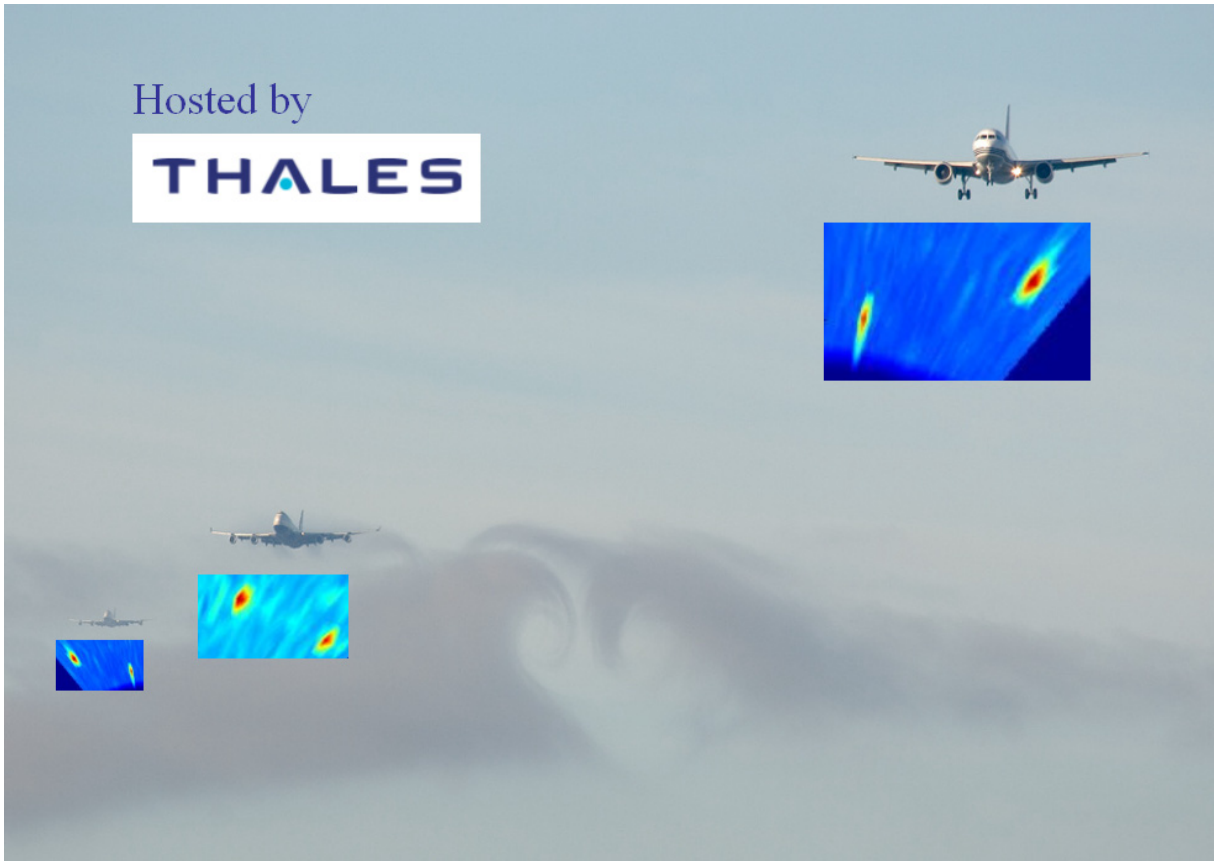
Wake Vortex & Wind Monitoring Sensors
Workshop



WAKENET-3 Europe / GREENWAKE DEDICATED WORKSHOP ON

"*WAKE VORTEX & WIND MONITORING SENSORS IN ALL WEATHER CONDITIONS*"

29th and 30th March 2010

Thales Research & Technology

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SEVENTH FRAMEWORK PROGRAMME

Wake Vortex & Wind Monitoring Sensors Workshop

Organizing Committee Chairman message

On behalf of both WAKENET-3 Europe and GREENWAKE boards, it is a great pleasure to welcome all delegates, representatives and participants from around the world to the 2010 dedicated workshop on "***Wake-vortex & wind monitoring sensors in all weather conditions***" in the auditorium of Thales Research & Technology in south of Paris, France. The conference is organized in the frame of the European relations set up between partners involved in WAKENET-3 Europe Coordination Action project (http://www.wakenet3-europe.eu/), and GREENWAKE project (http://www.greenwake.org/), both funded by European FP7 programme.

WAKENET-3 Europe Workshops cycle, initiated in Januray 2009 with a first plenary workshop on "Wake turbulence safety in future aircraft operations" coordinated by Thales & Airbus and hosted in Thales University Campus (http://www.wakenet3-europe.eu/index.php?id=63) with more than 120 attendees, will dedicate this 2nd workshop to Radar, Acoustic and Lidar Sensors for monitoring Wake-Vortex hazards and Wind on airport in all weather conditions. A new generation of low cost sensors has recently emerged, boosted by technological breakthroughs (e.g. : Electronic scanning and/or High Power X-band Radar, Electromagnetic Multi-static Radars, High Power 1.5 micron Lidar, UV Lidar, Forward-Looking Interferometer, …). These sensors will be key building blocks of critical Wake Vortex Advisory System that will be developed in SESAR WP12.2.2 "***Runway Wake Vortex Detection, Prediction and decision support tools***". In this future system, that should be operational in all weather conditions, Wind measurements with accurate/high space resolution and fast time update rate will be required to be ingested in "Wake Vortex Predictor" and Wake-Vortex detection/localization with strength assessment (circulation in m^2/s) will be a second fundamental requirement for Safety Net specifications.

WAKENET-3 & GREENWAKE boards have invited international guest keynote speakers & experts from Europe, USA & Asia to present their last technological sensor developments and end-users to report last sensors trials on airports. 34 talks will cover international state-of-the-art and testify the world wide interest for topics covered by WAKENET-3 Europe. The number of talks was equally distributed between academic labs, SMEs, Industries and End-Users.

After the Opening Session to welcome all attendees, 8 topics have been scheduled : Wind Monitoring Radars, Radar Wind Profilers, Lidar Wind Profilers, Airborne Sensors & Aircraft Met Data, Radar Wake Vortex Sensors, Acoustic Wake Vortex Sensors, IR & UV Wake Vortex Sensors & Multiple Sensors. The Technical Program covers all the main topics and highlights in the domain of Wake-Vortex & Wind Monitoring Sensors. Coffee/Lunch breaks will favour opportunities for fruitful exchanges, contacts between all attendees.

I would like to acknowledge all the Organizing Committee members from WAKENET-3 & GREENWAKE for their help, in agenda elaboration. I also give my thanks to authors and co-authors, for their tremendous effort and contribution.

We will be happy to meet you again in Toulouse for next WAKENET-3 Europe Plenary Workshop.

Frederic BARBARESCO
"Wake Vortex Sensors" Task Leader
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Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Next Generation Operational Met Office Weather Radars and Products

The reference topic

Topic : 1 (**Wind Monitoring Radars**)

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Summary of the presentation

This presentation will describe the current situation and the perspectives of the French operational weather radar network. Operational applications of advanced Doppler schemes (staggered triple-PRT schemes, windshear detection, 3D multiple-Doppler wind retrievals), dual-polarisation (hydrometeor classification, attenuation correction, accurate rain rate estimation, icing detection) and volumic scan strategies (e.g. Vertical Profile of Reflectivity corrections and NWP data assimilation) will be presented. The principles and the practical implementation of refractivity measurements with magnetron-equipped radars will be explained.

Statement how the presentation contributes to the topic

This presentation will brief the audience with current capabilities and perspectives of operational weather radar networks, noting that Europe is covered by more than 150 such radars (quite similar Figure in the US). The presentation will highlight the potential of advanced radars and advanced signal processing for wind measurements in precipitation or in clear-air.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Wind Field Observations with a Monostatic and Bistatic C-band Doppler Radar Network

The reference topic

Topic : 1 (**Wind Monitoring Radars**)

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Summary of the presentation

Doppler measurements with a single weather radar are limited to the observation of the radial wind component. With two or more weather radars the 3-dimensional wind vector can be retrieved. However, the investment and operation of a Doppler weather radar is associated with high costs. A bistatic Doppler radar network does considerably reduce the costs and has other advantages-, but on the other hand there are some limitations of the system. The presentation will discuss the various techniques and show the pros and cons of the retrieval of the 3-dimensional wind field using a network consisting of either monostatic or bistatic Doppler radars. Wind field retrievals with a bistatic Doppler radar network allow higher resolution than monstatic networks, however the sensitivity is less and a larger number of receivers is requires.

Statement how the presentation contributes to the topic

Monitoring of the wind field in the vicinity of an airport with a C-band weather radar.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Multi-Static X Band Radar

The reference topic

Topic : 1 (**Wind Monitoring Radars**)

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Summary of the presentation

In the 1990s a multi-static X band radar system for 3D wind measurements were developed in Norway. The basic scatter mechanism is forward Bragg scattering from clear air turbulence. The multi static geometry provides a scattering wave-number that couples to the inertial sub-range of the clear air turbulence. 3D wind speed and turbulence parameters are found through spectral analysis of the different multi-static channels.

The presentation summarizes the basic theory and provides well documented results from experimental 3-D wind measurements with a prototype system. The project status is described as well as the way forward to a commercial system. The operational capabilities of a fully functional real time system for measurement of wind, turbulence parameters and vortices are discussed.

Statement how the presentation contributes to the topic

The presentation describes a multi-static radar system for 3D wind measurements. The presentation contains both the theoretical basis and well documented results from experimental measurements.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

HYDRIX: An X Band Radar to Monitor Atmospheric Hazards for Airport

The reference topic

Topic : 1 (**Wind Monitoring Radars**)

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Summary of the presentation

The HYDRIX radar developed by NOVIMET possesses several characteristics making it useful to operate in an airport environment:

1- Its offset antenna with low side lobes, and its low detection threshold, favours the detection of clear air echoes. With its Doppler capability, this characteristic helps to map the wind field up to 20 km range in clear air under favourable weather conditions (thus to identify possible wind shears). There is probably also potential to detect wake vortex in the same conditions.

2- Its dual polarisation capability helps to measure four parameters under precipitation conditions: reflectivity, differential reflectivity, differential phase shift, correlation coefficient. These parameters are exploited by performing software (ZPHI software) that helps extracting an accurate estimate of the rainfall rate on the ground, and to identify the type of precipitation in altitude.

The information produced in real time by HYDRIX could be used for:
- detecting flooding of the runaways;
- detecting dangerous wind shear for aircraft landing;
- monitoring severe weather (as hailstorm)
- identifying icing conditions.
- Etc.

Statement how the presentation contributes to the topic

Presentation of new X-band radar sensor with potential weather hazards monitoring on airports.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

An Airborne X Band Weather Radar Simulator Environment

The reference topic

Topic : 1 (**Wind Monitoring Radars**)

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Summary of the presentation

The presentation describes a simulation environment capable of evaluating X band radar algorithms. From ground radar information, most of time S band, the weather situation is analysed converted in meteorological data and after converted within a 3D Buffer inX band reflectivity and attenuation.

The behaviour of a host radar can be simulated taking into account its specificities as well as location and view axis and antenna beam patterns, waveform and algorithms, additional ground clutter is added

This allow to compare the radar algorithms results to the initial weather situation

Statement how the presentation contributes to the topic

This simulator environment is a major tool for X band radar processing algorithms validation.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

DWD's New Remote Wind Sensing Equipment for An Integrated Terminal Weather System (ITWS)

The reference topic

Topic : 1 (**Wind Monitoring Radars**)

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Summary of the presentation

What are the drivers behind DWD's investment into remote wind sensing technology at the airports of Frankfurt and Munich? The growth in air traffic, the sharpening of the competition for the whole aerospace community and the increased awareness of environmental issues force all meteorological services to prepare for a demand of more detailed and precise weather observations and forecasts; especially in the TMA. Undertakings like SESAR will in the next years phrase formal requirements to that respect. DWD has decided to develop and employ an Integrated Terminal Weather System (ITWS) to cope with these future needs. ITWS will deliver all existing products in higher coverage and quality but also new products tailored to help ATC, airline and airport to optimise their operations regarding weather impacts. Measurement and indication of wake vortex is an explicit goal of the ITWS development.

Statement how the presentation contributes to the topic

The presentation is intended to enable the audience to understand DWD's motivation to go through a tender and to order remote wind sensing equipment comprising Radar and Lidar. The technology is introduced in many of the other presentations held by the vendors; DWD will talk about the application.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

All Weather Wind Monitoring with Integrated Radar and Lidar

The reference topic

Topic : 1 (**Wind Monitoring Radars**)

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Summary of the presentation

In many cases, the best solution for terminal area wind sensing is to combine Doppler radar with Doppler lidar to achieve an affordable and effective integrated capability that works in all weather conditions. This approach has been implemented with great success in Hong Kong, Japan, and the US. For a new German Weather Service (DWD) program, Selex SI GmbH and Lockheed Martin are integrating a Dual Polarization Weather Radar with a WindTracer® Doppler lidar to enable the first operational implementation of all weather radar-lidar in Europe.

Statement how the presentation contributes to the topic

This presentation is quite relevant to the workshop in general, and this topic in particular. LMCT has been a pioneer in developing Doppler lidar technology to support improved wind situation awareness at airports. In most cases, the lidar has been installed to provide significant complementary performance to existing Doppler radar sensors. Programs are now being implemented that factor the complementary nature of the sensors at the outset to achieve a robust solution.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Vaisala UHF Wind Profiler, Optimizing the Wind Measurement

The reference topic

Topic : 2 (**Radar Wind Profilers**)

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Summary of the presentation

In order to effectively monitor and forecast wake vortex advection, knowledge of wind profile, vertical wind shear and wind profile evolution over time is essential. In addition, turbulence estimates for decay forecast are important. The Vaisala LAP-3000 is a Doppler beam swinging radar wind profiler that provides continuous and real-time vertical profiles of horizontal wind speed and direction and vertical velocity up to 3 km above ground level. Maximum detection altitudes will change significantly depending on atmospheric conditions, profiler configuration, installation site and surrounding environment. Some of the main parameters affecting wind detection are the pulse width affecting both vertical resolution and effective maximum detection height, and time averaging of the measurement. Vaisala has been investigating the effect of different settings to the availability of detection of fast changing relatively small scale wind phenomena using data from an operational wind profiler.

Statement how the presentation contributes to the topic

Wind profilers are one of the most versatile sensors to monitor vertical wind profile and turbulence. Nevertheless, data availability in connection to vertical and temporal resolution needs a closer look in order to optimize measurement parameters. The presentation will discuss some findings done at Vaisala using an operational wind profiler.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

UHF Wind Profiler Radar Applications in Aviation Support

The reference topic

Topic : 2 (**Radar Wind Profilers**)

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Summary of the presentation

Wind profilers have been in use on airports around the world for more than 20 years. They do not simply provide vertical profiles of wind. Turbulence, boundary layer height, dry/humid air mass boundaries are easily identified. With RASS, even the temperature profile can be obtained in real time.

Statement how the presentation contributes to the topic

These instruments provide wind measurements under all weather conditions: in clear air, the refractive index variations caused by turbulence trace the winds aloft while in precipitations, it is the wind borne hydrometeors that are used to trace the wind. Neither fog, nor rain, nor haze, nor sleet, nor snow, nor insects will hinder these instruments.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Long-term Radar Wind Profiler and Windline Measurements for the Wake Vortex Warning System at Frankfurt Airport

The reference topic

Topic : 2 (**Radar Wind Profilers**)

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Summary of the presentation

DFS had developed a wake vortex warning system for Frankfurt airport. Although this system never became operational, two of its major components provided valuable and unique insights into the local wind field around an airport which substantially influences the behaviour of wake vortices shed by landing and departing aircraft. A radar wind profiler (wind temperature radar supplemented with a radio acoustic sounding system) is used to measure wind and temperature between 80 and 1500 m above ground level. A chain of 3d ultrasonic anemometers (windline) measured high resolution (25 Hz) wind data for more than a decade. Albeit the technical limitations of the latter technology it was not only used for very accurate characterisation of the wind field near the landing thresholds but also to collect wake transport data in ground effect for several 100.000 aircraft landings.

Statement how the presentation contributes to the topic

DFS, a German air navigation service provider, has more than 10 years experience in wind monitoring at a major European hub airport. A windline as well as a radar wind profiler have been developed, installed and operated in order to feed a wake vortex warning system with necessary meteorological data. The presentation will focus on the users view on the performance of a remote sensing system.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

New Long Range Lidar for Airport Wind Profiling

The reference topic

Topic : 3 (**Lidar Wind Profilers**)

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Summary of the presentation

LEOSPHERE has developed a new generation long range compact, eye safe and portable wind Lidar capable to fully determine the local wind profile in real time in the planetary boundary layer. The Windcube70 provides the horizontal wind, direction, and vertical wind every 10s at least at 40 different altitudes from 100m to 2000m. The accuracy of this wind profiler has been successfully validated against radar wind profilers and radiosondings during extensive test campaigns in the reference upper air stations and labs in Europe and in the United States. The presentation will present the lidar performances and experimental results.

Statement how the presentation contributes to the topic

Talk deals with wind profiler with long range capability for wind monitoring.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Aviation ZephIR: Lidar Wind Profiling and Wake Vortex Detection

The reference topic

Topic : 3 (**Lidar Wind Profilers**)

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Summary of the presentation

QinetiQ's ZephIR is a conical-scan coherent Doppler lidar operating eyesafe near 1.5 microns. It provides full 3D wind vector profiles including vertical and horizontal wind speed and direction up to 200 m altitude, updated at least once per minute. It thus senses a relatively small, but possibly critical, volume of air – for example the critical airport regions near takeoff and landing. It can use results within a single one-second scan, not only to measure the wind speed (vertical & horizontal), but also simultaneously to detect the presence of wake vortices. Over a few consecutive scans (typically 5 to 20 seconds), the vortices can be tracked within the lidar's measurement aperture (~ 100 m diameter at 100 m altitude) as they descend, develop, and are blown by the local wind.

This simultaneous and non-intrusive real-time measurement of wind vector (both headwind and crosswind) and of wake vortex behaviour, on the glideslope, is new and interesting. Important applications now being considered by the aviation community, for a measurement platform operating at airports in real-time and integrated within an overall ATM system, include time-based-separation (TBS) and crosswind-on-departure. We have deployed the lidar at Birmingham International Airport (where most aircraft are light or medium) and at London Heathrow Airport (used by many large Airbus and Boeing aircraft, and by the Airbus A380). We will present results on wind profiles, wake vortex detections, and vortex tracks.

Statement how the presentation contributes to the topic

This is a good example of extending modern lidar sensors into airport applications. More than 60 ZephIR production units are installed worldwide, mainly for the wind power market; their accuracy and robustness are proven in meteorology, wind farm assessment, and wind turbine studies. We have now shown that, while remaining entirely eyesafe, ZephIR can estimate the wind vector and detect vortices on a timescale of roughly one second. This is an appropriate compromise between two usually distinct tasks: very detailed lidar measurements of vortex behaviour, and spatially averaged wind measurements. Other variants of ZephIR have been demonstrated for particular needs e.g fine beam steering or wind direction sensing at low velocities.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Lidar Wind-Shear Detection: Nice Airport Trials

The reference topic

Topic : 3 (**Lidar Wind Profilers**)

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Summary of the presentation

Located along the Mediterranean Sea at the foothills of the Alps, Nice airports (3rd airport in France for the number of passengers) is occasionally subject to strong wind shears that can cause difficulties to landing aircrafts. One of the phenomena opposes two winds of nearly opposite directions, one from the North-East, the other one from the South-West, in an altitude layer that extends vertically from the surface to a few hundredths up to2000 meters. The conflict between opposed winds moves across the approach area at highly variable speeds and may affect one of the 3 different possible approaches. As all of them are above the sea, the wind-shears can hardly be detected by standard anemometers or a radar wind profiler. In Nice, wind-shear detection requires a remote sensor capable of sounding the wind field above the sea at distances of up to ~10km from the airport. As the vast majority of wind-shear events occur under clear-sky conditions, lidar techniques are an interesting candidate. A test experiment was conducted during 2 months in 2009 with a WindTracer system from LMCT. Several wind-shear events could be monitored. The presentation will show the results.

Statement how the presentation contributes to the topic

The presentation is a good example on how modern remote sensing techniques provide possible solutions for the detection of well-identified, previously undetectable, aviation hazards.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Wind Monitoring Using 2nd Generation Wind Lidars

The reference topic

Topic : 3 (**Lidar Wind Profilers**)

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Summary of the presentation

1st generation wind Lidars have proven useful in the wind power industry and are typically compact, portable and robust devices which provide a convenient means of acquiring wind profiles from a number of locations in succession. 1st generation wind Lidar methods have typically entailed a single azimuthal degree of freedom with regards to beam orientation, limiting the user to performing VAD and DBS scans. 2nd generation techniques are presented here which enable the acquisition of RHI and PPI scans using wind Lidars. Convergent beam scan geometries are also discussed in relation to the measurement of turbulence.

Statement how the presentation contributes to the topic

2nd generation wind Lidar techniques enable the detailed and accurate assessment of wakes and other flow structures by direct measurement. In addition, 2nd generation scan geometries enable the acquisition of data from locations remote from the site at which the measurement device is installed, whereas 1st generation techniques generally limit measurements to the volume of air immediately above the device. As a result 2nd generation devices have a longer range which enables them to acquire wind speed measurements at heights across the full 1000ft corridor.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Wind Lidar as an Aid to Airport Security Under Unfavourable Weather Conditions

The reference topic

Topic : 3 (**Lidar Wind Profilers**)

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Summary of the presentation

Wind shear, wake vortex and clear air turbulence at the airports and its neighborhoods are causing a significant number of air crashes. On-ground LIDAR system for measuring wind activity near the airport is being developed.

Three different setups are been considering: Wind-LIDAR based on coherent detection of optical carrier Doppler shift, Wind-LIDAR based on detection of the Doppler shift in a modulated optical carrier and Elastic Wind-LIDAR based on 1D Profile Correlation Techniques.

It will be presented the block diagram, pros and cons, researching steps, wind measurements and results regarding these three different LIDAR setups.

The accurate knowledge of wind activity during different phases of flight will improve the security, especially during landing and takeoff.

Statement how the presentation contributes to the topic

New signal processing algorithms have been developed which contribute to the improvement of profile correlation techniques. Furthermore, a LIDAR based on amplitude modulated lasers has been developed achieving a remote sensing system that doesn't need a highly pure spectral source like the classical coherent LIDAR.

The comparative table showing the advantages and disadvantages of each method contribute to the selection of the most effective technique depending on the atmospherically conditions, required computational time, resolution and distance of the measured area.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

LIDAR Airborne Aerodynamic Sensors

The reference topic

Topic : 4 (**Airborne Sensors & Aircraft Met Data**)

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Summary of the presentation

Thales has been active in the field of airborne LIDARs for aerodynamic parameters measurement for more than 25 years. These technologies have different applications

- Primary Air Data Systems for aircraft or helicopters
- Air Data reference
- Protection against atmospheric hazards (CAT, Wake Vortex)

Those different application require different LIDAR technologies

- IR LIDAR (CW or pulsed)
- UV LIDAR

Statement how the presentation contributes to the topic

General presentation of airborne LIDARs for aerodynamic parameters measurement.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Potential Use of Aircraft Derived Meteorological Data for Wake Turbulence Applications

The reference topic

Topic : 4 (**Airborne Sensors & Aircraft Met Data**)

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Summary of the presentation

The temporal and spatial scales of hazardous aircraft wake turbulence are critically dependent on ambient atmospheric conditions. Mid-term & far-term wake avoidance applications will require atmospheric profile information. Data link equipped aircraft have the potential to measure and report meteorological data at a high resolution, under all weather conditions, over regions of operational interest. A single set of data elements broadcasted over data links such as ADS-B can support both air-to-ground near-term and air-to-air long-term wake turbulence applications.

Statement how the presentation contributes to the topic

This presentation discusses an alternative means to collect atmospheric profile data for a wide range of applications utilizing existing aircraft sensor capabilities. The proposed data set and the frequency of data transmissions are consistent with previously envisioned meteorological uses of the 1090 and UAT squitters and other data links.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

High Resolution W-Band Radar Detection and Characterization of Aircraft Wake Vortices in Precipitation

The reference topic

Topic : 5 (**Radar Wake-Vortex Sensors**)

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Summary of the presentation

This paper reports on a radar technology that contributes to the challenge of detecting and characterizing wake vortices generated by aircraft during takeoff and landing operations. To this end, a high-resolution W-band radar has been demonstrated to readily detect wake vortices in precipitation at Boston's Logan International Airport. Specifically, meter-scale resolution of aircraft wake vortices in light rain has been demonstrated using a low power (100-mW), solid-state W-Band (94-GHz) radar system. The radar employs a 1.2 m diameter antenna on a scanning pedestal, providing a 1.5-m 6-dB cross-track beam pattern at 500-m range. Range resolution as fine as 1.0-m is achieved using stretch processing, which also provides processing gain on the order of 30 dB. Additional coherent gain is achieved through FFT processing at each range gate. Range sidelobe suppression in excess of 40-dB makes this system suitable for high spatial and temporal resolution atmospheric studies such as the investigation of wake turbulence behavior during aircraft takeoff and landing operations and the measurement of complex wind structure in the lower atmosphere.

Statement how the presentation contributes to the topic

The unique high spatial and temporal resolution possible with this W-band radar system can provide monitoring of wake vortices during precipitation events when other sensors such as lidar are compromised due to excessive hydrometeor scatter.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

High Doppler Resolution X-band Wake-Vortex Radar : CDG Airport Trials

The reference topic

Topic : 5 (**Radar Wake-Vortex Sensors**)

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Summary of the presentation

This talk deals with X-band radar trial campaigns 2006 and 2007 on Orly Airport, and June 2008 on Paris-CDG Airport, where a BOR-A550 radar has been deployed to assess short range (inferior to 2000 m) wake-vortex monitoring capabilities in all weather conditions (dry and wet conditions). Recorded data have been correlated with electromagnetic and fluid mechanical models of Wake Turbulences for better and more accurate understanding of roll-ups radar cross section (RCS) and Doppler signature. This capability could be exploited for operational use to track wake vortex (transport, decay, rebound) in extreme weather conditions and in dangerous areas (close to runways for departure and arrivals and along the glide slope). Thales has scheduled new radar campaigns on Paris-CDG and Frankfurt Airports in the framework of SESAR WP12.2.2 entitled “Runway Wake Vortex Detection, Prediction and decision support tools”

Statement how the presentation contributes to the topic

The main objective of Thales radar trials is to define, analyse and develop a verified wake turbulence system including wake-vortex monitoring sensors in a safety net approach in complement of Wind Monitoring Sensors coupled with Wake Vortex Predictor. Radar Wake Vortex Monitoring sensors could be integrated in 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.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Electronic-Scanning X-band Wake Vortex Radar: First Demonstrator

The reference topic

Topic : 5 (**Radar Wake-Vortex Sensors**)

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Summary of the presentation

The presentation will overview the demonstration radar, its associated development and deployment plan, as well as initial and future capabilities as required in support of both Terminal Area Wake Vortex and Weather Advisory Systems. The technology being utilised to achieve high performance at a low cost will also be discussed

Statement how the presentation contributes to the topic

This low cost radar potentially allows advanced wake vortex and weather capabilities at a fraction of the cost of current X-Band technology.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Study on Wake Vortex Electromagnetic Model and Radar Detection Technologies

The reference topic

Topic : 5 (**Radar Wake-Vortex Sensors**)

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Summary of the presentation

This presentation is dedicated to give an introduction of the preliminary research work on wake vortex electromagnetic model and radar detection technologies.

Based on the study of several preliminary problems including the dielectric constant distribution model and the oscillatory integral evaluation methods, some electromagnetic scattering characteristics of wake vortex are analyzed by computational simulation. Some main findings which include a new scattering mechanism, the RCS-Frequency relation, the high resolution range profile, the RCS-pattern of wake vortex will be presented here.

Further detection trials with KDIPR-X radar or other radar sensors are expected to verify the wake vortex electromagnetic model. To evaluate the detectability of aircraft wake vortices, the LMP (Locally Most Powerful) and GLRT (Generalized Likelihood Ratio Test) radar detectors are also deduced with performance assessment, and the main results will be presented.

Statement how the presentation contributes to the topic

The electromagnetic backscattering model of wake vortex is very important to the development of corresponding radar detection technology and the design of special radar sensors. This presentation is closely related to the topic of radar wake vortex sensors.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Multi-physics Electromagnetic/Fluid-Mechanical Simulator of Radar Wave-Vortex Monitoring

The reference topic

Topic : 5 (**Radar Wake-Vortex Sensors**)

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Summary of the presentation

The purpose of this preliminary simulator is to check the feasibility of the simulation of radar backscattering of wake vortex and the limitations of the simple methods used for the calculations. A first important parameter is the correct evaluation of the refractive index or the vortex. This necessitates the knowledge of the pressure (partial pressure of the various gases), humidity and temperature. These parameters have been evaluated in the preliminary version of the software, by using a pseudo-spectral code for the resolution of the fluid equations. The radar cross-section has been evaluated, using specific methods for the resolution of oscillating integrals. This implementation gives preliminary values of radar backscattering and some insight in the improvements to be included in the method.

A simulation tool for the calculation of the radar backscattering of wake vortices will deepen the knowledge of the influence of the various parameters of the radar on the detection of the vortices and will eventually be able to link the radar signal to the intensity of the vortex, in a given atmospheric environment.

Statement how the presentation contributes to the topic

Radar simulation is able to assess radar capability of wake-vortex monitoring for different weather conditions and sensors deployments.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Acoustic Technology for Wake Vortex Detection

The reference topic

Topic : 6 (**Acoustic Wake-Vortex Sensors**)

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Summary of the presentation

The presentation describes the experimental validation for an ultrasonic method of wake vortex detection. This method utilizes the travel time of acoustic pulses around a closed path to measure the net circulation within the acoustic path. In this application, the closed path encloses the trailing vortex from one wingtip of a general aviation aircraft. The magnitude and sign of the circulation detected is in agreement with the expected circulation generated for the speed and weight of the aircraft. The results validate the acoustic method for detecting aircraft wake vortices in the runway environment.

Statement how the presentation contributes to the topic

The presentation is an acoustic method of detecting wake vortices in the runway environment that utilizes the propagation time of ultrasonic pulses around a closed path to determine the enclosed circulation.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Bi-static Radio-Acoustic System for Wake Vortex Monitoring

The reference topic

Topic : 6 (**Acoustic Wake-Vortex Sensors**)

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Summary of the presentation

A bi-static radio (radar) acoustic system is used for wind measurements and vortex detection. The bi-static radar system is monitoring a vertical propagating acoustic wave and thus revealing how the acoustic propagation is influenced by atmospheric phenomena. The scattering mechanism is forward Bragg scattering by the periodic permittivity modulation imposed by the acoustic wave. In the bi-static geometry the radar scattering wave-number is decreasing with altitude along the vertical and the acoustic frequency can thus be used to focus the system on a particular height interval.

The presentation summarizes the basic theory and provides well documented results from experimental wind measurements and vortex detection with a prototype system. The project status is described as well as the way forward to a commercial system. The operational capabilities of a fully functional real time system for measurement of wind, temperature, turbulence parameters and vortices are discussed.

Statement how the presentation contributes to the topic

The presentation describes a bi-static radio acoustic system for measurements of wind, temperature and vortex detection. Well documented results from experimental campaigns involving detection of aircraft induced wake vortices are presented.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Enroute Wake Vortex Flight Data Acoustic Signature Characteristics

The reference topic

Topic : 6 (**Acoustic Wake-Vortex Sensors**)

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Summary of the presentation

NRC wake vortex in situ research flights have been conducted since 2004. Line-of-flight direct air data sensing has been used to derive wake vortex flow-field characteristics. Derived flow-field data can be analysed in the spatial-frequency domain – long-period spatial-frequency analysis applies to the direction of flight, whereas it is likely that short-period analysis better applies to the plane orthogonal to the direction of flight – for example elliptic instability, for which modes, the apparent modal peaks would align with frequencies of acoustic energy generation. Spatial-frequency analysis of past and recent NRC flight data from Heavy and Super Category wake generators has been conducted, to identify such potential acoustic signature characteristics, and compare with that expected from vortex instability theory. Included is the data from recent NRC flights, conducted in 2009, against A380 and B744 generators.

Statement how the presentation contributes to the topic

Scalar field senses may provide a means of detecting the approach of an encounter aircraft line-of-flight, to the immediate proximity of vortex cores from a trailing vortex pair. As such, acoustic field sensing has been investigated as a potentially suitable sensor for tracking vortices generated from aircraft on runway approach. On the other hand, the number of enroute-occurrence vortices point to a need to sense the presence of vortex cores in cruise. Research flight data is analysed, to gather acoustic generation characteristics and compare with that expected from vortex instability theory.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Pulsed 1.5 micron Lidar for Wake Vortex Measurements and Monitoring : CREDOS Trials on Frankfurt Airport

The reference topic

Topic : 7 (**IR& UV Wake-Vortex Sensors**)

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Summary of the presentation

For ten years, ONERA has been developing Coherent detection LIDAR for wake vortex characterisation or monitoring. New developments are based on 1.5µm fiber laser sources .

We will present the results obtained during CREDOS measurement campaign in Frankfurt with a pulsed lidar based on MOPFA 1.5µm fiber laser developed at ONERA, for detection and monitoring of wake vortices on airport fields (transverse detection). This development was down in collaboration of LEOSPHERE. Operational ranges larger than 400m have been demonstrated, with a 60µJ, 15kHz, 250ns pulsed fiber doped Er-Yb laser. Wake-vortex positions and circulations can be derived from recorded data. The wake vortex cores position resolution is ±2 m, the error on circulation 10%.

Statement how the presentation contributes to the topic

The presentation deals with new low-cost Lidar Technology for Wake-Vortex Monitoring.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Measurement of Aircraft Wake Vortices Using Doppler 1.5 micron LIDAR

The reference topic

Topic : 7 (**IR& UV Wake-Vortex Sensors**)

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Summary of the presentation

We have been conducting the measurement of wake vortex since April 2006 ongoingly by using Doppler lidar at Sendai airport in Japan. Our activity for wake vortex consists of lidar observation and numerical simulation. Regarding the lidar observation of wake vortex, advection database of wake vortex is constructed to understand the correlation between wake vortex behavior and weather factors such as wind directions and stability of the atmosphere. In addition, data mining method is applied to the database to understand the cross correlation of multidimensional weather factors.

Statement how the presentation contributes to the topic

This presentation will provide wake vortex research activity using Doppler lidar in Japan. After the brief descriptions of the Doppler lidar, data mining results from lidar measurements will be presented. Some other topics might be included in the presentation regarding the lidar observation of wake vortex.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Airborne and Ground based Wake Vortex Measurements with Pulsed Lidar

The reference topic

Topic : 7 (**IR& UV Wake-Vortex Sensors**)

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Summary of the presentation

DLR's 2-µm pulsed Doppler lidar has successfully been used to characterise aircraft wake vortices, both from a ground-based shelter scanning sideways as well as airborne in a research aircraft scanning downward. A four-stage data processing algorithm has been developed to achieve precise profiles of tangential velocities from which the vortex parameters such as trajectories, core separation, tilt angle, and circulation can be derived. The lidar tracks and measures the vortices in a range between 500 and 2000 m with high accuracy. This allows for observations over long periods from the moment of wake generation to a progressed state of vortex decay. Results from various ground-based and airborne campaigns will be discussed.

Statement how the presentation contributes to the topic

It contributes very well to the topic with a global survey of DLR Lidar measurements of wake vortex.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Assessment of Pulsed Lidar Measurements of Aircraft Wake Vortex Positions Using a Lidar Simulator

The reference topic

Topic : 7 (**IR& UV Wake-Vortex Sensors**)

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Summary of the presentation

Recent measurements of wake vortices have been obtained using the Lockheed Martin Coherent Technologies (LMCT) pulsed Lidar. The LMCT pulsed Lidar has been and is continuing to be used in many field measurement programs to measure wake vortex position and strength. However, the accuracy of the Lidar measurements has not been clearly established, mainly due to the lack of ground truth data to compare with the Lidar measurements. Under NASA funding, a Lidar Simulator Tool has been developed to quantify the accuracy of these Lidar field measurements.

Statement how the presentation contributes to the topic

The Lidar Simulator Tool produces realistic raw signal data generated from a wake vortex velocity field. Two types of truth data are used in the simulator. The first type is based on an analytical wake vortex model. The simulator can also use the wake velocity field from LES numerical models. In this presentation we concentrate on assessing the accuracy of the lateral and vertical vortex locations.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Radiometric Detection of Aviation Hazards

The reference topic

Topic : 7 (**IR& UV Wake-Vortex Sensors**)

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Summary of the presentation

The Forward-Looking Interferometer (FLI) is a new instrument concept for obtaining the measurements required to alert flight crews to potential weather hazards. The FLI concept is based on high-resolution Infrared Fourier Transform Spectrometry (FTS) technologies and is currently being evaluated for its potential to address multiple hazards, including clear air turbulence (CAT), volcanic ash, wake vortices, low slant range visibility, dry wind shear, and icing during all phases of flight (takeoff, cruise, and landing). Generally speaking, none of these six hazards is detectable by radar, yet each has some characteristic that makes it feasible for identification by radiometric means. This presentation will give an overview of the activities of the project to date with an emphasis on upcoming wake vortex studies.

Statement how the presentation contributes to the topic

New kind of sensor for wake vortex monitoring.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

GreenWake : UV LIDAR for Wake Vortex Detection

The reference topic

Topic : 7 (**IR& UV Wake-Vortex Sensors**)

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Summary of the presentation

The GreenWake UV direct detection LIDAR will measure wake vortices and wind shear at close range (< 200m). The presentation will provide an overview of the GreenWake requirements, the proposed solution as well as some of the simulations that have been made. The system will measure at two ranges: the first provides information to a feed-forward flight control system to allow dynamic control of the flight control surfaces to minimise the effects of the turbulent events experienced by the aircraft, both to improve passenger/crew safety and reduce stress on the airframe. The second range will allow characterisation of the turbulent event and report the event to the aircraft and ATC. The programme will develop a system simulator to fully determine the correct configuration of the instrument. A ground-based demonstrator will be built and tested both in a wind tunnel and at an airport, where it will be compared with a DLR coherent LIDAR.

Statement how the presentation contributes to the topic

The GreenWake system is a UV LIDAR for detecting wake vortices and wind shear. Presenting a UV system provides a good contrast and comparison for the IR LIDAR systems also to be presented. The UV system has the advantage of operating at shorter ranges than the majority of the IR systems being developed and offers further information and control options to tackle the issue of wake vortex detection.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

GreenWake : Wake Vortex Detection Simulations

The reference topic

Topic : 7 (**IR& UV Wake-Vortex Sensors**)

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Summary of the presentation

We present here a geometric simulator used in the GreenWake project to help defining the best geometric configuration (position, field-of-view, range, resolution, scanning pattern, etc.) for the sensor in order to maximize the probability of detection of atmospheric hazards. This simulator (of what an ideal velocity sensor would “see”, and thus independent from the technology of the real sensor) is to be used as a first simulation step, in order to ensure whether the geometric configuration of the sensor allows the atmospheric hazard to be detected or not. This first simulation step is being used in GreenWake to define the geometric parameters of the sensor and to discriminate among various atmospheric hazard detection scenarii the ones which could lead (or not) to a detection before feeding them to the full-fledged physical sensor simulator. We also present a “flight simulator” used to visualize in 3D and real-time data previously simulated using the actual GreenWake physical sensor simulator.

Statement how the presentation contributes to the topic

This presentation focuses on an “ideal” geometric simulator, providing quick, sensor-independent rough simulations, which could either be used to help defining the geometric parameters of the final sensor or providing an input to the actual physical sensor simulator (e.g. as axial or 3D velocity fields along the sensed lines-of-sight). This simulator is therefore aimed to be used along with (and *not* to replace) actual physical sensor simulators. It could also be used in order to avoid simulating and processing ill-posed scenarii where no detection could be expected, and to allow early development of detection algorithms.

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Wake Turbulence Measurements – Practical experience, considerations, contributions made to NAS and science to date

The reference topic

Topic : 8 (**Multiple Sensors**)

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Summary of the presentation

The talk highlights the State-of-the-Art Measurements in the context of wake turbulence, and some recent experience with multiple sensors in a more than purely “science” mode. The presentation is not intended to be a complete survey, and is biased by the experience / involvement of the Volpe Center.

Statement how the presentation contributes to the topic

Sufficient understanding exists in aspects of wake turbulence to provide near-term and mid-term wake mediation solutions via procedure changes and wind based con-ops

Wake Vortex & Wind Monitoring Sensors Workshop

Presentation title

Wake Vortex Tracker for Radar/Lidar Sensors

The reference topic

Topic : 8 (**Multiple Sensors**)

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Summary of the presentation

Current research activities at the Institute of Flight Guidance of the Technische Universitaet Braunschweig focus on a close coupling approach for wake vortex measurement, where the sensor (e.g. LIDAR or RADAR) is aided in acquisition, scanning pattern, and data interpretation by a model for the vortex evolution and in turn the model prediction is constantly updated based on measured data from the sensor. The coupling is done in an integrated fusion filter that allows to observe additional quantities that are not directly measured and will therefore offer an even more comprehensive situation awareness. This presentation gives an update on the current development status of the system.

Statement how the presentation contributes to the topic

Different kind of sensors for the detection and the tracking of wake vortices exist. They all include some kind of propagation model to assist the tracking of the moving object, i.e. the wake vortices. As wake vortex prediction algorithms get more and more mature nowadays, the ability of detection and tracking of wake vortex can be increased by using this models within the sensor detection algorithms. Future sensors thus can benefit from a collaborative system, by example to not only act as a safety net, but also to provide the function as a wake vortex predictor in one system. This presentation is a contribution to such a development.