



Preparatory study of wake vortex detection technology case

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Measuring WV: a comprehensive approach

Users' needs



Functional specs



Wakesep Project requirements



	All specs				
Lidar		●			
Radar					
Wind			●		●
Radar+Lidar	●			●	
Sodar Rass		●	●		

ASSESSMENT

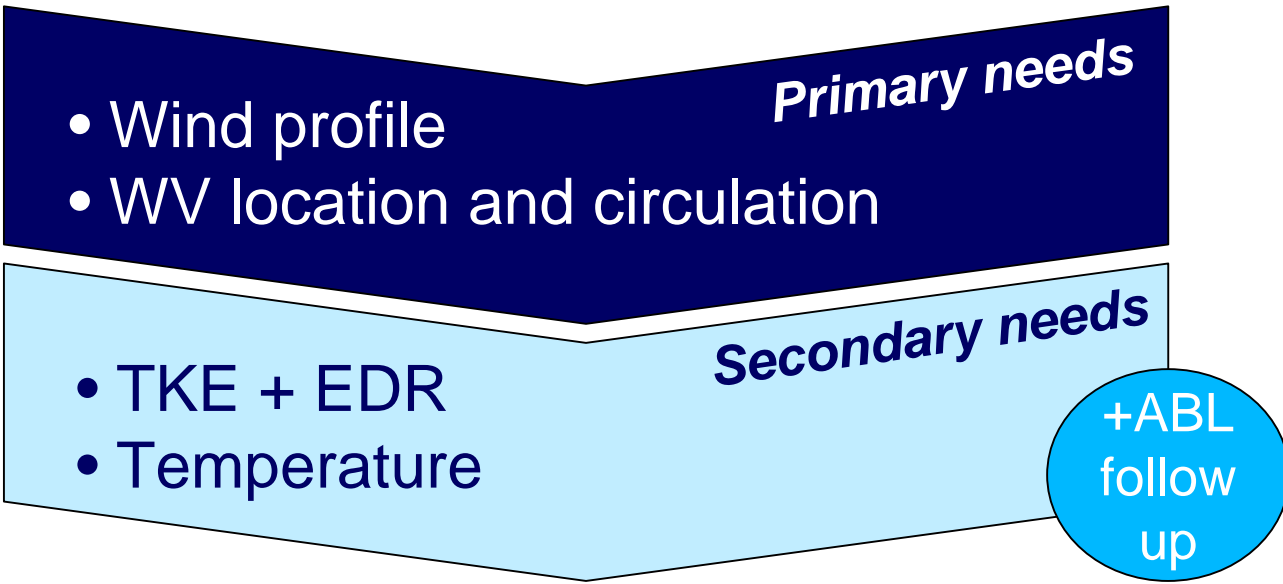
Technology state of the art



Preliminary scenarii :
Technological "packages"

User's needs

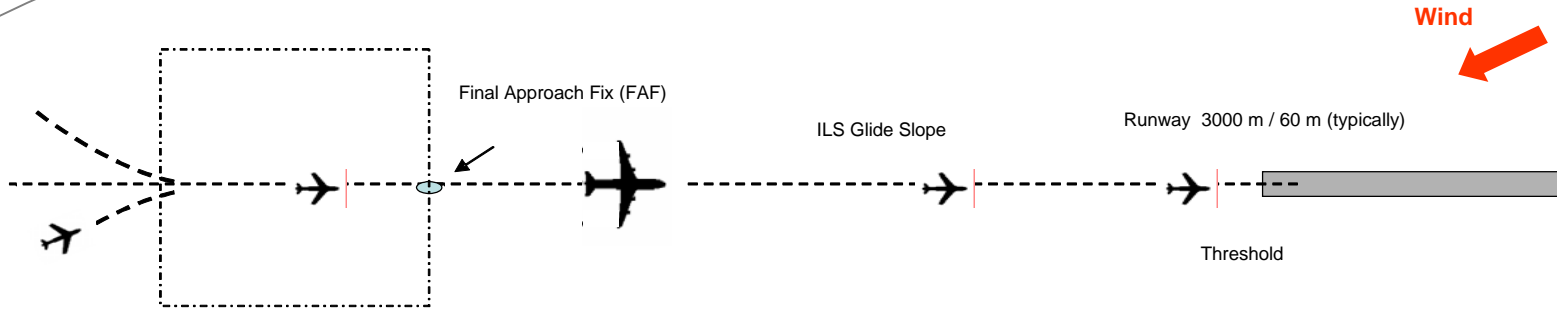
User's needs
Functional specs
Project specs
State of the art
Assessment
Tec. scenarii



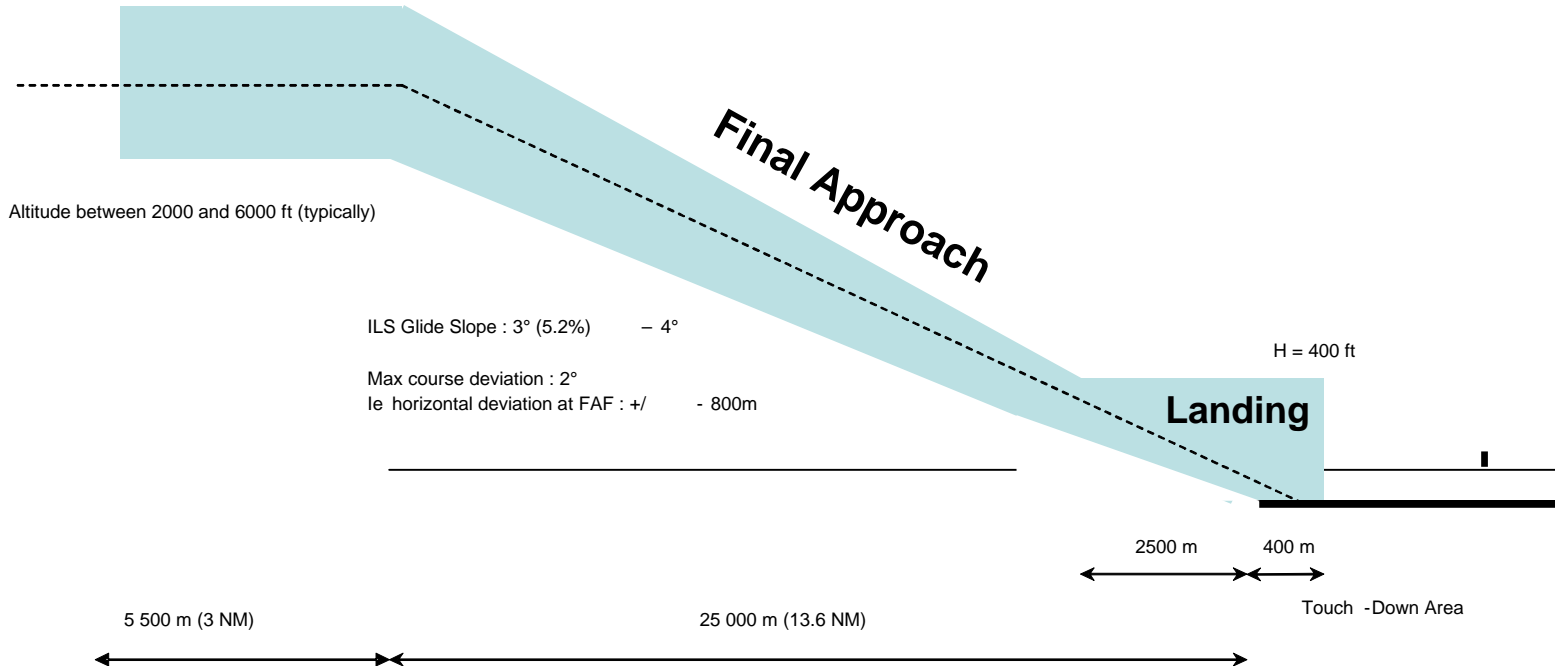
Where to measure?

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ARRIVALS

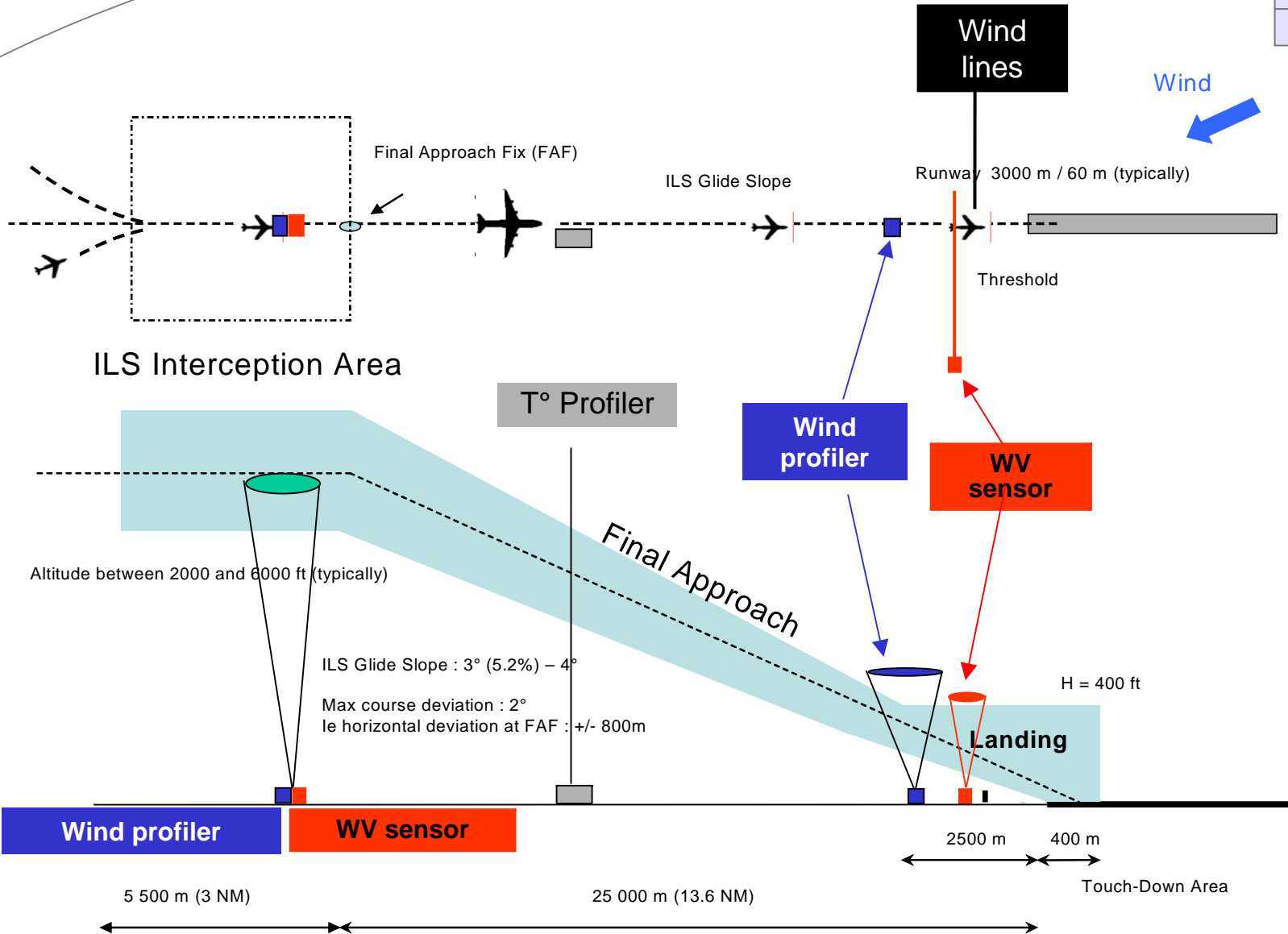


ILS Interception Area



Experimental setup for Arrivals

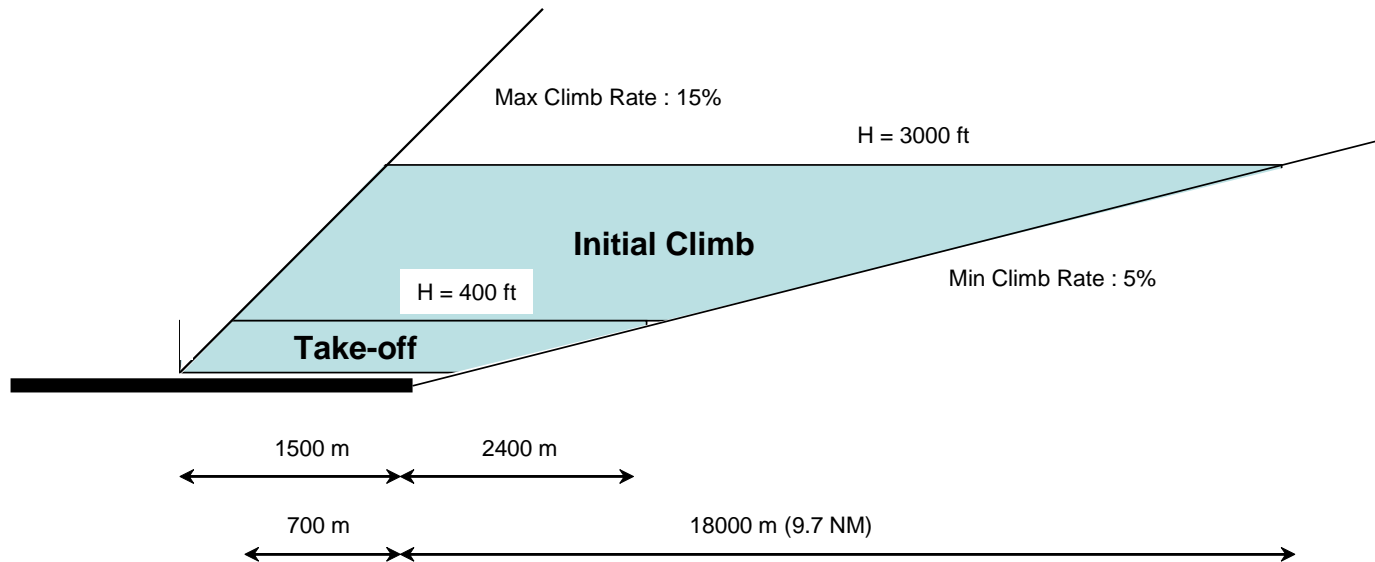
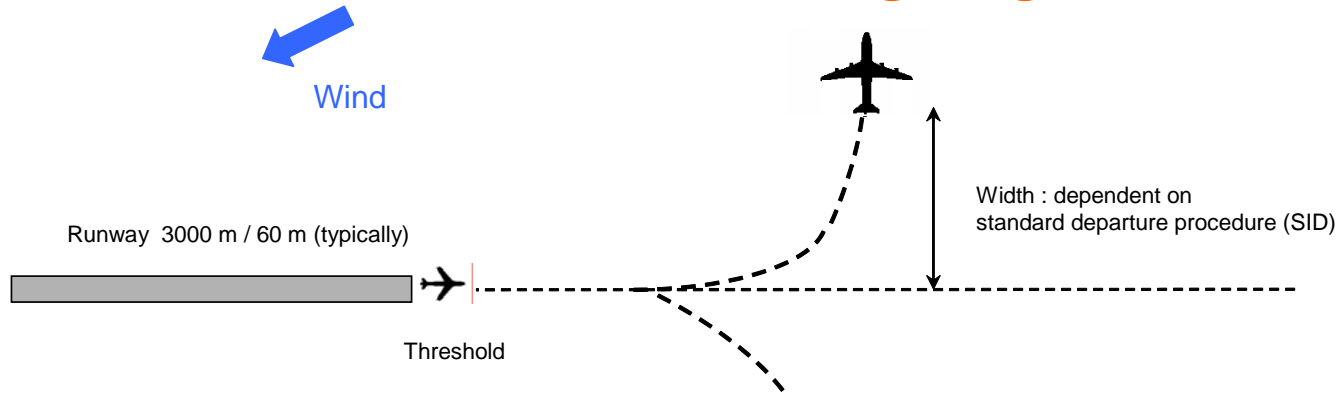
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Where to measure ?

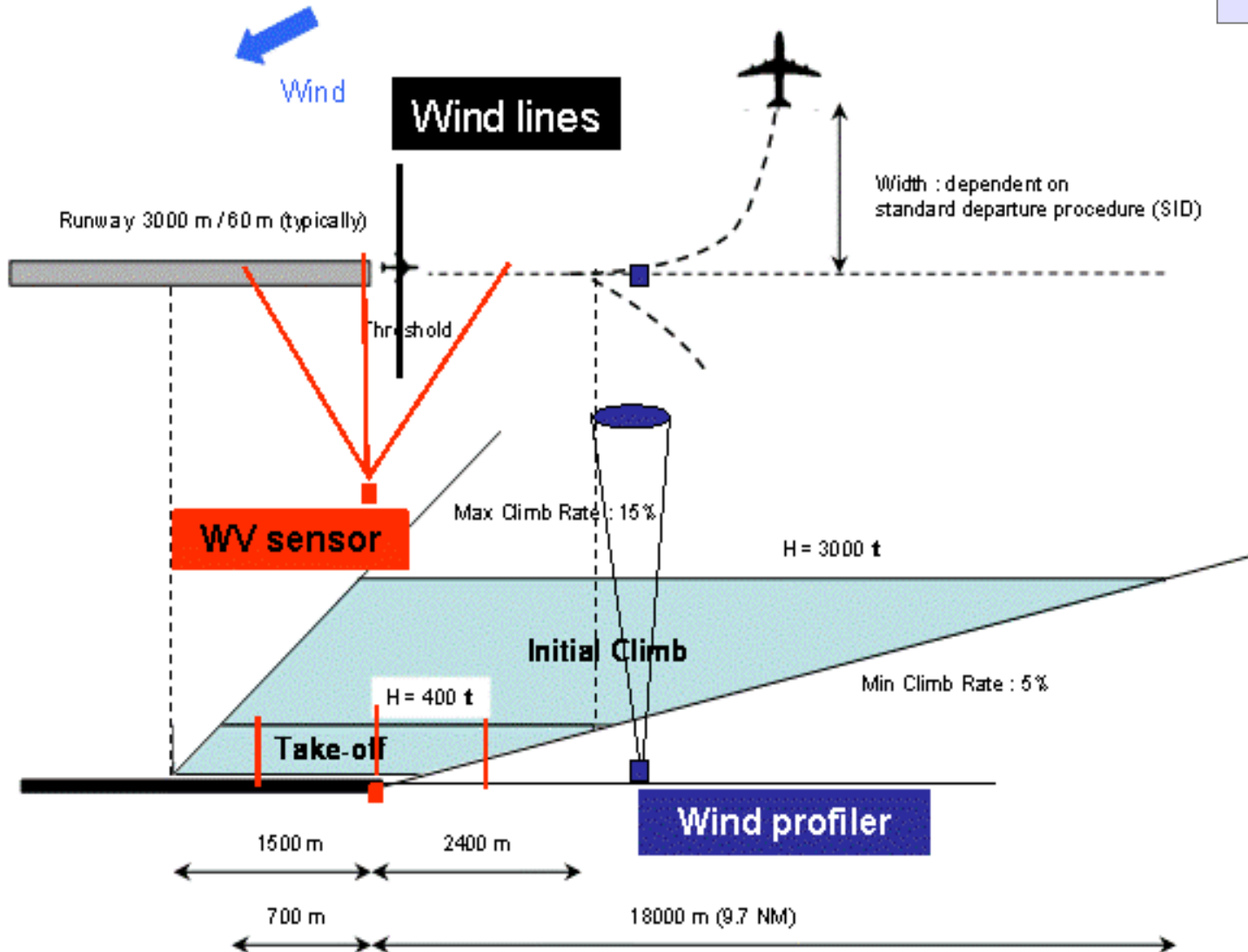
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DEPARTURES



Experimental setup for departures

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Functional specifications

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Approach/climb areas

Critical Areas

		Mandatory	Derived or Modelized	Accuracy	Data refreshment rate	Mandatory	Derived or Modelized	Accuracy	Data refreshment rate
Horizontal Windspeed profile	3D	X		1m/s $\Delta Z=50m$	25 sec. (Average every 2' with 1' refresh)	X		0,5m/s $\Delta Z = 15m$	<1mn
Wind direction profile	3D	X				X		N/A	1mn
Windshear profile	3D		X	1 m/s			X	0,5m/s	1mn
Turbulence (EDR or TKE)	3D		X			X		1 measurement at 10m	10 mn
Temperature profile (one location only - Same for takeoff and landing)	1D	X		1°K $\Delta Z=100m$	10mn	X		1°K	10 mn
Wortex core position	2D		X			X		< 10 m	6 sec.
Wortex circulation	2D		X			X		5 m ² /s	

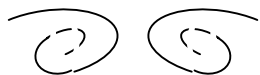
Constraints related to WakeSep project

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- Testing in an airport operational context
 - ☞ Safety
 - ☞ All-weather operations
 - ☞ Ease of operational set-up
 - ☞ Availability of operational prototypes
- Deploying throughout International airports
 - ☞ Cost
 - ☞ Level of R&D uncertainty
 - ☞ Level of dependency
 - ☞ ...

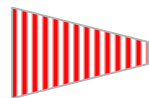
Candidate technologies

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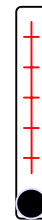
WAKE VORTEX DETECTION

- ☞ Coherent Lidar
 - Pulsed $2\mu\text{m}$
 - Pulsed $1,5\mu\text{m}$
 - CW
- ☞ Windlines
- ☞ LP2C Sodars
- ☞ S or X band RADAR
- ☞ Microphone array



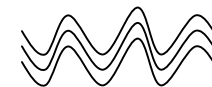
WIND PROFILE

- ☞ RADAR (UHF, TDWR, TEP, S or Xband)
- ☞ LIDAR (PC and CW, multi beam)
- ☞ SODAR
- ☞ Met Tower



TEMPERATURE PROFILE

- ☞ RASS + SODAR
- ☞ RASS +RADAR
- ☞ Microwave radiometer



TURBULENCE

- ☞ Met tower + sonic anemometer
- ☞ LIDAR
- ☞ TEP RADAR

■ R&D
■ COTS

Relevant technologies - 1st level assessment

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COTS REMOTE SENSORS

	WV monitoring	Wind profiles	Turbulence profile	Temperature profiles
Critical areas	Windline 2µm Pulsed Coherent LIDAR CW LIDAR	2µm Pulsed Coherent LIDAR Mini SODAR CW LIDAR TDWR	Tower + 3 sonic anemometers 2µm Pulsed Coherent LIDAR CW LIDAR	Microwave radiometer RASS/SODAR
Approach/Climb areas		2µm Pulsed Coherent LIDAR UHF RADAR SODAR TDWR	2µm Pulsed Coherent LIDAR	Microwave radiometer RASS/SODAR RASS/UHF RADAR
ILS interception	2µm ABL Pulsed Coherent LIDAR	UHF RADAR, SODAR (limit), TDWR		Microwave radiometer RASS/SODAR RASS/UHF RADAR

Relevant technologies – 1st level assessment

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MATURE R&D

	WV monitoring	Wind profiles	Turbulence profile	Temperature profiles
Critical areas	1.5µm short range Pulsed Coherent LIDAR LP2C sodar	1.5µm short range Pulsed Coherent LIDAR LP2C SODAR	1.5µm short range Pulsed Coherent LIDAR LP2C SODAR	
Approach/Climb areas		TEP RADAR	TEP RADAR	
ILS interception				

EMERGING TECHNOLOGIES

	WV monitoring	Wind profiles	Turbulence profile	Temperature profiles
Critical areas	Multi-beam LIDAR ? 1.5µm ABL Pulsed Coherent LIDAR	Multi-beam LIDAR X-band RADAR 1.5µm ABL Pulsed Coherent LIDAR	Multi-beam LIDAR X-band RADAR 1.5µm ABL Pulsed Coherent LIDAR	
Approach/Climb areas		1.5µm ABL Pulsed Coherent LIDAR Multi beam LIDAR	1.5µm ABL Pulsed Coherent LIDAR Multi beam LIDAR	
ILS interception	Multi-beam LIDAR ? 1.5µm ABL Pulsed Coherent LIDAR			

Relevant technologies – 2nd level assessment

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• Weather limitations

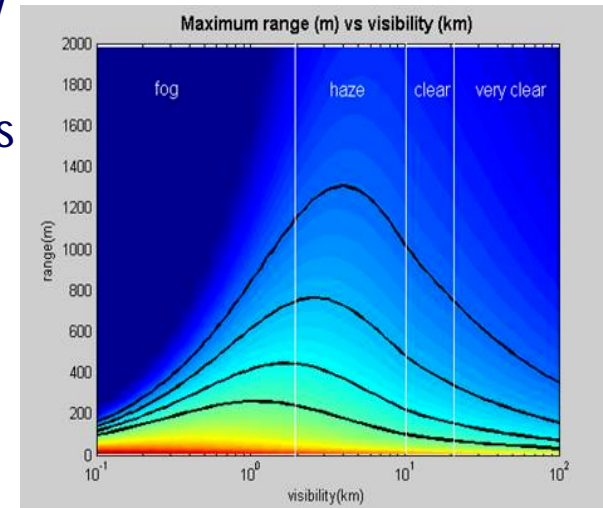
Clear stratified sky, low visibility, heavy rain, very low clouds

- ∞ Windline+Weather tower and TDWR : only solution under heavy rain
- ∞ LIDAR is adapted to most meteo situations

• Compliance with airport measurement protocol



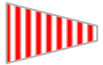
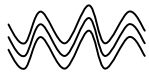
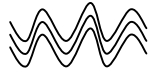

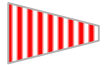

- ∞ Dual-mode: capability to switch from arrival to departure monitoring
- ∞ Safety

• Ease of operational setup



Ideal package


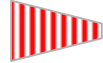
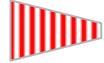
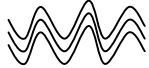
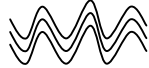

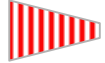

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ILS		Approach and Climb		Critical			
							
Vortex	Wind	Wind	Turbulence	Turbulence	Vortex	Wind	Temperature

No rain	Lidar PC2μ					RASS SODAR
Fog		RASS SODAR		Lidar PC2μ		RASS SODAR
Heavy rain		TDWR		Windlines and met tower (up to 45m)		

Alternative cheaper package

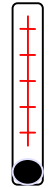



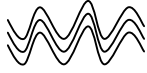


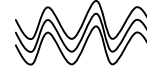
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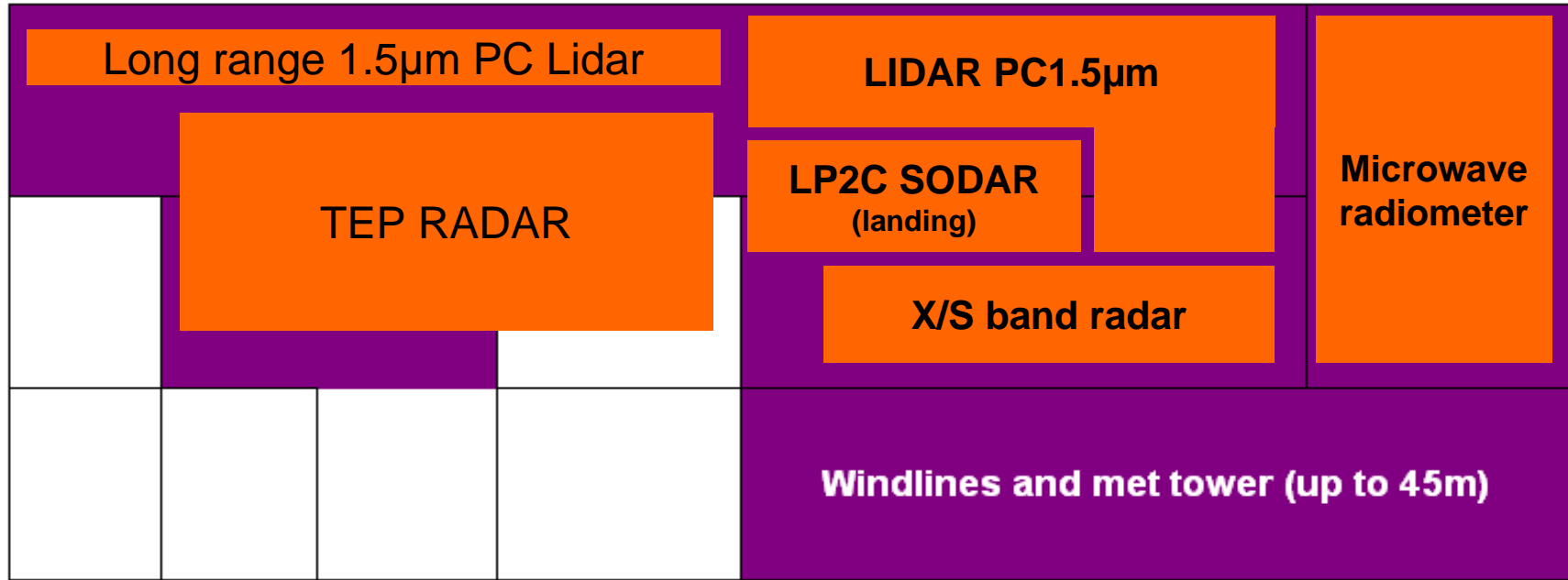
ILS		Approach and Climb		Critical			
							
Vortex	Wind	Wind	Turbulence	Turbulence	Vortex	Wind	Temperature

No rain	Lidar PC2μ						RASS+UHF RADAR
Fog	RASS + UHF RADAR		Lidar PC2μ				
Heavy rain				Windlines and met tower (up to 45m)			

Substitute by latest European and American R&D

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ILS		Approach and Climb		Critical areas			
							
Vortex	Wind	Wind	Turbulence	Vortex	Wind	Turbulence	



Next steps

- Validation field campaign:
 - Test the relevance of technological packages
 - Impact of weather conditions on performance
 - Estimation of overall (investment+operating) cost
 - Test of latest R&D solutions
 - Adaptation of experimental setup

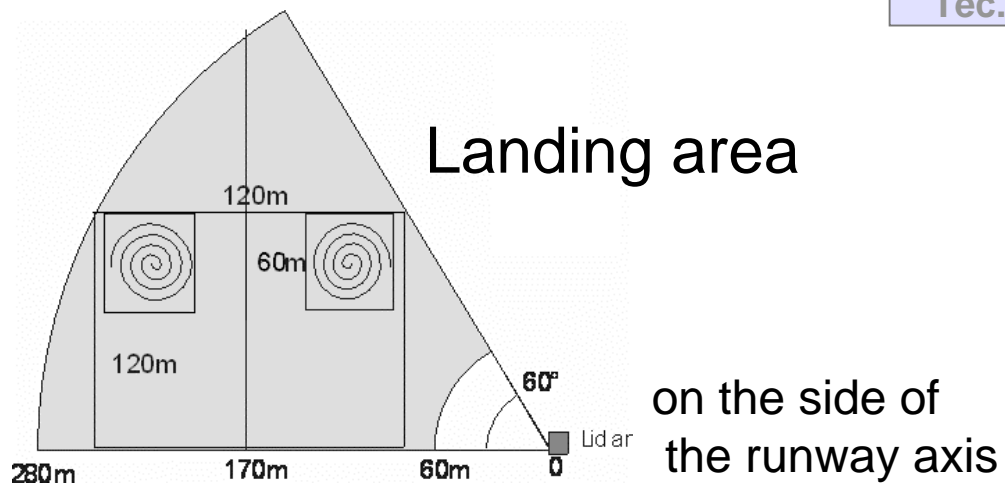


**Recommendation for a short term
operational solution**

- Backup slide

Experimental setup

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on the side of the runway axis

	ILS	FINAL APPROACH	LANDING	TAKE OFF	INITIAL CLIMB
First measurement point	900	120	0	0	120
Range min	1500	1500	130	280	1500
Range max			280	2000	

Scanning refreshment period shorter than 6s for vortex monitoring