aerodays2015
Aviation in Europe – Innovating for Growth
The 7th European Aeronautics Days

To optimize Wake Vortex separations

Fabrice ORLANDI THALES AIR SYSTEMS

UFO

ULTRA FAST WIND SENSORS

To optimize Wake Vortex separations

21/10/2015

http://www.ufo-wind-sensors.eu/

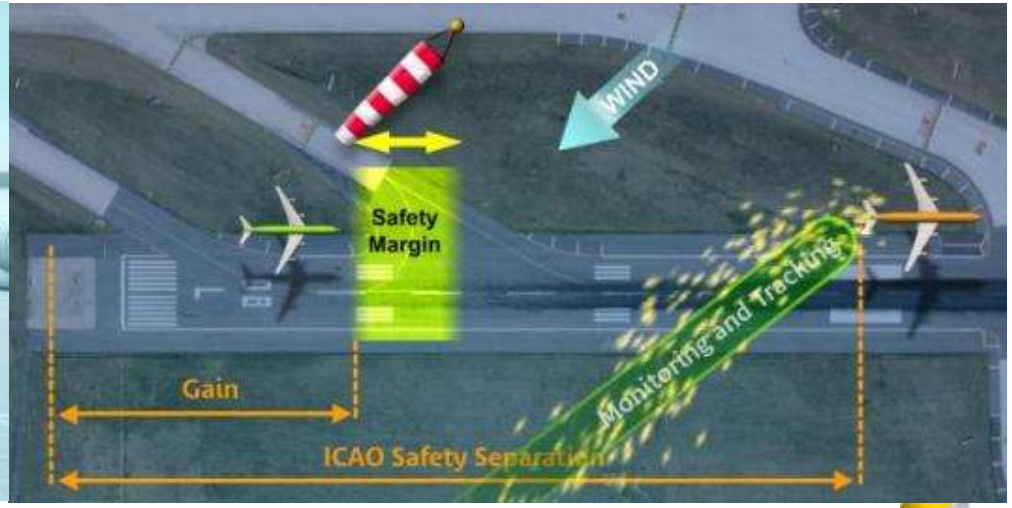
London

THALES · Leosphere · ONERA THE FRENCH AEROSPACE LAB · DWD · KNMI · DLR · NLR · Technische Universität Braunschweig · UPMC SORBONNE UNIVERSITÉS · TUDelft Delft University of Technology · UCL Université catholique de Louvain · Munich Airport · METEO FRANCE Toujours un temps d'avance · ISL · EUROCONTROL · dgac STAC

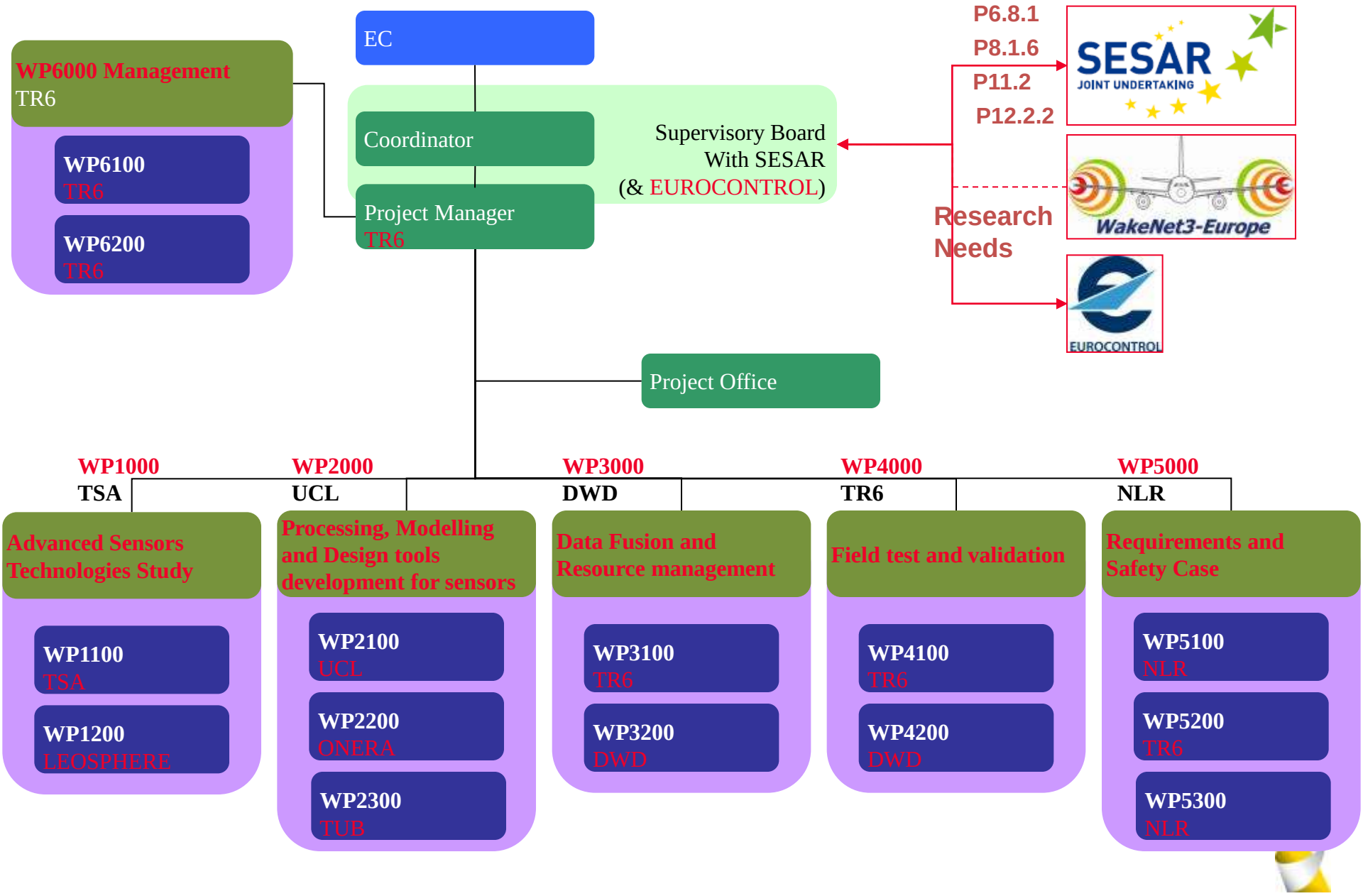
SEVENTH FRAMEWORK PROGRAMME

UFO OPERATIONAL GOALS

- UFO is studying dedicated Wind sensors compliant with future Airport Weather operations requirements
- Safety margin of Wake-Vortex Separations are dependent of Wind/EDR assessment accuracy (Wind for WV transport, EDR for WV decay), UFO has improved the update rate and the accuracy of Wind/EDR assessment: to optimize this Safety Margin and to generate Alert in case of abrupt changes of wind /EDR conditions
- UFO did also improve other wind hazards ultra-fast monitoring capabilities: Low Level Wind-Shear.



UFO Organization



A situation to be improved

- Airports become congested
  - Number of airports at >90% of runway capacity (IATA)
    - : Today : 6
    - : 2020 : 63
    - : 2030 : 125
- Wake vortex separations are a bottleneck for airport capacity
  - Defined in 70's they are considered as over conservative
  - Only based on 4 aircraft weight categories
  - Independent from weather
- Progress made in sensors and computer power allows reducing current wake separations
  - Refinement of categories to stick to aircraft characteristics
  - Wake vortex wind and air turbulence modeling
  - Wake vortex, wind and air turbulence monitoring

	A388 follower	HEAVY follower	MEDIUM follower	LIGHT follower
A388 leader	(*)	6 NM	7 NM	8 NM
HEAVY leader	(*)	4 NM	5 NM	6 NM
MEDIUM leader	(*)	(*)	(*)	5 NM
LIGHT leader	(*)	(*)	(*)	(*)

Table 1: Overview of ICAO longitudinal wake turbulence distance-based separation minima on approach phase

(*) When a wake turbulence restriction is not required, then separation reverts to radar separation minimum set for collision risk mitigation:

- as prescribed by ICAO as minimum radar separations – MRS – being 3NM (or 2.5NM under given conditions set in Doc 4444), or
- as prescribed by the appropriate ATS authority.

Wake vortex separations reduction could increase airport capacity

How to reduce safely wake vortex separations

- STATIC separations improvement
  - Taking into account aircraft type characteristics
  - Two steps planned
    - : RECAT 1 : 6 categories instead of 4, by splitting in two the Heavy category and the Medium category
    - : RECAT 2 : 9000 aircraft types grouped in 100 categories then refined airport by airport to cope with each airport traffic mix. As RECAT 2 will be optimized for the airport traffic mix, the capacity gain will be higher. This capacity gain will be assessed with a specific safety and cost/benefit assessment.
  - A tool showing the separation between aircraft could be used for RECAT1 and shall be used for RECAT2

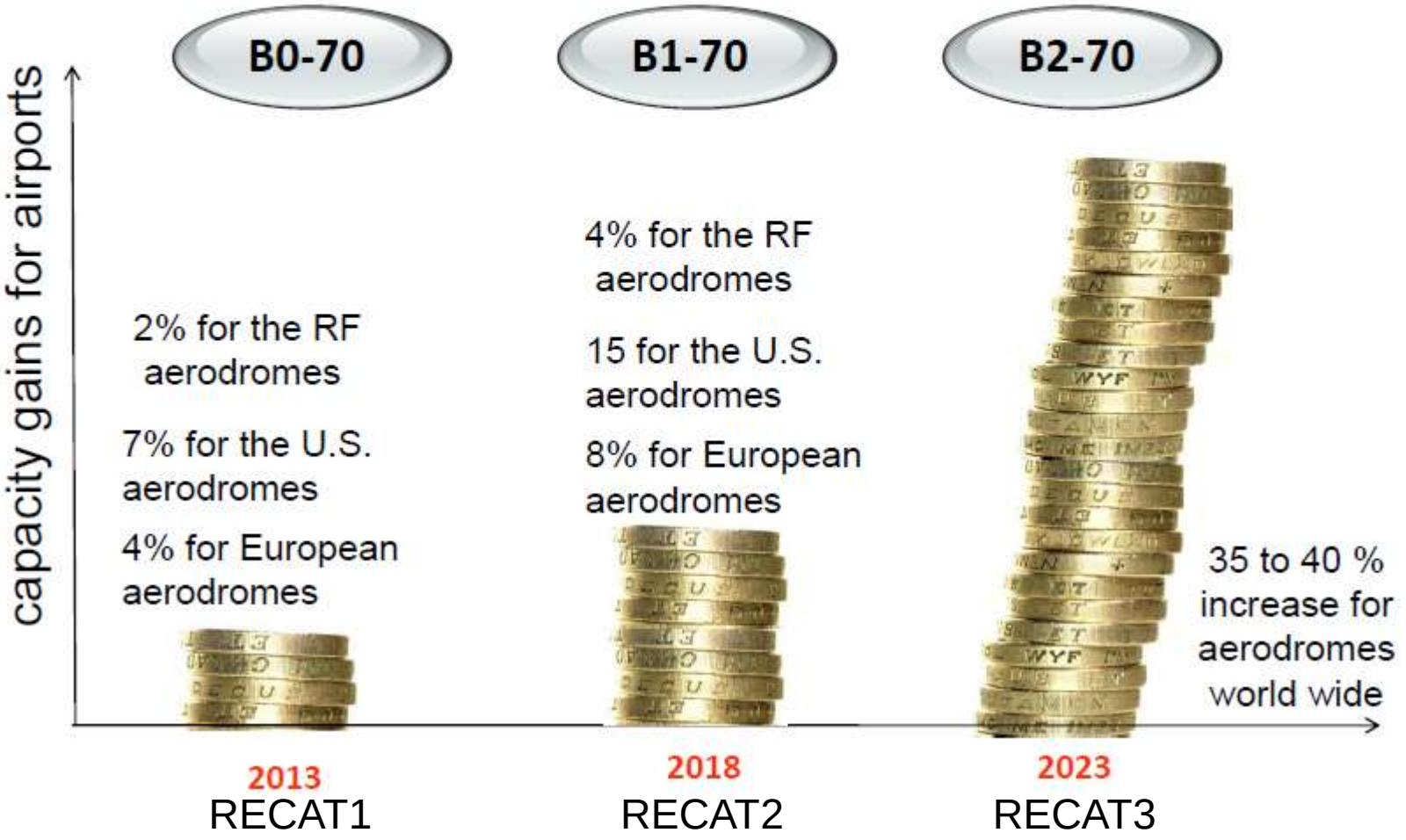
- Dynamic separations improvement
  - Time Based Separation (TBS) for arrivals. Has been validated within SESAR. Will be deployed in 15 European airports by 2023.
  - Weather Dependent Separation (WDS). Will be validated in 2016. Deployment could occur jointly with TBS deployment.
  - ICAO groups both TBS and WDS in RECAT3 concept. Europe decided to follow a more step by step approach (validation of TBS first, WDS later)

Wake vortex separations reduction will increase airport capacity

ICAO Roadmap

Wake Vortex Flight Safety System

Benefits



Static Separation : RECAT 1 EU

	A388 follower	HEAVY follower	MEDIUM follower	LIGHT follower
A388 leader	(*)	6 NM	7 NM	8 NM
HEAVY leader	(*)	4 NM	5 NM	6 NM
MEDIUM leader	(*)	(*)	(*)	5 NM
LIGHT leader	(*)	(*)	(*)	(*)

Table 1: Overview of ICAO longitudinal wake turbulence distance-based separation minima on approach phase

(*) When a wake turbulence restriction is not required, then separation reverts to radar separation minimum set for collision risk mitigation:

- as prescribed by ICAO as minimum radar separations – MRS – being 3NM (or 2.5NM under given conditions set in Doc 4444), or
- as prescribed by the appropriate ATS authority.

ICAO Doc 4444 Procedure (4 categories)

RECAT 1 EU (6 Categories)

Leader / Follower		Super Heavy	Upper Heavy	Lower Heavy	Upper Medium	Lower Medium	Light
		A	B	C	D	E	F
Super Heavy	A	3 Nm	4 Nm	5 Nm	5 Nm	6 Nm	8 Nm
Upper Heavy	B	(*)	3 Nm	4 Nm	4 Nm	5 Nm	7 Nm
Lower Heavy	C	(*)	(*)	3 Nm	3 Nm	4 Nm	6 Nm
Upper Medium	D	(*)	(*)	(*)	(*)	(*)	5 Nm
Lower Medium	E	(*)	(*)	(*)	(*)	(*)	4 Nm
Light	F	(*)	(*)	(*)	(*)	(*)	3 Nm

Table 5: RECAT WT distanced-based separation minima on approach

(*) means minimum radar separation (MRS) is applicable as per current ICAO doc 4444 provisions.

Separation Gain of RECAT 1 EU versus ICAO Doc4444

Leader / Follower		Super Heavy	Upper Heavy	Lower Heavy	Upper Medium	Lower Medium	Light
		A	B	C	D	E	F
Super Heavy	A	(+0.5 Nm)	-2 Nm	-1 Nm	-2 Nm	-1 Nm	
Upper Heavy	B		-1 Nm		-1 Nm		+1Nm
Lower Heavy	C		-1 (-1.5*) Nm	-1 Nm	-2 Nm	-1 Nm	
Upper Medium	D						
Lower Medium	E						-1 Nm
Light	F						(+ 0.5 Nm)

Separation Gain of RECAT 1 Europe for Arrivals versus ICAO Doc 4444

Leader / Follower		Super Heavy	Upper Heavy	Lower Heavy	Upper Medium	Lower Medium	Light
		A	B	C	D	E	F
Super Heavy	A		-20s		-40s	-20s	
Upper Heavy	B				-20s		+20s
Lower Heavy	C				-40s	-20s	
Upper Medium	D						
Lower Medium	E						-20s
Light	F						+20s

Separation Gain of RECAT 1 Europe for Departures versus ICAO Doc 4444

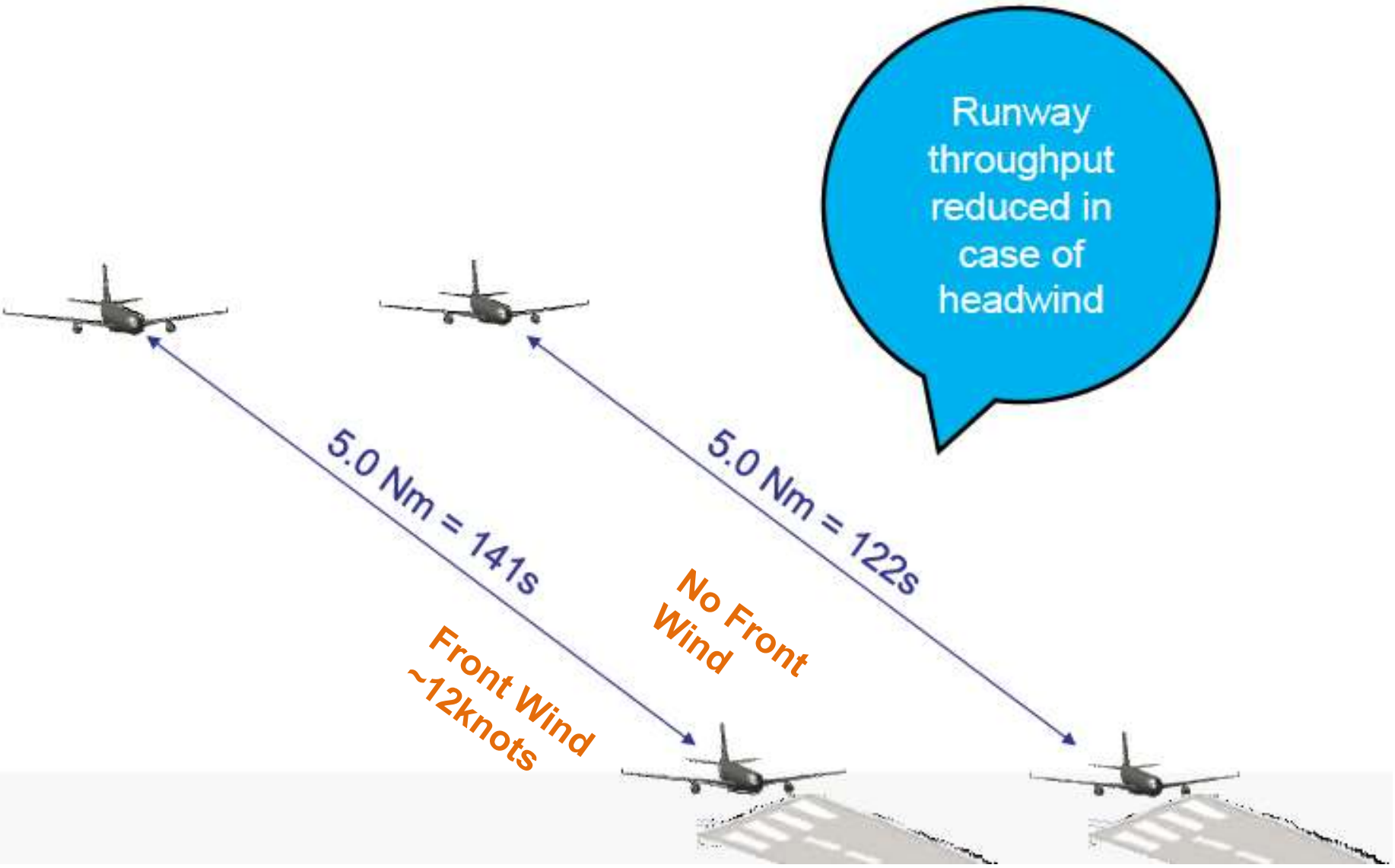
RECAT 1 is already deployed in 15 airport in USA. Is just deployed in Paris CDG and will be deployed largely in Europe

RECAT 2: Pairwise separation on more than 100 categories

'Super Heavy'	'Upper Heavy'	'Lower Heavy'	'Upper Medium'	'Lower Medium'	'Light'
'CAT-A'	'CAT-B'	'CAT-C'	'CAT-D'	'CAT-E'	'CAT-F'
A388	A332	A306	A318	AN32	FA10
A124	A333	A30B	A319	AT43	FA20
(…)	A342	A310	A320	AT45	D328
	A343	B703	A321	AT72	E120
	A343	B752	AN12	B462	BE40
	A345	B753	B736	B712	BE45
	A345	B762	B737	B732	H25B
	A346	B763	B738	B733	JS32
	A346	B764	B739	B734	JS41
	AN22	B783	C130	B735	LJ35
	B744	C135	IL18	CL30	LJ60
	B748	DC10	MD81	CL60	SF34
	B772	DC85	MD82	CRJ1	P180
	B773	IL76	MD83	CRJ2	C650
	B77L	L101	MD87	CRJ7	C525
	B77W	MD11	MD88	CRJ9	C180
	B788	TU22	MD90	DC93	C152
	IL96	TU95	T204	DH8D	(…)
	(…)	(…)	TU16	E135	
			(…)	E145	
				E170	
				E175	
				E190	
				E195	
				F70	
				F100	
				GLF2	

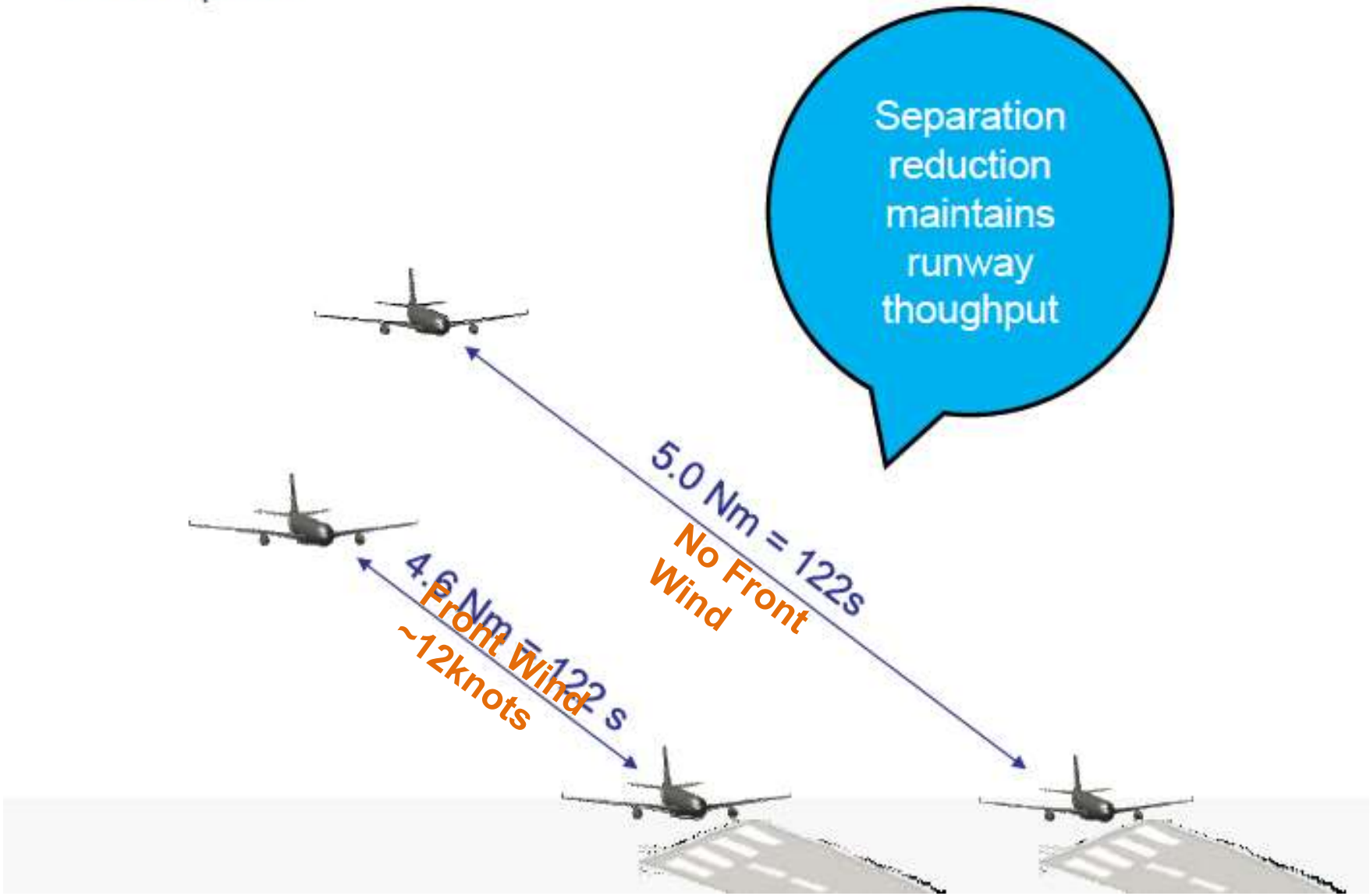
RECAT 2 will be tuned to take advantage of each airport traffic mix. A related cost/benefit assessment and a safety case will have to be performed

Dynamic separation: Time Based Separation concept



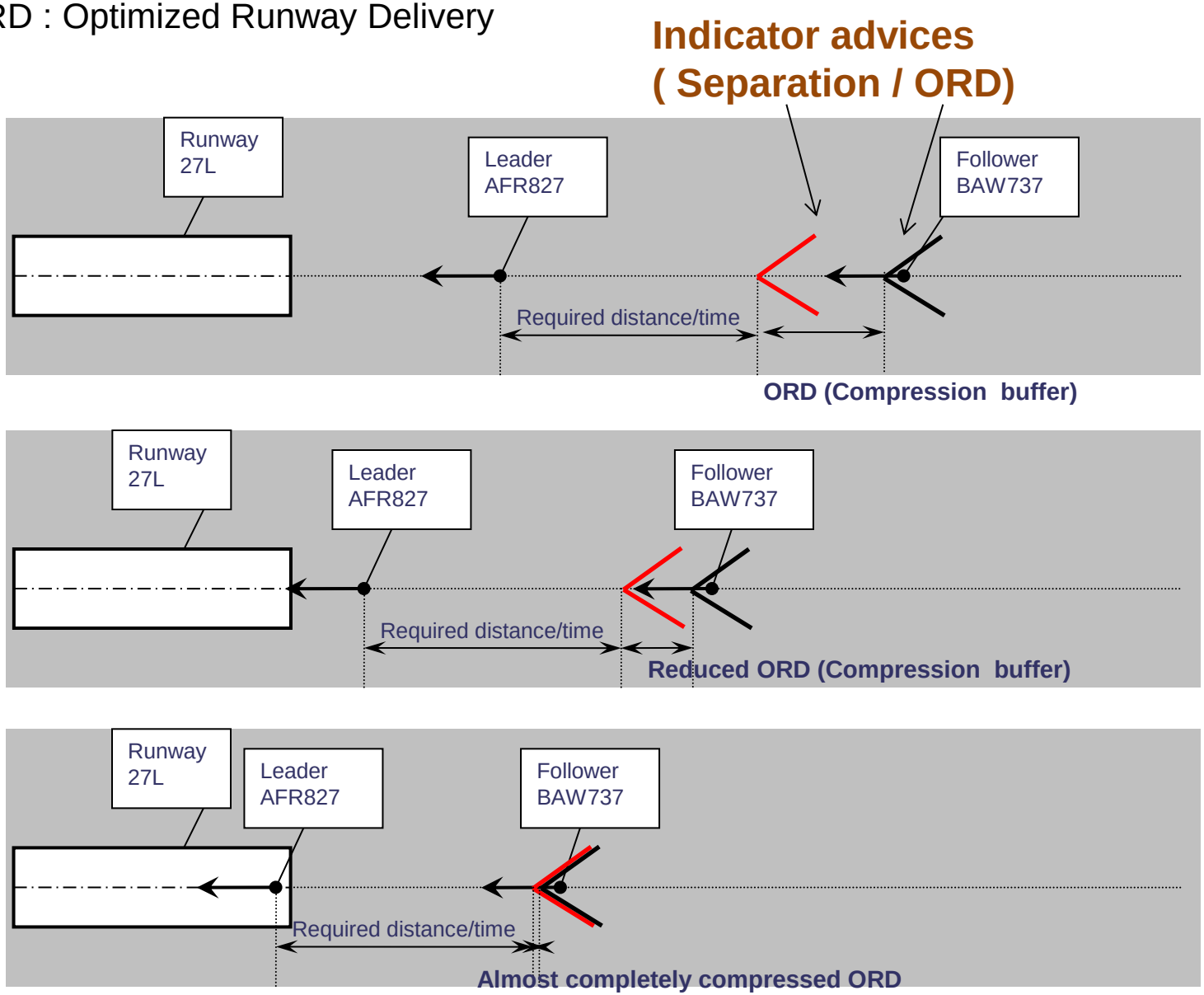
TBS concept

- Distance separation reduction for maintaining runway throughput is based on the wind profile



WVAS - ORD Details

ORD : Optimized Runway Delivery



2014 Time Based Separation Validation Exercise

- 3 Traffic samples
- 3 Weather conditions
- TBS or DBS rules
- RECAT or ICAO separations

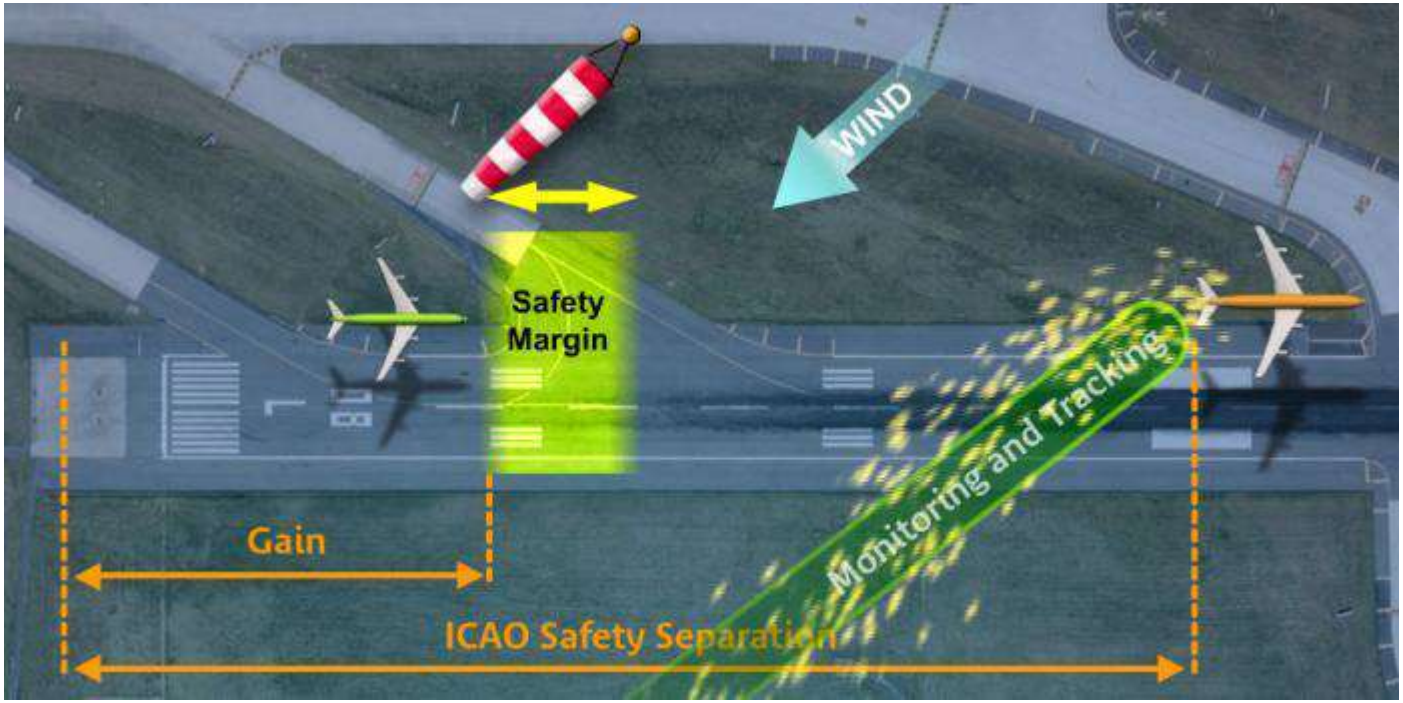
- Approach and Tower controllers
- Pseudo Pilots
- 1 week full time trials (Oct 2014)
- System and Human performance assessment

A video related to this validation exercise can be found here: **https://www.youtube.com/watch?v=8TjNF7dhdP0**

This validation demonstrated that the TBS concept allows to recover almost the whole loss of capacity in case of strong headwind

Weather Dependant Separation concept

- Weather Dependent Separation
  - TBS continuation. Will take into account the global wind, and especially the crosswind
  - Will allow a large capacity gain in favourable weather conditions
  - Validation will be performed in February 2016



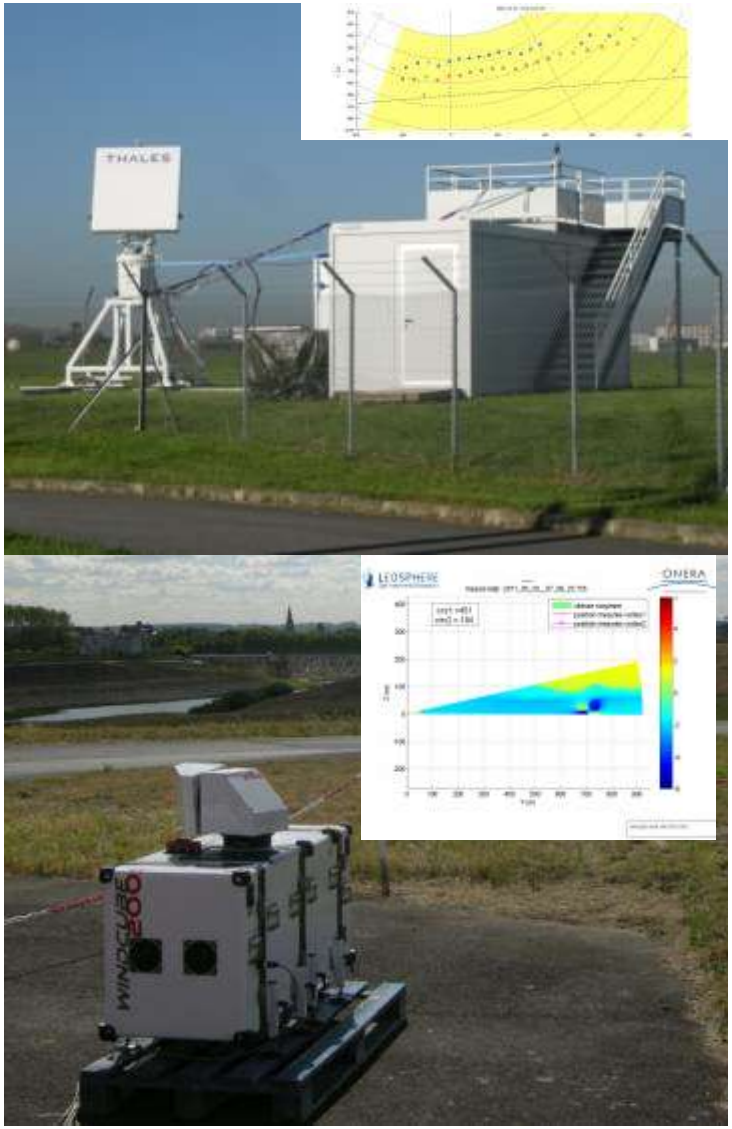
THALES Radar/Lidar sensors suite

- Collaborative Resources management
  - Collaborative modes between Radar and Lidar according to weather conditions
- THALES Radar/Lidar Sensors have been calibrated based on:
  - Radar/Lidar Sensors simulators mixing EM/EO models and Fluid Mech. Models
  - Collaboration with AIRBUS on flight trials at Toulouse Airport within UFO
- These sensors are operational to:
  - Develop a Wake-Vortex Database
  - Feed Safety Cases for RECAT deployment
  - Support Airport Capacity study
- These trial campaigns pave the way for upgraded operational systems deployment

The THALES sensors suite is the best existing tool to support RECAT 1 & 2 deployment and to prepare weather dependant airport capacity improvement

THALES Radar/Lidar sensors suite

- Radar/Lidar Combination
  - X-band Radar in Wet /Foggy conditions
  - 1.5 micron Lidar in Dry Conditions
- 3D scanner capabilities
  - Multi-function sensors (modes interleaving)
    - : Detection of wake-vortex (positions scanned every 7.5 s)
    - : Wake-Vortex Strength Retrieval (Circulation in m^2/s)
    - : Wind that induces Wake-Vortex Transport
    - : Air turbulence by EDR (Eddy Dissipation Rate) that induces Wake-Vortex Decay
    - : Rain Rate (Radar) for ground segment of ROT
- Additional functions
  - Wind-Shear
  - Wind Burst / Microburst



THALES Radar/Lidar sensors suite

- Previous trial campaign allowed to define the adequate set of sensors
  - Lidar and X Band radar are complementary
  - They must be multifunctions (Wake vortex and Weather monitoring)
- We developped remote controlled sensors compliant with needs
- We setup an automatic data processing chain
- At the end of 2015, we will have the required set (sensors and related data processing chain) to support RECAT and/or TBS deployment on any airport

UFO measurements synthesis example (DWD)

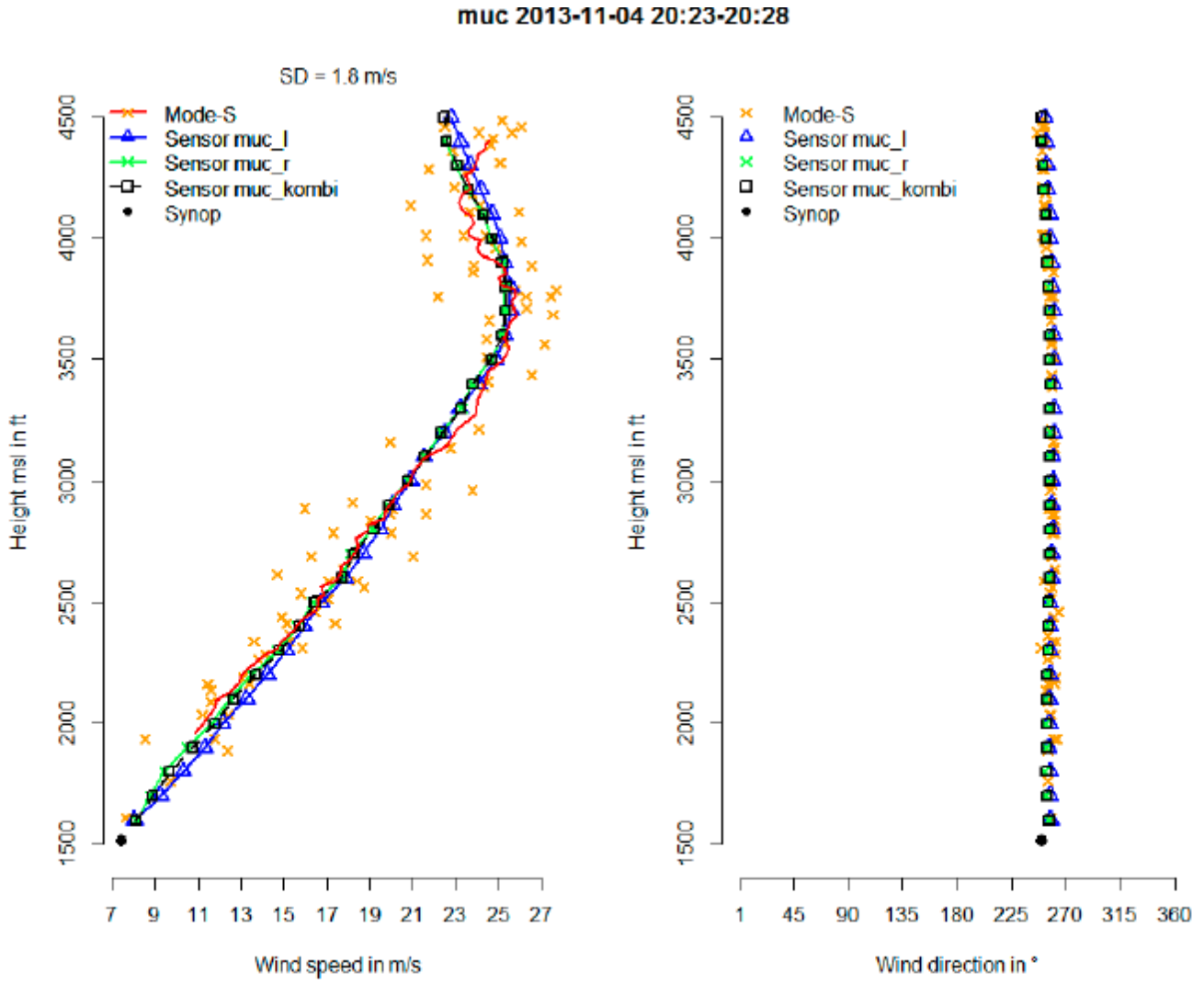


Figure 9: Vertical profiles of wind speed (left) and direction (right) of lidar (muc_l), radar (muc_r), the combination of both sensors (muc_kombi) and of Mode-S EHS (Mode-S) at MUC. Date: 04 November 2013, 20:23 UTC till 20:28 UTC for LLWAS wind and 20:18 UTC till 20:33 UTC for Mode-S EHS wind.

Example of charges/fees for CHANGI & ADP airports

REVENUE*

- **CHANGI : 1911 M S$ (~1146 M€)**
  - Airport fees: 609 M S$ (~ 365 M€)
  - Movement /year : 328.000 (~900/day)
    - ~ revenue per slot :per year : 407 k€
- **ADP : 2640 M€**
  - Airport fees: 867 M€
  - Movement / year : 721.000 (Orly+CDG)
    - ~ revenue per slot :per year : 438 k€
- **Average fee per slot is not the best way to value a slot – slot revenue is depending of aircraft type & PAX number**

* : source 2012 financial statement

FEES application for 3 aircrafts type

- **CHANGI :**

	Aircraft type		
Airport fees	A380	B777-300	A320-200
Fees per year (M€)	4,6	2,7	1,1

** : PAX occupancy : 80%*
1 S$ = 0,6€

- **ADP :**

	Aircraft type		
Airport fees	A380	B777-300	A320-200
Fees per year (M€)	4,4	2,6	1,8

- **Fees between Changi & ADP are moreless the same for large aircrafts**

Additional slots for large aircraft are generating important fees with direct impact on commercial airport activities, allowing a quick ROI for wake vortex separation improvement systems

aerodays2015

Aviation in Europe – Innovating for Growth

The 7th European Aeronautics Days

Questions ?

aerodays2015

Aviation in Europe – Innovating for Growth

The 7th European Aeronautics Days

LONDON

20–23 OCTOBER 2015