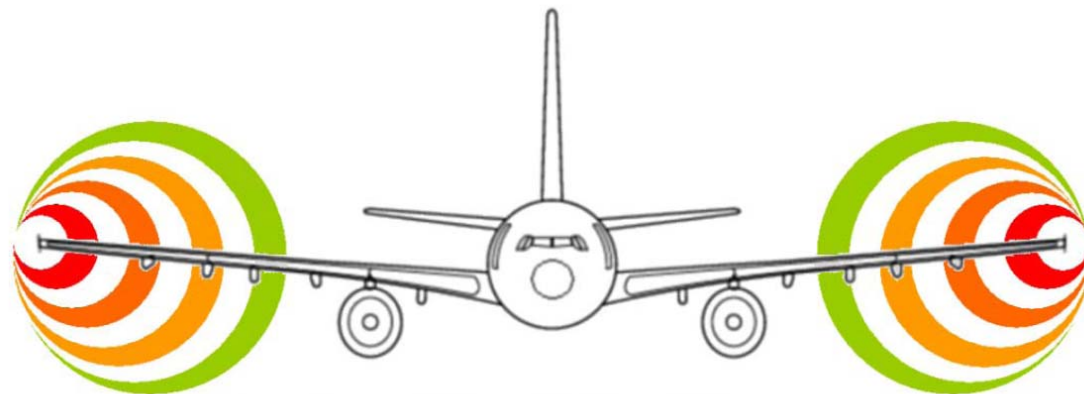


WakeNet3-Europe



Overview of active wake vortex concepts in Europe

October 2010



WakeNet3-Europe

A network on Aircraft Wake Turbulence

Prepared by Mr. Matt Ross

The NATS logo, featuring the word "NATS" in white capital letters on a background of colorful, wavy, concentric lines in shades of red, blue, and purple.

NATS

Contents

- In August 2009 a “Concepts Bulletin” was distributed to the wake vortex community with the intent on providing a summary of the major wake vortex concepts at the pre-implementation stage in Europe.
- This second edition of the Bulletin includes any recent developments and highlights.
- The wake vortex Groups and Concepts considered are:
 - **The European Wake Vortex Task Force (WVTF)**
 - **Crosswind concepts:**
 - **CREDOS, CROPS**
 - Wake Independent Departure and Arrival Operations (**WIDAO**)
 - SESAR WP6.8.1 and WP12.2.2
 - **Time-Based Spacing (TBS) and Transitional TBS**
 - **Wake vortex recategorisation (RECAT)**
 - **Wake vortex prediction/detection and avoidance projects**
 - **Greenwake**
 - **Weather & Flying**
 - **SESAR P9.11 and P9.30**



WakeNet3-Europe



- The Co-ordination Action **WakeNet3-Europe** promotes multidisciplinary information exchange between scientific and operational specialists in the field of **wake turbulence**.
- **WakeNet3-Europe** is funded by the European Commission within the 7th Framework Programme (2008 - 2012). It continues the work of WakeNet and WakeNet2-Europe and co-operates with other WakeNet projects worldwide (e.g. WakeNet-US, WakeNet-Russia).
- The aim of **Wakenet3-Europe** is to enable the development of a shared view on how to address capacity limitations caused by wake turbulence separations and how to assure air transport safety with regard to wake vortex encounters despite increasing air traffic density and increasing diversity of the operational aircraft fleet.
- For information about **Wakenet3-Europe** partners, deliverables, background, etc, please visit the website <http://www.wakenet3-europe.eu/>



WakeNet3-Europe



- **WakeNet3-Europe** is divided into three Co-ordination Areas, each of which comprise several Task Groups. Each Task Group deals with one specific wake vortex related issue and is lead by one **WakeNet3-Europe** Partner (see website for details).
- **Co-ordination Area 3** is focussed on **wake vortex concepts** and is led by **NATS**.
- A key objective of Co-ordination Area 3 is **"To provide information exchange between those working on wake vortex concepts, which are in the pre-implementation stage and operational stakeholders. This facilitates that appropriate scientific support is given to such concepts."**
- A **Bulletin containing updates and highlights** will be sent out to enable the dissemination of information about wake vortex concepts to operational stakeholders.



The EUROCONTROL Wake Vortex Task Force



- The **EUROCONTROL Wake Vortex Task Force (WVTF)** is a non-permanent group of the Airspace and Navigation Team and the Airport Operations Team formed in order to support; **Time-Based Spacing (TBS)**, Re-categorisation of the Wake Turbulence Separation Minima (**RECAT**) and **Crosswind Procedures** projects with technical and operational expertise.
- The WVTF co-ordinates development activities between EUROCONTROL and the FAA and facilitates the approach to ICAO for rule changes.
- The WVTF meet every six months and the last meeting took place on 2nd/3rd June 2010 in Brussels.
- A EUROCONTROL Wake Vortex website is currently in the process of being developed.



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Crosswind Concepts





Crosswind-REduced separations for Departure Operations (CREDOS) - Concept

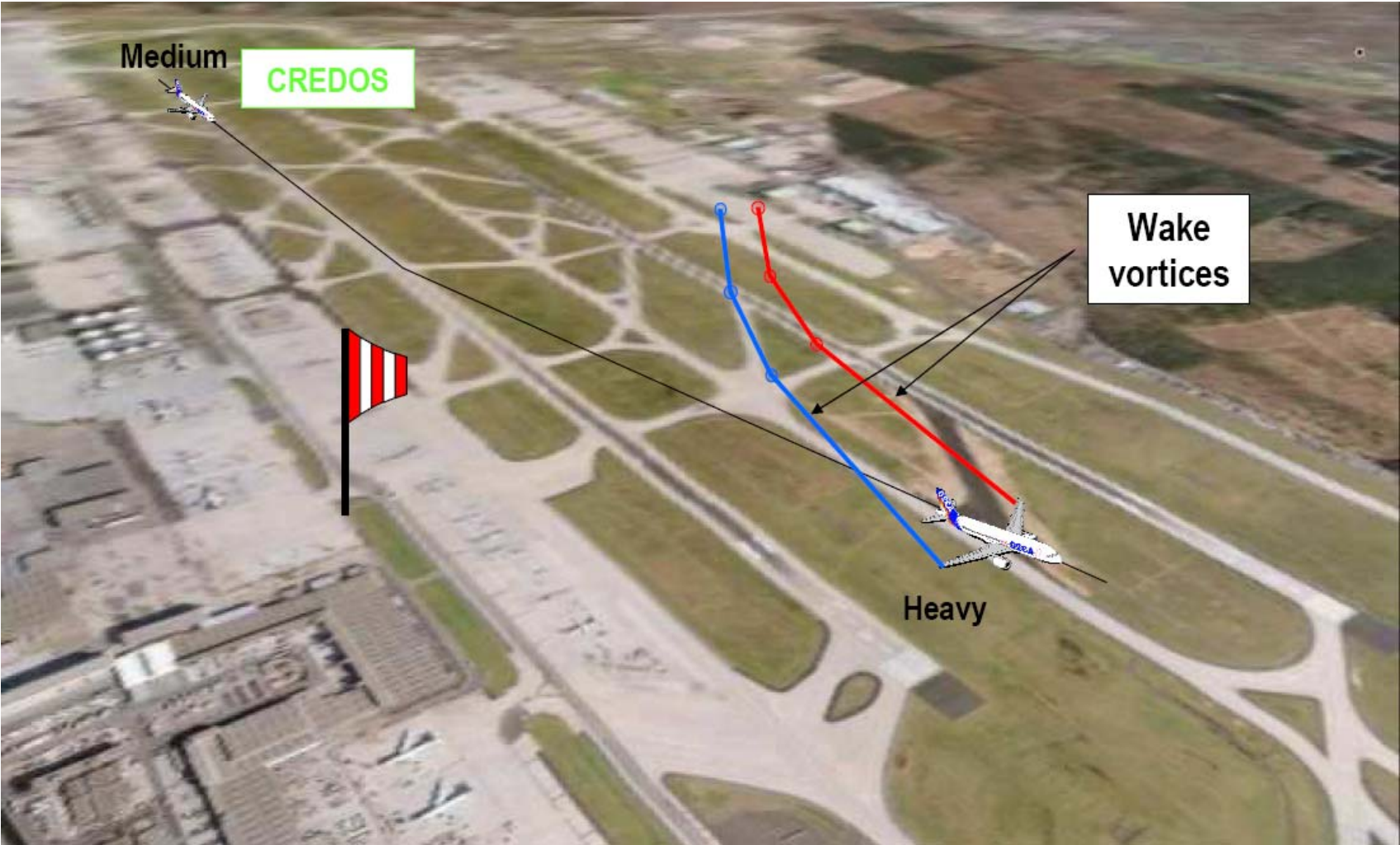
- CREDOS is a project of the 6th Framework Programme of the European Commission and is co-ordinated by EUROCONTROL.
- The CREDOS concept involves **suspending wake turbulence separations** under specific crosswind conditions for single runway departures.
- CREDOS assumes that a LIGHT, MEDIUM or HEAVY aircraft departing behind a HEAVY aircraft, or a LIGHT aircraft departing behind a MEDIUM aircraft, needs no wake turbulence separation in time or distance when crosswinds are supposed to be sufficient to transport any hazardous turbulence out of the track of a following aircraft.
- The benefit of CREDOS is to **temporarily increase the departure runway throughput** so that it absorbs capacity peaks or reduces departure delays. An increased departure throughput is mainly to be realised by reducing the separation to below the presently used 2 minutes, applicable for HEAVY-MEDIUM, MEDIUM-LIGHT and HEAVY-LIGHT aircraft combinations.
- The aim of the CREDOS project was to demonstrate whether this conditional approach to reducing separations is valid and feasible.
- Website: http://www.eurocontrol.int/eec/credos/public/subsite_homepage/homepage.html
- CREDOS Web portal: <http://www.credos-project.eu>



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CREDOS – Concept Illustration



CREDOS – Objectives and Deliverables



The **objectives** of the CREDOS project were to:

- Increase the body of knowledge relating to wake turbulence behaviour during the initial climb phase of flight. Of particular concern is the crosswind conditions under which the wake turbulence is blown laterally away from the runway, thus allowing a following aircraft to take-off sooner than is currently permitted by the ICAO standards.
- Develop, and then demonstrate the feasibility of a concept of operations allowing reduced separations for single runway departures under sufficient crosswind conditions.
- Provide all stakeholders with the required information to facilitate the implementation of the CREDOS concept of operations in the near-term (pre-2012).

The key **deliverables** of the CREDOS project are:

- A validated concept of operations for reduced separations for crosswind departures.
- End-users support packages & guidance.
- Enhanced wake vortex behaviour models and encounter risk models capable of use for departure situations.
- Proven wake vortex detection configuration for departures.
- Database of wake vortex recordings for departures including meteorological conditions from two sites.
- Documented application of validation.



CREDOS – Developments



- The CREDOS R&D project was completed in November 2009 when a final dissemination forum was held in Chantilly near Paris.
- Deliverables from the project include:
 - Generic concept of operations for reduced separations in crosswind departures.
 - End-users support packages and guidance.
 - Enhanced wake vortex behaviour models and encounter risk models capable of use for departure situations.
 - Database of wake vortex recordings for departures including meteorological conditions from two sites.
 - Human Factors, Safety, Business and Environmental Cases.
- Project concluded a minimum of **7 knots** surface crosswind is required to assure that the wake turbulence is either transported away from the runway centreline or decayed sufficiently that it does not cause a risk.
- Benefit assessment concluded CREDOS would enable an additional **3 to 5** departing aircraft per hour, depending on traffic mix.
- Note that the concept assumes that a **local validation** will be carried out by a collection of measurement data with LIDAR and wind meters. This will be necessary to prove that a safe crosswind component can be determined for the runway and first part of the climb path.



CROPSwind Operations (CROPS) - Concept



- CROPS is a new EUROCONTROL implementation project (SESAR IP1) focused on runway use optimisation by conditional reduction of separations for departures and/or arrivals in crosswind conditions.
- CROPS is a natural follow on from the CREDOS R&D project, but also includes elements of the ATC-WAKE concept of operations for arrivals.
- The main driver of CROPS is congestion at major airports and fixed ICAO separations (not weather dependent).
- The scope of the CROPS project is to propose a change in the current ATM procedures that enables ATC controllers to reduce separations without any support of a new ATC controller tool.
- CROPS will provide a transitional step towards SESAR IP2 related operational improvements to be addressed by the SJU project P6.8.1 in Phase 2 - Weather Dependent Separations (WDS).
- Reduction in wake turbulence separation for departures will result in spacing between 60s – 100s depending on SID layout and selection.
- Reduction of wake turbulence separation for arrivals is proposed to be 0.5Nm for all wake turbulence separated aircraft pairs.



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Crosswind Operations (CROPS) - Developments



- CROPS project management plan was delivered in Q1 2010.
- Initial generic concept of operations complete and presented at the EUROCONTROL WVTF in June 2010.
- Validation of the generic CROPS concept will be conducted by EUROCONTROL and should lead to preparation of the Preliminary Safety Case.
- Benefit study was conducted in Q2 2010 and it shows promising benefits for busy airports.
- Local adaptation will be addressed by the group of UK stakeholders (BAA, NATS, UK Met Office, UK CAA).



Wake Independent Departure and Arrival Operations (WIDAO) - Concept

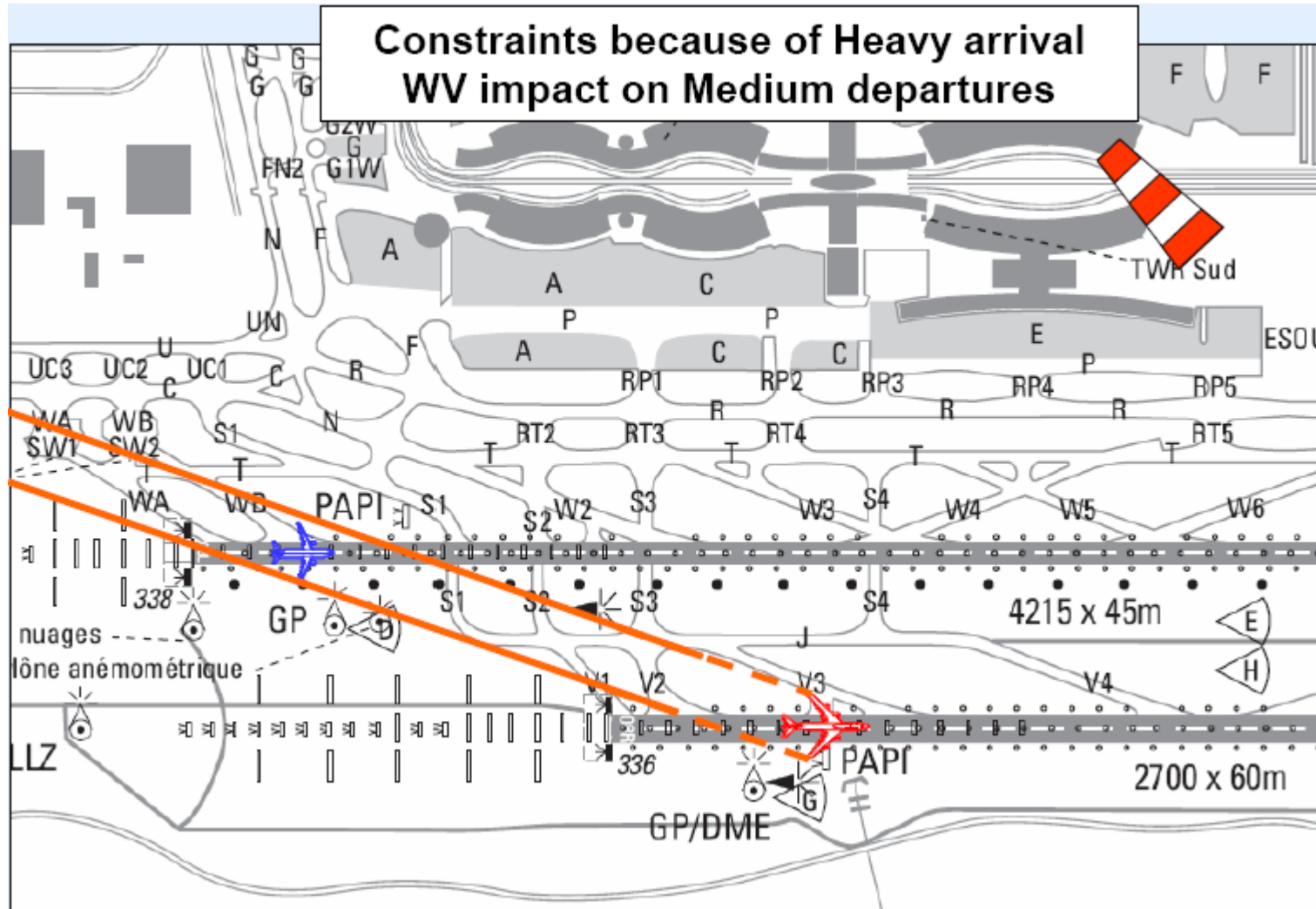
- The purpose of the WIDAO concept is to **relax constraints limiting the efficiency of closely-spaced parallel runway (CSPR) operations.**
- The WIDAO concept is a joint study between EUROCONTROL and DSNA (French ANSP).
- The study concentrated on Paris CDG airport where there are two CSPRs for departing and arriving aircraft. Departing aircraft on one of the runways had to join further down the runway to avoid wake turbulence from aircraft arriving on the adjacent runway.
- The aim of the concept is to allow aircraft to enter at the start of the runway by demonstrating that wake turbulence from aircraft landing on the adjacent runway does not present a significant risk on departure (see schematic on next slide).
- The EUROCONTROL WindTracer was installed on the roof of the K-bis tower at CDG in March 2007. It measured the behaviour of wake vortices generated by arriving traffic and the headwind along the last 4 to 8Nm of the glideslope. Data collection continued until June 2008.
- Initial analyses of the data showed that any vortices detected on the departure runway that had been transported from the arrival runway had decayed to a low-strength.



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WIDAO – Concept Illustration



WIDAO – Developments

Project findings

Segregated mode operations are safe because:

- Wake vortices vanish before reaching the CSPR.
- Aircraft rotated after the point the wake vortex reached the CSPR.
- Wake vortices encountered on the CSPR are comparable to wake vortices encountered in trail of landing aircraft at ICAO separation.
- The first phase of the Safety Case was presented to the French regulator (DGAC) in 2008 and was approved.
- First and second set of constraints were relaxed in November 2008 and March 2009, respectively (aircraft entered runway at an earlier point).
- Intention was to submit final safety case for relaxing third set of constraints in February 2010 assume this is now complete.
- CSPRs at Paris CDG now treated as independent.
- Hoped this will benefit other CSPR structures in Europe – generic safety case will be made available at a later date.
- For more information on WIDAO:

<http://www.eurocontrol.int/corporate/gallery/content/public/events/080916wakevortex/Widao.pdf>



Time-Based Spacing (TBS) – Concept

- The TBS concept aims to prevent the loss of runway arrival throughput, due to strong headwind conditions, whilst maintaining the required levels of safety.
- The TBS concept **would replace the existing Distance-Based Separations (DBS) with the equivalent minimum time intervals** between successive arrivals while on final approach. This would compensate for the reduction in runway capacity observed during strong headwind conditions with DBS.
- The application of minimum TBS intervals on final approach will enable ATC to sustain runway arrival throughput rates in all headwind conditions at values close to the throughput rates achieved in calm wind conditions with DBS.
- The concept is beneficial for capacity-constrained aerodromes where there is a high arrival demand.
- The TBS project is co-ordinated between EUROCONTROL and NATS, whereby NATS are currently developing a local validation case specifically for adopting TBS operations at London Heathrow Airport.



Eurocontrol contact: David Booth [david.booth@eurocontrol.int]

UK NATS contact: Charles Morris [charles.morris@nats.co.uk]



Time-Based Spacing – Project Status (EUROCONTROL)

- The TBS concept of operations is almost complete, but discussions are taking place between NATS and EUROCONTROL to agree on the definition of TBS - **Ongoing**
- **Initial safety case work** has been undertaken; **real-time simulations** have been carried out; **TBS modelling work** has been performed including missed approach considerations - **Complete**
- Fast-time simulations to be carried out - **Q1 2010**
- First Functional Hazard Assessment workshop – **Q1 2010**
- Operational trials - **TBD**
- Preliminary Safety Case - **Q3 2010**
- Proposals to ICAO – **Expected at the end of 2011**
- Co-ordination between NATS and Eurocontrol - **Ongoing**



'Full' TBS for Arrivals (Heathrow) – Developments

- NATS' Activities will utilise SESAR P6.8.1. Phase 1 TBS for validation as far as practical.
- Additional localised tailoring is also necessary to consider local implementation issues.
- Data collection on final approach at Heathrow using EUROCONTROL WindTracer LIDAR unit to measure wake vortices in or near ground effect. (IGE/NGE) – Successful data collection : measurement is ongoing prior to relocation.
- TBS validation activities ongoing (Heathrow Approach simulation Sept/Oct).
- Data collection for OGE is planned to start in Nov 2010.
- Safety activities ongoing (being re-planned to align to SESAR P6.8.1).



Procedural/Transitional TBS for Arrivals – Developments

- Transitional TBS concept involves reducing current DBS minima by 0.5Nm when the headwind exceeds XX kts.
- Procedure seen as interim measure while full TBS and necessary tools in development.
- Transitional TBS does not require introduction of additional controller support tools (it is anticipated that only surface wind indications will be required).
- Initial concept of operations for transitional TBS developed by EUROCONTROL and presented at EUROCONTROL WVTF in June 2010.

Headwind component XX kt		
Aircraft category		
Preceding aircraft	Succeeding aircraft	Distance-based wake turbulence separation minima
HEAVY	HEAVY	3.5 NM
	MEDIUM	4.5 NM
	LIGHT	5.5 NM
MEDIUM	LIGHT	4.5 NM

- LIDAR data collected at both Paris CDG and London Heathrow will be used to validate the transitional step.
- Safety plan under development and safety case will follow.



SESAR P6.8.1 – Flexible and Dynamic Use of Wake Turbulence Separations – Concept



The objective of P6.8.1 is to develop solutions to:

- Permanently provide arrival capacity resilience to challenging wind conditions to redress the current impact of such conditions on the achieved capacity (TBS).
- Conditionally provide arrival and departure throughput increases in favourable prevailing meteorological conditions to more efficiently handle peaks and queues in arrival and departure demand (WDS).
- Permanently provide arrival and departure capacity increases across all conditions for both more contingency provision for non-nominal conditions and more provision for capacity declaration across all conditions (PWS).



SESAR P6.8.1 – Project Tasks in 2010



- Task 3 – High Level OCD Definition (Eurocontrol) – **Ongoing**
 - Covering all 3 Phases and requiring airspace users and stakeholders review.
- Task 4 – High Level OSED Definition (Eurocontrol)
- Task 5 – TBS – State Concept and Assumptions (NATS)
- Task 6 – TBS – Set Validation Strategy (Eurocontrol)
 - Identify stakeholders and key performance areas.
 - Establish initial validation strategy and selecting appropriate validation tools & techniques.
- Task 7 – TBS – Determine the Exercise Needs (NATS)
 - Identifying stakeholder acceptance criteria and validation objectives.
- Task 8 – Research on WV Encounter Severity Metrics (Airbus) – **Ongoing**
 - Results to be incorporated in Phase 2.
- Task 9 – Permanent Data Collection – **Ongoing**
 - LIDAR, MET and OPS data collection ongoing.
 - LIDAR to be relocated in the near future.



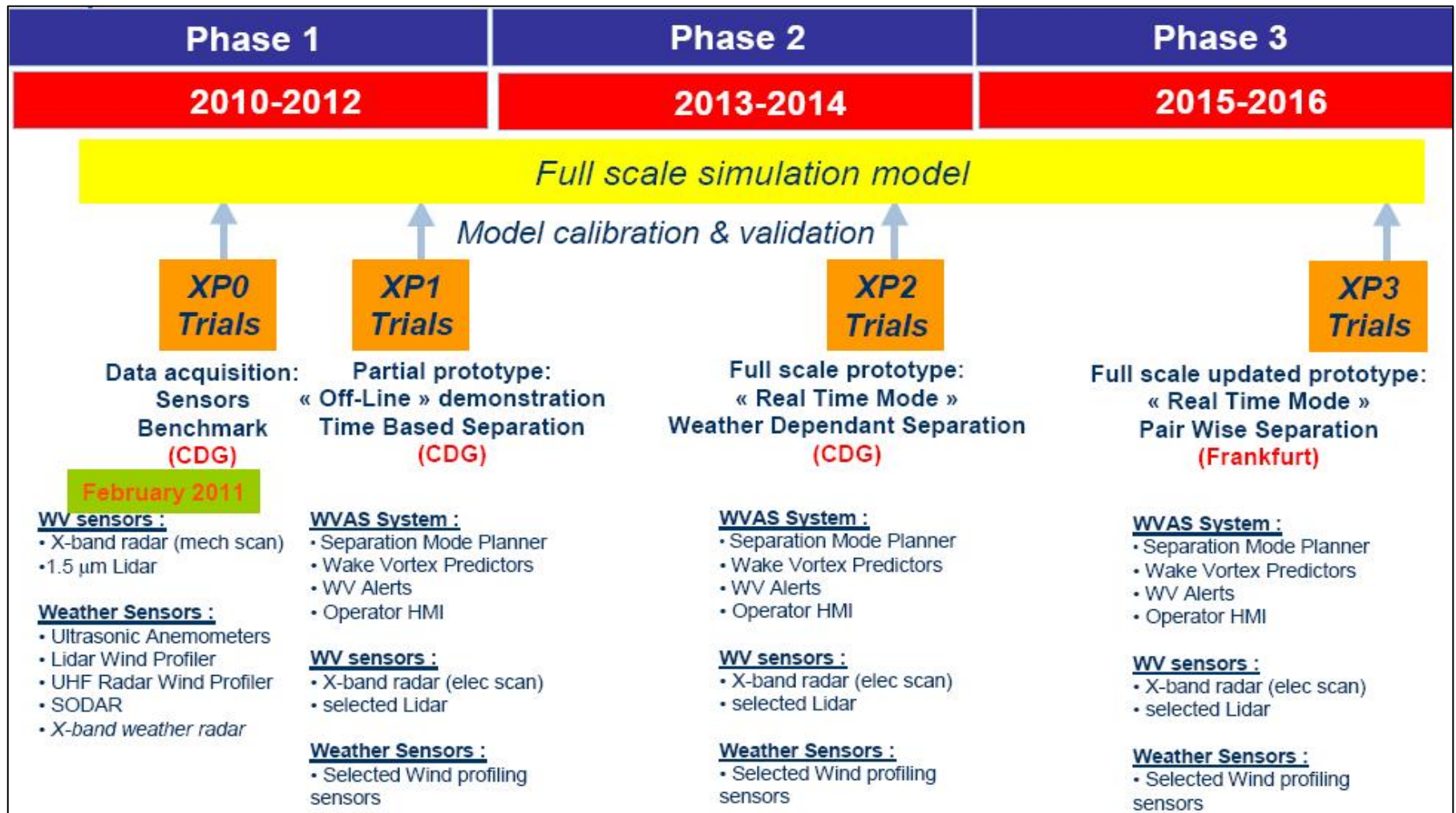
SESAR P12.2.2 – Runway Wake Vortex Detection, Prediction and Decision Support Tools – Concept



- The aim of P12.2.2 is to:
 - Develop and verify a Wake Vortex Decision Support System (WVDSS) according to the operational concept defined by P6.8.1.
 - Safely reduce final approach and departure wake vortex separations so that the runway throughput is increased and hence decrease delays.
- The WVDSS must be able to deliver in real time:
 - Information regarding the position and strength of the wake vortex.
 - A prediction of WV behaviour and the impact on safety and capacity.
 - Advice to stakeholders.
 - Taking into account MET information, aircraft characteristics and airport layout.
- The final WVDSS version will enable the validation of the concept to be deployed at airports with different runway layouts.

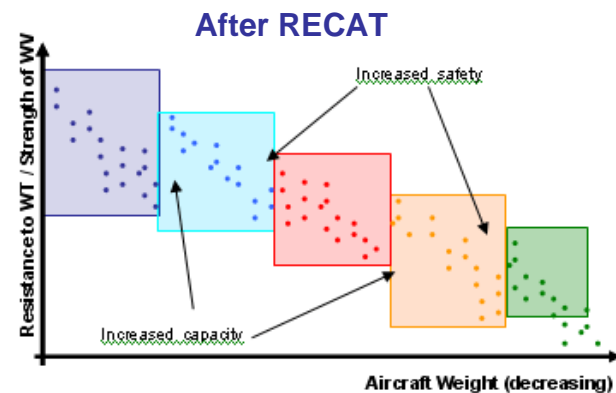
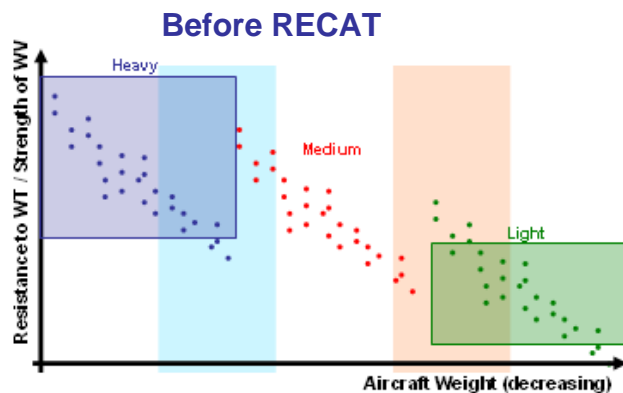


SESAR P12.2.2 – Project Overview



Revising wake turbulence categories to gain capacity (RECAT) – Concept

- RECAT is a EUROCONTROL-FAA initiative to increase capacity at airports through **redefining wake turbulence categories** and the associated minimum separations with the same or improved level of safety.
- RECAT will propose ICAO make an amendment to the existing wake turbulence categories and their associated prescribed separations.
- These new separations will be assessed using the latest models for wake behaviour, as well as models that estimate the impact of the wake on the following aircraft.



- For more information on RECAT:

http://www.eurocontrol.int/eec/public/standard_page/EEC_News_2008_3_RECAT.html



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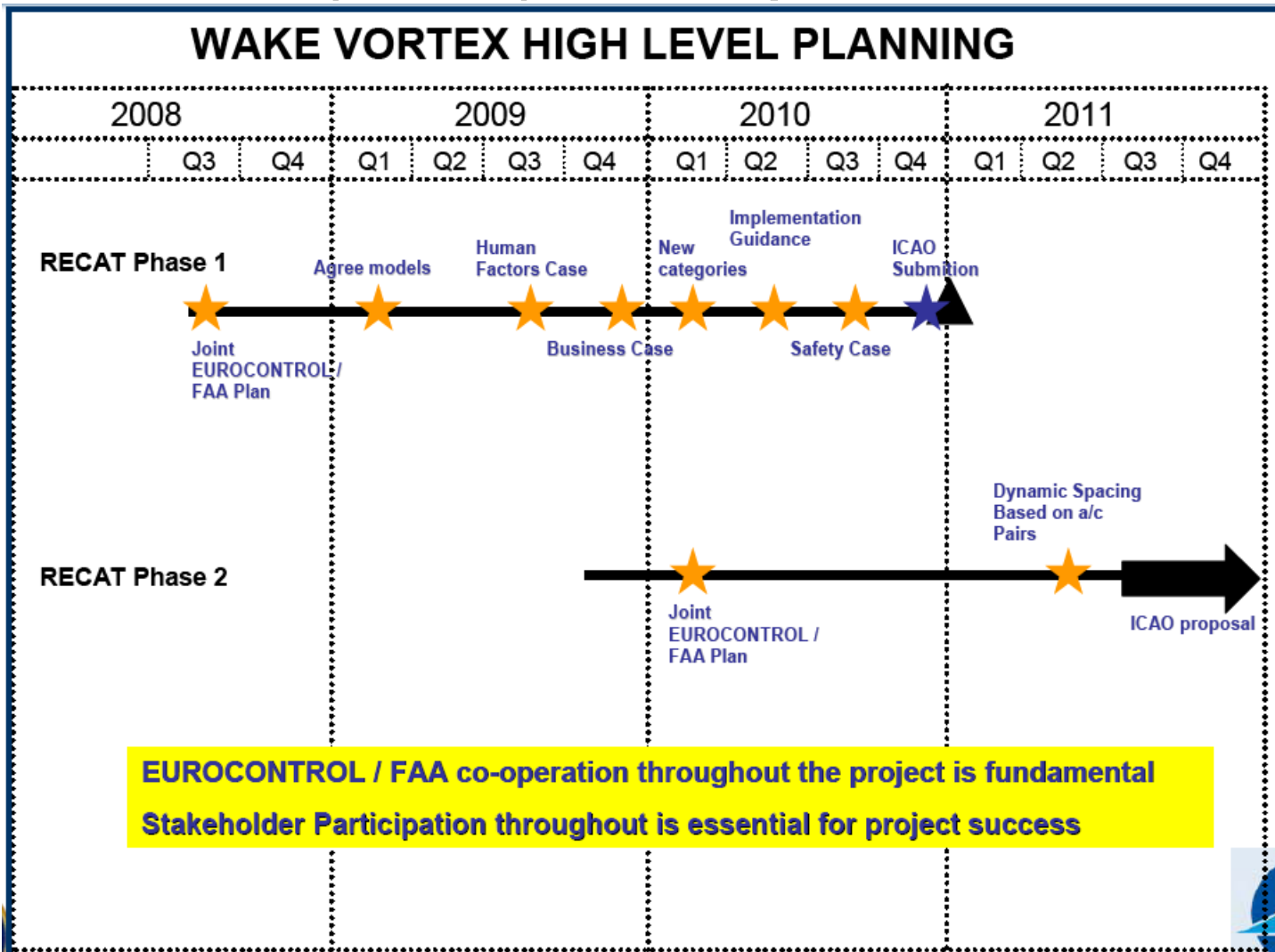


Revising wake turbulence categories to gain capacity (RECAT) – Developments

- First proposal of RECAT categories (although subject to change following safety assessment) has been completed.
- Grouped 61 a/c types (responsible for 80% of the European and American traffic).
- Methodology has been developed to classify the remaining 9000 a/c types described in ICAO Doc 8643.
- Complete benefit and safety assessments on the proposed set of revised wake separation distances/times and associated sets of aircraft groupings – **Q3 2010**.
- Complete documentation required for submittal of the proposed revised wake separation standards to ICAO – **Q3 2010**.



Revising wake turbulence categories to gain capacity (RECAT) – Developments



EUROCONTROL / FAA co-operation throughout the project is fundamental
Stakeholder Participation throughout is essential for project success

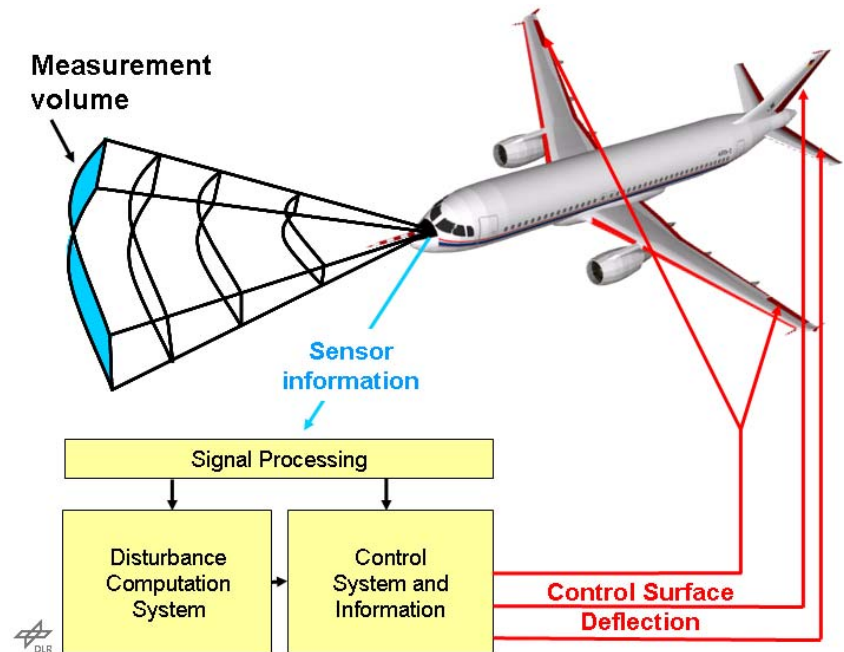


Wake turbulence prediction, detection and avoidance projects and concepts



Green-Wake - Concept

- Green-Wake is a three-year EC project of the 7th Framework Programme. It is due to complete by Summer 2012.
- The objective of Green-Wake is to develop and validate innovative technologies that will detect wake vortex and wind shear hazards in a timely manner.
- Green-Wake will develop and test an Imaging Doppler LIDAR system that is capable of detecting wake vortices and wind shear phenomena of the order of 50-100 metres in front of an aircraft allowing action to be taken to reduce or avoid the hazard.
- The aim of the project is to develop a system suitable for integration into a commercial aircraft, but also to look at how data are to be presented to the aircrew.
- The main products from the project are:
 - 1) A simulator which will allow the investigation and optimisation of the system which is to be built;
 - 2) The system itself which will be designed, built and evaluated within the project.



Contact: Steve Bowater [sbowater@sula.co.uk]



Green-Wake – Developments



- The Green-Wake consortium has established the user requirements.
- The Wake Vortex and Wind Shear Simulator is nearing completion.
- A Doppler LIDAR system concept has been developed and a prototype will be built during the second and third years of the project.
- GreenWake co-hosted a two-day workshop with WakeNet3-Europe on Ground/On-Board Wake-Vortex & Wind Monitoring Sensors in March 2010.
- Plans to create wake vortices and wind shear in a wind tunnel have been developed.
- At the end of the project, public dissemination will be organised to share the results, promote discussion within the wake vortex community and to solicit comments and inputs for further work.
- Further information on the project and contact details can be found on the Green-Wake project website at www.greenwake.org. The Green-Wake consortium would welcome comments from and contact with anyone interested in the project.



SESAR P9.11 & P9.30 – Concept



There are two WV projects contained in SESAR WP9 – ‘Aircraft Systems’ both of which officially started in June 2010. Airbus is the sole member in both projects.

- P9.11 – Aircraft systems for wake encounter alleviation.
- P9.30 – Weather hazards/Wake vortex sensors.

The project goal is to advance concepts for on-board systems for the prevention of severe wake encounters, providing two interacting and complementary Wake Encounter Prevention Systems (WEPS):

1. On-board wake encounter prediction, alerting and avoidance system (P9.11):

WEPS-P

- Identification of potential wake encounters based on air-to-air datalink and model-based prediction.
- Determination of small scale avoidance manoeuvre.

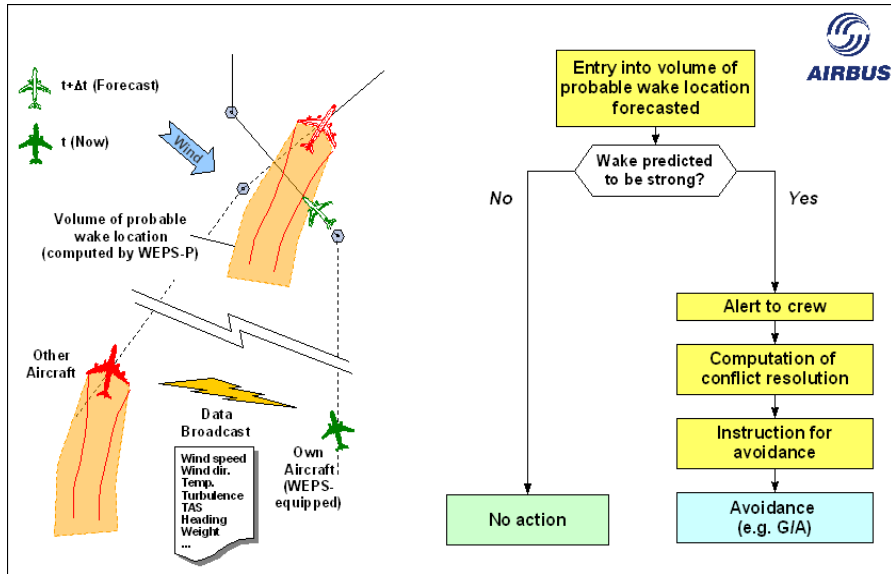
2. On-board wake encounter alleviation system enabled by detection (P9.30):

WEPS-C

- Alleviation of wake encounter upsets through dedicated flight control function.
- More robust, less vulnerable aircraft.



SESAR P9.11 & P9.30 – Concept



WEPS-P:

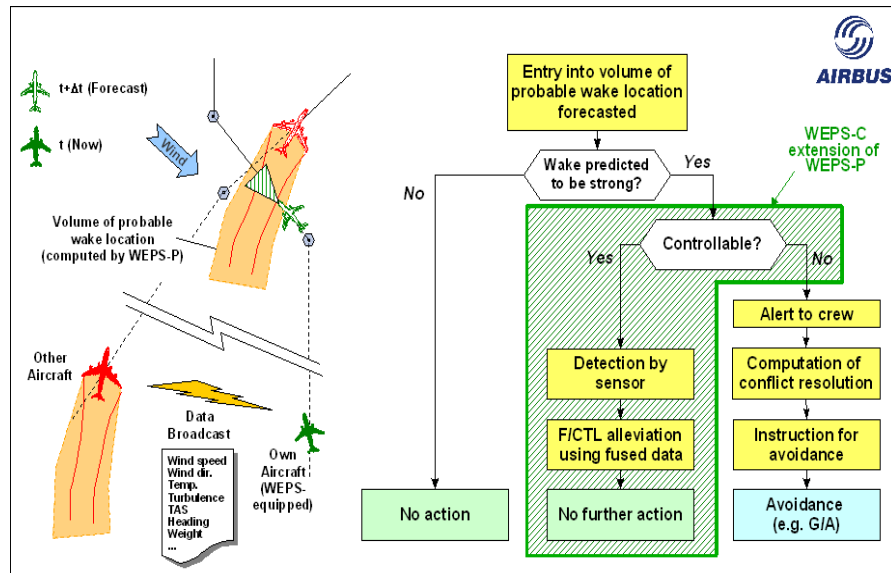
Prediction, alerting and avoidance system (P9.11)

- Prediction of evolving wakes by surrounding aircraft using probabilistic wake prediction models & broadcast of traffic and MET data to WEPS equipped aircraft.
- Conflict detection of geometrical conflicts between intended flight path and wakes.
- Conflict resolution by e.g. vertical/lateral manoeuvre, speed adjustment, go-around.
- HMI and interaction with existing systems.

WEPS-C:

Encounter alleviation system enabled by detection (P9.30)

- Alleviation flight control using characterisation of the wake to allow reduction of the effect of the wake on the aircraft.
- New forward looking, short-range LIDAR sensor capable of measuring line-of-sight velocity enabling wake characterisation.
- Extension of WEPS-P concept.

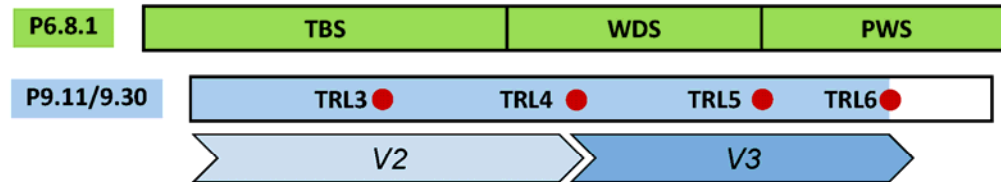


SESAR P9.11 & P9.30 – Project Overview



Scope of SESAR projects:

- Advance WEPS-P and WEPS-C concepts by 2016
- Develop the concepts towards operational feasibility and acceptance including:
 - ConOps development
 - Development of HMI and operating procedures
 - Evaluation of system level behaviour and performance



TBS: *Time-Based Separations*

TRL: *Technology Readiness Level*

WDS: *Weather-Dependent Separations*

PWS: *Pair-Wise Separations*

- Consideration of the concepts in the SESAR P6.8.1 Operational Concept for Pair-Wise Separations

Outside of SESAR scope:

- Development of a forward-looking wake detection sensor
- Full-scale integration with other aircraft systems
- Flight tests



Wetter & Fliegen (Weather & Flying) – Concept



- Weather & Flying is a four-year project of DLR, which started in January 2008.
- The two key aims of the project are:
 - To provide timely, tailored and concise meteorological information, especially for adverse weather, to ATC, airline operating centres, pilots and airports.
 - To build automated flight control systems and design evasion-manoevre methods to minimise the impact of adverse wind & wake conditions on aircraft.
- Detection and forecast of weather phenomena (including wake vortices) will be achieved by setting up an Integrated Terminal Weather System (ITWS) at Frankfurt & Munich airports.
- Weather & Flying will continue development of DLR's **WSVBS** wake vortex advisory system.
- WSVBS supports **dynamic adjustment of aircraft wake vortex separations** dependent on weather conditions and the resulting wake behaviour without compromising safety. This aims at a tactical increase of airport capacity for approach and landing.
- WSVBS uses prediction tools and dedicated meteorological information. Wake vortex prediction is conducted with the Probabilistic Two-Phase (P2P) wake vortex decay model.
- A LIDAR monitors the correctness of WSVBS predictions in the most critical gates at low altitude.



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Weather & Flying/WSVBS – Developments



- WSVBS demonstrated its functionality at Frankfurt Airport for closely spaced parallel runways from 20th December 2006 to 28th February 2007.
- A description of the design and performance of the WSVBS has been published in Air Traffic Control Quarterly, Vol. 17, No. 4, 2009, pp. 301 - 346.
- The elements of WSVBS are generic and can be adapted to other runway systems & airports.
- Recently, the WSVBS has been adapted for landings of time-spaced individual aircraft pairings on single runways. Improved weather prediction skill has been achieved employing time-lagged-ensemble prediction systems with assimilation of local meteorological measurements.
- The advanced WSVBS has demonstrated its functionality at Munich airport during a field measurement campaign in July-August 2010.
- Further planned activities for WSVBS in Weather & Flying are:
 - Preparation for implementing WSVBS at an airport.
 - Risk analysis and assessment of capacity gain of WSVBS.
 - Proposal for re-categorisation of aircraft according to wake vortex separation.
 - Components of WSVBS will also to be developed and tested within project 12.2.2 of the SESAR-Joint Undertaking.



For more information: <http://www.pa.op.dlr.de/wirbelschleppe/>



WakeNet3-Europe



If you have any questions about the content of this bulletin please contact Matt Ross at:

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Alternatively, for more detailed information about one of the wake vortex concepts featured, please contact the technical leader for the concept listed.

