WakeNet3-Europe

Grant Agreement No.: ACS7-GA-2008-213462

Deliverable D-4.01

Report 1 from Link activities and Trips

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Work Package: 4

Dissemination level: .....PU

Version: .....Final Report

Issued by: .....EUROCONTROL

Reference: v1

Date: .....12th March 2010

Number of pages: 41

Project acronym: WakeNet3-Europe

Project full title: .....European Coordination Action for Aircraft Wake Turbulence

Project coordinator: .....Airbus Operations S.A.S (*)

Beneficiaries:		
	A-F	Airbus Operations S.A.S (*)
	TR6	Thales Air Systems
	THAv	Thales Aerospace
	DLR	Deutsches Zentrum für Luft- und Raumfahrt
	NLR	Nationaal Lucht- en Ruimtevaartlaboratorium
	DFS	DFS Deutsche Flugsicherung GmbH
	ONERA	Office National d'Etudes et Recherches Aérospatiale
	NERL	NATS En-Route Plc.
	UCL	Université catholique de Louvain
	TUB	Technische Universität Berlin
	ECA	European Cockpit Association
	TU-BS	Technische Universität Braunschweig
	A-D	Airbus Operations GmbH

(*) pending formal change of contract.

Document Revisions

Version	Date	Modified page(s)	Modified section(s)	Comments
0.1	5th Feb 2010			Initial draft for review
0.2	22nd Feb 2010	7, 9, 33, 37-44	2.1, 3, and 10	Updates from A-D: - Minor corrections for sections 2.1 and 3 - Section 10 is replaced by an inserted "pdf" file at the end of section 5.3.
		14	5.2	Input from DFS
		29-30	7.4	Input from TR6 about the OPTIMAL project
		14-15	5.1	Input from NLR about the Amsterdam LSG
		20-21	6.2	Input from NLR about the link with the Rulemaking authorities
				Inputs and corrections from NERL to all sections
1.0	12th March 10	37	7.7	Correction from NLR
		10-11	4.1, 4.2	Minor corrections from A-D
		35-36	7.6	Change proposed by A-D, Addition of cruise flight phase work for the A380
		1	-	Title according to DoW

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1. Executive Summary

The Coordination Action WakeNet3-Europe promotes multidisciplinary exchange between scientific and operational specialists in the field of wake vortex turbulence. It enables the development of a shared view on how to address capacity-related issues caused by wake turbulence.

It was established to continue the Thematic Networks WakeNet and WakeNet2-Europe.

This report refers to the Link activities that have been built in order to: (1) widen the WakeNet community or (2) communicate about the results, or the needs of the community itself.

A first effort is provided via the WakeNet3 website (http://wakenet3-europe.org/index.php?id=9) that provides information about the various activities undertaken by the different partners, and through the WakeNet3 workshops, which, every year, allow WakeNet3 partners to present their work, meet other experts and promote discussion. These workshops are also an opportunity to invite partners from other networks working on wake vortex turbulence, including outside Europe, or also to communicate to ATM experts with an operational or regulatory concern.

Under the auspices of WakeNet3, different Links were thus established:

- **Outside Europe**:
-
    - With the FAA and “WakeNet USA”, which has led to many working partnerships (e.g. CREDOS FP6 project), and even joint working groups on specific issues (e.g. Wake turbulence separations behind the A380, Revision of the wake turbulence categories - RECAT).
    - With “WakeNet Russia”
    - With Canada

    Efforts are made to strengthen the working partnerships with other WakeNet communities (e.g. Russia) but also to broaden the collaboration to participants from new countries (e.g. China, Japan, etc.) within a “Global WakeNet”. A first Global conference on Wake vortex issues has already taken place in Brussels, on 9-10 November 2009, to set up the basis for further activities. ICAO has granted its full support to this objective of global harmonisation and a common objective for the vortex work that is presently underway. Moreover, the future “Global WakeNet” workshops could be convened under the auspices of the ICAO wake turbulence study group, which is scheduled to be established during 2010.

- **With local stakeholder groups, pilot associations and regulatory authorities**: to increase the auditory amongst European ATM operational experts. EUROCONTROL has also established a specific Wake Vortex Task Force that reports on the status of possible operational solutions to alleviate the wake turbulence separation constraints, and allows exchanges on possible issues that would need further investigation from the European WakeNet community.

- **Within different European projects**: most of these FP projects have involved several partners from Wakenet3, and their results have been communicated via, either specific dissemination workshops or via presentations during the various Wakenet3 Europe workshops. These projects are now over and their findings will be further developed within SESAR P 6.8.1 for the ATM operational concept and user requirements; in P 12.2.2 for the verified ground-based wake turbulence system, and in P9.11 and P9.30 for airborne wake turbulence warning, avoidance and alleviation systems. Following the same principles as those that were considered to set up a “Global WakeNet”, the link between SESAR Joint Undertaking activities and the outside world is under consideration as it was agreed by all partners that it had to be.

2. Presentation of the Link Activities

2.1. Terms of Reference

The following explanation can be found in the description of work of Wakenet3 Europe [1]

Links are used to establish and sustain contacts with specific organisations and groups that are active in the area of wake turbulence. The following types of link are established:

- Links to non-EU activities (US, Canada, Russia etc.)
- Links to Local Stakeholder Groups at large airports
- Links to specific organisations and groups (rulemaking authorities, pilots)
- Links to projects

The links shall provide information in both ways. Besides personal contacts, contributions to the yearly report, visits (requiring trip reports) and contributions to conferences or workshops substantiate a link. One WakeNet3-Europe partner is tasked for each link, but, if necessary, he can engage other partners or beneficiaries to provide additional information or for specific contacts. See Table 1 for all links. More links may be created during the runtime of WakeNet3-Europe when new projects etc. appear; other links may disappear instead when projects end.

Type of link	Link	WP	Responsible partner
Non-EU activities	USA	WP4.1	EEC
	Canada	WP4.2	UCL
	Russia	WP4.3	A-D
Local stakeholder groups	Amsterdam	WP4.4	NLR
	Frankfurt	WP4.5	DFS
	UK Wake Encounter Working Group	WP4.6	NERL
	Paris	WP4.7	TR6
Organisations	Pilots	WP4.8	ECA
	Rulemaking authorities	WP4.9	NLR
Projects	CREDOS	WP4.10	A-D
	FLYSAFE	WP4.11	THAv
	FAR-wake	WP4.12	UCL
	OPTIMAL	WP4.13	TR6
	Weather and Aviation	WP4.14	DLR
	A380 operational activities	WP4.15	A-D
	SESAR	WP4.16	EEC

Table 1: Wakenet3 – Europe Links

2.1.1. Links to non-EU Activities

Since mid 2002 there exists an Action Plan (AP-14) “Joint co-operation on wake vortex research”, established by the joint FAA / EUROCONTROL Research & Development. A network “WakeNet-USA” has been created with a similar function as the European networks, and a link between both networks was established during the runtime of WakeNet2-Europe. This exchange will be further strengthened during WakeNet3-Europe. The FAA has recently confirmed the interest from the US side in a closer cooperation. The WakeNet3-Europe consortium intends to obtain a respective agreement.

There is also an active wake vortex community in Canada, centred on the aviation authority (Transport Canada).

Valuable research is also performed in Russia. A (virtual) network has recently been created, and contacts have been established between Russia and the European WakeNet. WakeNet3-Europe will support the Russian experts in building efficient network structures. The links between both networks shall be intensified and regular (at least annual) mutual participation to events is foreseen.

Other wake vortex activities are also emerging in Japan and China. The WakeNet3-Europe partners will closely observe this scene and establish an organised link as soon as the intensity and degree of organisation of those research activities permits it. Japanese researchers have already expressed interest in such a link.

2.1.2. Links to Local Stakeholder Groups

At several of the largest airports in Europe (AMS, FRA, CDG) local stakeholder groups dealing with wake vortex issues already exist or are under formation. A UK-wide wake encounter working group has also been established. These groups comprise members from various stakeholders (airports, airlines, ATC organisations, pilot unions, research, aviation authorities). They work closely together in everyday work on solutions to practical wake vortex issues linked to the specific situation of each large airport, e.g. improvement of operational procedures or introduction of new technological instruments.

For WakeNet3-Europe it is advantageous to lean on these groups, which are already experienced in multi-stakeholder cooperation on the subject. Via local stakeholder groups, representatives of stakeholders that usually have more distance from R&T activities (airports, airlines etc.) are attracted to participate in WakeNet3-Europe activities. Direct feedback of WakeNet3-Europe outcomes into all stakeholder groups is ensured.

For each local stakeholder group, one WakeNet3-Europe partner (who is in most cases himself a member of the local stakeholder group) acts as focal point.

2.1.3. Links to Specific Organisations and Groups

Links to specific organisations and professional groups (rulemaking authorities, pilot organisations) are maintained in order to:

- Have a focused entry point to communicate outcomes of current projects to specific stakeholders,
- Get feedback from them about applicability of new technologies and procedures.

2.1.4. Links to Specific Projects

Actual research work as well as development and implementation of new rules and procedures is not performed in the Coordination Action WakeNet3-Europe, but in specific projects, either EU Collaborative Projects or similar nationally or self-funded ones. For each major project running within the duration time of WakeNet3-Europe, one Partner is in charge of maintaining a link to the project team. Preferentially this is the project leader or a major project partner, if they are at the same time WakeNet3-Europe partners. The content of this link is:

- to care for feeding project outcomes into WakeNet3-Europe, in order to optimise dissemination among other project teams and all stakeholders (confidentiality aspects being, of course, taken into account),
- to care for feeding back comments, appreciations and additional requirements from other stakeholders into the project team, giving them the opportunity to adapt their work plan accordingly.

See Table 1 for all current project links. The largest among these projects will be SESAR. If new wake vortex-related projects are launched, new links will be established.

A number of Wake Vortex projects have recently been terminated. The main project partners are still available and asked to present the outcome of these projects in the framework of WakeNet3-Europe. Optimal benefit is taken from these projects in terms of dissemination of results and application for follow-on R&T activities and/or for operational use.

2.2. Structure of the report

This report addresses the work that was done between April, 1st 2008 and December, 31st 2009.

It is structured as follows:

- **Section 3** presents the general dissemination efforts that are available through the Wakenet3 Europe website and via dedicated workshops;
- **Section 4** reports about the links with non European partners;
- **Section 5** reports about the links with local stakeholder groups;
- **Section 6** reports about the links with specific organisations and groups, such a pilot associations and regulatory authorities
- **Section 7** reports about the dissemination activities that were undertaken within certain wake vortex-related projects.

3. The Wakenet3 Europe dissemination efforts

Most of the information available about the activities of Wakenet3 Europe (WN3E) can be found on the Wakenet3 website (http://wakenet3-europe.org/index.php?id=9), which is funded by the European Commission within the 7th Framework Program (FP7).

The website provides information about the different WN3E **task groups** (12 "Task Groups": each one deals with one specific wake vortex related issue and is led by one WakeNet3-Europe partner;), **points of contact** for the different WN3E partners; **links to wake vortex-related projects;** as well as a few **publications** and information about the **WN3E workshops**. These workshops allow the WN3E partners to present the status of their work, as well as to discuss new research opportunities. Attendees to these workshops include, in addition tol representatives from European ANSPs, pilot associations, regulators as well as partners from wake vortex-related communities outside Europe (e.g. WakeNet USA, WakeNet Russia…) in order to facilitate exchange of information and emulate new work partnerships.

The first WN3E workshop took place on the 8th-9th January 2009 at THALES University in France. About 100 stakeholders participated to this workshop. The agenda and the presentations can be found on the web at the following link:
http://www.wakenet3-europe.eu/index.php?id=63

In addition to this workshop, the EUROCONTROL Agency had also hosted a **Wake Vortex Workshop** on **16th of September 2008** to discuss a number of enhancements that can be made to the existing wake vortex separation criteria. The objective of the Workshop was specifically to present to a broad aviation stakeholder community the Agency's Wake Vortex Activities and Projects that had a clear focus on short term improvements - within a three to four year timescale. Around 100 stakeholders attended the workshop, representing all segments of the aviation community, and there was clear and unanimous support for this work.

The list of presentations that were given on that day can be found at the following link:
http://www.eurocontrol.int/corporate/public/event/080916_wakevortex.html

4. Links to non-EU activities

4.1. WP4.1 – Link to WakeNet USA and to EUROCONTROL-FAA Action Plan 14

Close co-operation has been established with the FAA in the field of vortex developments under the auspices of the Action Plan 14 (AP14). This co-operation extends to agreed project plans, research areas, sharing of information and data, agreeing on common concepts and objectives. As part of the Action Plan, managerial co-ordination meetings are held twice a year to oversee the results of the technical work and agree on the way forward.

The main objective of this link is to facilitate collaboration on wake vortex-related issues to avoid duplication of the work and provide a common point of view that could be turned into updates of ICAO provisions.

The AP14 Annual Research Plan provides a description of the activities in the research areas of new technology and new processes/procedures to safely mitigate the wake vortex constraints on increasing the capacity of the air transportation system.

The collaboration focussed mainly on Closely Spaced Parallel Runway (CSPR) Solutions, CRosswind OPerationS (CROPS), Time-Based Separation (TBS) on Approach, Wake Recategorisation, and Wake Separation Standards for New Aircraft, and Wake Standards for NextGen/SESAR different Wake Vortex projects.

Specific joint working groups were established for the Airbus A380, the RECAT (REvision of the wake turbulence CATegories and associated separation minima), and the Boeing B747-8.

The FAA also actively participated to the CREDOS Research project that was part of the 6th European Commission Framework Program (see Section 7.1). The FAA provided LIDAR equipment at Frankfurt Airport to collect the Wake Vortex data during the 2008 full year. The FAA also granted access to LIDAR data measured at US airports that was useful to the project. A USA Concept of Operation Evaluation Team has also produced two very comprehensive reports on the potential for Crosswind–dependent Arrivals and Crosswind-dependent Departures at US airports. Finally FAA Air Traffic Control experts participated to the CREDOS Real Time Simulation.

The wake-vortex related projects developed by the FAA were presented during the WN3E workshop on 8th-9th January 2009 that took place at THALES University in France; representatives from WN3E were also invited to attend to the WakeNet USA workshop, which took place in Miami in May 2009, where they presented the work done by some European projects. The next Wakenet-USA workshop will be taking place in Miami on 17th -18th March 2010, at the Airbus Training Centre. Representatives from WN3-Europe area will be attending and will present on activities within Wakenet3-Europe.

For more information about AP14, the point of contact is Peter Eriksen (EUROCONTROL).

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For those interested in attending future Wakenet-USA meetings, the point of contact is **Thomas Proeschel** (NASA), thomas.h.proeschel@nasa.gov

4.2. WP4.2 – Link "Canada"

Between April 2008 and December 2009, the following initiatives were taken by Gregoire Winckelmans from the UCL:

- Meeting with Anthony Brown of the National Research Council of Canada (NRC) and discussion during the 1st WN3E workshop on 8th-9th January 2009 at THALES University (Versailles, France) about the organization of the future activities of the link with Canada.

- Attendance at the EUROCONTROL/FAA/Russia Global Wake Vortex Conference on 9th-10th November 2009 at EUROCONTROL, Haren, Belgium, where Anthony Brown presented on "Defining Acceptable Wake Vortex Encounters – Issues from the NRC Canada Perspective", and further meeting and discussion with him on the wake vortex prediction tools to be used for wake vortex encounter studies.

- Email correspondence with Anthony Brown and planning of a trip to Ottawa, Canada, likely during Q3 or Q4 2010, to meet with the people active in wake vortex research at NRC, Carleton University and Transport Canada.

- Email and phone discussions with Anthony Brown on inviting some WN3E partners, e.g. F. Holzaepfel (DLR), Klaus-Uwe Hahn (DLR), Robert Luckner (TUB), Grégoire Winckelmans (UCL), T. Gerz (DLR), A. De Bruin (NLR), L. Jacquin (ONERA), E. Coustols (ONERA), T. Leweke (IRPHE) etc…, in a special ASE/AFM (Atmosphere and Space Environments / Atmosphere Flight Mechanics) invited session devoted to "Managing Wake Vortex Encounters" during the AIAA AFM/ASE/GNC/MST conference in Toronto 2nd-5th August 2010.

Useful links:
www.aiaa.org/events/ase ; www.aiaa.org/events/afm ; www.aiaa.org/events/gnc ; www.aiaa.org/events/mst

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4.3. WP4.3 – Link "WakeNet Russia"

In Russia various activities in the area of wake vortex investigation have been undertaken; several years ago a (virtual) network was created ("WakeNet Russia") to integrate them.

Since the mid 90s Russian research institutes concentrated their attention on wake vortex prediction. This project was carried out in a very close collaboration with Canadian partners as well as with UCL from Belgium. In the scope of this project, Russian partners from SABIGO took part in the development of the Vortex Forecast System (VFS), funded by Transport Canada (TC). VFS is a deterministic and operational wake vortex predictor (transport and decay). Finally, in collaboration with the USA, performance comparisons of the VFS with the AVOSS predictor algorithm were carried out.

The major Russian projects have been integrated in the national program for Wake Vortex Flight Safety, dealing with efficiency, performance and safety evaluation of the integrated wake vortex safety system as well as the integration into CNS/ATM technologies. Project partners have been the company "Spetstekhnika", the State Research Institute of Aviation Systems GosNIIAS and the Computer Centre, Russian Academy of Science (CCAS, RAS). Furthermore the Central Aero-hydrodynamic Institute (TsAGI) was working on onboard wake encounter prevention systems in the frame of the EC-co-funded project FLYSAFE.

At the first WakeNet3-Europe workshop on Wake Turbulence Safety in Future Aircraft Operations, in January 2009, Eduard Falkov from GosNIIAS (together with Dr. Andrey Belotserkovsky from the Russian Academy of Sciences and Mikhail Kanevsky from GosNIIAS) gave a presentation on "Wake Vortex Safety – Russian Approach". The overall approach to wake vortex safety presented includes a ground-based wake vortex monitoring and prediction system for TMA as well as transmission and reception of wake vortex data between aircraft and ground stations. Importantly, flight tests of a Wake Vortex safety system prototype have been prepared and conducted, with transmission of wake vortex information through an ADS-B data link using VDL Mode 4 technology between a generating and a follower aircraft and display of vortex information in the cockpit of the follower. The flight tests used as generator a Tupolev 154 M commercial aircraft and as follower a Let L-39 jet trainer, both from the Flight Research Institute.

In October 2009, Peter Eriksen from EUROCONTROL along with wake vortex experts from Technical University Braunschweig (TU-BS) visited GosNIIAS in Moscow, and received a deeper insight into the prediction model algorithms used by this Russian "Vortex Vision System" and into the working principles of the system itself. They also talked to the model developers and to the system designers. Such a meeting was useful to start a dialog with the Russian wake vortex researchers at a technical level and further developments in this area will be tracked.

E. Falkov and M. Kanevsky also presented their work at the Global Wake Vortex Conference organised by EUROCONTROL in Brussels, 9-10 November 2009. At this conference they emphasised the need for harmonisation of requirements for national wake vortex flight safety systems. Also, in 2008 and 2009, GosNIIAS was actively pursuing closer ties with European partners, with one potential prospect being the evaluation of the GosNIIAS flight tested warning system on other flight test platforms. Options to increase the level of cooperation and information exchange between Russian and European partners through WakeNet3-Europe were discussed but resulted in no formal changes.

For more information about the Link with "WakeNet Russia", contact Andreas Reinke (Airbus).

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4.4. Towards a "Global WakeNet"

Ultimately the goal is that the entire present vortex related work will result in ICAO provisions being updated. None of the development work will result in new procedures or techniques that will only be applied in single states - they will have global applicability. To enable this to succeed it will be necessary to involve as many organisations from around the world as possible. It is clear that before any results are presented to ICAO, part of the consultation has to ensure their global acceptability.

To broaden the cooperation, the Russian State Research Institute (GOSNiiAS) is already involved and similar close co-operation agreements are envisaged. On behalf of EUROCONTROL, a first global conference on Wake Vortex was organised in Brussels and held 9th and 10th November 2009. The objective of this conference was to establish who is doing what on a global basis and to investigate how this work could be fully aligned. The Deputy Director of the ICAO Air Navigation Bureau participated fully in the conference and supports the objective of global harmonisation and the common objective for the vortex work that is presently underway. Many presentations were made by different organisations and it is clear that not all the objectives and goals of existing wake vortex work are fully aligned. During the discussions at the conference it was agreed that full alignment is essential, and one way to ensure this is to convene global workshops to discuss the various elements of the vortex work and agree on a concept of operations that could be used to drive the associated work programmes. It is possible these workshops could be convened under the auspices of the ICAO Wake Turbulence Study Group (WTSG), which is scheduled to be established during 2010.
If this goal can be achieved it will ensure there is no duplication of work and that common globally agreed results can be presented to ICAO in the future.

It has been agreed that a total of three global conferences should be organised to ensure full co-ordination mechanisms are put in place. The second conference will be held in the USA during 2010 - date and location to be confirmed.

For more information about the “global Wakenet” initiative, contact Paul Wilson (EUROCONTROL).

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5. Links to Local Stakeholder Groups

For convenience, the acronym LSG will be used in the rest of this document to designate a Local Stakeholder Working Group.

5.1. WP4.4 – Link to LSG Amsterdam

The aim of the LSG Amsterdam is to support preparation and realization of concepts of operation leading towards the implementation of conditionally-reduced Wake Vortex separations at Amsterdam Schiphol Airport (AAS). This activity is catalyzed by the current research into the effect of meteorological conditions on Wake Vortex decay and transport. Essential part in the development of such concepts is the local participation, support and operational input of all (operational) stakeholders at specific airports. For the development of an initial concept of operations for AAS, a LSG that consists of the participating members as given in Table 2 has been formed.

Stakeholder	Organisation	Point Of Contact	Position
ATC	LVNL	Jeroen Vermeij	ATM procedures
Air Traffic Controllers	LVNL	Marcel de Kat Gerhard Nijenhuis	Air Traffic Controller Air Traffic Controller
ATM Expertise	Independent	Nanne Dijkstra	Senior Advisor, Air Traffic Controller (retired)
Airport Authority	AAS	Rob ten Hove	Senior advisor Development Airside
Pilot Union	VNV	Robert Brons	Captain 737
Regulator	DGTL	Bert Kraan	Senior advisor
Pilots	NLR	Robert Tump Arun Karwal	NLR research test pilots
Wake Vortex and Meteorology expertise	NLR, KNMI	(if required) Anton de Bruin	Senior research engineer
Airlines			Not participating

Table 2: Members of the Amsterdam LSG with the points of contact

As follows from Table 2, LSG Amsterdam is formed by a group of major stakeholders of the operation at Schiphol airport. This group participated in meetings organised by NLR. The LSG played an important role in identifying local requirements related to conditionally reduced WV separation and in determining in which way the reduced separation might bring benefits to Schiphol airport. Given this input, NLR has proposed initial operational concepts for conditionally reduced WV separations for departures and arrivals at Schiphol. In various meetings, these concepts have been reviewed by the stakeholders, resulting in stakeholder-accepted versions of these concepts [1, 2].

During LSG meetings, it was discussed in which way the proposed concepts could enhance capacity and/or punctuality at Schiphol. It was realized that any increase in departure capacity would rely on a certain crosswind to be present. It was also realized that any increase in arrival capacity would rely on certain meteorological conditions to prevail. Such conditions cannot be predicted well in advance with sufficient accuracy and therefore any increase in departure capacity could not be included in the so called (strategic) “declared capacity” (the declared capacity is the long-term capacity that is issued by the airport authorities and is used by the airlines for their timetables [movements per hour; inbound- and outbound]). The proposed departure concept could bring tactical benefit to airport operations when recovering from a period with outbound delays. The proposed arrival concept could also bring *tactical* benefit to airport operations, especially when recovering from a period with delays: reduced separation can be used to clear the stacks. When wind conditions are favourable, both the departure and arrival concepts could facilitate additional departures and/or arrivals per hour to reduce a backlog. This would increase the *robustness* of the declared departure/arrival capacity and therefore also punctuality.

Departures
Two initial concepts have been developed by the working group [1]. The first concept may be feasible within 2-5 years and is based on actual wind measurements. A minimal crosswind component must be present in the measurements for operation with reduced separation to take place. A second concept requires measurement of wake vortex in the immediate departure area and might be feasible within 5-10 years.

Arrivals
Two initial concepts have been developed by the working group [2]. The concepts focus on arrivals during *crosswind* conditions only. Concepts with reduced separation during only headwind conditions are expected to be associated with serious safety concerns. The first concept may be feasible within 2-5 years and is based on actual wind measurements, a short-term wind field prediction model, and a wake behaviour model. A second concept, feasible in 5-10 years, depends on prediction/monitoring of wake vortices in the approach area whereby detailed wind measurements are used.

References:

1. R.S. Tump, J. Weijts, A.P.R. Gibbs; Departures with crosswind - Initial Concept of Operation for departures with reduced separation at Amsterdam Airport Schiphol, NLR-CR-2006-617, 2006 (EUROCONTROL Contract Number C06/22053TC);
2. R.S. Tump, J. Weijts, A.P.R. Gibbs; Arrivals with crosswind and/or headwind Initial Concept of Operation for arrivals with reduced separation at Amsterdam Airport Schiphol, CR-2007-131, 2007 (EUROCONTROL Contract C06/22053TC).

The point of contact with the Amsterdam LSG group is Lennaert Speijker, speijker@nlr-atsi.nl

5.2. WP4.5 – Link to LSG Frankfurt

DFS has initiated some consultations with stakeholders, but nothing is significant enough to be reported in this section.

5.3. W4.6 – Link to UK Wake Encounter Working Group

The link will enable issues, which are raised at the UK Wake Encounter Working Group, to be promulgated to the WakeNet3-Europe consortium. Issues raised by the Working group are likely to be operational in nature. Similarly, a flow of information will also occur from discussions and developments rose through WakeNet3-Europe to the UK Working Group. This information is likely to be looking to future developments and often relates to the operational questions raised.

Summary of UK Wake Encounter Working Group:

NATS maintains a wake encounter database of all reported incidents of wake turbulence by agreement with the CAA. In addition to the data received from the Mandatory Occurrence Reporting (MOR) scheme, the database is also populated with data mainly from two source areas; Pilots and NATS units, via a voluntary Wake Turbulence Encounter Reporting Scheme.

As strong growth in traffic continues, it was considered that wake encounter data collection should be publicised to a wider audience. In order to increase access to statistical analysis and evolving mitigation measures and knowledge on developments in wake separation optimisation projects, it was decided to set up a National Wake Turbulence Encounter Reporting Scheme Working Group, to be known as the UK Wake Encounter Working Group (WEWG).

The objective of the WEWG is to provide a forum for all interested parties to share information and data on the important issue of wake turbulence encounters primarily in the UK. This objective is achieved through discussion of:

- Wake turbulence encounter trends (UK and other states)

- Significant wake encounter incidents
- Concepts and developments in the wake encounter arena (including European wake research activities)
- Amendments to UK wake requirements

The group is co-chaired by the CAA and NATS, and consists of representatives from CAA, NATS, Airline Operators Association (AOA), UK Flight Safety Committee (UKFSC), British Airline Pilots' Association (BALPA), British Gliding Association (BGA), The Guild of Air Traffic Control Officers (GATCO), The Guild of Air Pilots and Air Navigators (GAPAN), British Midlands (BMI), British Airways (BA), Virgin, Ryanair, Easyjet, TAG Aviation (dedicated to Business Aviation) and any appropriate relevant party that may have a contribution. The UK WEWG meets annually.

Contacts for UK Wake Encounter Working Group:

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Wakenet3-Europe link

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Meeting/conference participation:

- Debbie Mitchell attended the first UK WEWG meeting on 4th September 2008. She presented a summary of the 2007 UK Wake Vortex Annual Report. Claire Pugh from NATS also presented on the wake vortex encounter reporting process in the UK.
- NATS hosted the second UK WEWG meeting on 16th November 2009 at NATS Corporate & Technical Centre in Fareham. Debbie Mitchell presented a summary of the 2008 UK Wake Vortex Annual Report and UK involvement in European wake vortex-related projects. David Booth from EUROCONTROL also presented an overview of wake vortex concepts and projects that are currently active in Europe. Charles Morris from NATS R&D presented on the current status of the UK Time-Based Spacing (TBS) project.

Information exchange between Wakenet3-Europe and UK Wake Encounter Working Group:

The UK WEWG meetings in 2008 and 2009 provided an excellent opportunity to update operational stakeholders about the status of active wake vortex concepts and projects in Europe.

The meetings were attended by the following stakeholders: NATS, SRG, the UK Flight Safety Committee, British Airways, BMI, Virgin Atlantic, Flybe, CityJet, EUROCONTROL and East Midlands Airport.

NATS presented a summary of UK involvement in global and European wake vortex concepts and projects, which included the EUROCONTROL Wake Vortex Task Force (WVTF), CREDOS and CROPS, Wakenet3-Europe and the ICAO Wake Turbulence Study Group. EUROCONTROL presented on the function of the EUROCONTROL WVTF and gave a summary of active wake vortex concepts and projects

in Europe, which included A380/B748 wake vortex research, closely-spaced parallel runway concepts, cross-wind concepts (e.g. WIDAO), RECAT and TBS.

The presentations successfully promoted discussion and feedback from the operational stakeholders on a range of topics, which included:

- The effect of changes in ground speed during final approach (leading to unstable approaches) as part of the TBS project, which could lead to go-arounds.
- The timeframe for the introduction of an intermediate phase for TBS whereby wake turbulence separations will be reduced by 0.5Nm without tools when the wind exceeds a certain threshold.
- Whether EUROCONTROL have considered using UK separation standards for the RECAT project.
- The airlines provided feedback on the con-ops for TBS: the con-ops stated that pilots would report to ATC if their landing speed would be outside of the range 140-155 kts; the airlines remarked that most aircraft at Heathrow have landing speeds below 140 kts and it was agreed that the con-ops would be revised.

NATS produced detailed notes from the 2009 UK WEWG meeting, which were disseminated to attendees of the meeting, stakeholders who were unable to attend and members of the Wakenet3-Europe Consortium. Some members of the Wakenet3-Europe Consortium commented that the notes were a useful source of information on stakeholder reaction to wake vortex concepts and the status of wake encounter reporting in the UK. These meeting notes are in the following document.

Notes from UK WEWG 161109

5.4. WP4.7 – Link to LSG Paris CDG

In 2009, the achievements of the “Link with Local Stakeholder Group CDG” are the following:

- THALES AIR SYSTEMS (TR6) has organized a meeting with ADP (Aéroport de Paris) & DNSA, on 30th April 2009 in the framework of SESAR Program to study the deployment of Wind & Wake-Vortex Sensors at Paris-CDG Airport in the framework of the WP12.2.2 “Runway Wake Vortex Detection, Prediction and decision support tools” project.

- THALES AIR SYSTEMS (TR6) has organized a meeting with DSNA/DTI to discuss collaboration on SESAR WP12.2.2 “Runway Wake Vortex Detection, Prediction and decision support tools” project and WP6.8.1 “Flexible and Dynamic Use of Wake Vortex Separations” project.

- THALES AIR SYSTEMS (TR6) has developed some contacts with Wind and Wake-Vortex Sensors Providers and more especially with sub-contractors for SESAR WP12.2.2 project on “Runway Wake Vortex Detection, Prediction and decision support tools”.

- THALES AIR SYSTEMS (TR6) has developed networking by means of inviting Paris-CDG authorities, ADP and DSNA to attend to workshops in France:

    - Thales Air Systems (TR6) has organised and hosted at Thales University the first Wakenet-3 International Workshop in coordination with AIRBUS on “Wake Turbulence Safety in Future Aircraft Operations” with more than 120 attendees (FAA, EUROCONTROL, DSNA, DFS,NATS, ADP…).
      All details are given on the web page: http://www.wakenet3-europe.eu/index.php?id=63

    - Thales Air Systems (TR6) is preparing a Dedicated Workshop on “Wake Vortex & Wind Monitoring Sensors”. The agenda of this workshop was initiated in 2009 and includes a selection of guest speakers to give talks on radar, LIDAR and acoustic sensors for wind

or wake-vortex monitoring. This event will take place at Thales Research & Technology in Palaiseau, France (South of Paris), 29th-30th of March 2010.

- In 2008 and 2009, EUROCONTROL has also worked in partnership with DSNA and ADP on the WIDAO project (Wake Independent Departure and Arrival Operations). The EUROCONTROL WindTracer Pulsed LIDAR has been used to collect wake vortex measurements at the Paris-Charles de Gaulle airport (between February 2007 and August 2008). Analysis of the evolution of these wake vortices has allowed a safety case to be built in order to relax certain wake turbulence constraints concerning the operation of the runways in segregated mode. The project is under finalisation and has already brought useful insights for Closely Spaced Parallel Runways (CSPR) operations.

Contacts with the local French stakeholders (Paris-CDG Airport, ADP and DSNA)

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To know more about activities of Thales Air Systems with the LSG Paris, contact Frederic Barbaresco (TR6).
Frederic Barbaresco, Frederic.barbaresco@thalesgroup.com

To know more about the WIDAO project, contact Vincent Treve (EUROCONTROL)
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5.5. The EUROCONTROL Wake Vortex Taskforce

The Wake Vortex Task Force (WVTF) is a non-permanent group of the EUROCONTROL Airspace and Navigation Team (ANT) and the Airport Operations Team (AOT) constituted in order to support the EUROCONTROL Agency's wake vortex related projects with technical and operational expertise. It was established initially to look at the Time Based Separation (TBS), Re-categorisation of the Wake Turbulence Separation Minima (RECAT) and Crosswind Procedures projects (Crosswind-reduced Departure & Arrival Operations – CREDOS and Closely-Spaced Parallel Runways Operations – CSPR).
The WVTF meets twice a year (once in spring, once in autumn).

The tasks of the WVTF are mainly operationally focused and include:

- Contribute, review and update the projects' documents;
- Review and update the ATS procedures related to the projects;
- Assess the need for additional studies and activities related to the projects;
- Support trials and real time wake vortex measurements, when necessary.

The members of the WVTF should be operational experts with knowledge of Wake Vortex issues. The WVTF will collaborate with the FAA on any wake vortex issue to ensure best use of resources and that

there is no duplication of effort. Depending on the WVTF agenda, experts from various other fields and organisations may be invited.

The WVTF will be jointly chaired by the wake vortex project managers from the EUROCONTROL airspace and airport units. Observers may be invited by the Chairmen from other relevant international organisations or professional groups.

Up to now, four WVTF meetings have taken place (4th June 2008, 14th October 2008, 12th May 2009, and 6th-7th October 2009) where the progress of the different projects were presented to the attendees, mostly representatives from various Air Navigation Services Providers (e.g. Skyguide, DGAC/ DSNA, NATS, Austrocontrol, ENAV, DFS), and where these attendees could also comment on the proposed operational solutions. New subjects were also suggested for possible future projects such as en-route wake vortex, a wake turbulence reporting scheme, helicopters' wake turbulence.

For further information about the EUROCONTROL Wake Vortex Task Force, the points of contact are:

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6. Links to Specific Organisations and Groups

6.1. WP4.8 – Link to International Professional Airline Pilots Community

Publications:

- ECA, the European Cockpit Association, published in their "Cockpit News" (May 2008) an article on ECA's participation within WakeNet3-Europe.

Link: http://www.eurocockpit.be/media/ECA_CN_May2008_F.pdf

- VC, Vereinigung Cockpit, the German Airline Pilots Association, featured two wake related articles in their magazine "VC Info" (Edition 11/12 2008).
    - The first one was on the European WakeNet effort in general, giving an overview of WakeNet projects from 1998 till today. It is available under the title "AG ADO: Das WakeNet – koordinierte europäische Wirbelschleppenforschung" on VC's website: www.vcockpit.de (German only).
    - The second one dealt with Airbus' A380 wake flight test campaign and gave an extensive overview of the flight-test program Airbus conducted to measure and compare the A380 wakes. It is available under the title "AG ADO: Die A380 Wirbelschleppen-Flugversuchskampagne" on VC's webspace, too (as well in German only).

Participations:

- ECA took part in the Kick-Off meeting April 2008, at Airbus, Hamburg
- ECA participated in the first major workshop in January 2009 at Thales University, Jouy-en-Josas.
- ECA joint the CREDOS final forum in November 2009, Chantilly, on invitation of Anna Wennerberg, EUROCONTROL (see "Further Activities").

Further Activities:

As the usage of the valuable link to the pilots' community faded out during 2009, an initiative was started to get more activity. As a direct reaction, we received the invitation to participate in the CREDOS final forum. ECA is, at present, in the phase of evaluating all the information given at this meeting. Based on this information, ECA/VC is preparing a comment from the pilots' community. This comment will incorporate statements about operational questions, e.g. regarding selection of runway in use into-the-wind vs. crosswind. Results may be brought to IFALPA's Aircraft Design and Operation (ADO) and Air Traffic Services (ATS) committees for consideration.

Due to changes in VC's sorganization, the ECA/VC representation will be taken over by a fellow colleague, Markus Wahl, within 2010.

Contacts:

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6.2. WP4.9 – Link to Rulemaking Authorities

The aim is to strengthen existing links with the international and national regulatory authorities in order to open up further channels for information exchange in support of a common understanding on the applicable rules, regulations and associated safety requirements (both for operators and air navigation service providers) for the introduction of wake vortex related risk reduction systems, measures and/or systems.

It is important to connect closely with FAA, EASA, EUROCONTROL and ICAO, because the regulatory framework, and specific acceptable means of compliance are defined by those bodies. In this context, it is

noted that NLR - as part of its basic research programme - participates as member a in e.g. the following relevant groups:

- ICAO Separation and Airspace Safety Panel (SASP);
- European Strategic Safety Initiative (ESSI);
- European Commercial Aviation Safety Team (ECAST).

Whenever Wake Vortex safety concerns have been addressed, NLR has brought these working groups up-to-date on the current status of Wake Vortex research and developments, with a particular emphasis on recent Wake Vortex safety findings. NLR supports the FAA continuously through an existing FAA/IVW/NLR Memorandum of Cooperation and also keeps the EUROCONTROL wake vortex representatives informed on wake vortex safety studies (such as those performed for the LVNL). NLR has informed the Dutch national aviation safety authorities (via Mr. Jos Nollet of IVW and Mr. Rob van der Boom of DGLM) on (at least) a quarterly basis about the progress of European Wake Vortex research developments, including safety studies.

The point of contact for this link is Lennaert Speijker, speijker@nlr-atsi.nl

6.3. WP4.9 – Link with Wind and Wake-Vortex Sensors Providers, Sensors Experts and Sensors Users

This section includes a relevant list of worldwide contacts both from Research and Industry.

6.3.1. Wind Monitoring Sensors Providers & Users

- **Radar Sensors**

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7. Links to Specific Projects

7.1. WP4.10 – Link to CREDOS

CREDOS is a project of the 6th Framework Programme of the European Commission (DG-RTD) and co-ordinated by EUROCONTROL.

The CREDOS project is investigating the possibilities of **safe conditional reduction of wake turbulence separation minima**. Although limited in its scope to single runway departures, the CREDOS concept of operation is one possible solution to improve airport capacity and reduce delays at airport.

The project started on the June 1, 2006, and finished in November 2009. The work involved eleven European organisations (AIRBUS, Berlin Technical University, DFS, DLR, EUROCONTROL, INECO, M3 SYSTEMS, NATS, NLR, ONERA, and Université Catholique de Louvain), including already many WN3E partners, with also an active collaboration with the FAA (see Section 4.1 for more details about it).

The project website gives access to a full description of the work as well as to all its deliverables:
http://www.eurocontrol.int/eec/credos/public/subsite_homepage/homepage.html

Some results of the project were presented during the first WN3E Workshop on Wake Turbulence Safety in Future Aircraft Operations on January, 9th 2009, and at the Global Wake Conference on 9th and 10th November 2009, in Brussels. A final dissemination forum, to which many Wakenet3 Europe and WakeNet USA partners were invited, also took place on November, 18th and 19th in Chantilly close to Paris. The CREDOS operational concept was also regularly presented during the EUROCONTROL Wake Vortex Task Force meetings (see Section 5.5) to allow dissemination and feedback from operational experts with knowledge of wake vortex issues.

A CREDOS end-user portal is now available for pilots and air-traffic controllers who would like to learn more about the operational concepts developed within the project.

The CREDOS end-user portal: http://credos.bluskyservices.com/

For more information about CREDOS, the point of contact is Marie-Therese Meloni (EUROCONTROL).

Marie-Therese Meloni, marie-therese.meloni@eurocontrol.int, +33(0)1 69 88 75 02

7.2. WP4.11 – Link to FLYSAFE

The FLYSAFE project is a European Commission funded project aiming at improving flight safety through the development of a Next Generation Integrated Surveillance System (NGISS). The NGISS will provide information to the pilot on a number of external hazards, with particular emphasis on weather, traffic (including both air traffic when airborne and ground traffic when on the runway) and terrain. The NGISS will include, in particular, ground-based and on-board prediction and alerting of wake vortex aspects.

WN3E Contacts:
The exchange of expertise between the network and the FLYSAFE project is made via the External Expert Advisory Group (EEAG) of FLYSAFE that meets once a year in January or early February. The last EEAG meeting was held in February 2008 and is thus not in the reporting period.

Further contact with the experts was maintained to support the FLYSAFE part-task evaluations and full-task evaluations. The part-task evaluation of the airborne Wake system was covered remotely from the rest of the FLYSAFE platform at the AIRBUS Hamburg facilities, a deliverable has been produced whose information is summarized below:

D 2.3.1-2	Flight simulator test results on wake predictor
Version	Version A released on 17/06/2008
Classification	Restricted to a group specified by the consortium – please contact project manager Marc Fabreguettes (marc.fabreguettes@fr.thalesgroup.com) for approval to release

The design of the ground-based wake vortex system was documented in 2007 and is also available under certain conditions from the consortium. The validation of the system was performed at the Frankfurt airport trials.

Periodic Reporting:
Progress and results from the FLYSAFE project were reported to the WP3 Concepts via quarterly Question & Answers ending with the completion of the project and the final dissemination forum in June 2009.

FLY_730THA_MPM_Results4WN3E	FLYSAFE Presentation of Wake Vortex Results
Version	Version A released on 08/06/2009
Classification	Public – copies can be obtained via Laurence Mutuel (Laurence.mutuel@fr.thalesgroup.com)

Visits:
No specific visits were made under this link.

Contribution to conferences, workshops, working groups:
The FLYSAFE standardisation activities, together with WakeNet-USA contacts, led to a presentation at the first WakeNet3-Europe workshop in 2009. The focus was to draw the attention to the need to initiate the standardisation effort for wake related information based on previous research (consolidated under WakeNet and WakeNet2 networks) and the FLYSAFE results.

WN3E_WVstd_02	Standardisation Activities for Wake Vortex Datalink Services
Version	Version 02 released at the conference
Classification	Public – available from the WakeNet3-Europe workshop 1 weblink

From the presentation, contact was made with representatives of the appropriate Eurocae/RTCA groups and work is underway to standardise wake information as recommended in the following services and technologies:

- ADS-B using 1090 ES
- FIS using the Hazardous Weather services (D-HZWX)
- Planning, Near-Term and Immediate MET datalink services

On-going activities:
FLYSAFE is now completed. Ground-based wake systems will be further investigated within SESAR under the leadership of Thales Air Systems. Airborne turbulence alleviation systems will be further investigated within SESAR under the leadership of Airbus.
Thales Avionics remains the key focal point for the wake related standardisation activities.

For further information, the point of contact to FLYSAFE is Laurence Mutuel.

Laurence Mutuel, Laurence.mutuel@fr.thalesgroup.com

7.3. WP4.12 – Link to FAR-Wake

The FAR-Wake project was the continuation of a previous effort, on a European level, to characterise, understand and control aircraft wake turbulence. Dedicated to fundamental research in this area, the project started in February 2005 and finished officially on May, 31st 2008.

More information about the FAR-Wake project can be found on its website where various presentations, reports, and publications are also available (lhttp://www.far-wake.org/index.html).

Note that, due to the end of the project in 2008, the link to FAR-Wake was not funded by WNE3: indeed 0 PM were allocated in the revised description of work, after budget reduction.

The following points refer to the co-operation work that started after the end of the FAR-Wake project:

- Email discussion with FAR-Wake partners (T. Gerz, F. Holzaepfel, A. De Bruin, L. Jacquin, E. Coustols, T. Leweke, etc.) on the potential research subjects on wake vortices that could/should be pursued as a follow up to FAR-Wake, and on the potential of submitting a follow up project to the FP program.

- Discussions with F. Barbaresco (THALES) and D. Vanoenacker-Janvier (UCL, radar specialist) on a research project focusing on radar wake vortex detection and characterisation. This resulted in the beginning of a collaboration. A UCL Master's thesis was already devoted to a study: R. della Faille de Leverghem and B. van Switen (promoter D. Vanhoenacker-Janvier and G. Winckelmans, collaborators L. Bricteux and I. De Visscher) "Detection by radar of aircraft wake vortices", September 2009. The results obtained will be presented at the dedicated WN3E/Green-Wake workshop on "Wake Vortex and Wind Monitoring Sensors", March 29th-30th 2010. The master thesis will soon be available on the Wakenet3 Europe website (http://wakenet3-europe.org/index.php?id=9)

For more information contact Pr. Gregoire Winckelmans:

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7.4. WP4.13 – Link to OPTIMAL

The OPTIMAL project is an FP6 integrated project. Project summary is depicted below.

As traffic grows steadily, airport congestion and environmental impacts become a mounting problem and already a limiting factor at some airports. OPTIMAL is an air-ground co-operative project which is aiming to define and validate innovative procedures for the approach and landing phases of aircraft and rotorcraft in a pre-operational environment. The goal is to minimise external aircraft/rotorcraft noise nuisance and increase the ATM capacity while maintaining and even improving safety. Those achievements will be enabled by new precision approach landing aids (MLS, SBAS, GBAS), more accurate navigation means (RNP 0.1) and enhanced airborne systems, such as FLS, for Non-Precision Approaches. The target time frame for the operational implementation of the OPTIMAL operational concept is 2010 and beyond, it will therefore participate in reaching the targets for airport capacity developments identified in the ATM 2000+ Strategy and in the ACARE Strategic Agenda. The work to be conducted during the 4 years project is ranging from the elaboration of the operational concept up to simulations and pre-operational flight trials implying effective modifications of avionics onboard aircraft and rotorcraft and ground systems. On the ground system side, special attention will be placed on the new tools that will be necessary for Air Traffic Controller to efficiently and safely manage the OPTIMAL procedures. The OPTIMAL project team is composed, among others, by the major European aircraft, rotorcraft and airborne & ground systems manufacturers, major European research institutes, various ATS providers, and key experts in procedures specification and validation exercises. This team quite early identified the key methods and

tools to manage adequately all work-packages of the project. Particular emphasis is made on the project management organisation, the methodology to define the procedures and the validation methodology.
One work package of the OPTIMAL project was dedicated to Ground Functions Development, including Advanced Safety Nets and Monitoring Aids functions, i.e. Ground Based Safety Nets. In the scope of the Ground Functions Development, a Wake Turbulence Encounter Advisory (WTEA) capability has been studied and implemented in a Ground Based Safety Nets sub-system. The aim of this capability is to monitor flight progress on the ILS slope and raise an advisory to the air-traffic controller, through a proper HMI, in case the separation between leader aircraft and follower aircraft is predicted to infringe ICAO Wake Turbulence Separations in the short term.

Dedicated to research and development for approach and landing phase, the project has started in February 2004 and has finished officially on October, 31st 2008.

More information about the OPTIMAL project can be found on its website where various presentations, reports, and publications are also available (www.optimal.isdefe.es).

The following points refer to the co-operation work that has started after the end of the OPTIMAL project. This work has consisted in presenting of the Wake Vortex Advisory System, which includes the Wake Turbulence Encounter Advisory function, a function being drawn from the previous work done in OPTIMAL:

- Presentation of the Wake Vortex Advisory System to Wakenet3 partners during the 1st Wakenet3 workshop.
  Thales Air Systems (TR6) has organized and hosted at Thales University the 1rst Wakenet-3 International Workshop in coordination with AIRBUS on “Wake Turbulence Safety in Future Aircraft Operations” with more than 120 attendees (FAA, EUROCONTROL, DSNA, DFS,NATS, ADP…). All details are given on the web page: http://www.wakenet3-europe.eu/index.php?id=63

- Presentation of the Wake Vortex Advisory System to Wakenet USA partners in San Francisco - San Francisco International Airport, Terminal 3 Mezzanine Level, Conference Room A Tuesday, October 21, 2008

- Presentation of the Wake Vortex Advisory System to Global Wake partners during the Global Wake conference in BRUSSELS on the 9th and 10th November 2009 hosted by EUROCONTROL in Brussels.

To know more about activities of Thales Air Systems with the OPTIMAL project, contact Jean-Francois MONEUSE (TR6).

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7.5. WP4.14 – Link to Working Group “Aviation and Weather” and to DLR Project “Wetter und Fliegen”

The Working Group “Aviation and Weather” was not active in the reporting period because the required activities have been and will be pursued in the EU-projects FLYSAFE and ALICIA, in the German projects Wetter & Fliegen and iPort, and in SESAR.

The DLR project “Wetter & Fliegen” aims at increasing safety and efficiency of air traffic. In cooperation with the German Weather Service (DWD), DLR develops Integrated Terminal Weather Systems (ITWS) for the airports Frankfurt and Munich that consider wake vortex, thunderstorm, and winter weather. The aim of the ITWSs is to provide tailored weather information in the terminal manoeuvring area. The ITWS “wake vortex” focuses on approach and landing on closely-spaced parallel runways and on single runways. However, the elements of the system are largely generic and can also be applied for departure as it was done in the EU-project CREDOS.

Further, the project improves the detection of wake vortices and wind gusts with airborne sensors, develops automatic flight control systems in order to improve the flight performance and safety, and provides information systems to improve the situational awareness of the pilots with respect to the disturbances ahead.

The Kick-off Meeting of the project Wetter & Fliegen took place on 22 - 23 April 2008 at Munich Airport Center together with research partners (DWD, HYDS, Nowcast GmbH, Uni Hannover, TU Berlin) and potential customers (Airbus, DFS, DLH, EADS, FMG, FRAPORT). Since that time a first meeting was conducted at DLR Oberpfaffenhofen on 30 - 31 March 2009 and the second meeting took place at DLR Braunschweig on 21-22 September 2009.

Some highlights of the work conducted so far are listed here:

- Onboard sensor technology may only provide very limited information of the complex wake vortex flowfield ahead of the aircraft. This data alone is not sufficient for automatic compensation of wake encounter effects by aircraft control. An algorithm has been developed that may identify wake vortex parameters from the coarse available measurement data and that may discriminate between atmospheric turbulence and wake vortices. A corresponding patent has been filed. [3]

- A feedback control has been developed (as a part of a flight control system) and it has been demonstrated that it may keep an aircraft automatically, and with high precision, on a desired complex flight track in the presence of strong wind disturbances. The feedback control shall be combined with a feed-forward control in order to optimally compensate wake vortex encounters.

- Large Eddy simulation data [4] have been used in a flight simulator in order to study the differences between encounters of straight idealised vortices (as is done in such studies by default) and encounters of realistic, turbulent, and deformed vortices (which is a major step regarding the simulation of outmost realistic encounters).

- Monte-Carlo Simulations using WakeScene-D have been used to investigate the wake vortex encounter probabilities for crosswind departure scenarios within the EU-project CREDOS. Comprehensive sensitivity analyses have been conducted regarding the effects of various crosswind scenarios, departure route combinations, flight path adherence, wake vortex modelling, the development of aircraft separations during the departures, the sample size of the Monte Carlo simulations, aircraft type combinations, aircraft take-off weights, meteorological conditions, airport operation times, and a comparison to approach and landing. [5,6]

- In 2009, several aircraft incidents and accidents occurred where the uplink of ground-based weather observation and the prediction of thunderstorm activity could have improved the situational awareness of the pilots (e.g. hail damage of Windjet A319 on 1 Oct. 09, loss of AF447 over Atlantic Ocean on 1 June 09, encounter of severe turbulence of AF445 over Atlantic on 30 Sept. 09). [1,9]

The developed methods for the prediction of thunderstorms and wake vortices will be demonstrated in a measurement campaign in Summer 2010 at Munich airport.

More information is available on the project Web site: www.pa.op.dlr.de/wirbelschleppe

Publications based on the work in the project:

[1] Forster, Caroline, Tafferner, Arnold (2009) An integrated user-oriented weather forecast system for air traffic using real-time observations and model data. European Air and Space Conference (CEAS), 26 - 29 October 2009, Manchester, UK.

[2] Gerz, T., F. Holzäpfel, W. Gerling, A. Scharnweber, M. Frech, K. Kober, K. Dengler, S. Rahm, THE WAKE VORTEX PREDICTION AND MONITORING SYSTEM WSVBS PART II: PERFORMANCE AND ATC INTEGRATION AT FRANKFURT AIRPORT, Air Traffic Control Quarterly, Vol. 17, No. 4, 2009, pp. 323-346.

[3] Hahn, Klaus-Uwe, Schwarz, Carsten Walter (2008) Alleviation of Atmospheric Flow Disturbance Effects on Aircraft Response. In: ICAS 2008 Proceedings. Optimage Ltd., Edingburgh, UK and ICAS. 26. Congress of International Council of Aeronautical Sciences (ICAS), 2008-09-14 - 2008-09-19, Anchorage, Alaska, USA.

[4] Hennemann I., Holzäpfel F., Aircraft Wake Vortex Curvature and Resulting Risk Potential for Following Aircraft, CEAS 2009 European Air and Space Conference, Manchester, UK, 26-29 October 2009, 9 pages.

[5] Holzäpfel, Frank, Jan Kladetzke, Swantje Amelsberg, Helge Lenz, Carsten Schwarz, Ivan De Visscher, Aircraft Wake Vortex Scenarios Simulation for TakeOff and Departure, Journal of Aircraft, Volume 46, Number 2, March-April 2009, pp. 713-717.

[6] Holzäpfel F., Kladetzke J., Assessment of Wake Vortex Encounter Probabilities for Crosswind Departure Scenarios, CEAS 2009 European Air and Space Conference, Manchester, UK, 26-29 October 2009, 14 pages.

[7] Holzäpfel, Frank, Thomas Gerz, Performance of the Wake Vortex Prediction and Monitoring System WSVBS at Frankfurt Airport, CEAS 2009 European Air and Space Conference, Manchester, UK, 26-29 October 2009, 12 pages.

[8] Holzäpfel, F., T. Gerz, M. Frech, A. Tafferner, F. Köpp, I. Smalikho, S. Rahm, K.-U. Hahn, C. Schwarz, THE WAKE VORTEX PREDICTION AND MONITORING SYSTEM WSVBS - PART I: DESIGN, Air Traffic Control Quarterly, Vol. 17, No. 4, 2009, pp. 301-322.

[9] Tafferner, Arnold, Forster, Caroline, Sénési, Stéphane, Guillou, Yann, Tabary, P.,Laroche, P., Delannoy, A., Lunnon, B., Turp, D., Hauf, T., Markovic, D. (2009) Nowcasting thunderstorm hazards for flight operations: the CB WIMS approach in FLYSAFE. European Air and Space Conference (CEAS), 26 - 29 Oct. 2009, Manchester, UK.

Additional information can also be obtained from Frank Holzaepfel (DLR).

Frank Holzaepfel, Frank.Holzaepfel@dlr.de

7.6. WP4.15 – Link to wake vortex-related “A380 operational activities”

In preparation of the Airbus A380 entry into service, Airbus engaged in extensive wake vortex research, measurements and evaluations including vortex modelling, model-based and in-flight vortex measurements, encounter simulations, cruise encounter flight tests and safety assessments. These activities have been reviewed by an international A380 Wake Vortex Steering Group (SG) composed of EASA, EUROCONTROL, the FAA and Airbus as well as ICAO as observer. Findings by this Steering Group have been transmitted to ICAO and culminated in several ICAO State Letters, which provide recommendations on safe wake turbulence separations for A380 operations to ICAO member states.

Based on dedicated back-to-back flight tests performed at cruise altitudes and confirmed by LIDAR measurements the A380 Wake Vortex SG identified no need for additional separations – neither horizontally nor vertically – for en-route operations. This includes RVSM vertical separations of 1000'.
The last related ICAO State Letter (TEC/OPS/SEP – 08-0294.SLG) was issued July 8th,2008. In this State Letter the A380 radar wake turbulence separation minima for approach have been recommended as follows: no separation requirement for an A380 as follower aircraft, 6 NM for a Heavy following an A380, 7 NM for a Medium and 8 NM for a Light. These separation minima are smaller than those recommended in previous State Letters as a result of increased confidence in the dedicated evaluations performed by the A380 Steering Group. These recommended separations behind an A380 are 2 NM larger than those recommended behind a Boeing B747. But with no wake separation required in front of A380 aircraft the overall impact on capacity is somewhat mitigated.

The latest A380 ICAO recommendations were initially adopted by the UK Civil Aviation Authority (CAA) in August 2008. This included the transformation of the A380 recommendations to the British separation scheme , which differs from that recommended by ICAO. In January 2009, the CAA issued a Supplementary Instruction in which a requirement for 4 NM separations in front of A380 aircraft – in contrast to the last ICAO State Letter which has no requirement – was introduced. This was explained by "caution", not linked to any event and supposed to be re-evaluated after 18 months of operational experience.

In the USA, the FAA Air Traffic Organization (ATO) re-issued Interim Procedures for Airbus A388 Flights in October, 2009. For radar separation during approach these still require 6 NM for Heavies, 8 NM for Large and 10 NM for Small follower aircraft behind the A380. In fact, these separations are matching those given by an earlier ICAO State Letter (dating from October 2006) but not the latest. It states that "*Although ICAO recently has issued revised guidance regarding reduced wake separation criteria behind the A388, the ATO has not fully evaluated the revision*." It remains to be seen by when the FAA will issue the latest separation guidance agreed by the international A380 Steering Group, which includes the FAA.

In the meantime, Airbus has conducted an unprecedented number of wake encounter flight tests in cruise and approach flight conditions. These unique test programs have been aimed at directly comparing the wakes of the A380 and selected reference Heavy aircraft by flying into their wakes with different follower aircraft types. Evaluation of these tests by Airbus indicate that the current ICAO recommendations for approach are overly-conservative for Heavy and Medium follower and that the A380 could in fact be classified the same way as other Heavy aircraft. This was, for example, presented by Claude Lelaie, Airbus at the WakeNet3-Europe workshop on Wake Turbulence Safety in Future Aircraft Operations, January 2009, in his presentation on "Airbus wake vortex flight test campaigns and general conclusions". In consequence of these findings, the international A380 Wake Vortex Steering Group decided to continue the evaluation of A380 separations in early 2009 and to prepare an updated safety case with improved recommendations based on additional evidence from wake encounter flight tests. Since such tests have never been used to set separation standards in the past, the flight test techniques, evaluation methods and results are subject to intense review by EASA, EUROCONTROL and the FAA. At the Global Wake Vortex Conference organised by EUROCONTROL in Brussels, 9-10 November 2009, Airbus gave an update on this ongoing activity.

For additional information, the point of contact is Andreas Reinke (Airbus).

Andreas Reinke, andreas.A.REINKE@airbus.com

7.7. WP4.16 – Link to SESAR

EUROCONTROL is co-ordinating **SESAR P 6.8.1** "**Flexible and Dynamic Use of Wake Vortex Separations**". This operational project will develop a wake turbulence related operational concept and specify user and high level system requirements in order to, conditionally or permanently reduce landing and departure wake turbulence separations and, consequently, to increase the runway throughput in such a way that it safely absorbs arrival demand peaks and/or reduces departure delays.

The proposed 'Dynamic Pair-wise Separation' concept and system shall allow for controllers to sequence arriving or departing aircraft using Time-Based Weather Dependant Pair-wise wake turbulence separations consisting of the three following concept functionalities:

- Time-Based Separations (**TBS**) will ensure a more consistent runway throughput independent of (in particular) headwind conditions on the day of operations.
- Weather-Dependent application of wake turbulence Separations (**WDS**) will increase runway throughput in favourable weather conditions and introduce dynamic spacing concepts.
- A definition of wake turbulence Pair-Wise Separations per pair of aircraft type (**PWS**) will increase runway capacity. This will be achieved by taking into account the potential wake vortex encounter severity as a function of the leading aircraft's wake generation and the following aircraft wake response characteristics.

These functionalities will be progressively developed and integrated in the concept and system along the three proposed phases of the project. P 6.8.1 is to start in early 2010, Phase 1 (operational TBS) is planned to finish at the end 2012, Phase 2 (operational WDS) by the end 2014, Phase 3 (operational PWS) at the end of 2016.

In 2009, a P 6.8.1 early start project work has been performed under the co-ordination of EUROCONTROL. The early start project has delivered a "State of the Art" review encompassing existing wake-vortex models, wake vortex and MET sensors, wake vortex-related datasets, safety assessments principles, as well as existing wake vortex-related operational rules, concepts and regulatory decisions. The document is available upon request to Vincent Treve (EUROCONTROL).

To know more about SESAR P 6.8.1, contact Vincent Treve (EUROCONTROL)

Vincent Treve, vincent.treve@eurocontrol.int, +33 (0)1 69 88 72 50

Other SESAR projects than P 6.8.1 will also look at wake vortex issues:

- **P 12.2.2** "**Runway Wake Vortex Detection, Prediction and decision support tools**". The main objective of this project is to define, analyse and develop a verified wake turbulence system according to the operational concept developed by P 6.8.1 in order to, punctually or permanently reduce landing and departure wake turbulence separations and, therefore, to increase the runway throughput in such a way that it safely absorbs arrival demand peaks and/or reduces departure delays. This global objective will be achieved by means of developing a wake vortex advisory system able to deliver in real time position and strength of the wake vortices and to predict their behaviour and potential impact on safety and capacity, taking in account actual weather information as well as the airport specific climatological conditions, aircraft characteristics (generated wake vortex and wake vortex sensitivity) and airport runways layout.

  These functionalities will be progressively included in the wake vortex advisory system to be validated and deployed at airports in order to optimise the runway throughput and reduce delays. The process will take place in 3 phases:
  - to develop and validate a wake vortex advisory system to acquire the needed information about the position, strength and behaviour of the wake vortices in case of sufficient headwind in order to allow the validation of a time based separation in arrivals.
  - to develop and validate the wake vortex advisory system capacity to assess in real time the wake vortices strength and position, and to predict their behaviour as a function of weather conditions, in order to allow a reduction of the wake turbulence separations to be applied in departures and arrivals when weather conditions are favourable.
  - to demonstrate the system capacity to deliver dynamically a safe wake turbulence separation per pair of aircraft, taking as input an aircraft types characteristics database regarding wake vortex (generated wake vortex and wake vortex sensitivity).

  P 12.2.2 planning has been defined according to P 6.8.1 needs for operational validation. The 3 phases of P 12.2.2 will thus have identical deadlines as the 3 phases of P 6.8.1.

P 12.2.2 will be co-ordinated by Thales Air System and the point of contact for this project is Philippe Juge (philippe.juge@thalesgroup.com).

- **P 9.11 "Aircraft Systems for Wake Encounter Alleviation"** and **P 9.30 "Weather Hazards / Wake vortex sensors"** will investigate at the level of the aircraft, wake turbulence warning, avoidance and alleviation systems. Both projects will be lead by Airbus. The point of contact for P 9.11 and P 9.30 is Andreas Reinke (andreas.A.REINKE@airbus.com)

Following the same principles as those that were considered to set up a "Global WakeNet" (Section 4.4), the link between SESAR Joint Undertaking (SJU) activities and the outside world is under consideration as it was agreed by all partners that it had to be.

7.8. Link to the Green-Wake Project

Wake vortexes and wind shear are major causes of accidents and injuries to passengers and crew of all aircraft types. There are currently few options for protection against these phenomena, and the main way of reducing accidents is to impose mandatory separation times between aircraft which can affect the operating performance of airports.

Wake vortex and wind shear detection is therefore the focus of research programmes funded within Europe and the US and the LIDAR technique (Light Detection And Ranging) has already been shown to offer a technical solution for detection of wake vortices and wind shear.

The Green-Wake project is a collaborative project funded by the European Commission which will develop and test a short-range (50-100m) Imaging Doppler LIDAR system that is capable of detecting and measuring wake vortexes and wind shear phenomena in front of an aircraft. 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 supplied to the aircrew most effectively.

The first project year has been completed in October 2009. A 6-month and a 12-month review meeting took place. The work package on "user requirements" for airborne forward looking detection (LIDAR) for flight control has been completed. Work on a system simulator and the development of a prototype is on-going, with wind tunnel and field tests in preparation.

The projects WakeNet3-Europe Task 1.2 and Green-Wake will be co-hosting an event on ground-based and on-board wake vortex and wind monitoring sensors at the Thales Research and Technology Centre in Palaiseau, France on 29/30 MARCH 2010 "Wake Vortex & Wind Monitoring Sensors" (preparation meeting on 24 JUNE 2009 in Paris).

More information about the project is available on the project web site at: http://www.greenwake.org or from Carsten Schwarz (DLR)

Carsten Schwarz, Carsten.Schwarz@dlr.de

8. Reference

[1] "*Description of Work*", *Wakenet3 Europe, European Coordination Action for Aircraft Wake Turbulence*, 7th Framework Program, Wakenet3-Europe Contract, Annex 1, version 1, May 2008

9. List of Acronyms

AAS	Amsterdam Schiphol Airport
A-D	Airbus Operations GmbH
ADP	Aéroport de Paris (Paris Airport)
ANSP	Air Navigation Service Provider
AP14	Action Plan Fourteen
ATC	Air Traffic Controller
ATM	Air Traffic Management
ATO	Air Traffic Organisation
CAA	Civil Aviation authority
CNS	Communication, navigation and Surveillance
CROPS	Crosswind Operations
CSPR	Closely Spaced Parallel Runways
DFS	DFS Deutsche Flugsicherung GmbH
DLR	Deutsches Zentrum für Luft- und Raumfahrt
ECA	European Cockpit Association
EU	European
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration
FLS	Flight Suspension Message
FPn	n^{th} Framework Program
GBAS	Ground Based Augmentation System
ICAO	International Civil Aviation Organisation
ITWS	Integrated Terminal Weather Conditions
LIDAR	Light Detection And Ranging
LSG	Local Stakeholder Group
MLS	Microwave Landing System
MOR	Mandatory Occurrence Reporting
NERL	NATS En-route Plc.
NLR	Nationaal Lucht- en Ruimtevaartlaboratorium
NRC	National Research Council of Canada
RECAT	Revision of the Wake turbulence categories
RNP	Required Navigation Performance
RTCA	Requirements and Technical Concepts for Aviation
SBAS	Satellite Based Augmentation System
SJU	SESAR Joint Undertaking
TBS	Time-Based Separations
TC	Transport Canada
THAv	Thales Aerospace
TR6	Thales Air Systems
UCL	Université Catholique de Louvain
VC	Vereinigung Cockpit

VFS	Vortex Forecast System
WEWG	Wake Encounter Working Group
WIDAO	Wake vortex Independent Departure and Arrival Operations
WN3E	WakeNet 3 Europe
WVTF	Wake Vortex Task Force

End of document