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LIDAR SYSTEM

AS AN AID TO AIR NAVIGATION IN UNFAVORABLE WEATHER CONDITIONS

WAKENET 3
Workshop
March 29th 2010

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

ICFO Institut de Ciències Fotòniques

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Introduction

ATLAS LIDAR AIMS TO obtain WIND DATA from several miles (up to 5NM) from the airport allowing the monitoring of three different wind phenomena affecting aircraft near the airport:

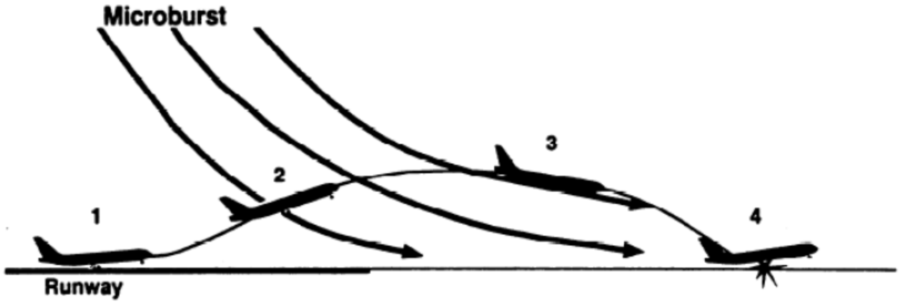
- **Microburst and Wind Shear:** develops a strong downdraft which causes damaging on winds or near the ground. Large changes in wind velocity and direction (wind shear) sizes the microburst shape

- **Wake Vortex:** each aircraft develops a wake in flight caused by a pair of counter-rotating vortices trailing from the wing tips.

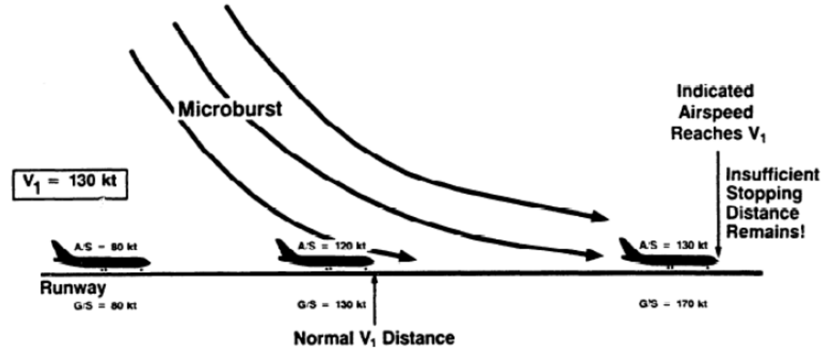
- **Crosswind :** Lateral winds affecting roll and yaw control laws in aircraft during take-off and landing maneuvers

Wind Phenomena Encounters

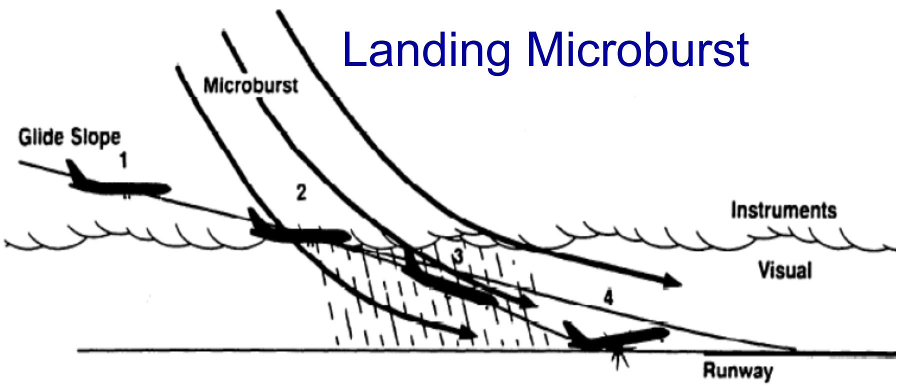
Take-off Microburst



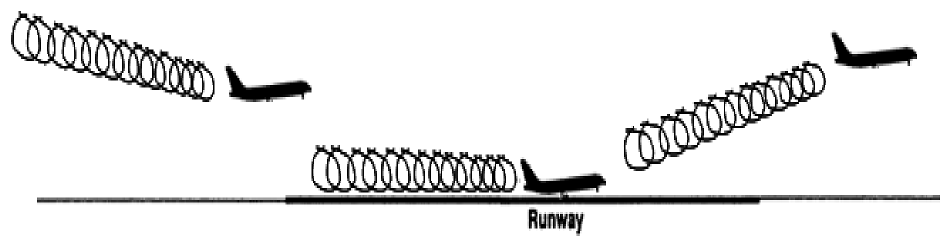
Runway Microburst

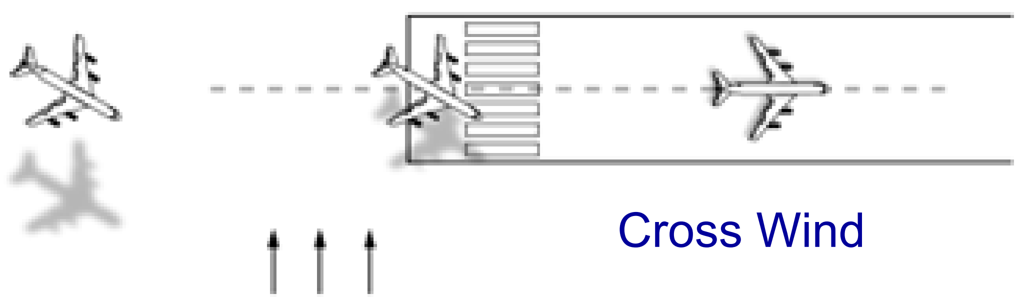


Landing Microburst



Landing/Runway/Take-off Wake Vortex





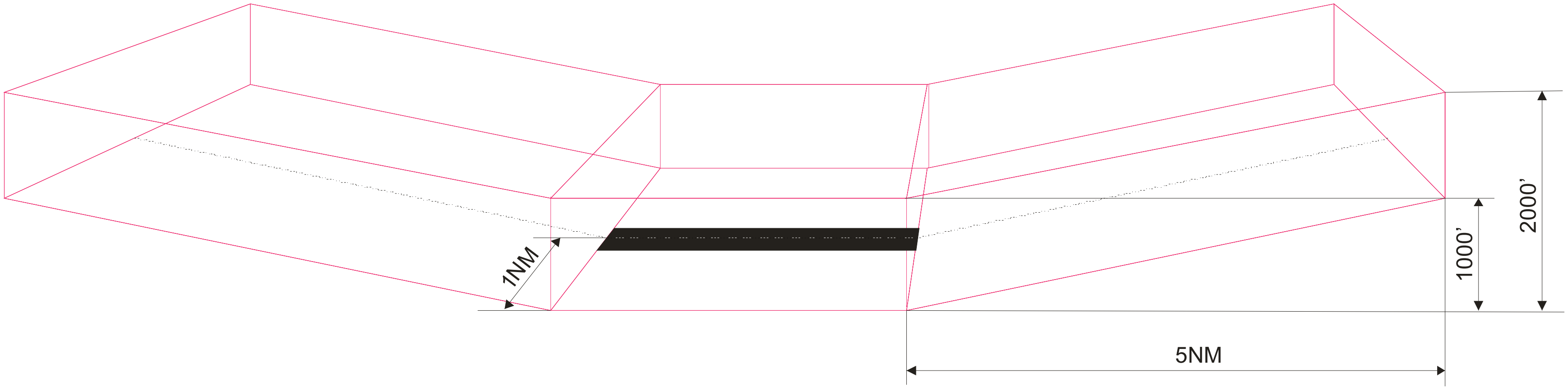
Cross Wind

Predictable Progress with ATLAS LIDAR

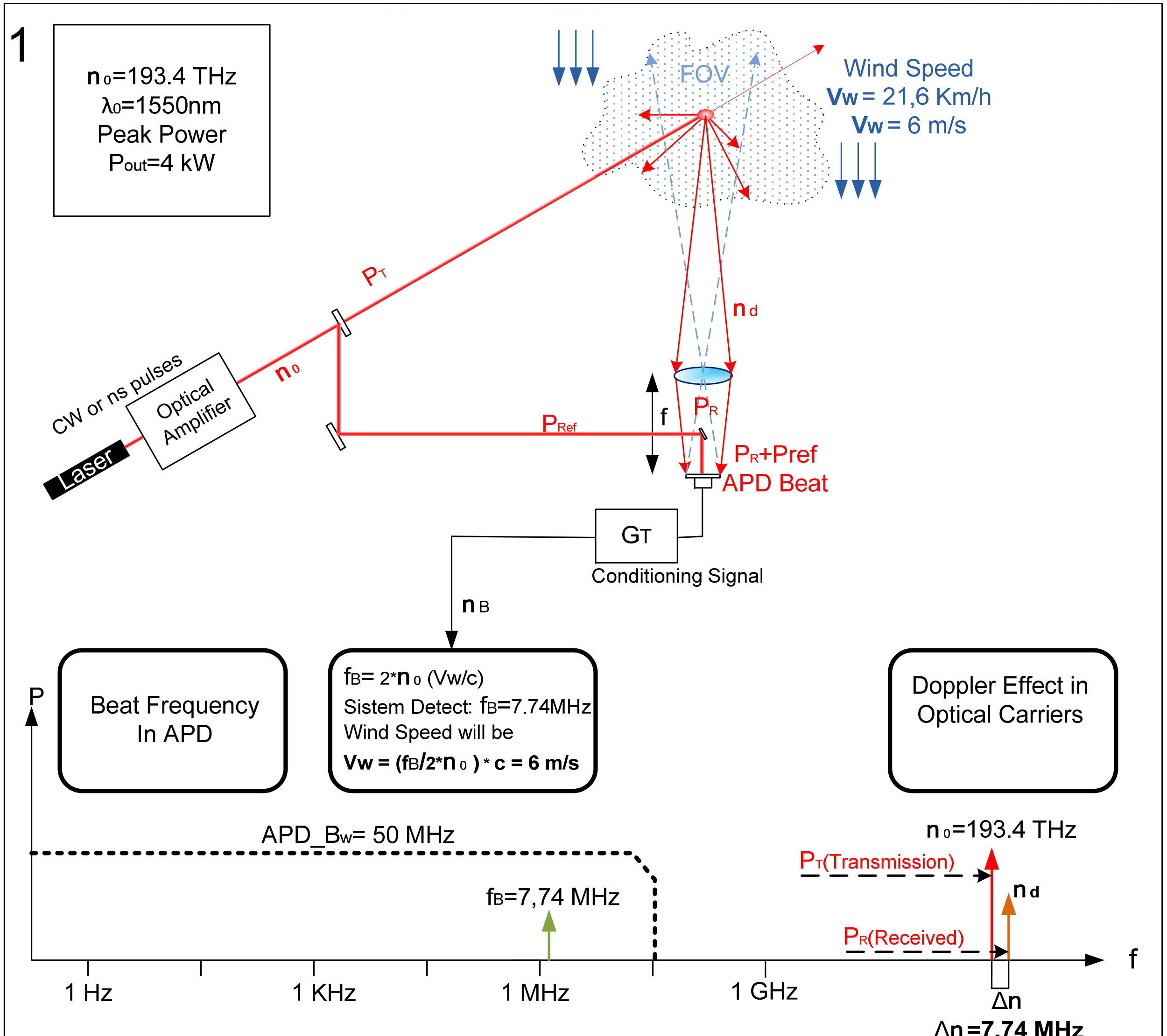
o **Trajectory and Performance Operations :** LIDAR wind data aim to predict wind phenomena during aircraft take-off/landing trajectory

o **Airport Runaway Operations Optimization :** Wake vortex measurement, wind data and airport automatic weather systems aim to forecast runway operations

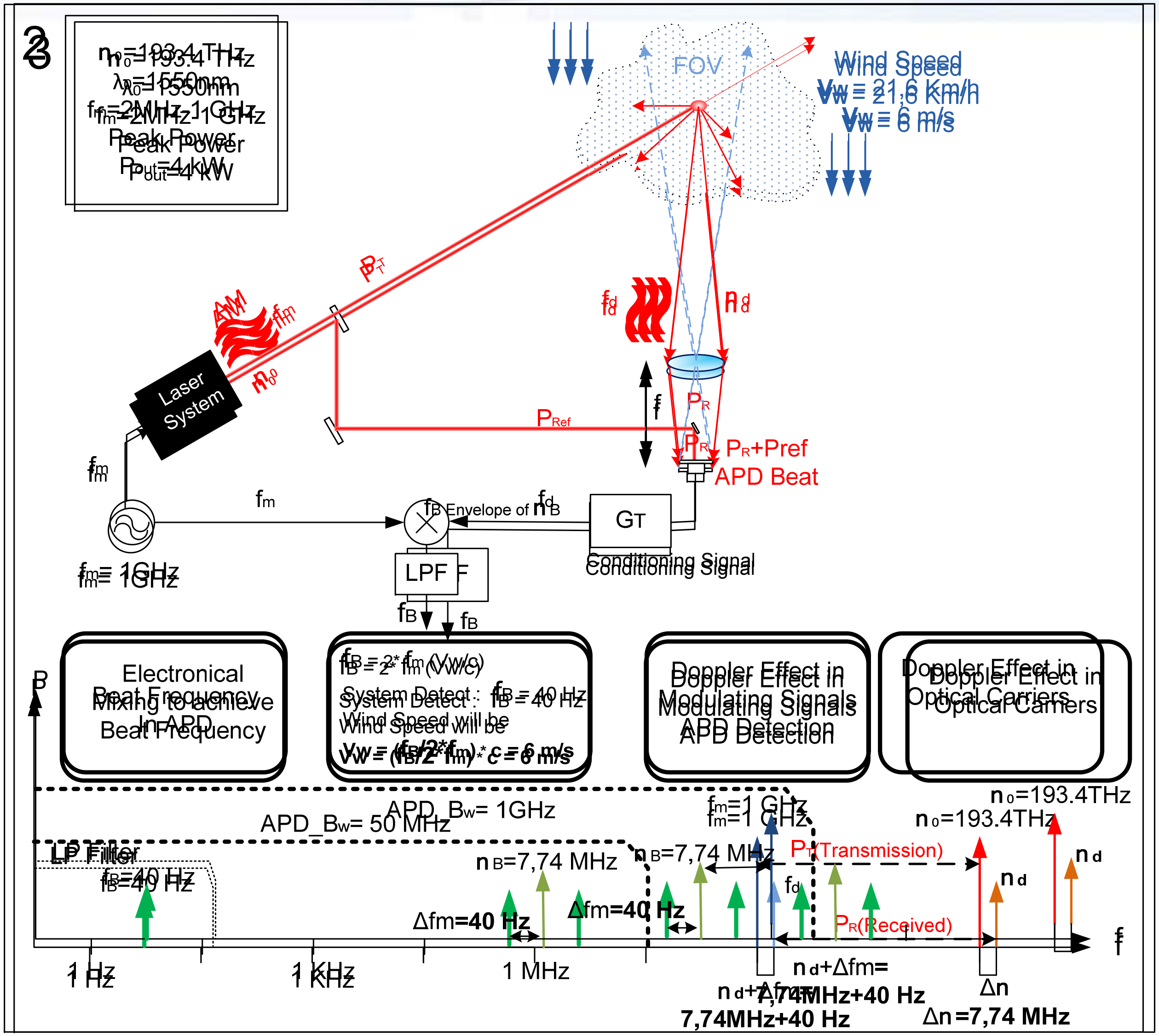
o **Weather Information Improvement** :Advance in the creation of a better weather prediction system



CASE STUDY 1: COHERENT WIND LIDAR

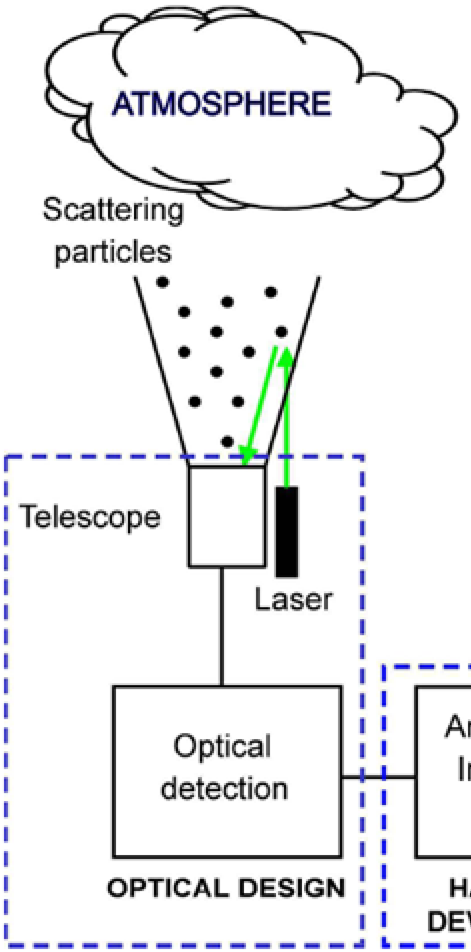


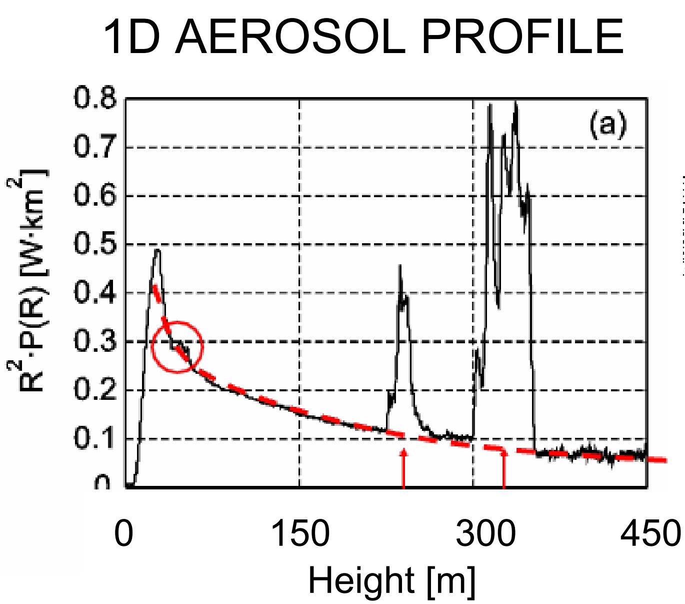
CASE STUDY 2: AMPLITUDE MODULATED WIND LIDAR

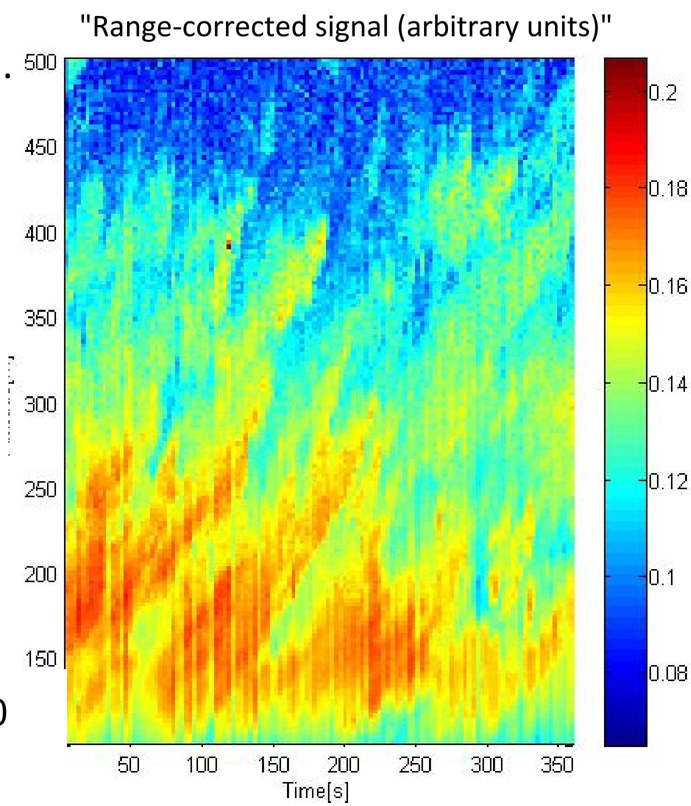


WIND LIDAR BASED ON 1D PROFILE CORRELATION EVALUATION HARDWARE

Backscattered Optical Power (1D PROFILE) vs Range.







Backscattered Received Power

WIND LIDAR BASED ON 1D PROFILE CORRELATION

EVALUATION HARDWARE

Laser	**Quantel Brilliant T-64**
Type	Nd:YAG (with SHG)
Wavelengths	1064 / 532.1 nm
Pulse energy	130 / 130 mJ
Repetition rate	20 Hz
Divergence	0.5 mrad half angle
Pulse duration	3.6 ns (typ.)
Telescope	**CELESTRON CGE1400**
Geometry	Schmidt-Cassegrain
Main mirror diameter	0,4m
Focal length	3.91m
Field-of-view	0.35 mrad
Fiber bundle	**CeramOptec**
Active area diameter	3 mm
Numerical aperture	0.12 ± 0.02
Transmissivity	50 %

Photodetectors	
APD (1064 nm) PMT (532 y 607 nm)	Hamamatsu S8890 Hamamatsu R7400-U
1. **Data acquisition card** 2. **(1064 y 532 nm)**	**Spectrum MI.3011**
Type Sample frequency Word length	Analog 2 x 20 Msamples/s 12 bit
Photon counter (607 nm)	**Licel TR20-160**
Type Maximum count rate Time resolution (bin) Word length	Mixed acquisition: Analog+ PC 250 MHz (PC mode) 50 ms 12 bit

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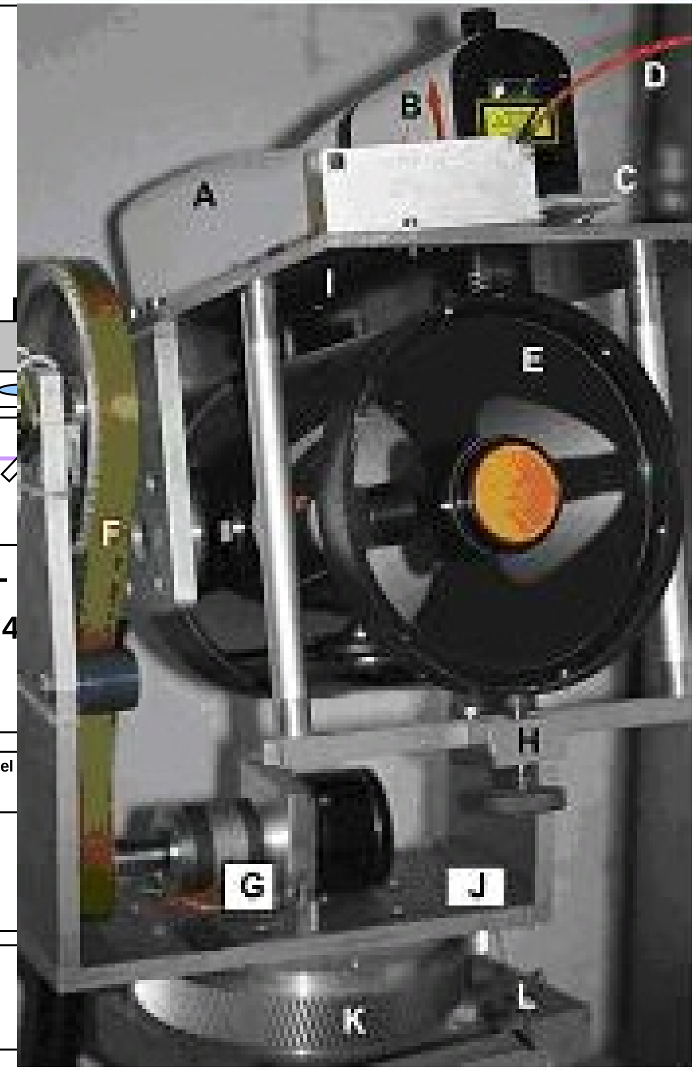
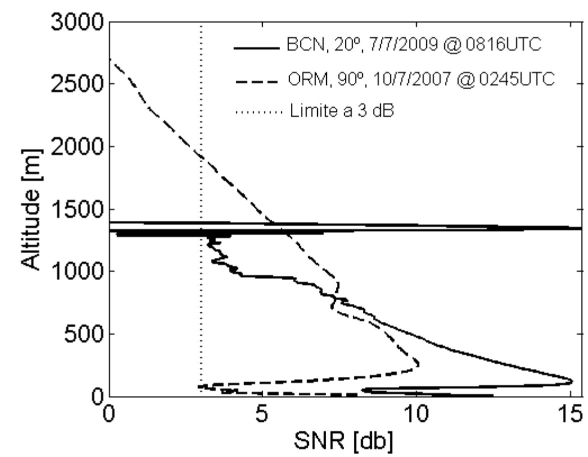
UPC WIND LIDAR



Power Balance

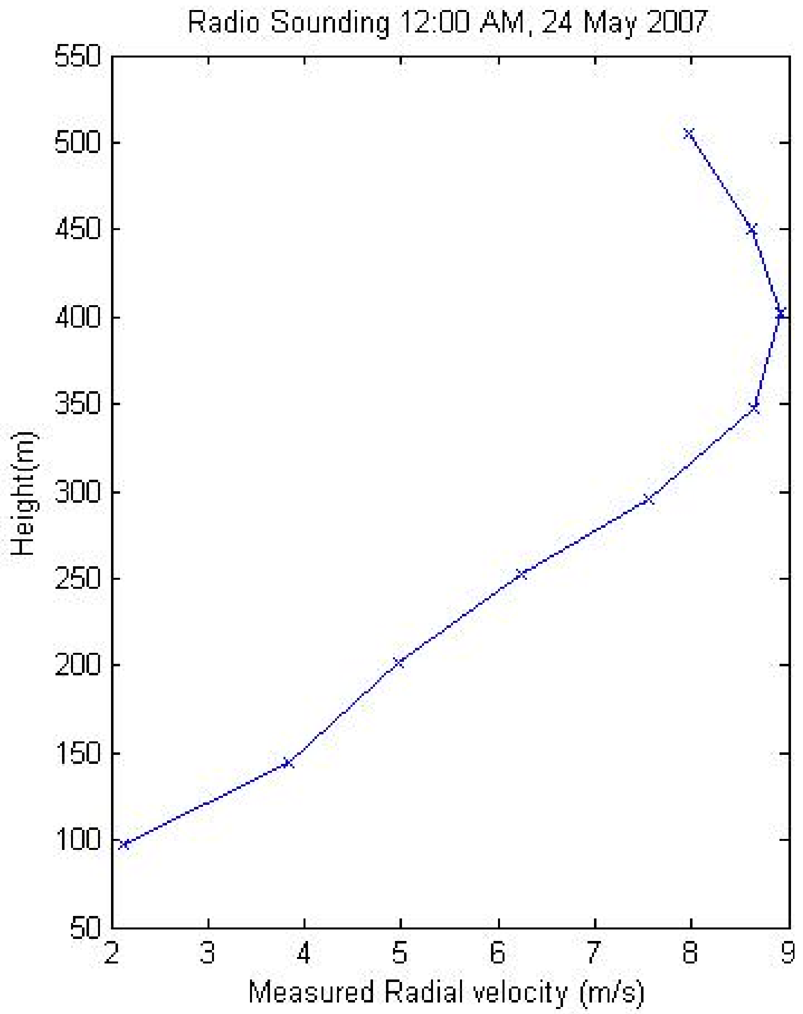
LIDAR PARAMETERS	**VALUE**	**UNITS**
Laser Wavelength	1,064	[µm]
Peak power	21,7	[MW]
Pulse duration	6	[ns]
Distance Resolution	7,5	m
Transmitted pulse energy	130	[mJ]
PRF (Pulse Repetition Frequency)	20	Hz
Transmitted beam diameter	1	[cm]
Radius of curvature of the beam	1	[Km]
Beam shape compensation factor	0,75	
Transverse coherence radius	1,23	[cm]
ATMOSPHERIC SCENARIO PARAMETERS	**VALUE**	**UNITS**
Structure constant of refractive index	1,00E-14	[$m^{-2/3}$]
Range	2	[Km]
η overall detector-optics system efficiency	0,1	
Atmosphere backscatter coefficient	1,00E-07	[$m^{-1}sr^{-1}$]
Atmosphere extinction coefficient	5,00E-06	[m^{-1}]
LIDAR ratio	50	[sr]

DATA ADQUISITION PARAMETERS	**VALUE**	**UNITS**
One SHOT SNR (linear)	0,29	
One SHOT SNR (dB)	-5,35	[dB]
PRF (Pulse Repetition Frequency)	20	Hz
Averaged Pulses	100	
Integration Time	5	s
SNR (lineal) AVRG mode	**2,92**	
SNR(dB) AVRG mode (R=2Km)	**4,65**	**[dB]**

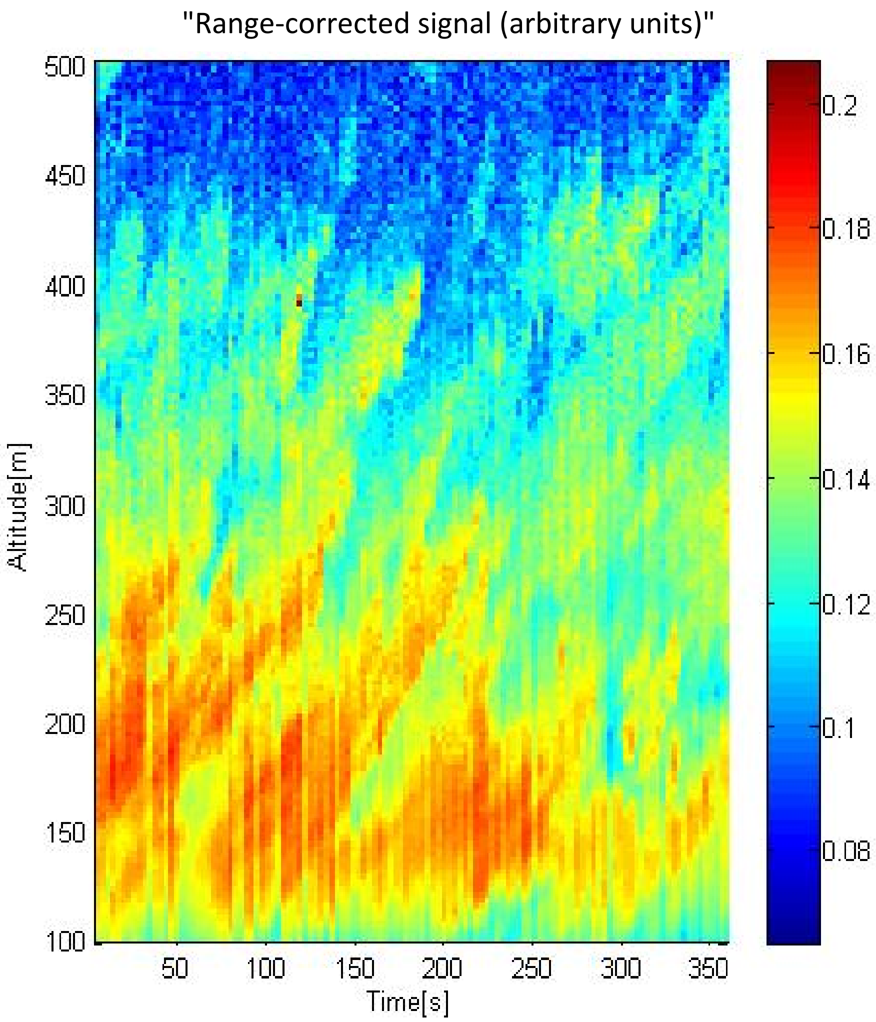


SNR(dB) at Range=1Km	**7**	**[dB]**

THI(Time-Height) Image

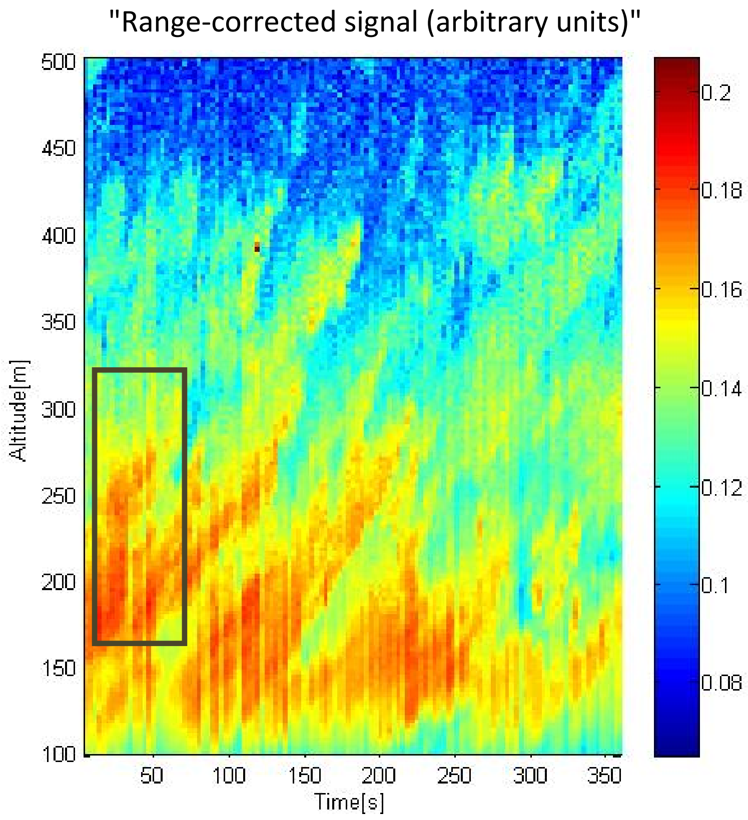


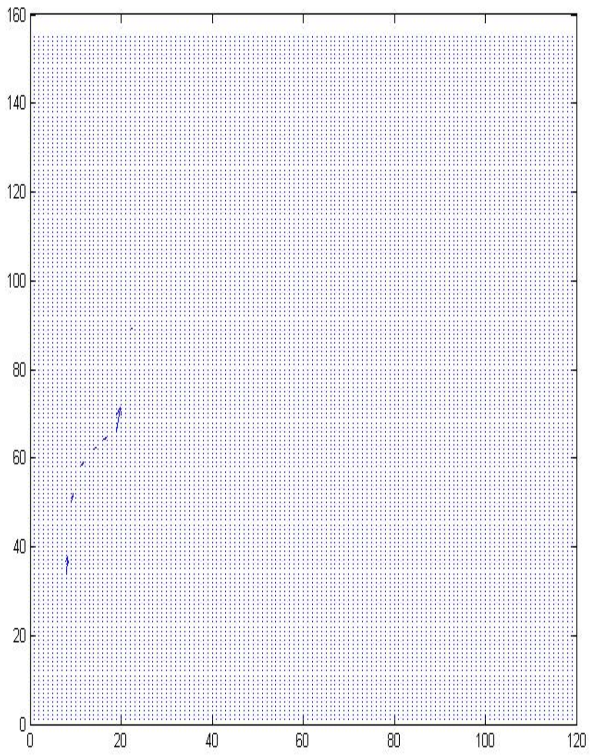
Radio-Sounding



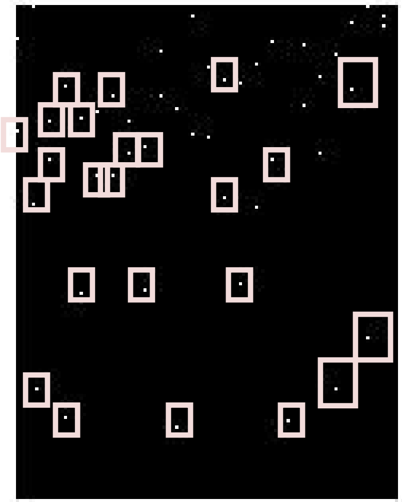
Received Power

Radial Velocity Computation based on 2D-Image Normalized Cross-Correlation Algorithm

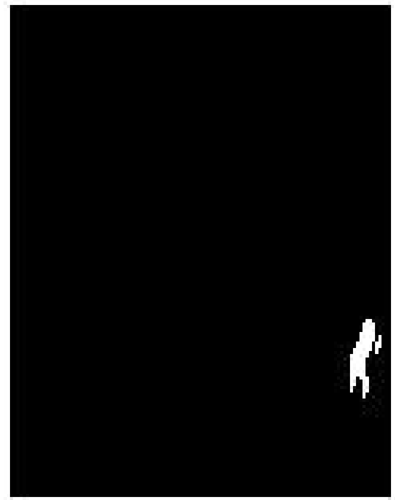




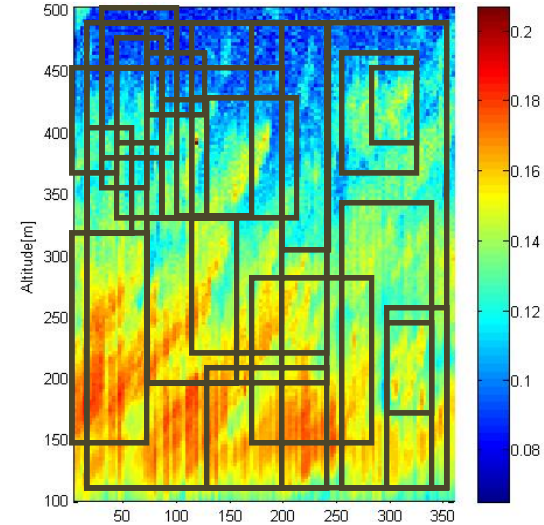
Initial points to analyze:

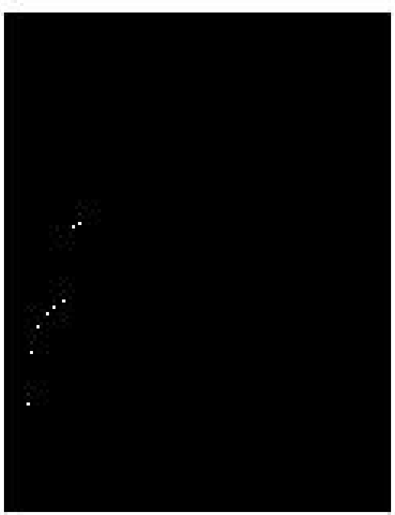


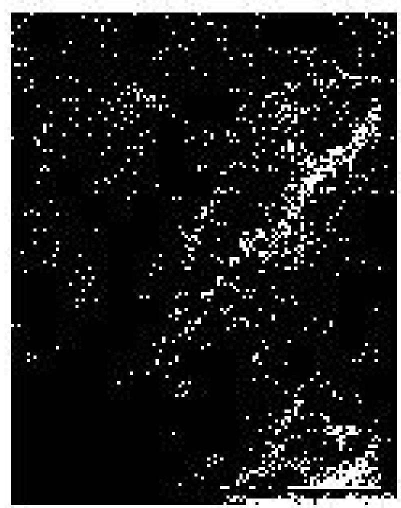
Normalized Cross-correlation Mask:

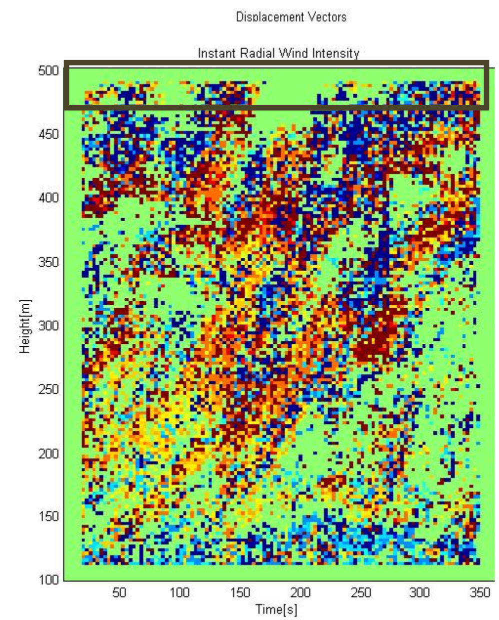


"Range-corrected signal (arbitrary units)"

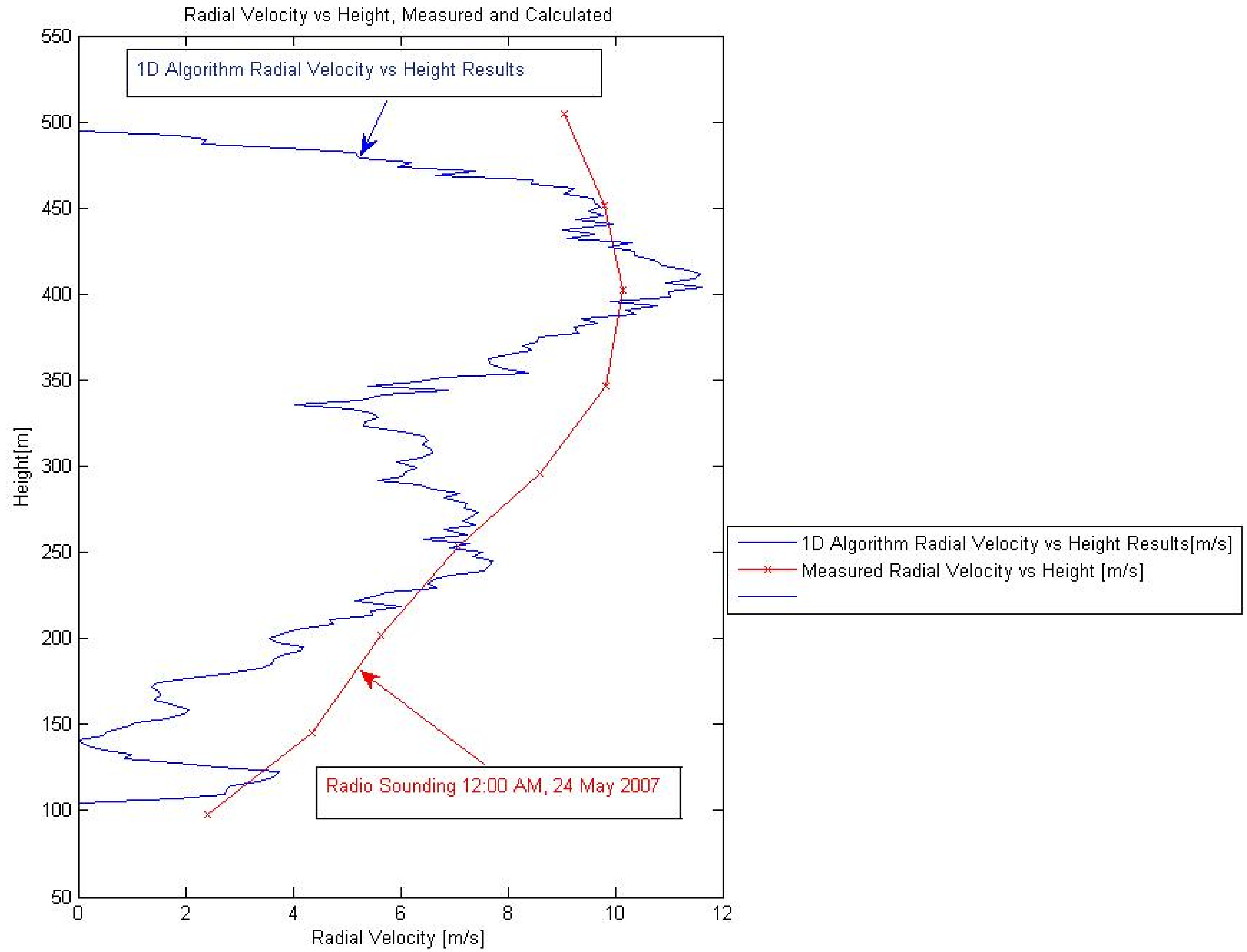








Radial Velocity Computation based on 2D-Image Normalized Cross-Correlation Algorithm



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COMPARATIVE TABLE

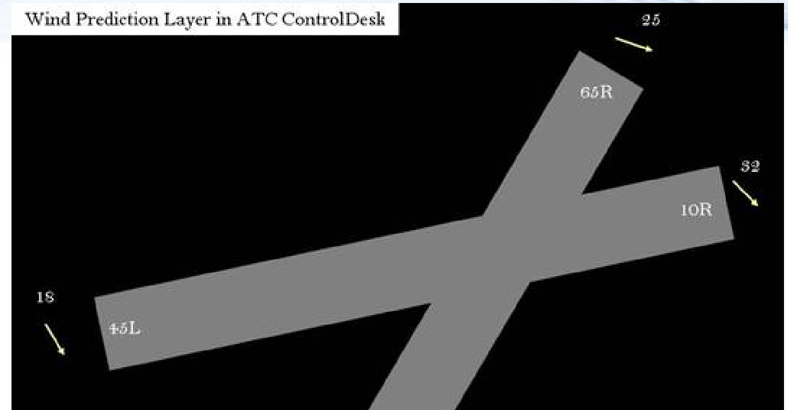
LIDAR SYSTEMS	COHERENT WIND LIDAR	AMPLITUDE MODULATED WIND LIDAR	WIND LIDAR BASED ON 1D PROFILE CORRELATION
Coherent Detection	YES	NO	NO
Technology	WELL KNOWN	UNDER STUDY	ATLAS DEVELOPING
Source Spectral Bandwidth	NARROW ,H Coherency →CW LASER+OA →LOW PEAK POWER	WIDE BW, Low Coherency →PULSED LASER	WIDE BW, Low Coherency → PULSED LASER
Range	→ SHORT	→LONG	→LONG
Noise Bandwidth	HIGH	HIGH	LOW (Averaged Acquisition)
SNR	→LOW	→LOW	→HIGH
Integration Time	LOW	HIGH	HIGH
Camera Detector	NO	YES	NO
Cost	EXPENSIVE	LOW COST	LOW COST

Actual Wind Data Interface

Wind Direction @ Runaway (degrees)

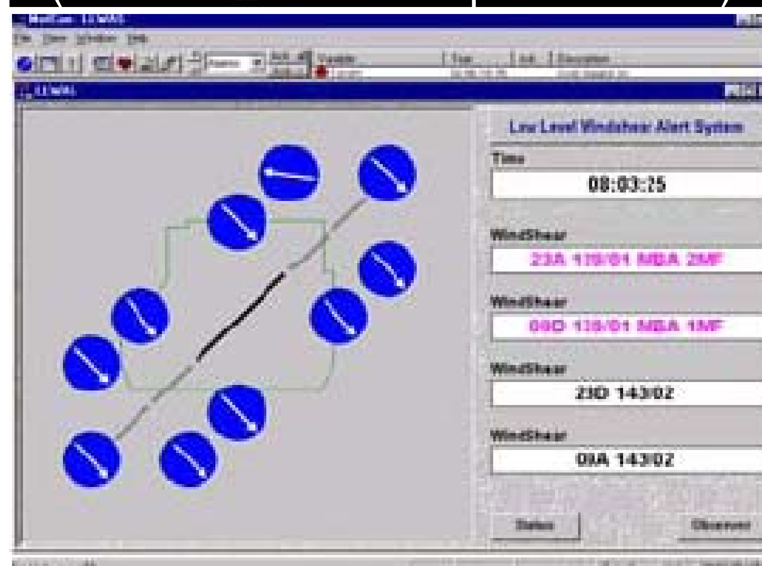
Wind Modulus (knots)

TELVENT – Wind Data Interface Unit



Example of HMI layer with wind data at end of runways

(used in Barcelona Airport – El Prat)



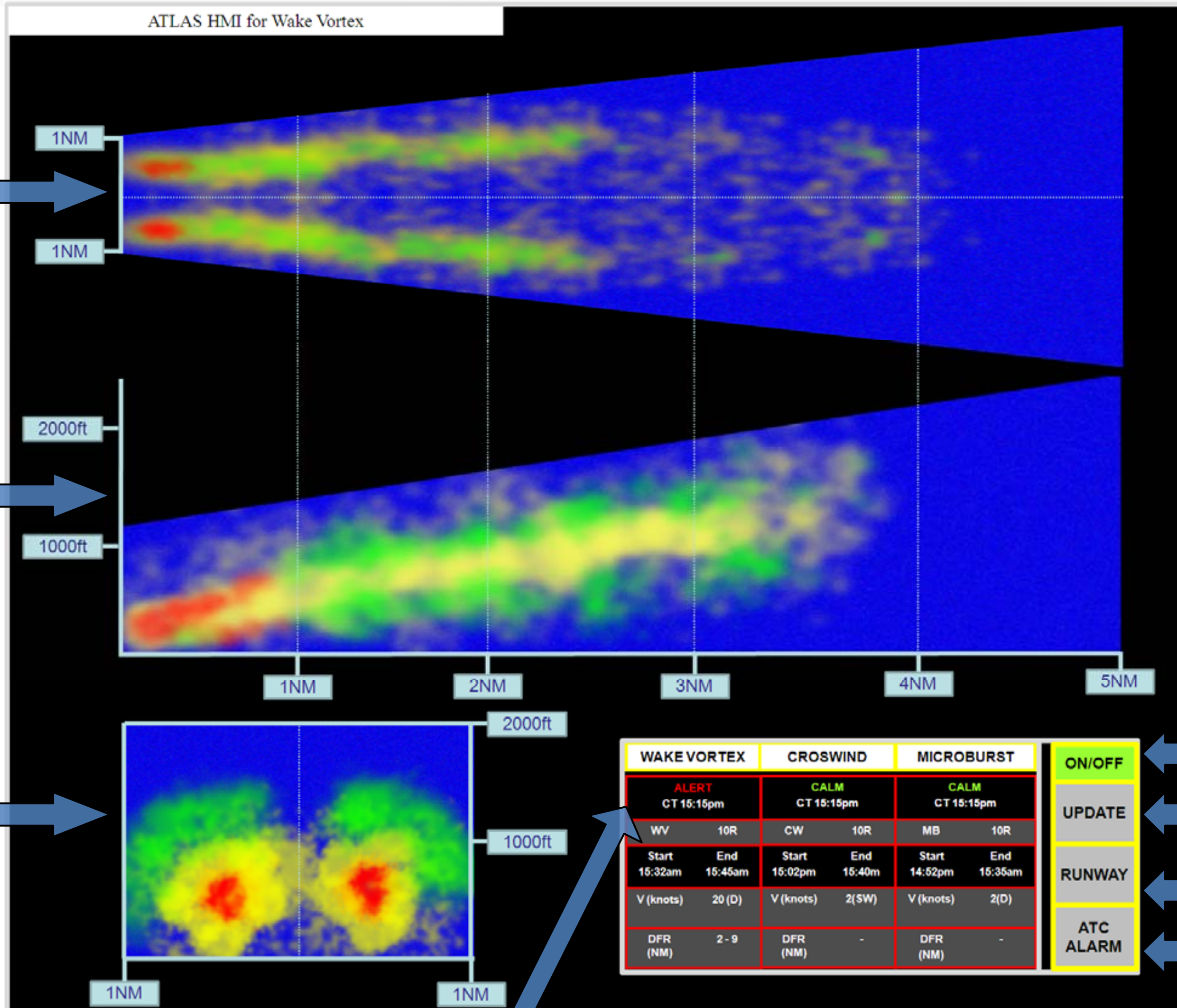
Wind Information Tenerife Airport

ATLAS User Wind Data Interface (Wake Vortex)

ATLAS LIDAR Wind Data Acquisition Example (Horizontal Layer)

ATLAS LIDAR Wind Data Acquisition Example (Lateral Layer)

ATLAS LIDAR Wind Data Acquisition Example (Front Layer)



Start/Reset/Close Application

Refresh Application Manually

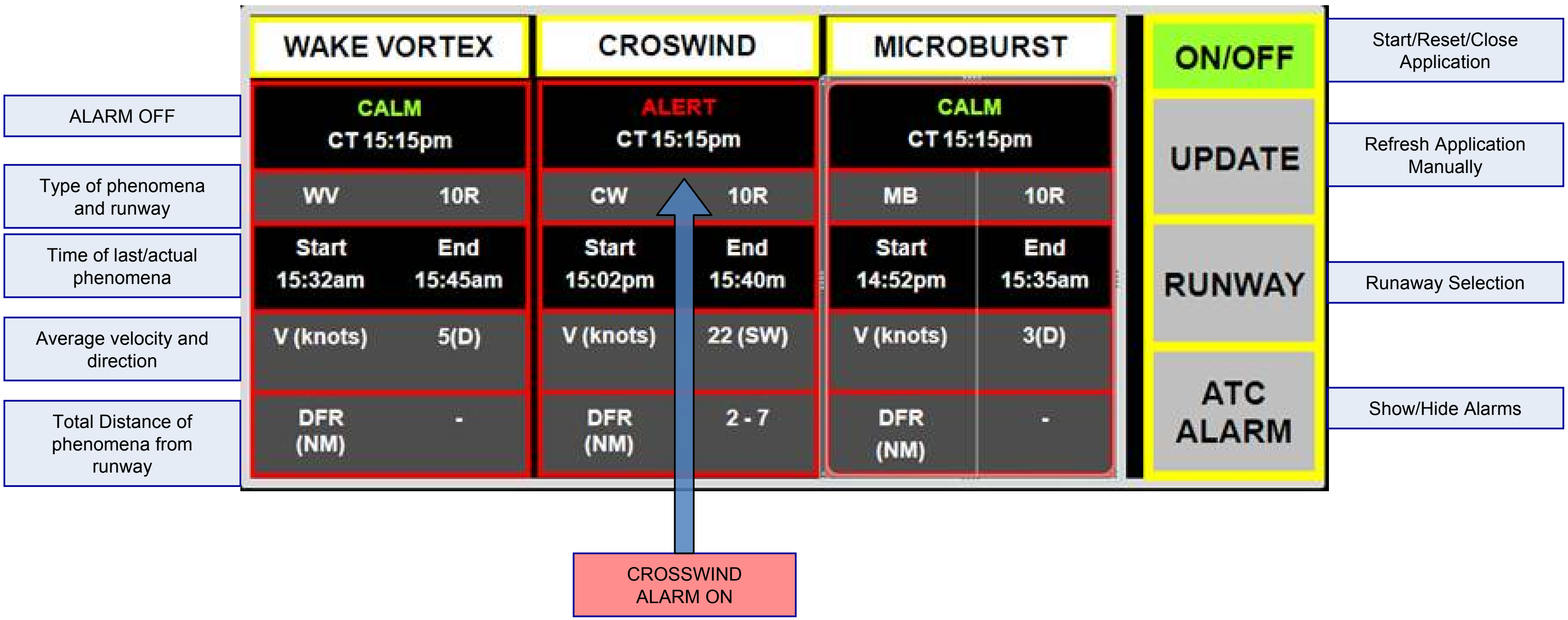
Runaway Selection

Show/Hide Alarms

WAKE VORTEX ALARM ON

ATLAS HMI Alert System

ATLAS HMI Alert System



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