Real-Time Safety Advising System in Reduced WV Separations Operation, as Developed in ATC-Wake

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Notes: presentation aimed at representing the work of all involved partners. V. Treve is at AIRBUS since October 1

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The ATC-Wake Project

**Consortium:**

- ATC Wake
- Information Society Technologies
- NLR
- DLR
- Eurocontrol
- Thales
- UCL
- Term

**User group:**

- NATS
- AECMA
- Airbus
- NASA
- Transport Canada
- Nav Canada
- Thales Air Traffic Management
Partners main activities

- National Aerospace Laboratory (NLR, coordinator)
  » Safety and Capacity Analysis and subsystems integration
- Deutsches Zentrum fur Luft- & Raumfahrt (DLR)
  » Weather and Wake forecasting and monitoring
- EUROCONTROL Experimental Center (EEC)
  » System requirement and Operational feasibility
- Thales Air Defence (TAD)
  » Weather monitoring and functional subsystems integration
- Thales Avionics (TAV)
  » Specification and design of “weather” and “wake” tools
- Université catholique de Louvain (UCL)
  » Wake forecasting
1. ATC-Wake: Objectives

2. Planning and Tactical Operations
   - Planning Operations
     » Separation Mode Planner (SMP)
   - Tactical Operations
     » “Predictor” System

3. Wake Vortex Predictors used in Tactical Operations
   - P2P
   - P-VFS

4. HMI: Wake Vortex Vector (WVV)
ATC-Wake: Objectives

Develop and build a wake vortex safety and capacity platform to:

- Evaluate interoperability with existing ATC system
- Assess possible safety and capacity improvement

This platform is an essential step that will lead to installation of an integrated ATC decision support system at airports, enabling air traffic controllers to apply new optimised weather based aircraft spacing.
Planning Operations and Tactical Operations (WP1000: System requirements)
On the basis of weather forecasting, the SMP forecasts a safe landing rate (typically 40 min. in advance). This requires weather persistence.
“Predictor” System

“Predictor” System means:

– the whole real-time subsystem used to assess the suitability of the separations provided by the SMP (ICAO or reduced)

– thus, not just the “WV prediction”

– It determines, in real-time, the part of the glide slope potentially affected by WV

– The information is provided to ATC, using a wake vortex vector (WVV)
“Predictor” System

1. Input data from:
   - Weather monitoring/nowcasting systems
   - Airport surveillance systems (radar, aircraft type, ID, transponder code)

2. Databases describing:
   - Airport layout (runways)
   - Aircraft characteristics (span, weights: MLW, MTOW, EMW)

Note: In the ATC-Wake “Virtual IP”, the various “data providers” are emulated
ATC-Wake Integrated Platform (V3.1)

- WAVIR (look-up table)
- Proposed separation mode and minima
- Selected separation mode and minima
- Supervisor HMI
- NOWVIV
- SKEWIND
- others
- Meteo Forecast
- Meteo Nowcast
- Traffic Situation
- VFS P2P
- WV Prediction Individually AC
- ATC-Wake Monitoring & Alerting
- Alarm
- LIDAR DOPVOR
- ATCo HMI
- Flight Plan
- Approach Controller
- Tower Controller
- Ground Controller
- HMI
- Supervisor
- AC Type
1. NOWVIV data

- 25 weather profiles along glide slope (from mesh grid points)
- From DLR databases (Wake-OP and Wake-TOUL campaigns)
2. **TAAM data** ("total airport and airspace management" simulator)
   - Airport simulation (provided by EUROCONTROL)
3. Radar data

- Radar emulator (made by THALES)

- The emulator uses TAAM data and provides aircraft positions (radar plots and tracks), with uncertainties, “as if they were measured by radar systems”
Input Data: summary

Airport layout used in the TAAM simulations merged with the NOWVIV mesh points.

TAAM simulations, extended by RADAR emulator.

Wake Vortex Predictor simulations.
Wake Vortex Predictors

P2P: “probabilistic two-phase”: probabilistic wake vortex transport and decay model (developed by DLR)

VFS: “vortex forecast system”: deterministic wake vortex transport and decay model (developed by partners from Russia (SABIGO), Belgium (Winckelmans of UCL) and Canada (OTI, Yaras of Carleton). Funded by Transport Canada (1994-2000)

P-VFS: upper software layer for “probabilistic use of the VFS” (developed by UCL)
Probabilistic use of the VFS

based on many VFS runs, using combinations of the uncertainties/variations (on aircraft, weather profiles, and modelling parameters)
Summary of Wake Vortex Behaviour Models

- **Transport**
  - Vortex-induced velocities
  - Cross and head-wind velocity profiles
  - Stratification effects
  - Wind shear effects (when significant vertical variation of cross-wind profile)

- **Critical demise time and Decay**
  - Based on EDR and/or on TKE
  - “Two-phase” decay models, “accumulated damage” models
  - also sensitive to stratification effects
  - also sensitive to wind shear effects

- **Ground Effects**
  - Models for inviscid Near Ground Effect (NGE)
  - Models for viscous In Ground Effect (IGE)
WV prediction using 2D gates, and 3D reconstruction using multiple gates
WV prediction using 2D gates, and 3D reconstruction using multiple gates.
WV prediction using 2D gates, and 3D reconstruction using multiple gates.

A case with head- and cross-wind.
Examples of WVP Validation Results (cases NGE/IGE)

Simulations against measurements

MEMPHIS case 1353
DFW case 20224
DFW case 20217

P2P

P-VFS
The length of the WVV is defined as the distance between the generator aircraft and the first gate considered as “vortex free”.

Wake Vortex Vector (WVV)
WVV: a case at CDG with parallel runways

Top view:

case with a lateral wind

Note: different axis scales!
WVV: a case at CDG with parallel runways

Side view:
ATC-Wake User HMI: Demo

Grid points where weather profiles are provided
ATC-Wake User HMI: Demo

Time = 1 h 12 min 53 s
ATC-Wake User HMI: Demo

Time = 1 h 15 min 25 s
Conclusions

- ATC-Wake “Predictor” system developed and tested, using a first version (in Labview, and with friendly user interfaces) of the Virtual Integrated Platform: the “Virtual IP”

- The output information is provided to ATCO through an HMI, using a “wake vortex vector” (WVV)

- The HMI has been validated, through a “tower simulator” campaign, involving controllers from three European countries (France, The Netherlands, Belgium) and pilots

- The results are preliminary. Yet they already show the potential of the system, even in complex weather/traffic situations

- The finalization of the Virtual IP is ongoing work, using middle-ware technology (SPINEware)
Further comments

• The WVV must be seen as an “advising tool” for the ATCO
  • as for “speed vectors” and “traces”
  • It is not a “control tool”
  • Various ATCO instructors also highlighted the interest of such platform (software only) in education of controllers on WV issues and awareness, for training sessions

• If pilots follow the ILS with more accuracy (as in the new “precision approach” concepts), the size of the critical area will decrease, and thus the length of the WWV