European Commission

FUTURE SKY SAFETY

“Big data Analytics” of braking distance at Paris-CDG airport

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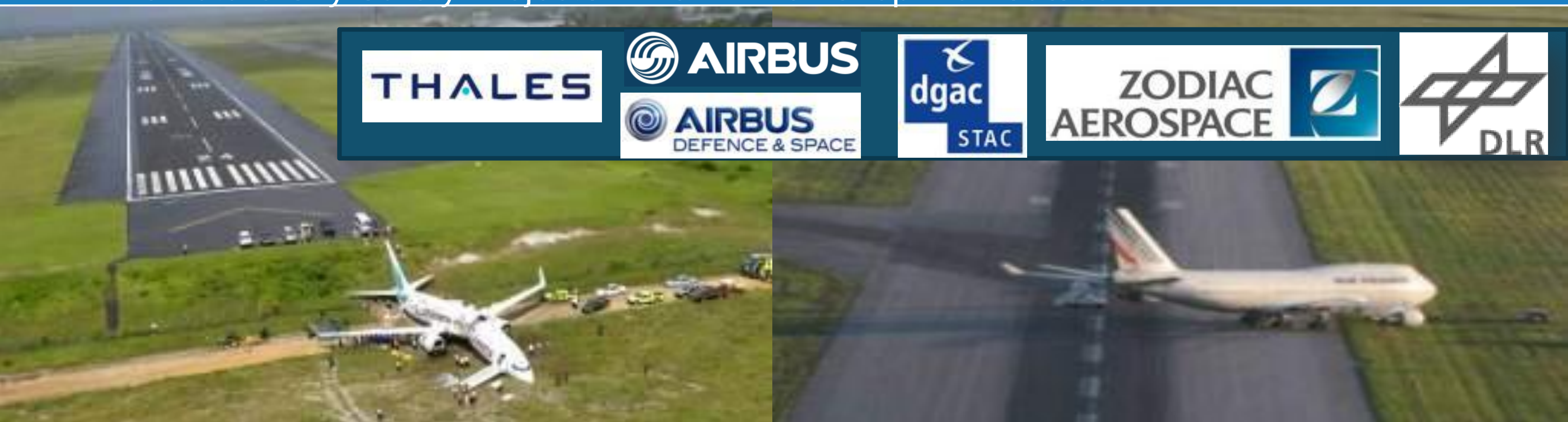
FP8 Future Sky Safety Project / WP3.4 : Workshop 2017/03/08

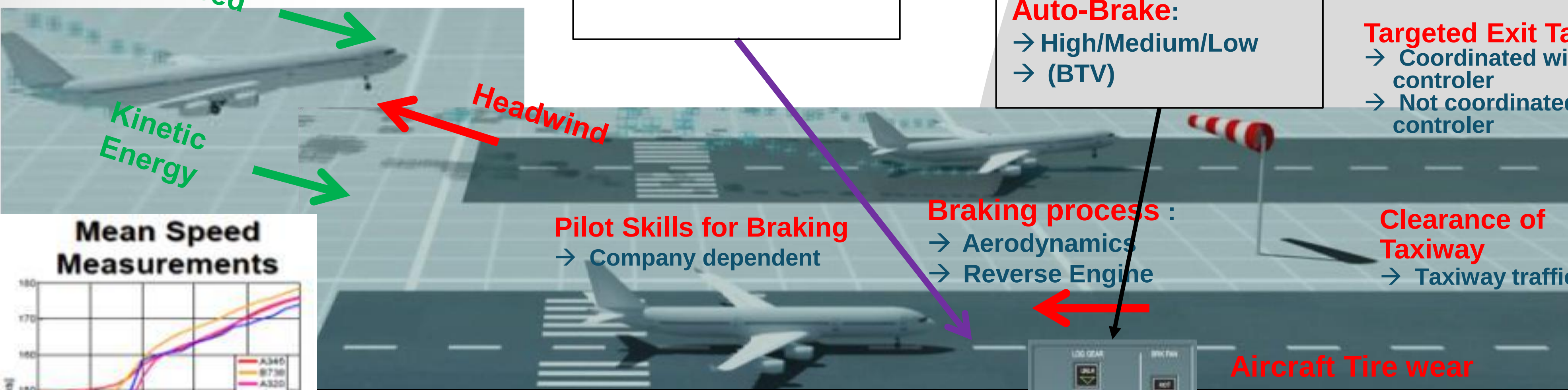


at a glance

- Paris-CDG northern runways (27 and 09) traffic
- Merging relevant information in a « Big Table » from different sources
- Establishing how runway occupancy time (ROT) and braking distance (BD) could depend on MET or on traffic
- Predictability of braking capability in perspective

Braking Distance (to full stop) and ROT analysis

Main factors impacting Braking Distance



Approach Speed

Kinetic Energy

Headwind

Runway state
→ Friction Coefficient

Auto-Brake:
→ High/Medium/Low
→ (BTV)

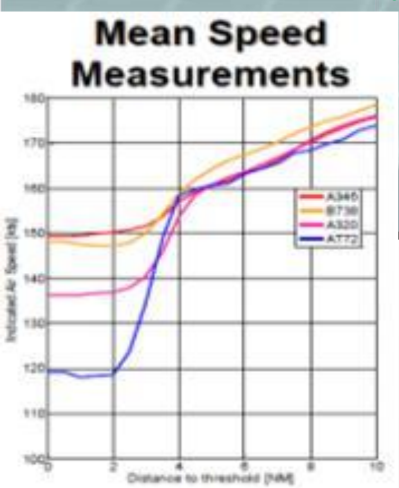
Targeted Exit Taxiway
→ Coordinated with controler
→ Not coordinated with controler

Pilot Skills for Braking
→ Company dependent

Braking process :
→ Aerodynamics
→ Reverse Engine

Clearance of Taxiway
→ Taxiway traffic

Aircraft Tire wear



Cross-Wind conditions
→ Pilot in the loop to compensate (differential braking)

Runway Gumming

MAIN QUESTION

"Are BD or ROT parameters predictable ?"

at which level of accuracy ? What do they depend on ? (Inputs)

The steps are :

- collecting a larger set of relevant data : A/C movements and MET data
- establishing statistics on landings and sorting cases to be more explicated
- applying "Big Data algorithms" in order to find and establish finest correlations

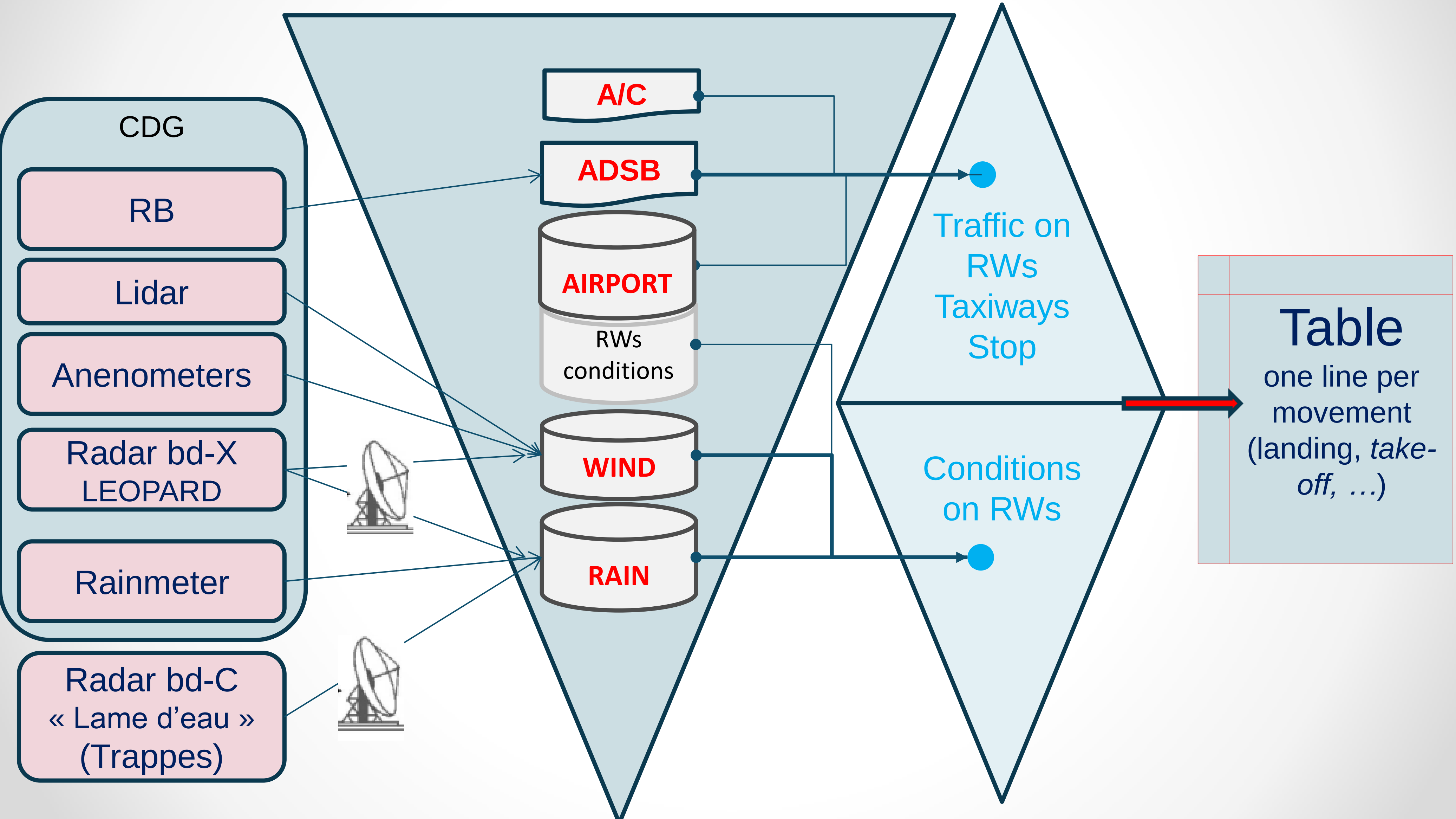
INPUTs at CDG northern runways [27R, 09L] and [09R, 27L]

- ADSB, Lidar
- Météo-France data : local sensors and radars (scanning up to <250km)

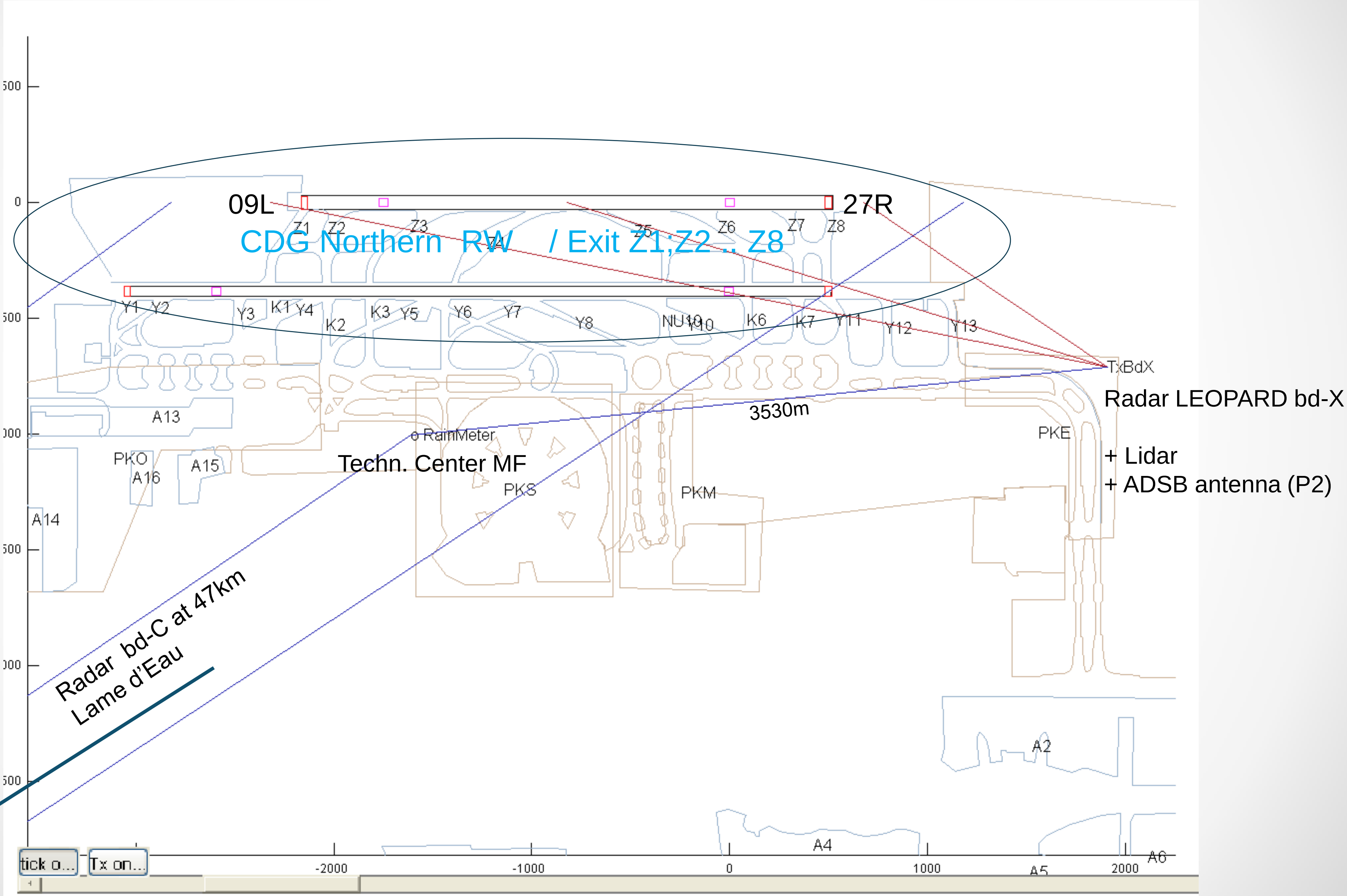
OUTPUT Data

- ROT, deceleration for northern runways [27R, 09L] and [09R, 27L]
- List of cases out of mean statistics

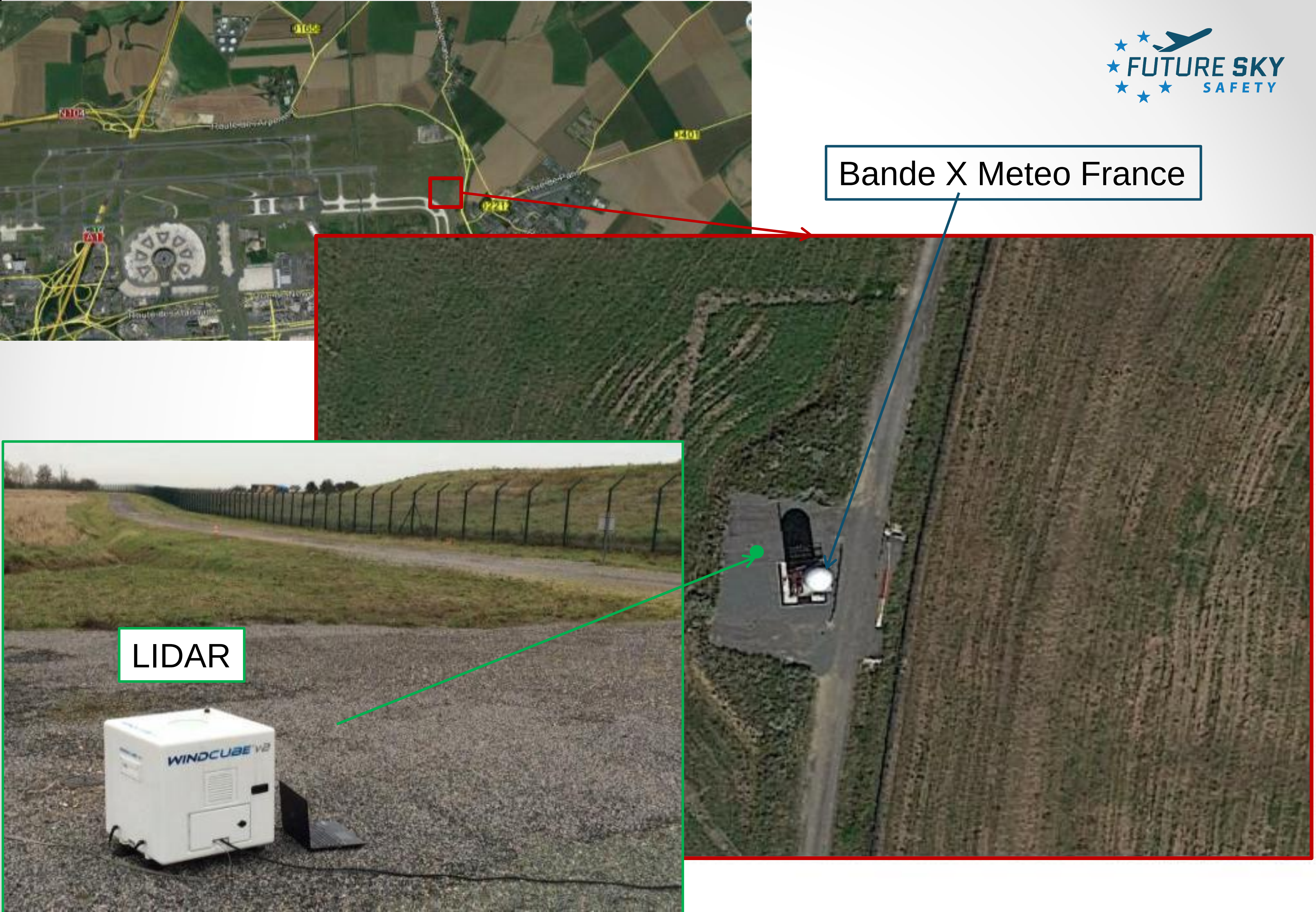
COLLECTING and MERGING



CDG back-clipping plane for A/C path finding



FUTURE SKY SAFETY



INPUTs : two periods P1 and P2

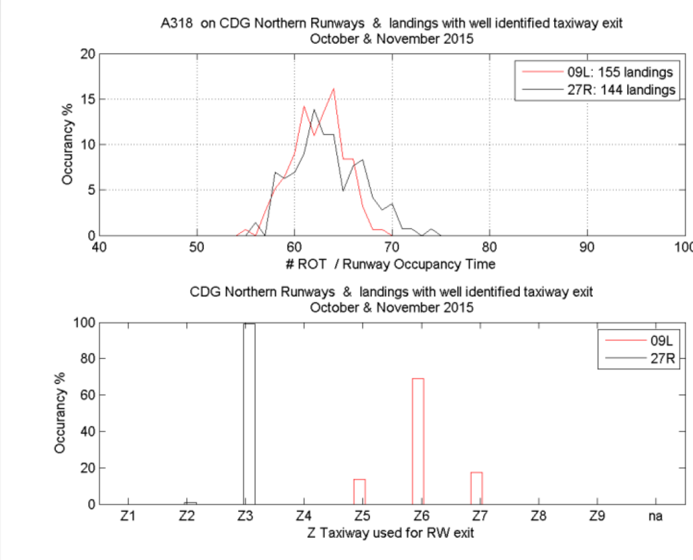
21/01/2017

Data	Type	From	Machine	Rate	Raw data per month (approx.)	Merged in TABLE	Status A: analysed C: Corrrelation ML: Machine Learning	Oct-15	Nov-15		Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	
ADSB	latitude longitude altitude	THALES	BaseStation CDG (r1)	about 1s	500Mo	yes	A,C	x x x x	x x x x													P1
			BaseStation CDG (r2)	about 1s	8Go	yes	A,C					x	x x x x	x x + +	+ + + +	+ + + +	? ? ? ?	? ? ? ?	? ? ? ?	? ? ? ?	? ? ? ?	P2
LAME d'EAU	RR 1kmx1km grid	Météo France	Bd-C TRAPPES	5mn	<200Mo	yes	A C (Pluviometer)	+ + + +	+ + + +			x x x x	x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	P1+P2
PLUVIO meter	RR 1kmx1km grid	Météo France	1 sensor Techn. Center CDG	mn	<150Ko	yes	A,C	x x x x	x x x x			x x x x	x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	P1+P2
				hour	<50Ko	no		+ + + +	+ + + +			x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	P1+P2
LEOPARD	dBZ Doppler	Météo France	LEOPARD Bd-X CDG	5mn	5 Go (HDF5)	on going		not available				x x x x	x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	P2
WIND Aero	direction [°] speed [m/s] "instantaneous", mean or max in last 10mn	Météo France	2 sensors 27L & 9L CDG	mn	9Mo	yes	A,C	x x x x	x x x x			? ? ? ?	x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	P1+P2
				hour	<100Ko	na		x x x x	x x x x			x x x x	x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	
			1 sensor Techn. Center CDG	mn (raw)	<100Ko	yes	C vs Lidar	x x x x	x x x x			x x x x	x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	P1+P2
				hour	<50Ko	no		x x x x	x x x x			x x x x	x x x x	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	
WIND Lidar		LEOSPHERE WLS7-550	1 sensor near LEOPARD radar	10 mn	1Mo	yes	A C vs anemoter				x	x x x x	x x x x	x x								P2

A/C movements in Table

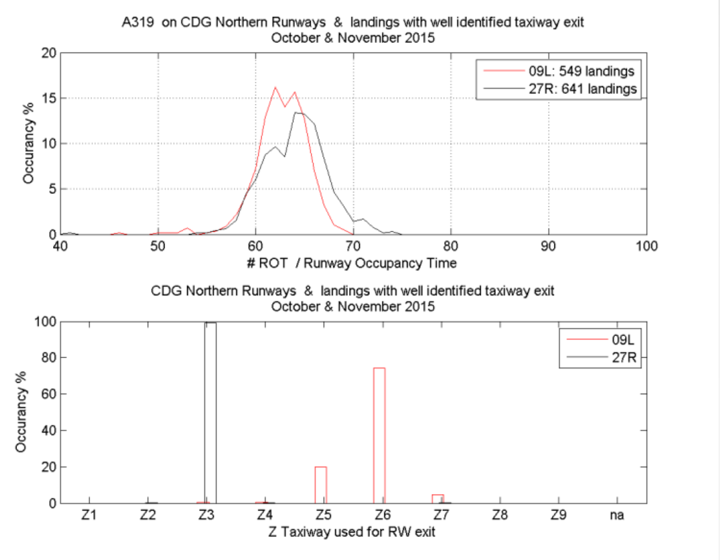
1. **P1 (from 2015/10/01 to 2015/11/24)**
   - 55 ICAO types
   - 22575 movements
   - Landings (well identified trajectory / exit)
     - 09L : 3901
     - 27R : 4303
     - 27L : 312
2. **P2 (from 2016/12/22 →)**
   - 46 ICAO types
   - 33620 movements
   - Landings (well identified trajectory / exit)
     - 09L : 4322
     - 27R : 3949
     - 27L : 114

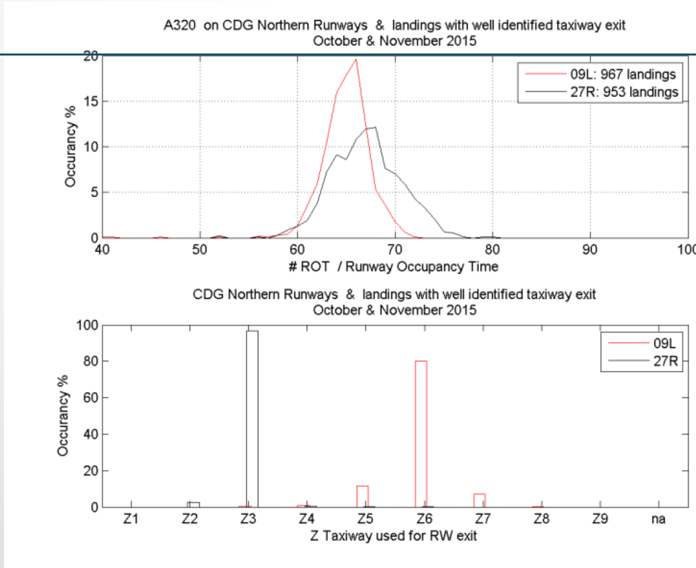
Stats : ROT on Landings A318-A319-A320-A321

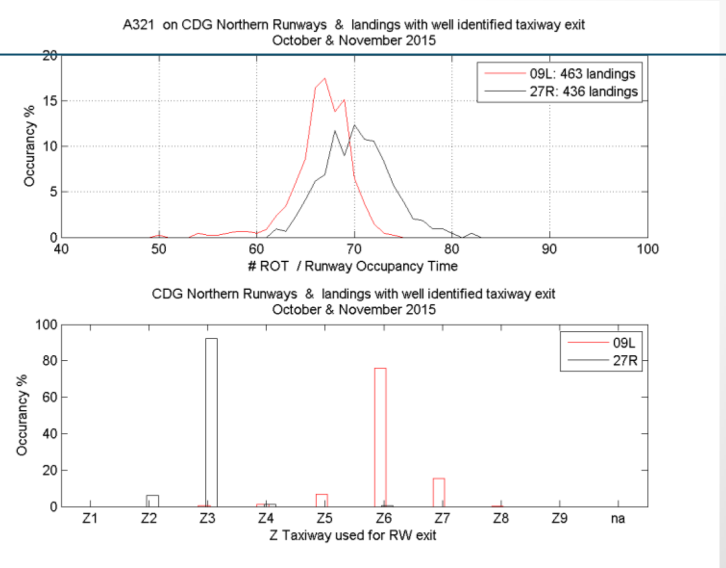


27R

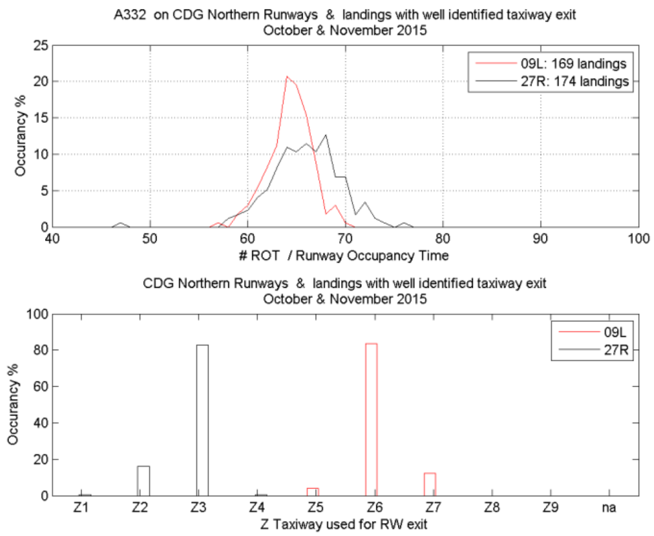
09L





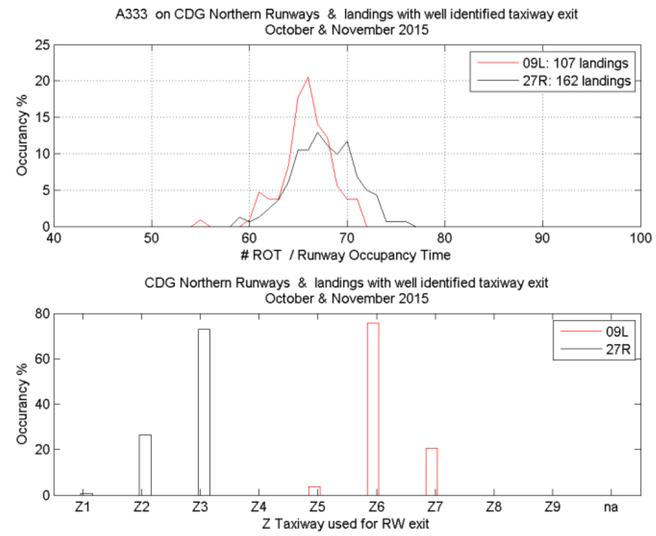


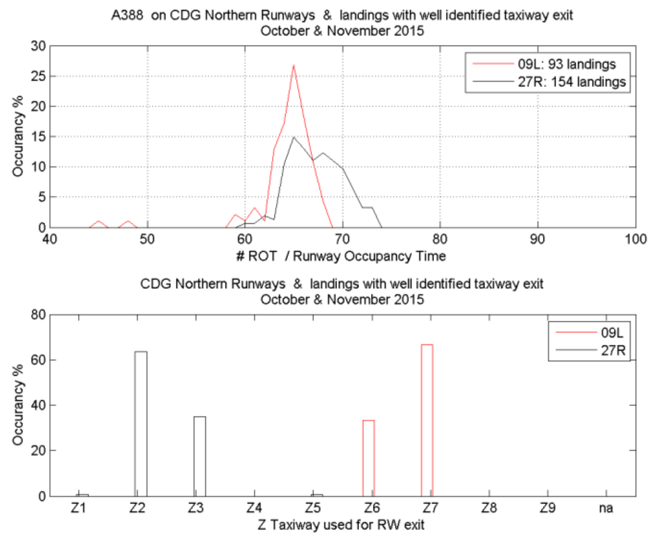
Stats : ROT on Landings A332-A333-A388



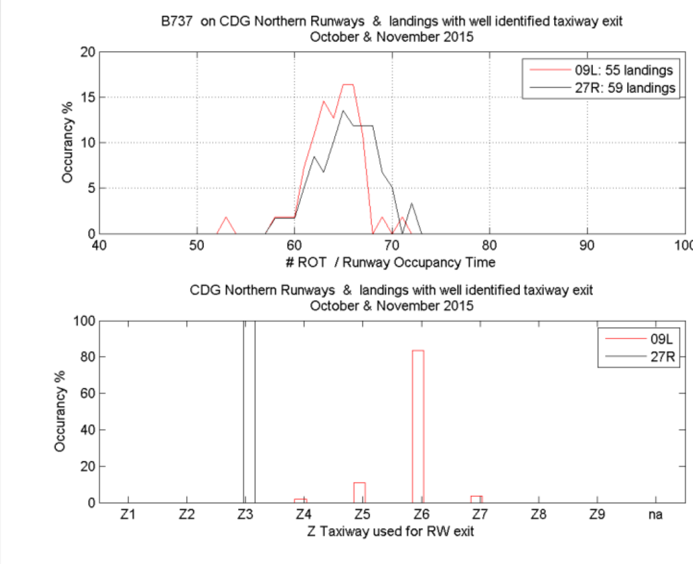
27R

09L



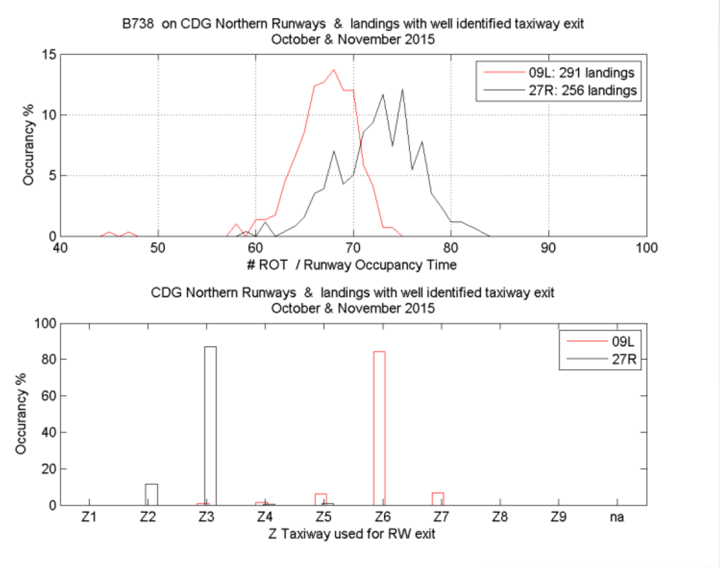


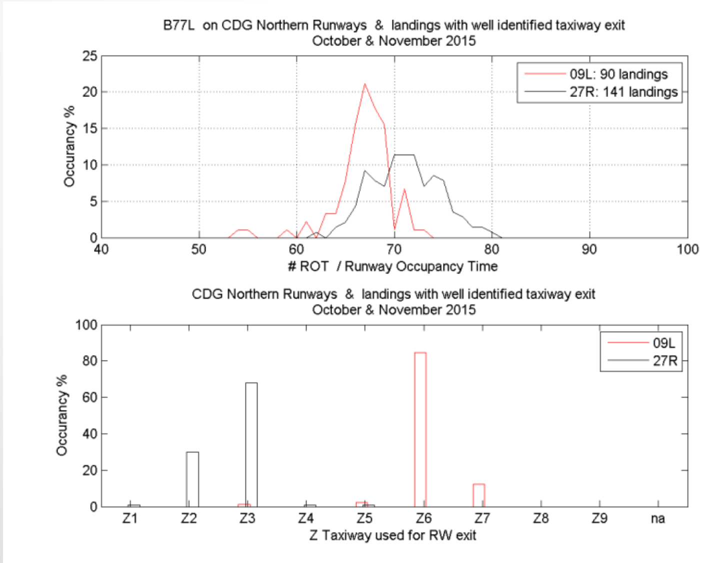
Stats : ROT on Landings B737-B738-B77L-B77W

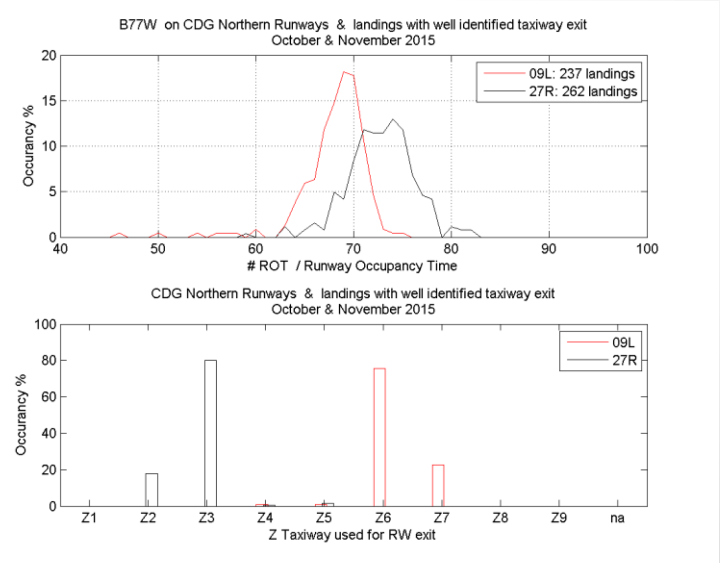


27R

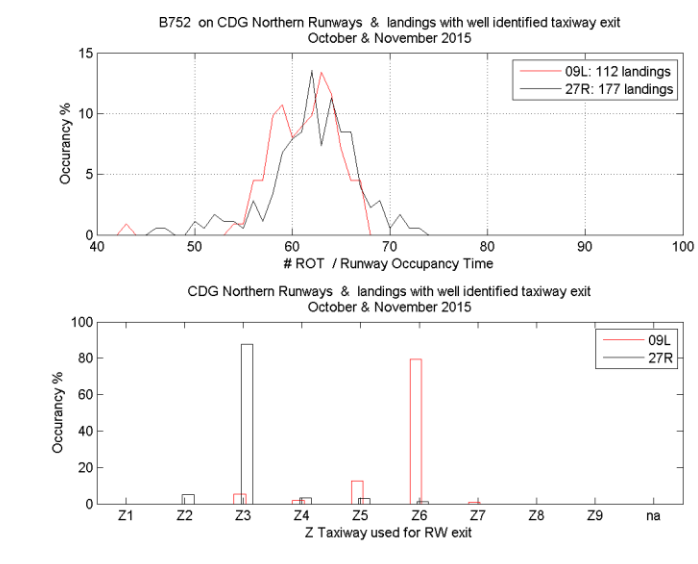
09L





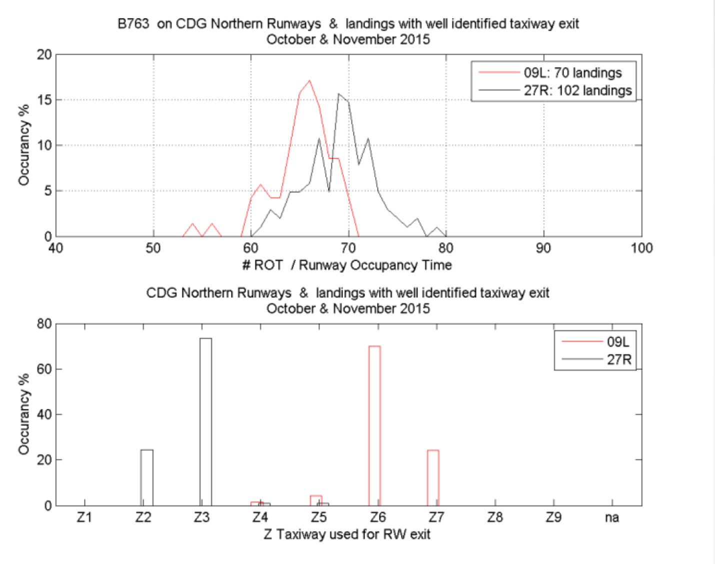


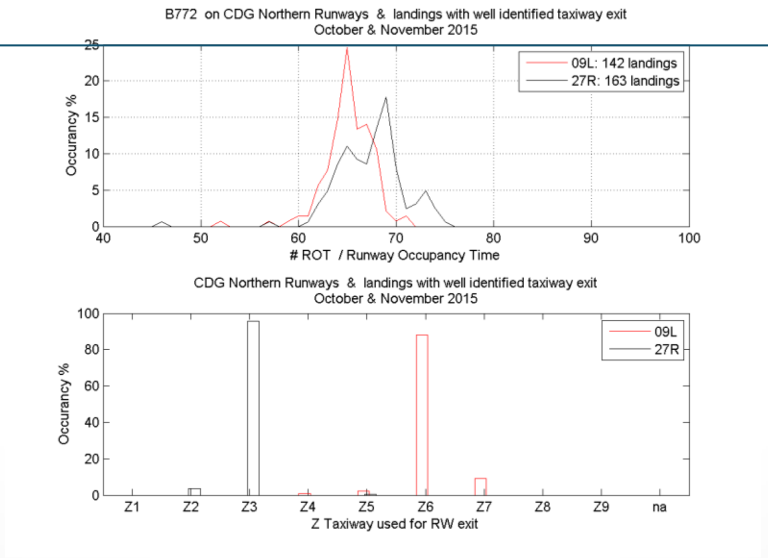
Stats : ROT on Landings B752-B763-B772



27R

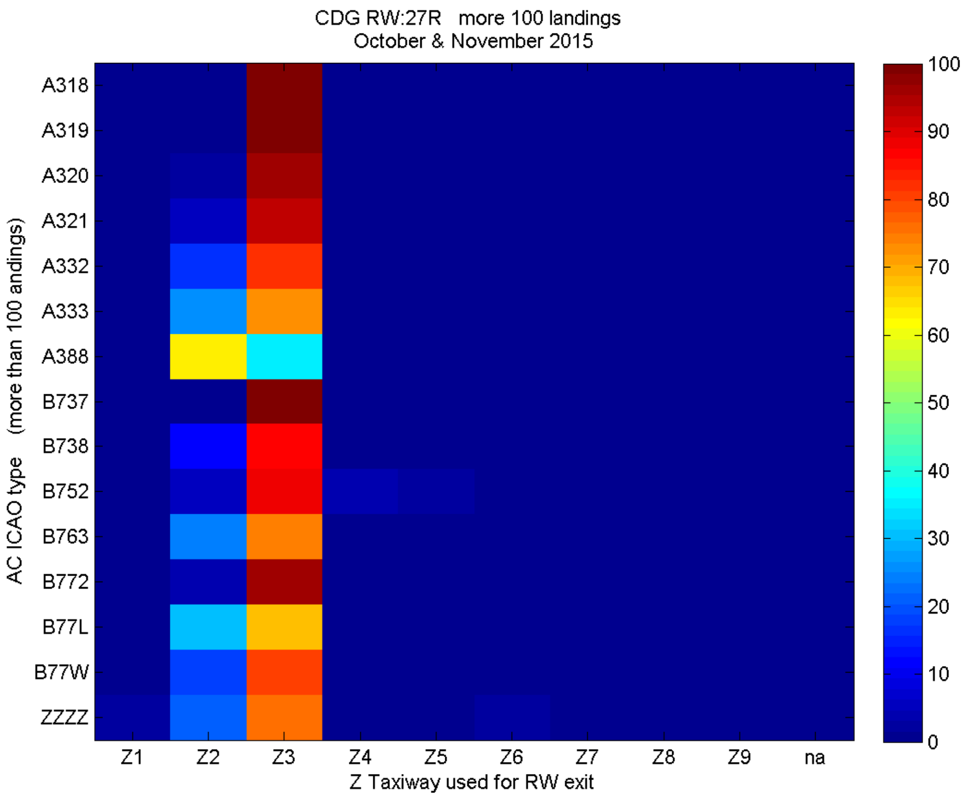
09L

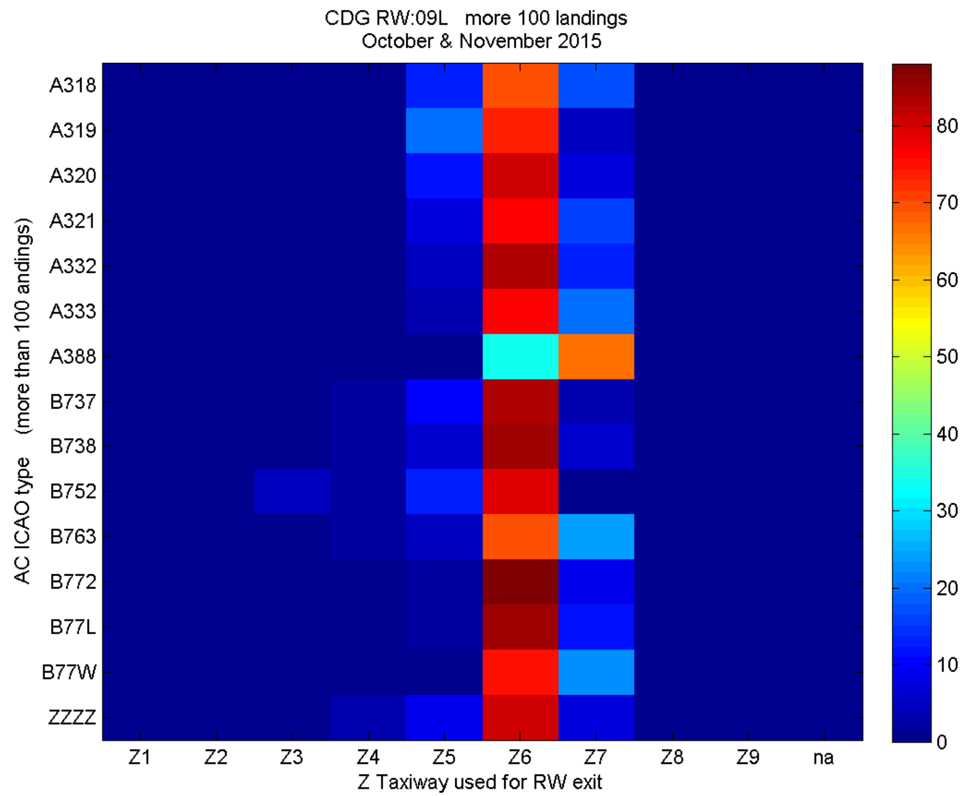




Stats : Exit Taxiway per A/C type

- Z3 and Z6 are mostly used (70%), except for A388
- A388 prefers the next farer taxiway (Z2, Z7) (>60%)

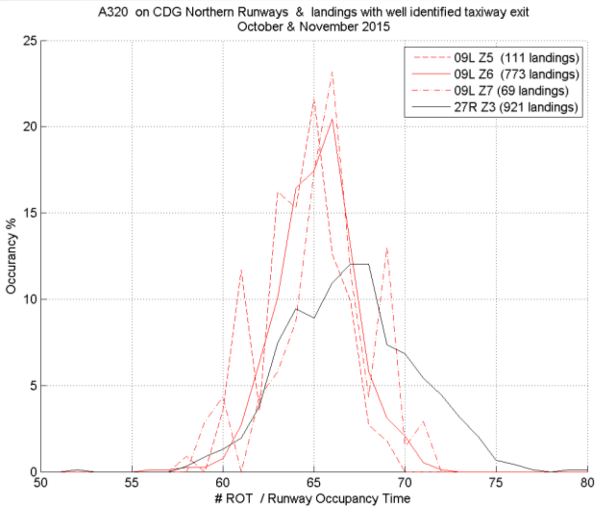


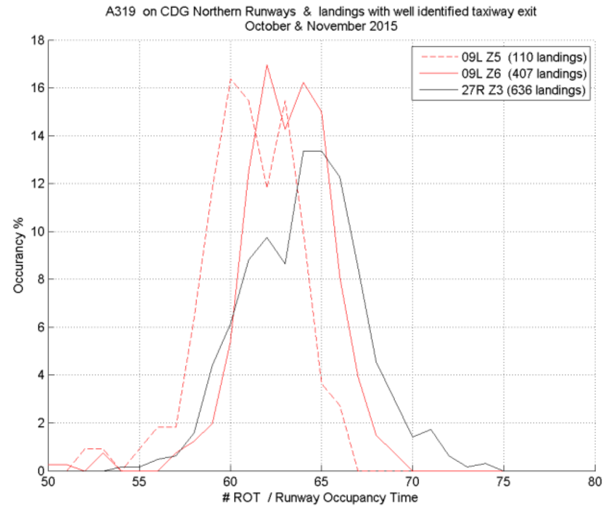


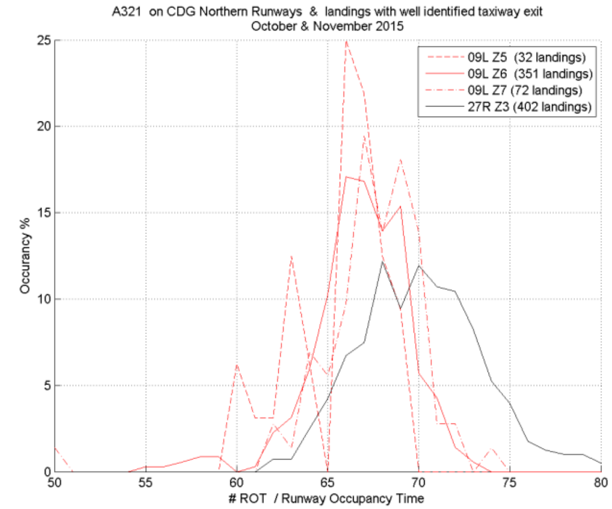
Stats : ROT focus on the most frequent A/C

27R

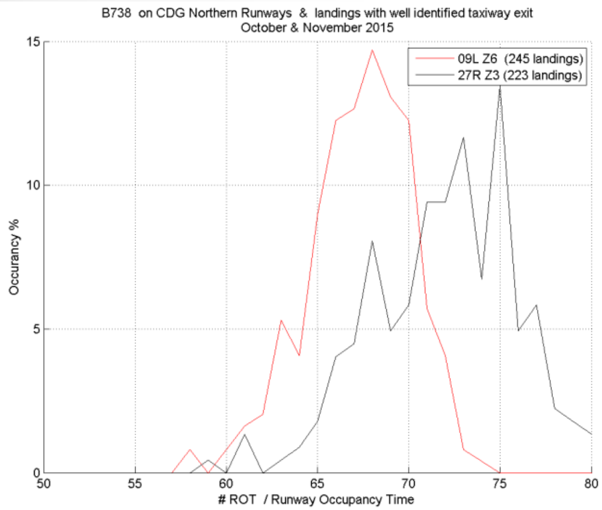
09L

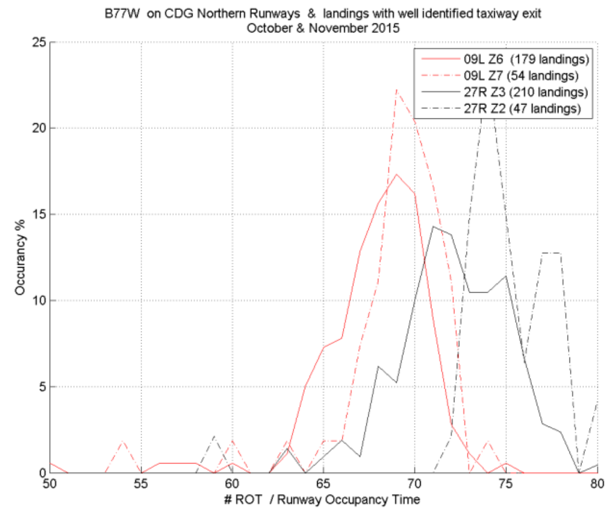


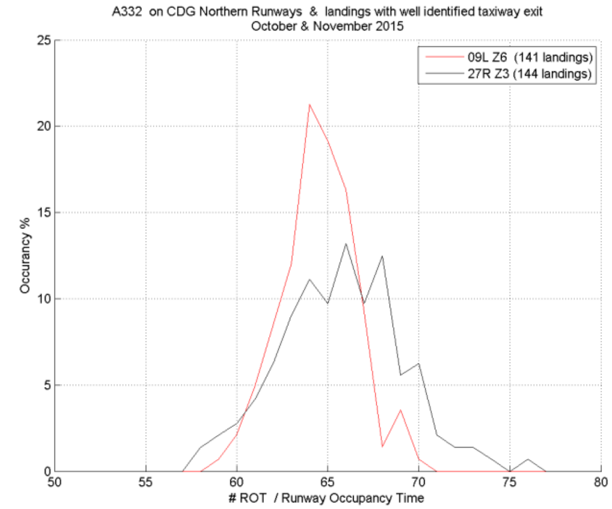




- ROT histogram depends on A/C type and on airport configurations (Westward or Eastward).It is little bit larger and staggered for Westward
- Less than about 3s between successive exits (500m distant) shows that each landing has one targeted TWY exit.

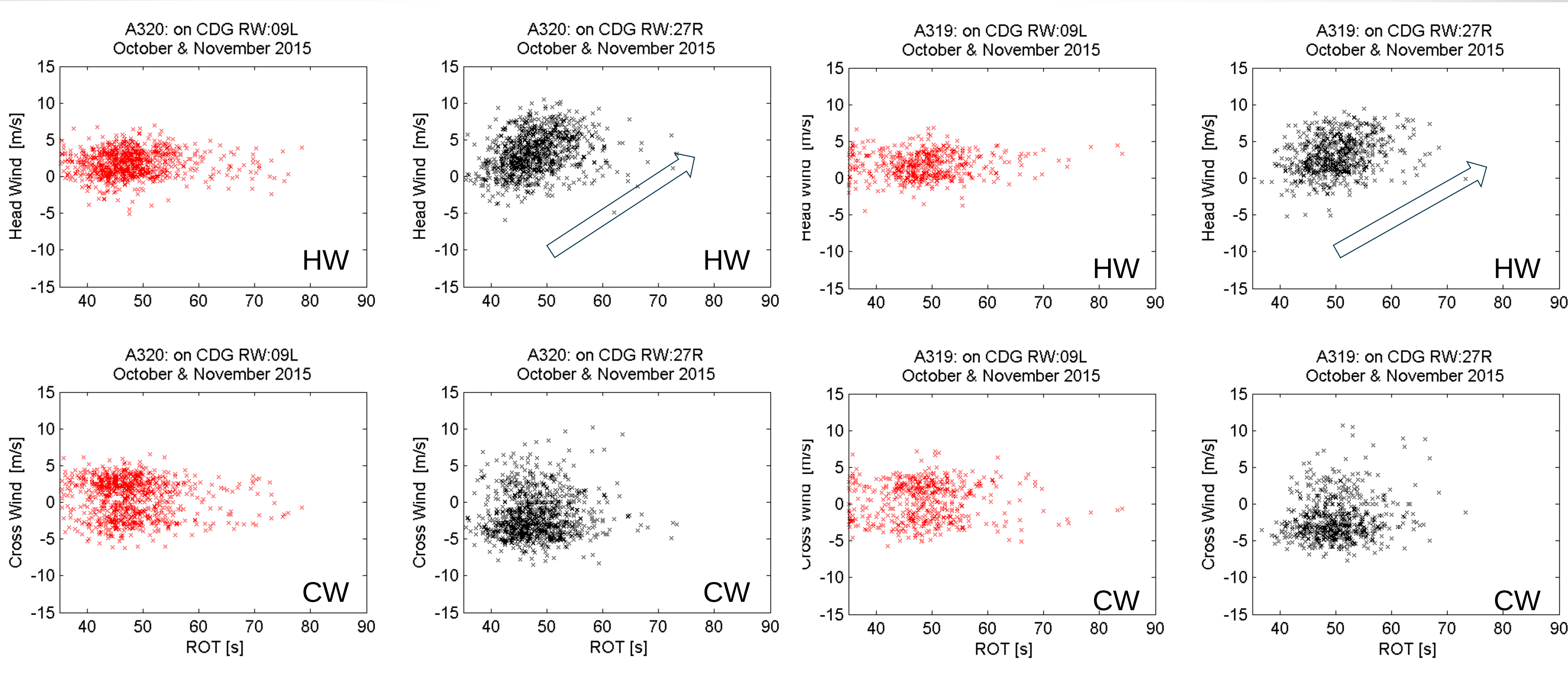






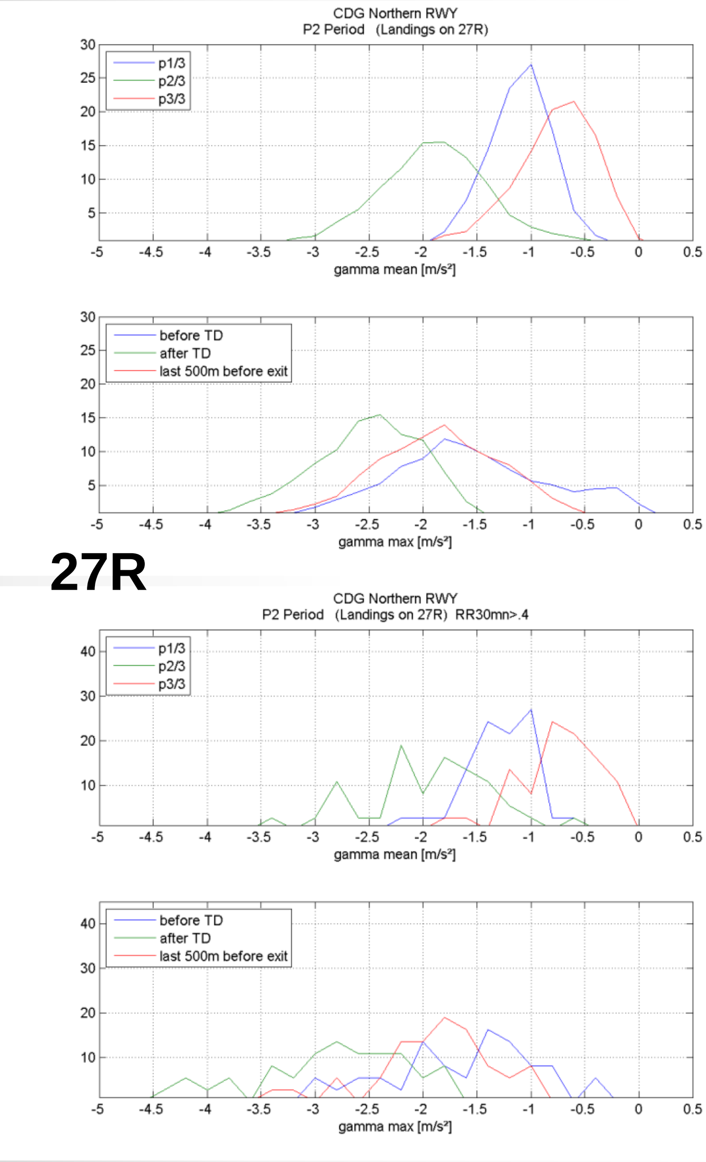
Stats : ROT vs Head and Cross Wind
on the most frequent A/C

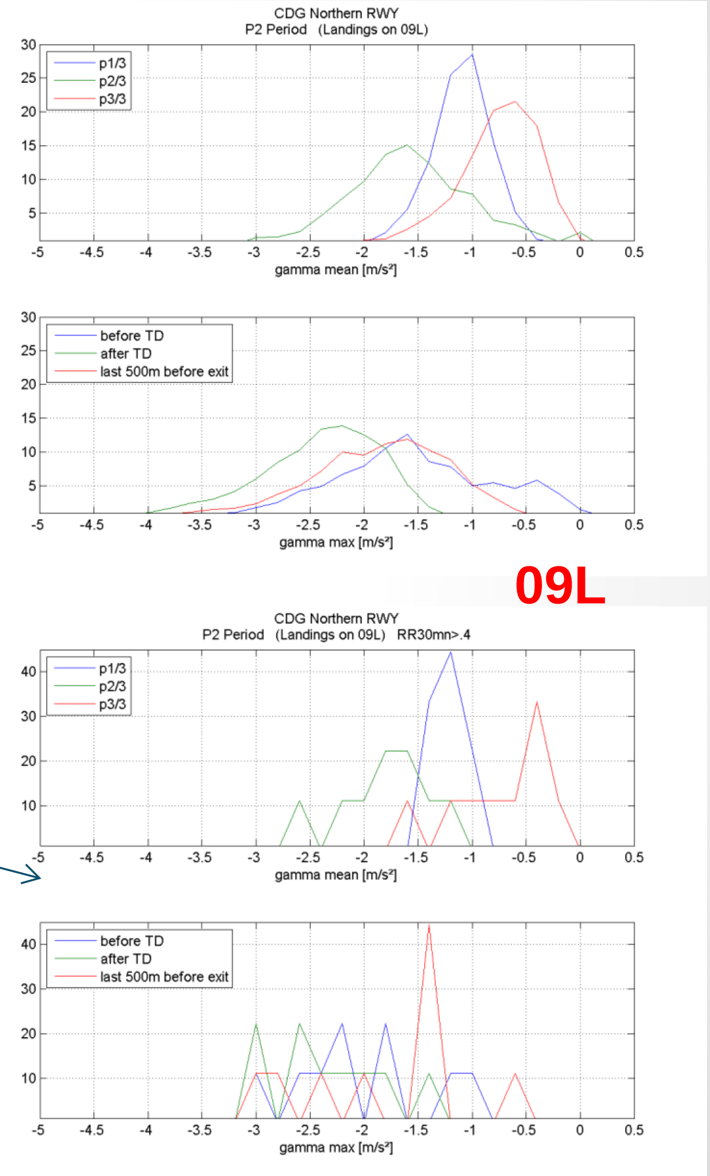
27R
09L



- Wind ranges are not the same for the two configurations : Eastward (red) < Westward(black)
- A trend appears on black diagrams : ROT is sligthy increasing with the head wind speed.

Stats : Deceleration
histograms for different phases





RR30mn>.4

CONCLUSION
P1 and P2 (2016/12/22 ➔ 2017/01/31)

1. Each landing has one targeted TW exit
2. Exit Taxiway and ROT are closely related to A/C type
3. ROT increases slightly when head wind grows
4. Braking with full stop on RWY was not observed
5. Deceleration range is large enough within each phase (before and after TD, …).
6. Rain, as observed so far, does not reduce this observed range.

7. More input data are required in order to collect more rainy days
8. Further analysis is required to detail this deceleration range. The purpose is to find subsets of A/C, MET and runway parameters, each subset being associable with a deceleration level, and at a scale of a few minutes.

Ongoing :

1. **Period P2 (from 2016/12/22) still under analysis**
   - data from LEOPARD radar (dBZ and radial wind) : with possible finer resolution
   - Further data will be merged (at least up to April)
2. **Isolating some « abnormal or extreme » cases**
   - rain or wind conditions
   - stronger braking ?, full stop on RWY ?
   - TW exit
3. **Modeling rain cumulative rule for giving an account of abnormal cases**

FUTURE SKY
SAFETY

Consortium

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Office national d'études et de recherches aérospatiales
Centro para a Excelência e Inovação na Indústria Automóvel
Centro Italiano Ricerche Aerospaziali
Centre Suisse d'Electronique et Microtechnique SA
Institutul National de Cercetari Aerospatiale "Elie Carafoli"
Instituto Nacional de Técnica Aeroespacial
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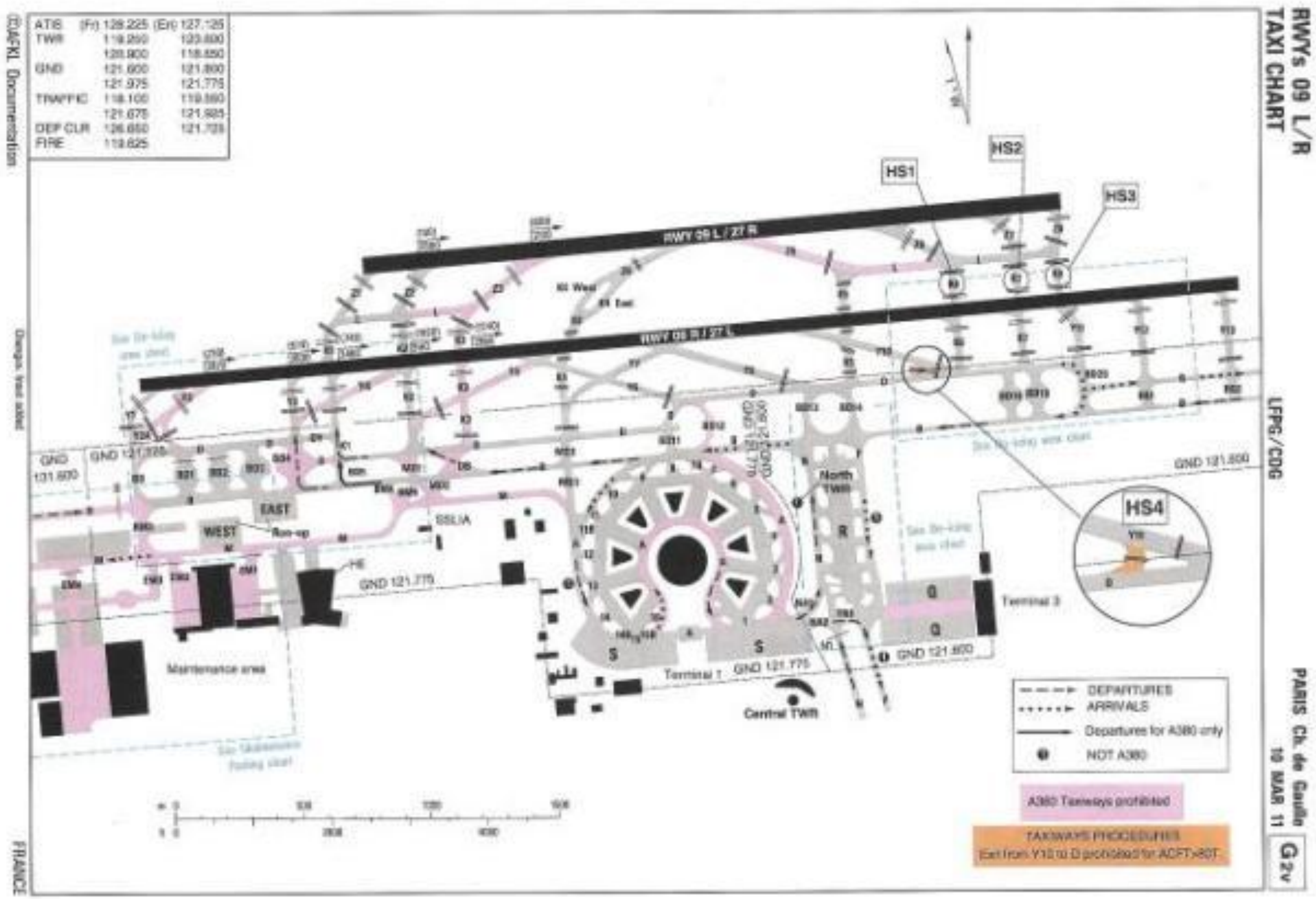
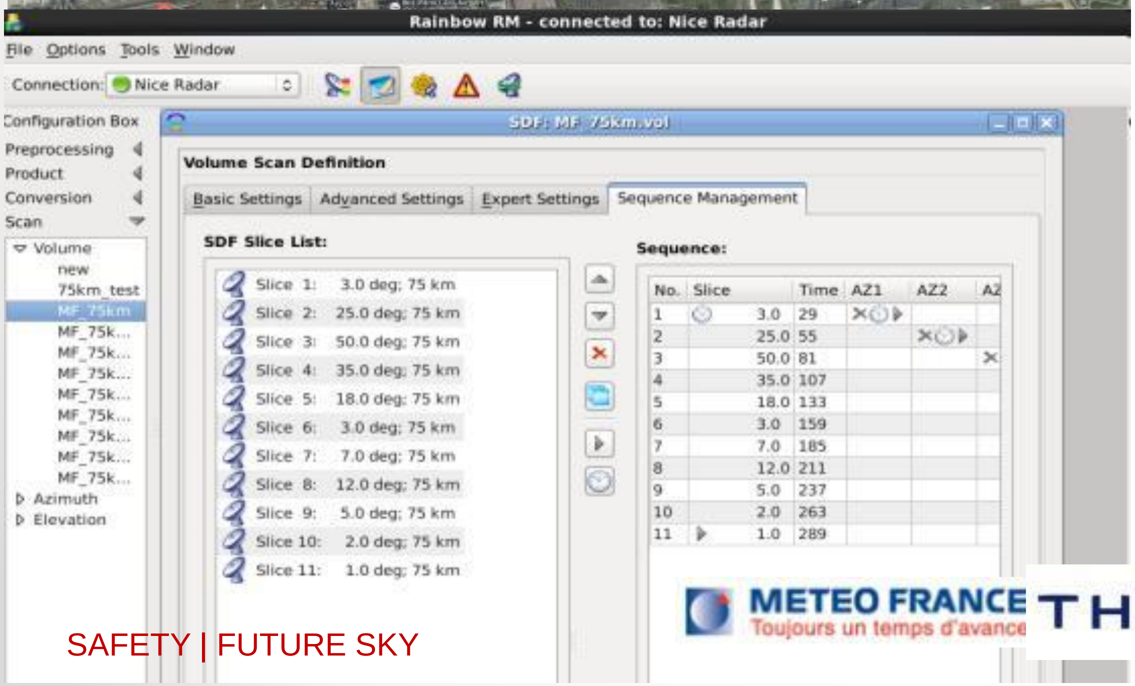

RWYs 09 L/R
TAXI CHART
HS1
HS2
HS3
HS4
RWY 09 L / 27 R
RWY 09 R / 27 L
LFPG/CDG
PARIS Ch. de Gaulle
10 MAR 11
G 2v
DEPARTURES
ARRIVALS
Departures for A380 only
NOT A380
A380 Taxiways prohibited
TAXIWAYS PROCEDURES
Maintenance area
Terminal 1
Terminal 3
Central TWR
North TWR
GND 121.775
GND 121.800
EAST
WEST
©AFKL Documentation
FRANCE

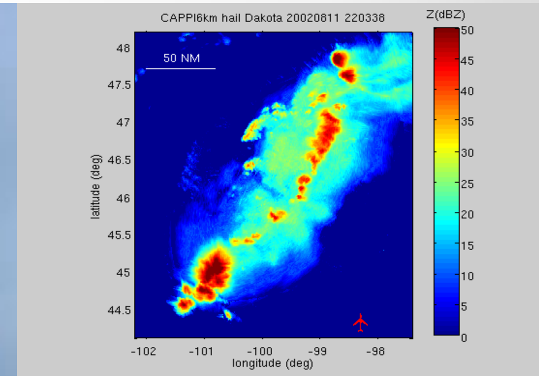
LIDAR Sensor :
Measure low altitude wind with high resolution

Transmission characteristics

- **Vertical beams :** 56 wide cone, 5 beams
- **Low altitude :** [40m ; 200m],
- **High resolution :** 20m default altitude resolution

LEOPARD Radar of Météo-France (weather X-band Radar for CDG Airport)





Operational Product at CDG:

- Wind on 15 km/80 km at elevation 3°
- dBZ on 15 km/80 km at elevation 3°
- Windshear on runway at elevation 3°
- Vertical Profil of Wind along runway : (5 km long x 4 km Altitude)

METEO FRANCE Toujours un temps d'avance

THALES