulator (WVS)

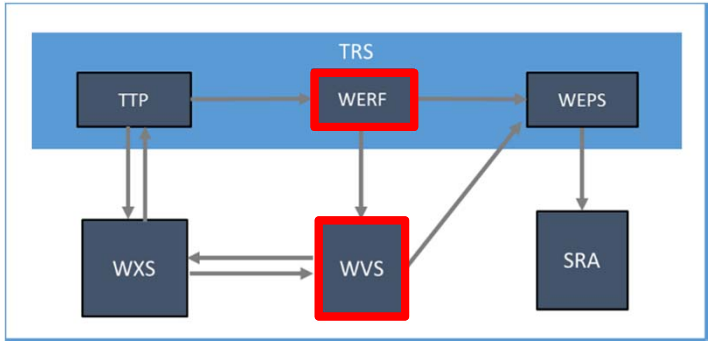
- **Traffic and Trajectory Planner (TTP)**
  - Generates and simulates traffic scenarios based on real or future traffic demand and considering weather data fed by the weather simulator
  - Applies the corresponding ATM constraints according to the concept of operations modelled



THE R-WAKE PROJECT
STEP 2 – MACRO-ANALYSIS

- **Wake Encounter Region Finder (WERF)**:
  - Identifies regions of airspace (volumes) in which potential wake vortex encounters could occur
  - Filter to reduce computational burden

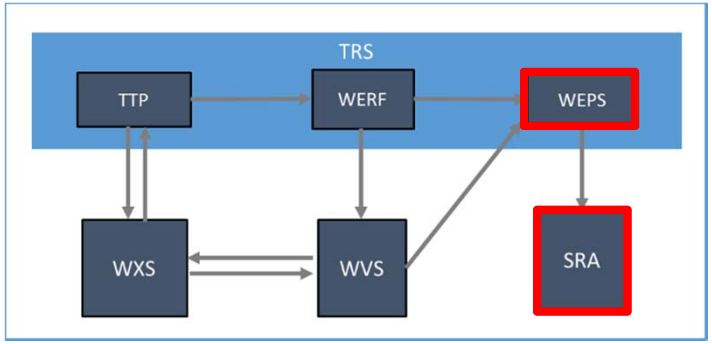
- **Wake Vortex Simulator (WVS)**
  - Simulates realistic wake vortexes given the flight parameters of each trajectory (aircraft mass, speed, path, etc.) and the weather for the airspace region of interest
  - Generate a simplified macro-model of the vortexes represented as a 4D tube



THE R-WAKE PROJECT
STEP 2 – MACRO-ANALYSIS

- **WV Encounter Prediction System (WEPS)**
  - Detection of encounters
  - Calculation of upsets produced by the encounters
  - Conversion between upset to severity using the severity matrix from the Step 1

- **Safety & Robustness Analysis (SRA for Step 2)**:
  - Represents a process rather than a simulator
  - Knowledge generated will be an evidence-based proposal of new separation standards and methods



Integration test

Design of experiment

- Data origin: Demand Data Repository (DDR2)

Number of flights	200
Aircraft type	A320
Crossing area	FRANCE
Date	28/07/2016
Weather	Only vertical
ConOps	Structured route
Horizontal Separation Standard	5 NM
Vertical Separation Standard	1000 ft

Integration test

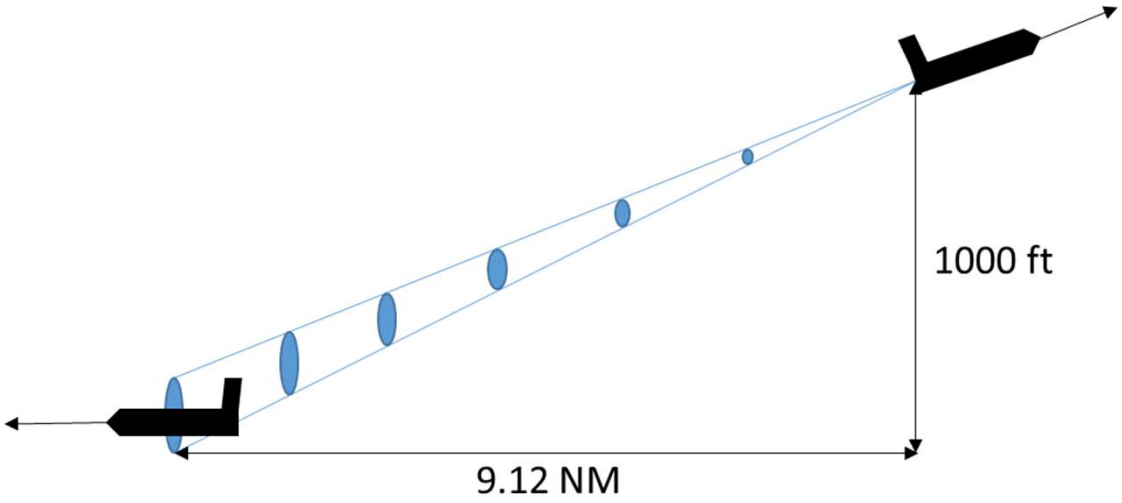
Results:

- The Region Finder detected 13 potential encounters (aircrafts closer than 10NM)
- Only in one potential encounter the vortex generator was closer enough to create possible encounter

Altitude change	0.0036741 m
Bank angle	2.9445e-05 rad
Rate of Climb/Descent	0.0022483 m/s
Airspeed change	0.00049465 m/s

Severity level 1 -> 'No significant safety effect'

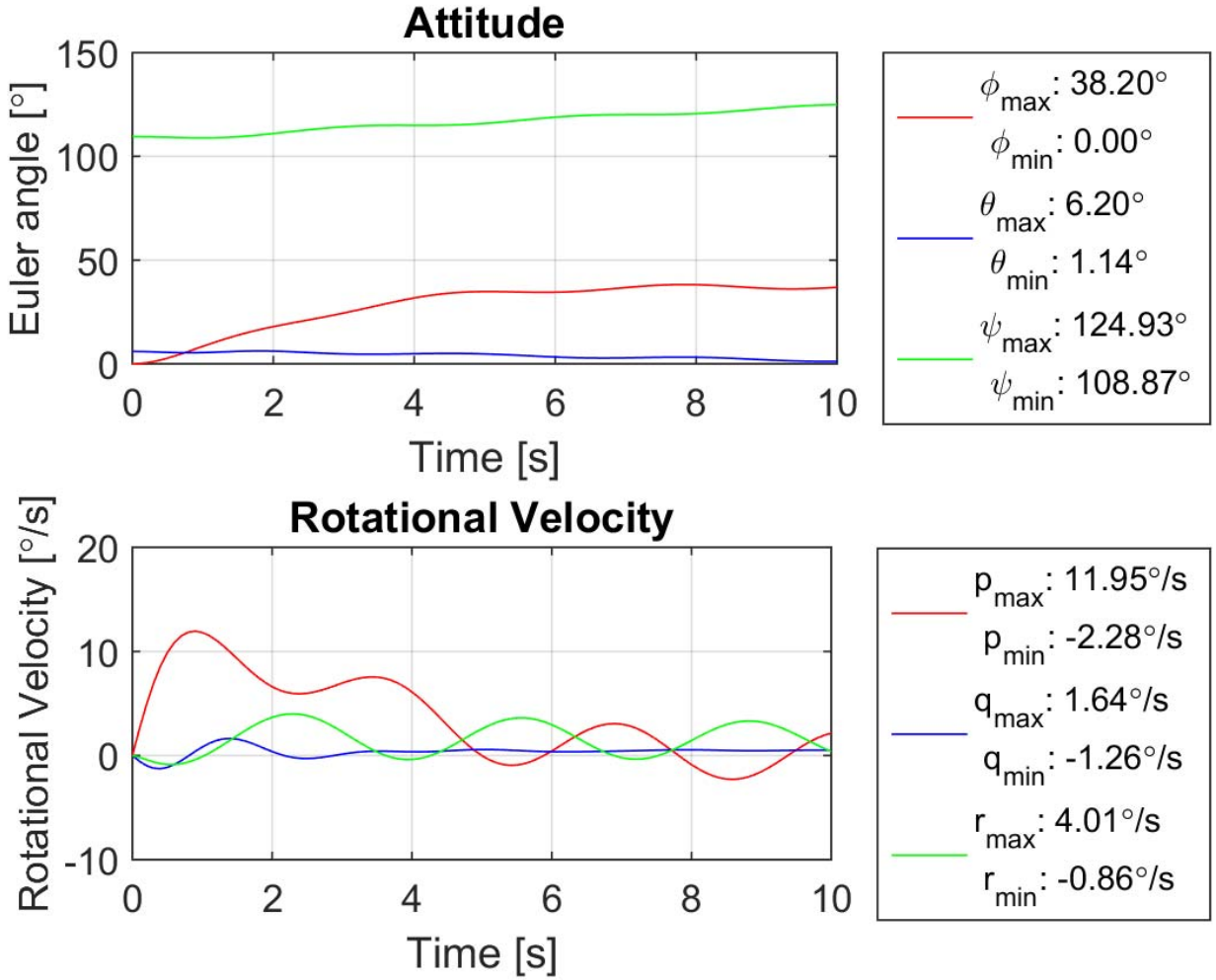
Controlled scenario



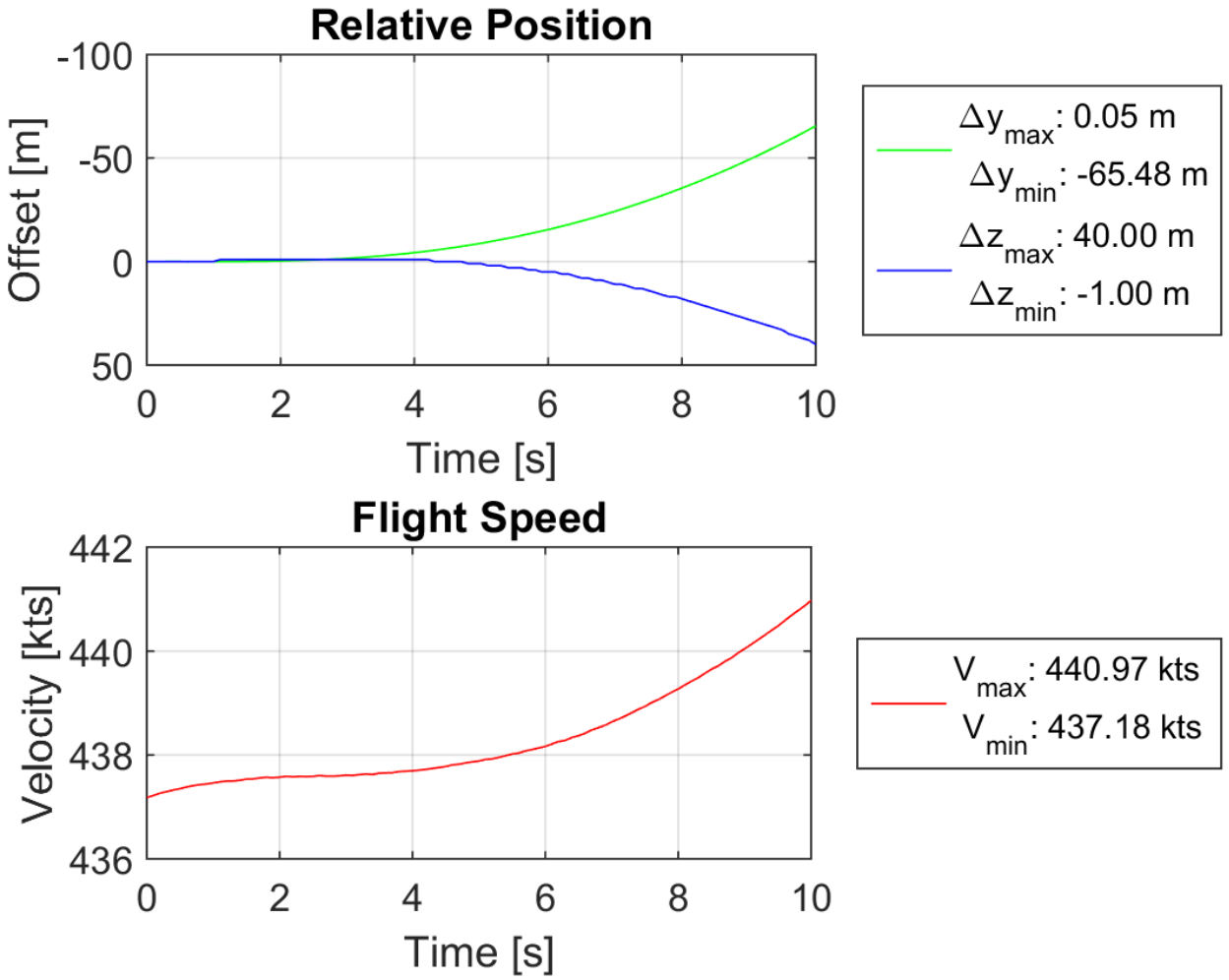
Altitude change	40 m
Bank angle	38.20º
Rate of Climb/Descent	12.617 m/s
Airspeed change	1.9492 m/s

Severity level 3 -> Major safety consequence'

Controlled scenario



Controlled scenario



Conclusions

- The integration test has been useful as a validation exercise of the R-WAKE framework, showing that the macro-scale framework is ready to be used and all its modules are working well together.
- No significant wake encounters have been found in the integration test scenario.
- The traffic sample is still not fully representative of the entire traffic demand patterns in the ECAC area

- The controlled scenario has shown that severe encounters with major consequences for either the crew, the aircraft, or both, can actually happen in the en-route environment

Future work

- Simulations traffic data sets that are more representative of the actual ECAC demand
- The hazard risk will be explored and benchmarked with the application of different separation standards
- A new separation standard will be defined and proposed to reduce over-conservative separations and to protect better the flights in some cases, if it is found necessary

Thank you very much
for your attention!

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SESAR WP-E Exploratory Research project #699247

Topic: Sesar-07-2015 Separation Management and Separation Standards

R-WAKE: Wake Vortex simulation and analysis to enhance en-Route separation management in Europe