

SJU P6.8.1

WakeNet 3 Europe Workshop
London, 8th of February



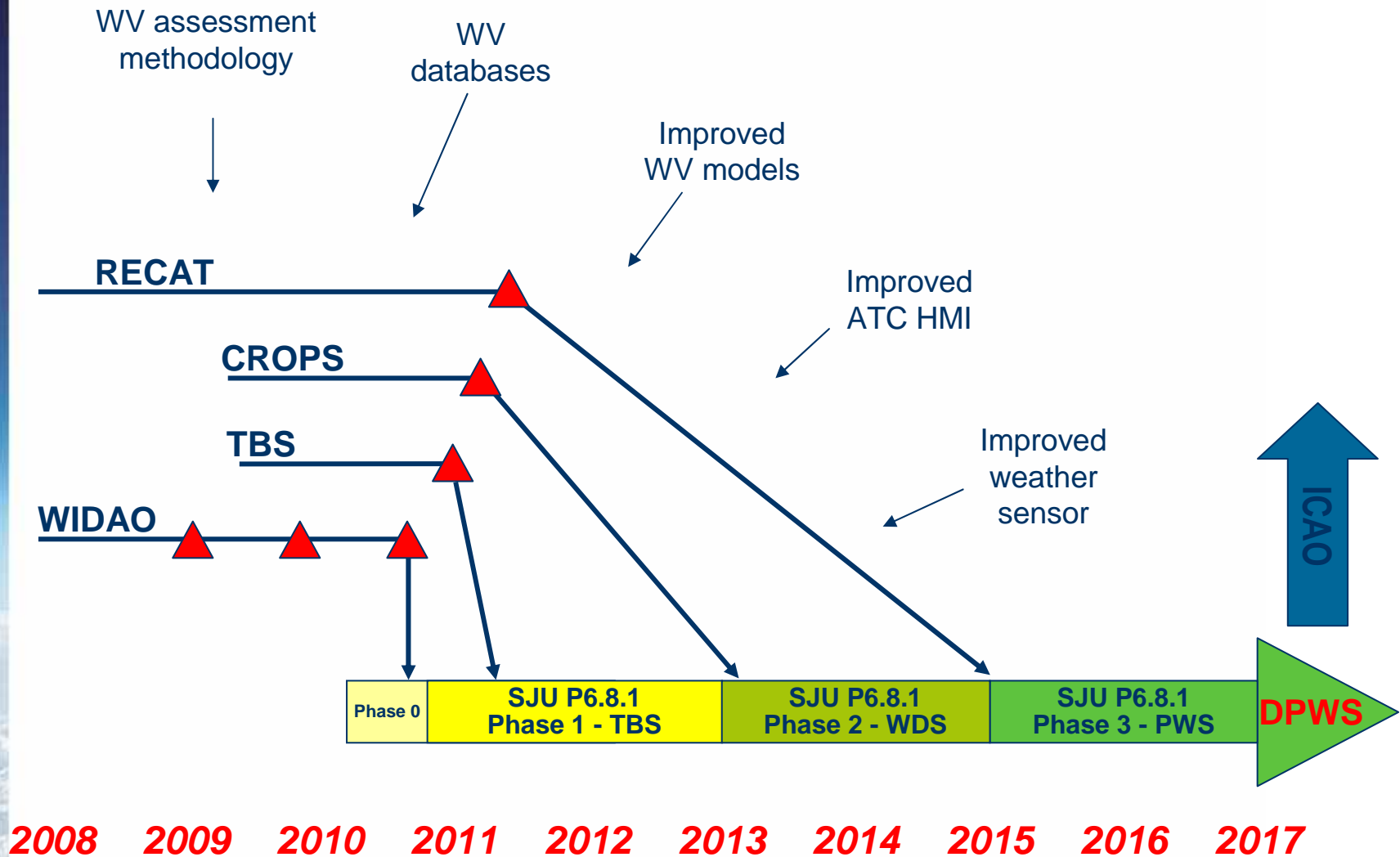
Vincent TREVE, EUROCONTROL

P6.8.1 Flexible and Dynamic Use of Wake Turbulence Separations

The objective of P6.8.1 is to develop solutions to:

- Permanently provide arrival capacity resilience to challenging wind conditions to redress the current impact of such conditions on the achieved capacity (TBS)
- Conditionally provide arrival and departure throughput increases in favourable prevailing meteorological conditions to more efficiently handle peaks and queues in arrival and departure demand (WDS)
- Permanently provide arrival and departure capacity increases across all conditions for both more contingency provision for non-nominal conditions and more provision for capacity declaration across all conditions (PWS)

SJU P.6.8.1 and short term projects





Project Tasks

Task 1 – Project management plan

Task 2 – Project management reporting

Task 3 – High-level OCD preparation

Task 4 – High level OSED preparation

Completed

Task 5 – (TBS) - State concept and assumptions

Task 6 – (TBS) - Set validation strategy

Ongoing

Task 7 – (TBS) - Determine the exercise needs

Task 10 – (TBS) - Conduct exercises

Task 11 – (TBS) - Determine the results

Task 12 – (TBS) - Disseminate information

2011 - 2012

Task 8 – Research on Wake Vortex Encounter severity metrics

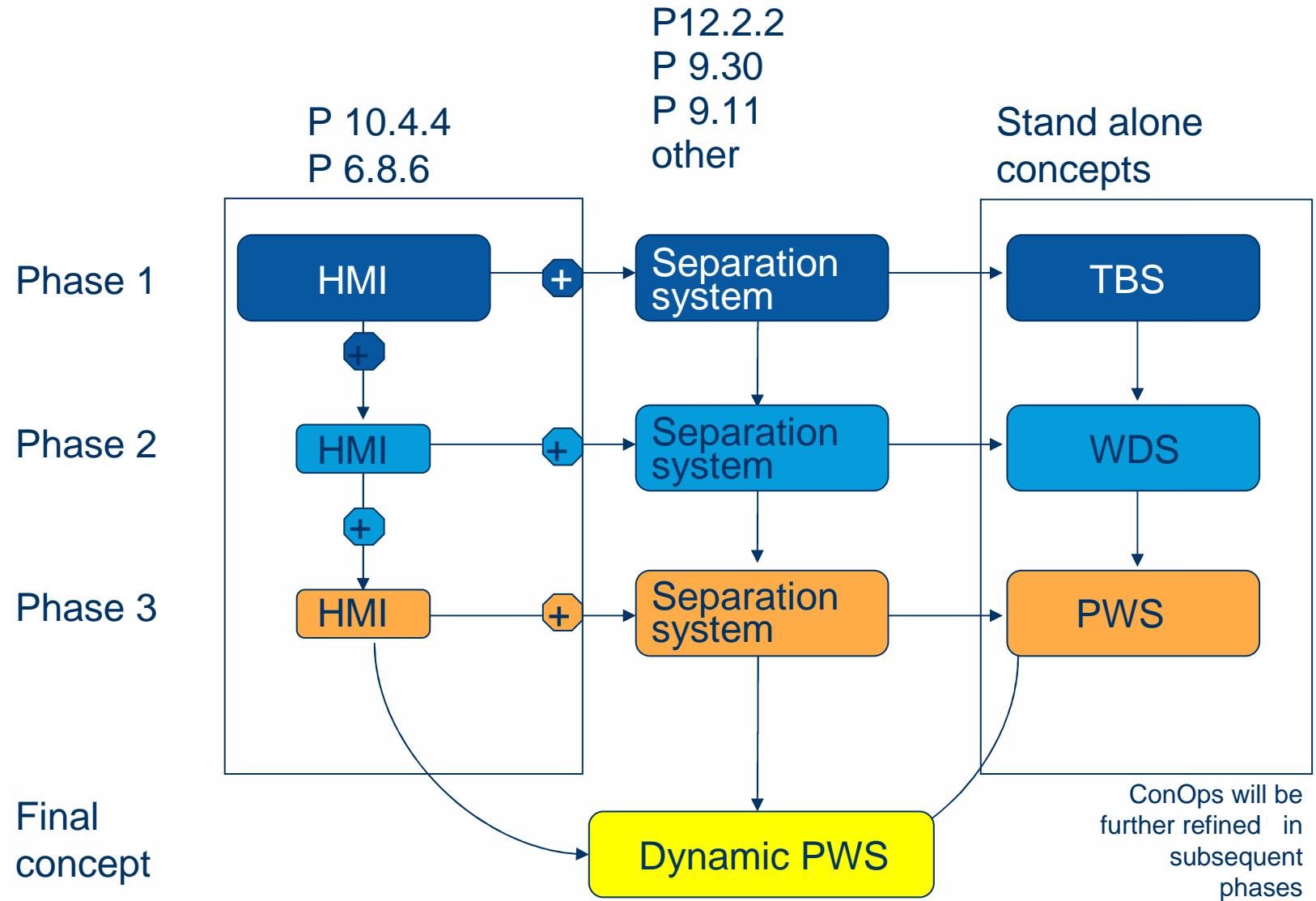
Task 9 – Permanent data collection

Ongoing

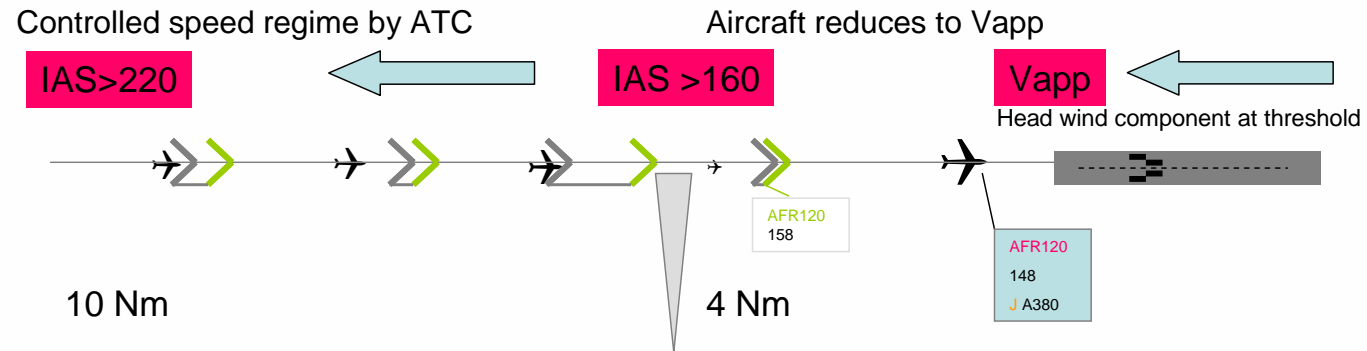
Project Tasks

Task 13 – (WDS) - State concept and assumptions	2013 - 2014
Task 14 – (WDS) - Set validation strategy	
Task 15 – (WDS) - Determine the exercise needs	
Task 16 – (WDS) - Conduct exercises	
Task 17 – (WD) - Determine the results	
Task 18 – (WDS) - Disseminate information	

Task 19 – (TBS) - State concept and assumptions	2015 - 2016
Task 20 – (TBS) - Set validation strategy	
Task 21 – (TBS) - Determine the exercise needs	
Task 22 – (TBS) - Conduct exercises	
Task 23 – (TBS) - Determine the results	
Task 24 – (TBS) - Disseminate information	



Task 5 - Detailed TBS OSED Definition (preliminary)

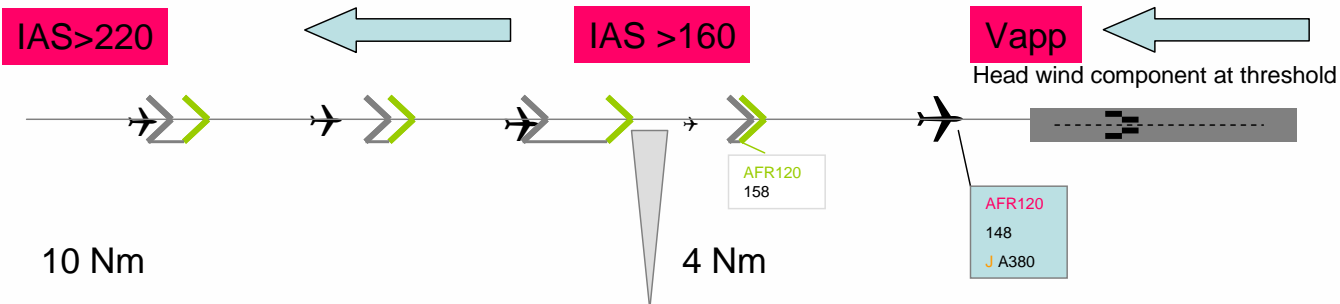


- > Minimum time separation based on preceding aircraft's past position (**T_Sep**) translated into distance (**D_Sep**)
- > Minimum time separation based on preceding aircraft's past position (**T_Sep**) translated into distance (**D_Sep**) + expected catch-up time (**T_CatchUp**) translated into distance (**D_CatchUp**)

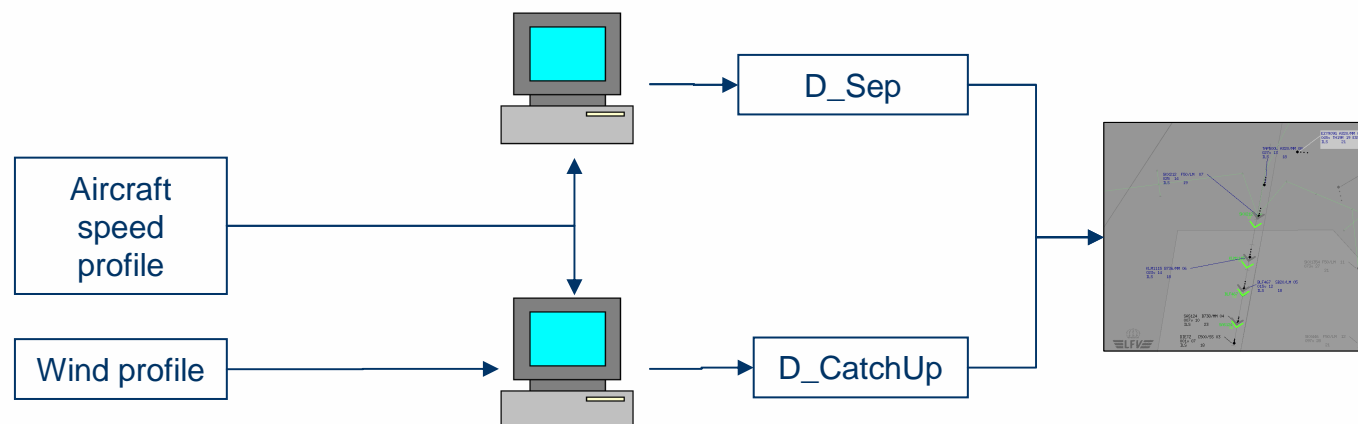
Task 5 - Detailed TBS OSED Definition (preliminary)

Controlled speed regime by ATC

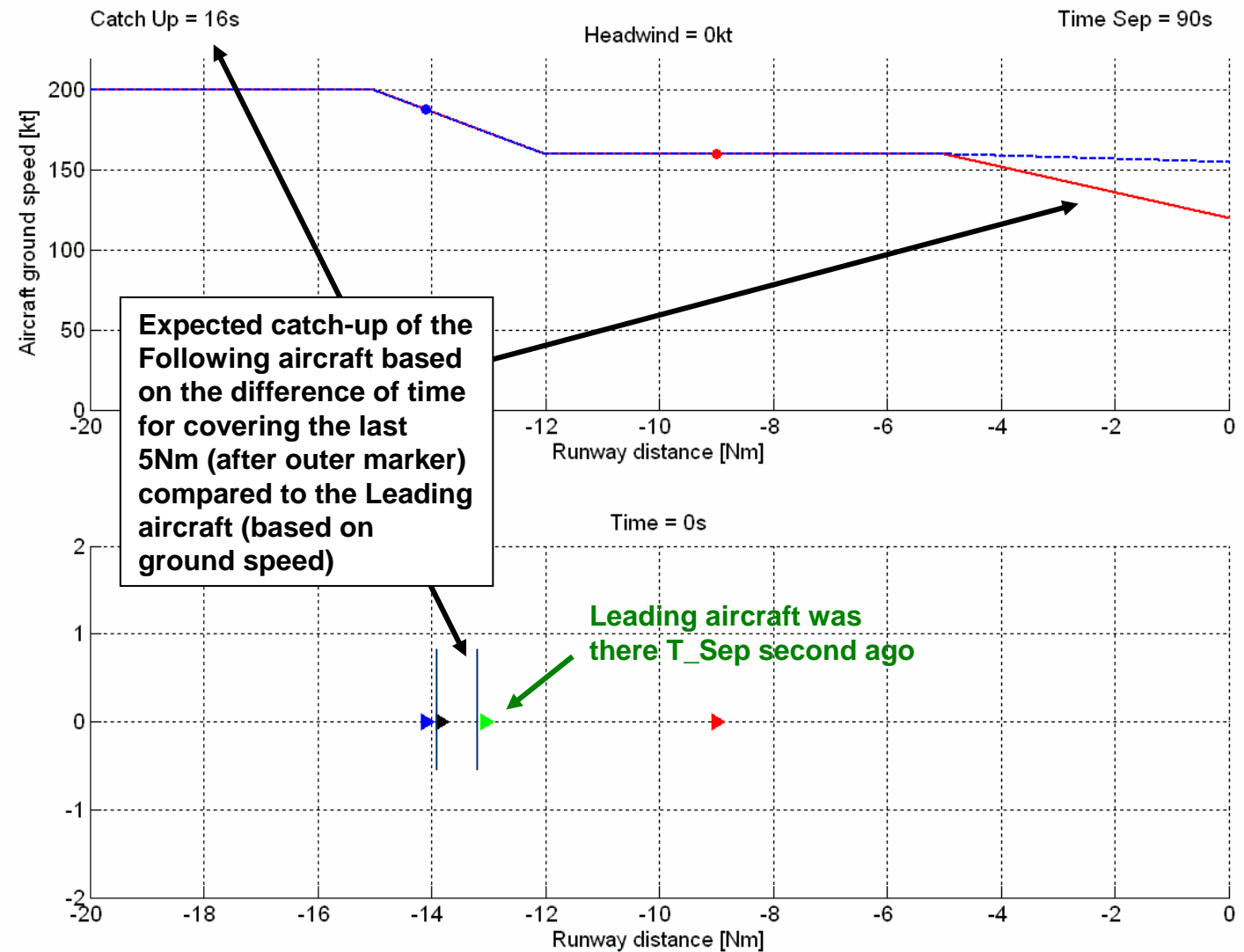
Aircraft reduces to V_{app}



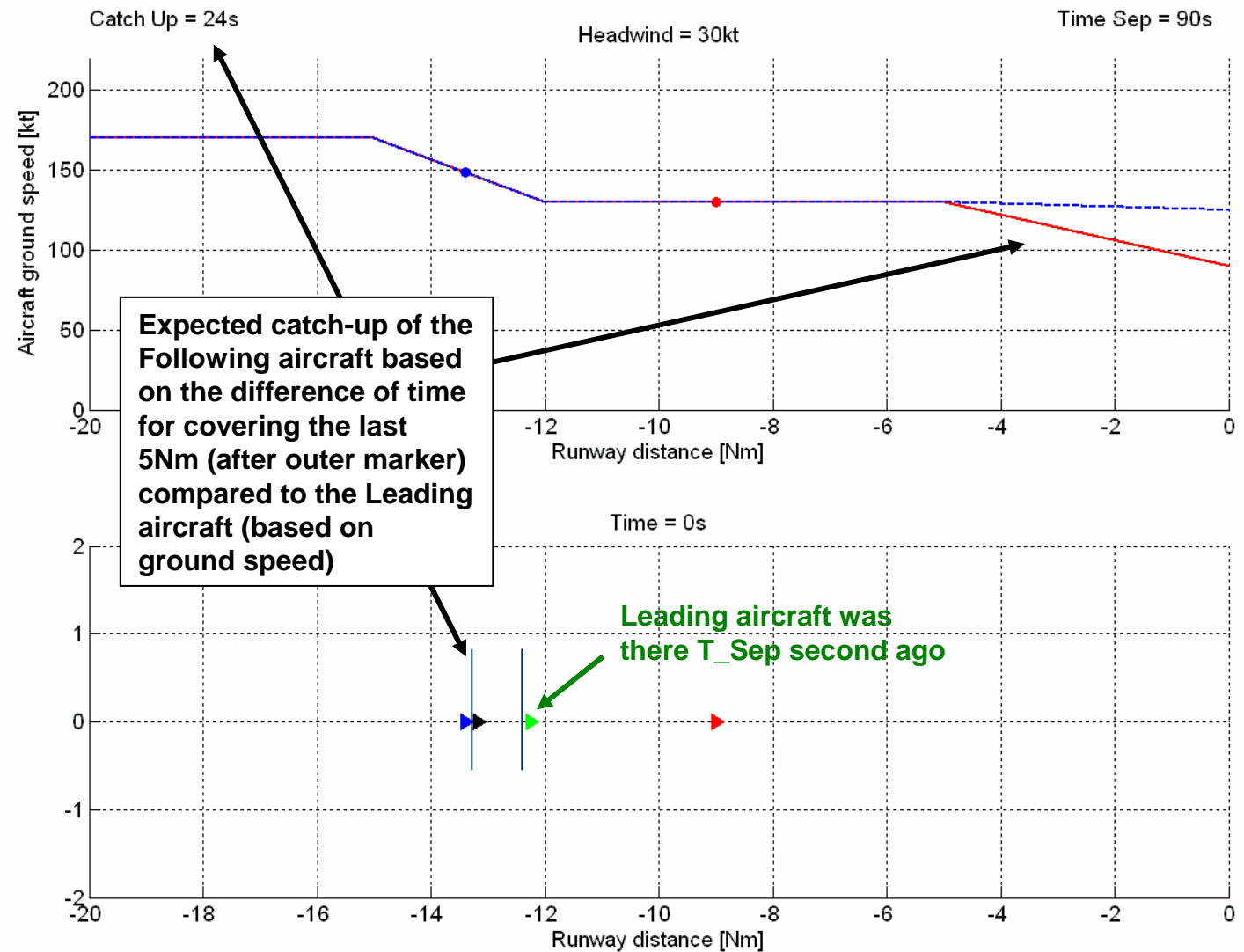
- > Minimum time separation based on preceding aircraft's past position (T_{Sep}) translated into distance (D_{Sep})
- > Minimum time separation based on preceding aircraft's past position (T_{Sep}) translated into distance (D_{Sep}) + expected catch-up time ($T_{CatchUp}$) translated into distance ($D_{CatchUp}$)



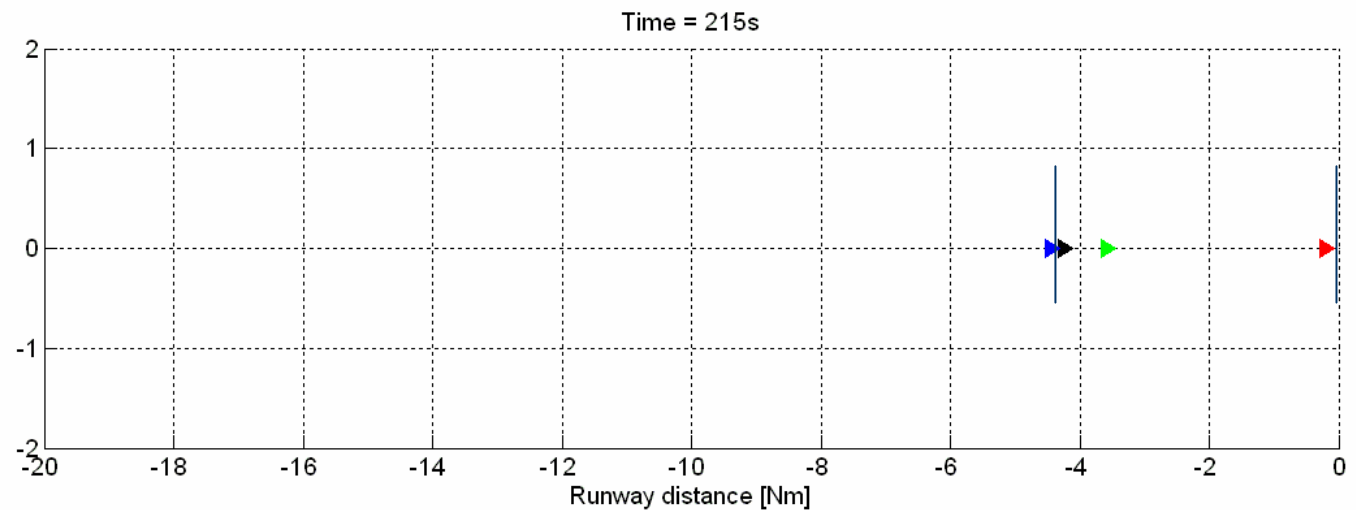
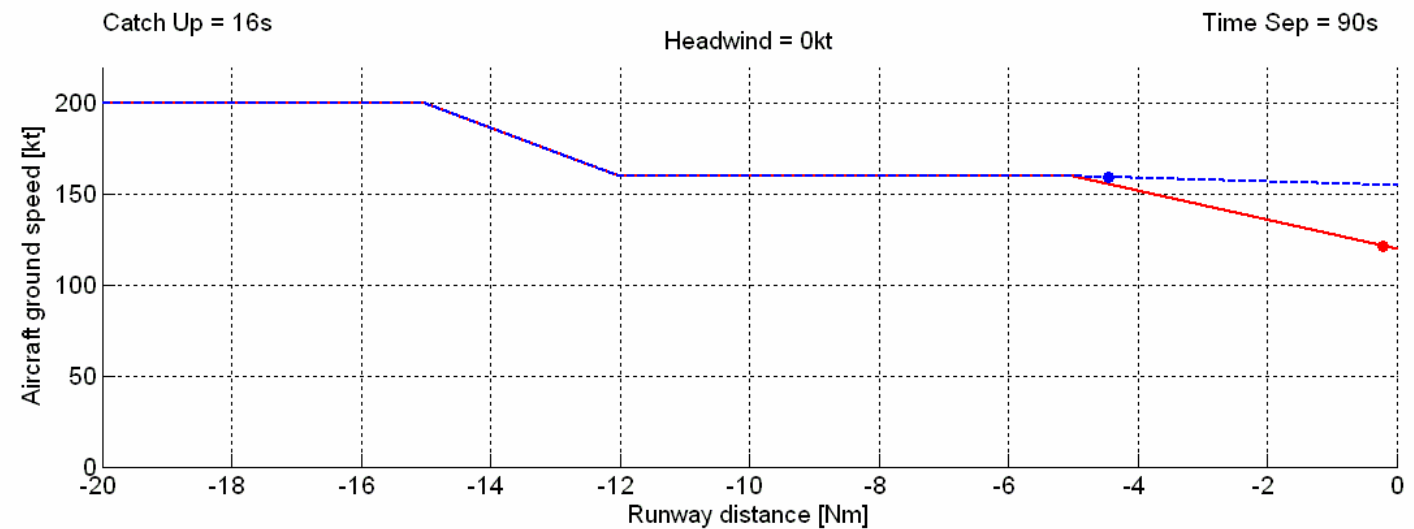
Task 5 - Detailed TBS OSED Definition (preliminary)



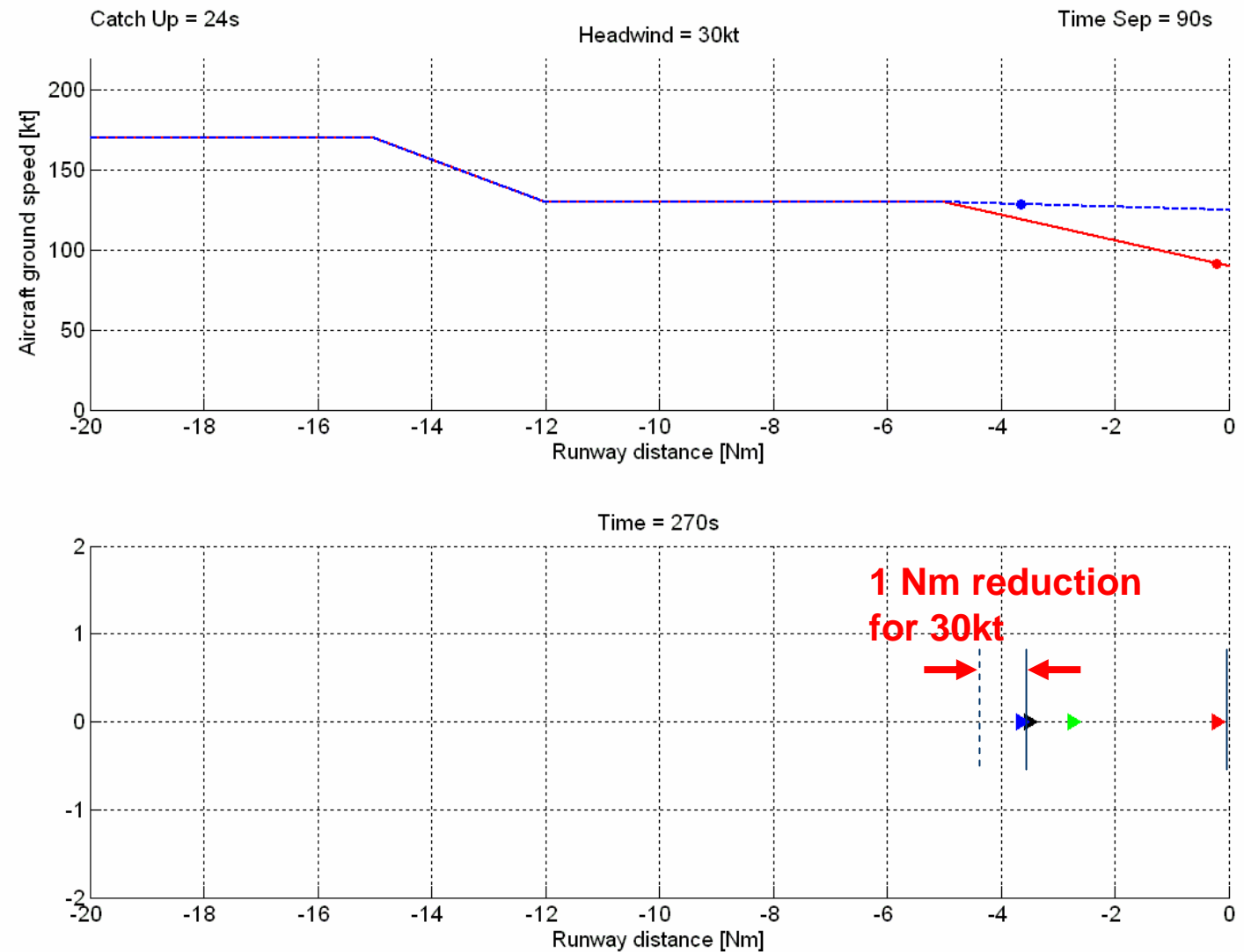
Task 5 - Detailed TBS OSED Definition (preliminary)



Task 5 - Detailed TBS OSED Definition (preliminary)



Task 5 - Detailed TBS OSED Definition (preliminary)



Task 5 - Detailed TBS OSED Definition (preliminary)

Sequence CMP				Landing List 161			
A	N	CALLSIGN	A	P	RTA	N	CALLSIGN
1	8	VLT2009	N	N	10:33	26	
2	7	DLH0428	N	N	10:32	25	ETH0725
3	6	SWR1760	N	N	10:31	24	DLH5628
4	5	MAS15	N	N	10:29	23	AZA403
5	4	AZA437	N	N	10:28	22	SWR1760
6	3	AZA191	N	N	10:26	21	MAS15
7	2	SAS681	N	N	10:24	20	SWR162
8	1	BRU85	F	N	10:23	19	AZA437
9					10:21	18	AZA203
10					10:20	17	AZA191
11					10:19	16	BAW1830
12					10:17	15	AZA571
13					10:16	14	AFR1604
14					10:15	13	ISS433
15					10:13	12	ADH591
16					10:11	11	ETE781

Advanced arrival
sequence manager

OR

Aircraft
downlink

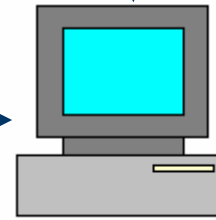


Aircraft
TAS
profile

3.0 RUS reduction		Heavy-Medium															
Weight/Weighted	Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1																
2	2																
3	3																
4	4																
5	5																
6	6																
7	7																
8	8																
9	9																
10	10																

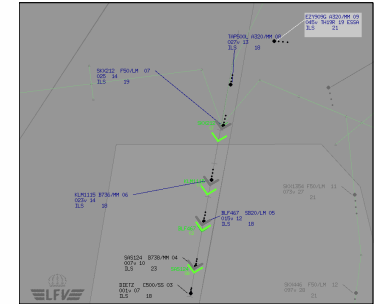
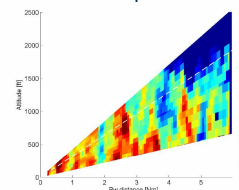
Validation of the
new separations

T_Sep



Separation
definition

Headwind
profile

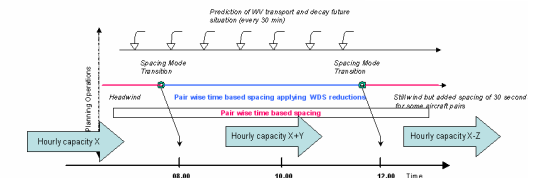


Controller
separation tool

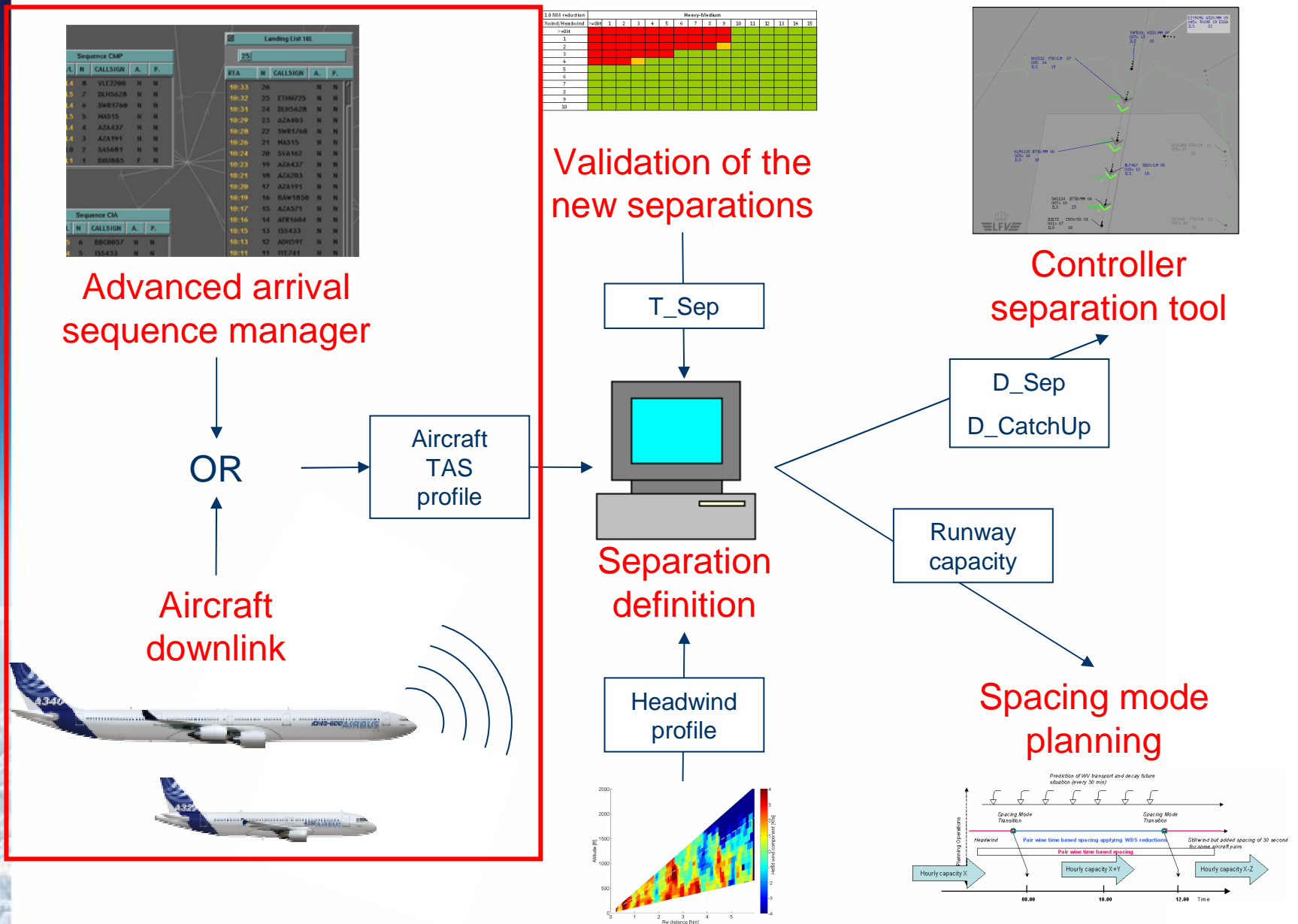
D_Sep
D_CatchUp

Runway
capacity

Spacing mode
planning



Task 5 - Detailed TBS OSED Definition (preliminary)



Task 5 - Detailed TBS OSED Definition (preliminary)

Sequence CMP				
A	N	CALLSIGN	A	P
1	8	VLL2200	N	N
2	7	DUI0428	N	N
3	6	SWR1760	N	N
4	5	MAS15	N	N
5	4	AZA437	N	N
6	3	AZA191	N	N
7	2	SAS681	N	N
8	1	BRU855	F	N

Sequence CA				
A	N	CALLSIGN	A	P
1	6	DBC0857	N	N
2	5	ISS431	N	N

Landing List 161				
RTA	N	CALLSIGN	A	P
10:33	26		N	N
10:32	25	ETH0725	N	N
10:31	24	DRH5628	N	N
10:29	23	AZA083	N	N
10:28	22	SWR1760	N	N
10:26	21	MAS15	N	N
10:24	20	SVA162	N	N
10:23	19	AZA437	N	N
10:21	18	AZA283	N	N
10:20	17	AZA191	N	N
10:19	16	BAW1830	N	N
10:17	15	AZA571	N	N
10:16	14	AFR1604	N	N
10:15	13	ISS433	N	N
10:13	12	ADH591	N	N
10:11	11	DET081	N	N

Advanced arrival
sequence manager

OR

Aircraft
downlink



Generic speed profile based on
aircraft type provided by the
sequence manager

OR

Generic speed profile +
Landing speed defined by
aircraft type or broadcasted

OR

Expected speed profile
broadcasted by the aircraft
(ADSB Out?)

OR...

Task 5 - Detailed TBS OSED Definition (preliminary)

Sequence CMP				Landing List 161			
A	N	CALLSIGN	A	P	RTA	N	CALLSIGN
1	8	VLL2200	N	N	10:33	26	ETH8725
2	7	DH0428	N	N	10:32	25	ETH8725
3	6	SWR1760	N	N	10:31	24	ETH8725
4	5	MAS15	N	N	10:29	23	AZA483
5	4	AZA437	N	N	10:28	22	SWR1760
6	3	AZA191	N	N	10:26	21	MAS15
7	2	SAS681	N	N	10:24	20	SWR1760
8	1	BRU885	F	N	10:23	19	AZA437
9					10:21	18	AZA293
10					10:20	17	AZA191
11					10:19	16	BAW1830
12					10:17	15	AZA571
13					10:16	14	AFR1604
14					10:15	13	ISS433
15					10:13	12	ADH591
16					10:11	11	ETE781

Advanced arrival
sequence manager

OR

Aircraft
downlink

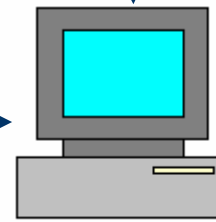


Aircraft
TAS
profile

3.0 RUS reduction		Heavy-Medium															
Weight/Weight	Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1																
2	2																
3	3																
4	4																
5	5																
6	6																
7	7																
8	8																
9	9																
10	10																

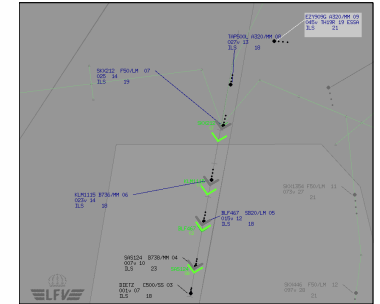
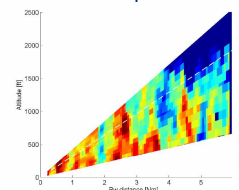
Validation of the
new separations

T_Sep



Separation
definition

Headwind
profile

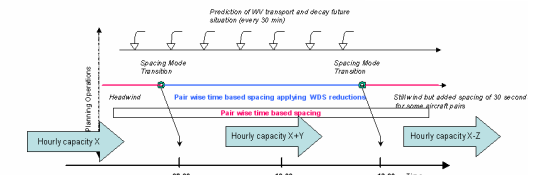


Controller
separation tool

D_Sep
D_CatchUp

Runway
capacity

Spacing mode
planning



Task 5 - Detailed TBS OSED Definition (preliminary)

Sequence CMP				Landing List 161			
A	N	CALLSIGN	A	P	RTA	N	CALLSIGN
1	8	VLT2009	N	N	10:33	26	
2	7	DH0428	N	N	10:32	25	ETH8725
3	6	SWR1769	N	N	10:31	24	DRH5628
4	5	MAS15	N	N	10:29	23	AZA483
5	4	AZA437	N	N	10:28	22	SWR1769
6	3	AZA191	N	N	10:26	21	MAS15
7	2	SAS681	N	N	10:24	20	SVA162
8	1	BRU855	F	N	10:23	19	AZA437
					10:21	18	AZA293
					10:20	17	AZA191
					10:19	16	BAW1838
					10:17	15	AZA571
					10:16	14	AFR1664
					10:15	13	ISS433
					10:13	12	ADH591
					10:11	11	ETE781

Advanced arrival
sequence manager

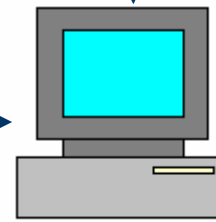
OR

Aircraft
downlink

Aircraft
TAS
profile

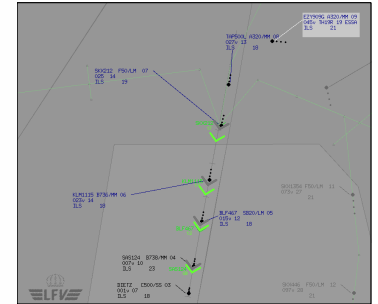
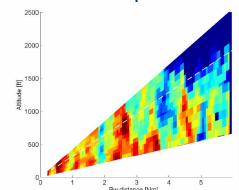
Validation of the
new separations

T_Sep



Separation
definition

Headwind
profile

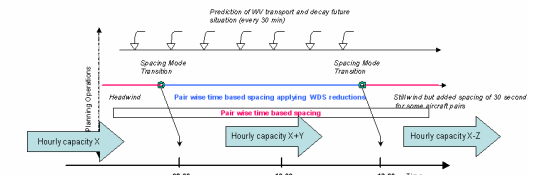


Controller
separation tool

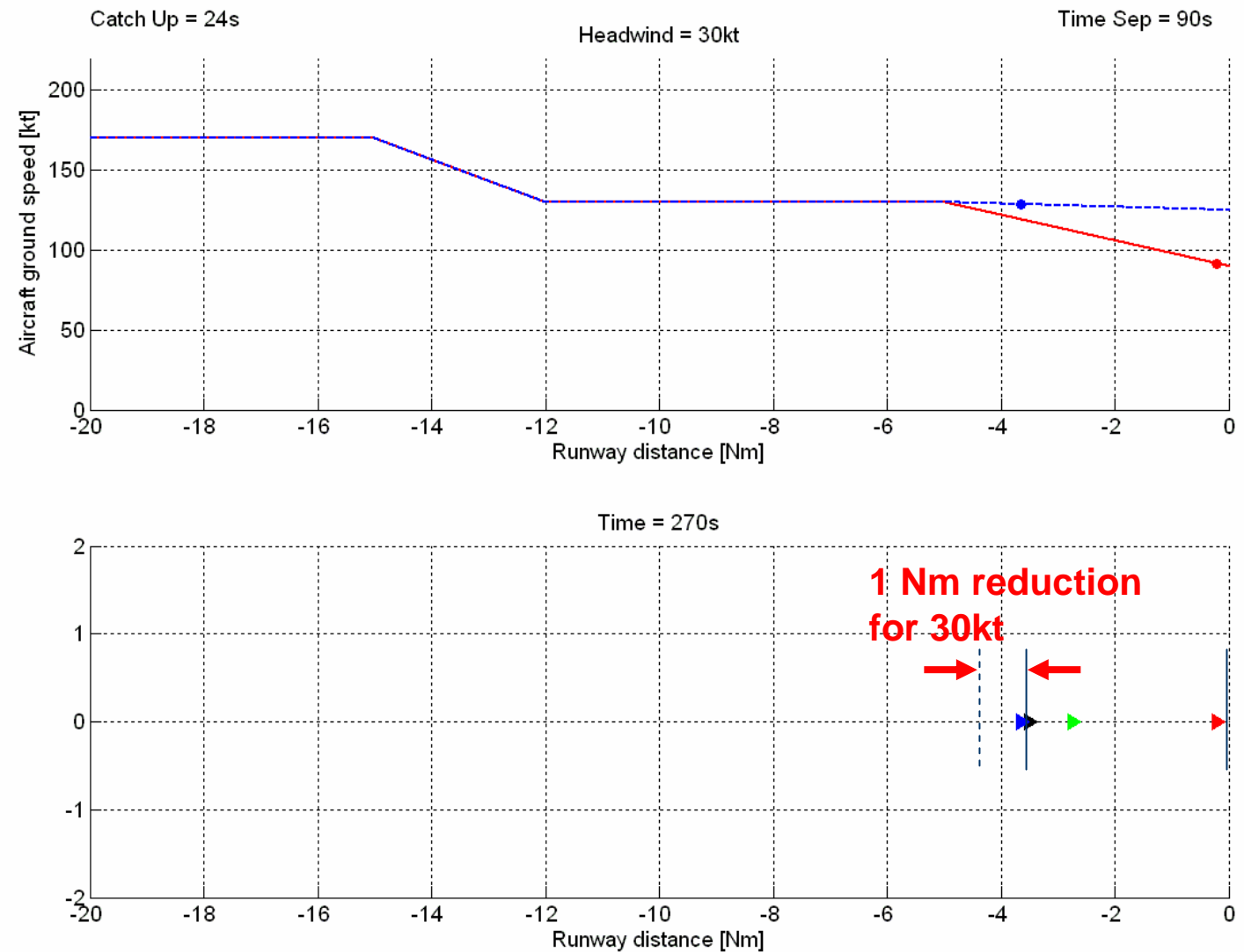
D_Sep
D_CatchUp

Runway
capacity

Spacing mode
planning

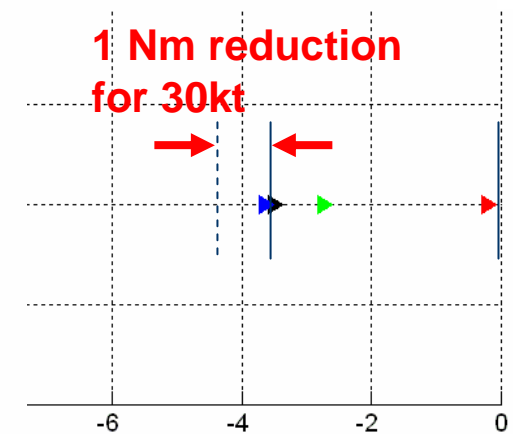
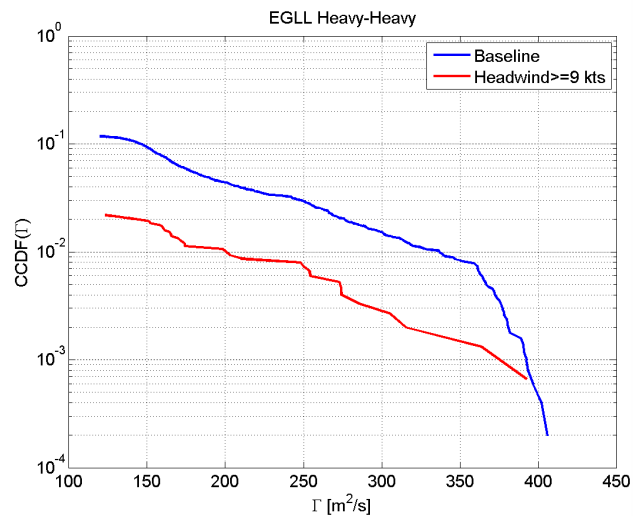
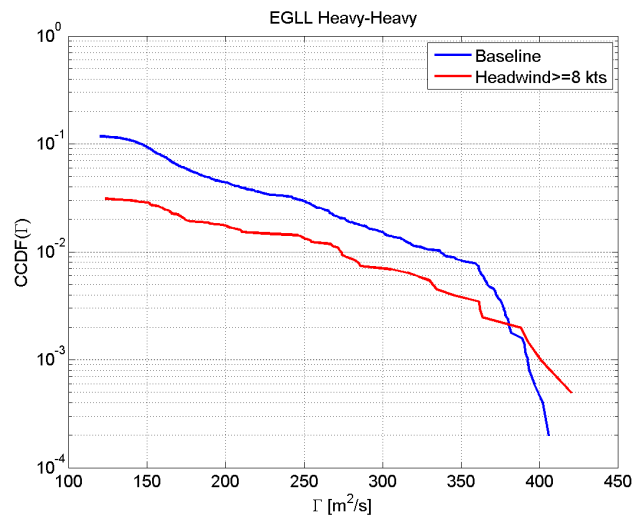


Task 5 - Detailed TBS OSED Definition (preliminary)



Task 5 - Detailed TBS OSED Definition (preliminary)

1.0 NM reduction	Heavy-Heavy															
Xwind/Headwind	>=0kt	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
>=0kt																
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																



Task 5 - Detailed TBS OSED Definition (preliminary)

Sequence CMP				Landing List 161			
A	N	CALLSIGN	A	P	RTA	N	CALLSIGN
1	8	VLT2009	N	N	10:33	26	
2	7	DLH0428	N	N	10:32	25	ETH0725
3	6	SWR1760	N	N	10:31	24	DLH5628
4	5	MAS15	N	N	10:29	23	AZA403
5	4	AZA437	N	N	10:28	22	SWR1760
6	3	AZA191	N	N	10:26	21	MAS15
7	2	SAS681	N	N	10:24	20	SWR162
8	1	BRU85	F	N	10:23	19	AZA437
9					10:21	18	AZA203
10					10:20	17	AZA191
11					10:19	16	BAW1850
12					10:17	15	AZA571
13					10:16	14	AFR1604
14					10:15	13	ISS433
15					10:13	12	ADH591
16					10:11	11	ETE781

Advanced arrival
sequence manager

OR

Aircraft
downlink

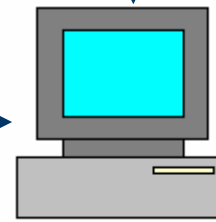


Aircraft
TAS
profile

1.0 RUS reduction		Heavy-Medium															
Weight/Weight	Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	1																
2	2																
3	3																
4	4																
5	5																
6	6																
7	7																
8	8																
9	9																
10	10																

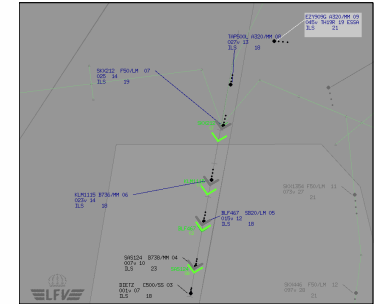
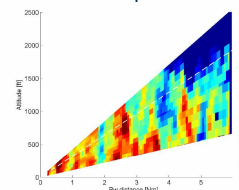
Validation of the
new separations

T_Sep



Separation
definition

Headwind
profile

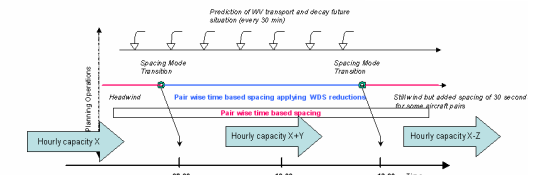


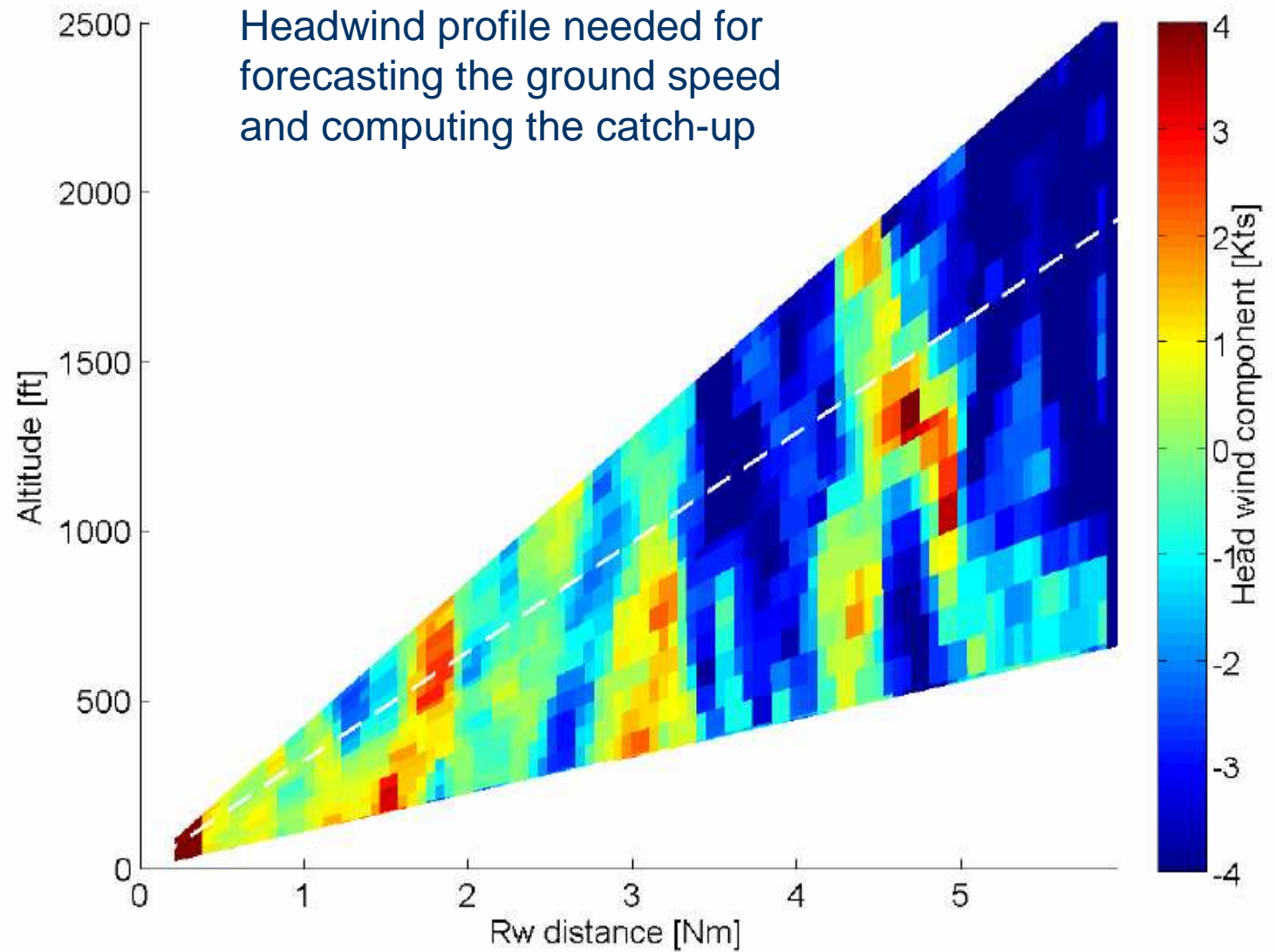
Controller
separation tool

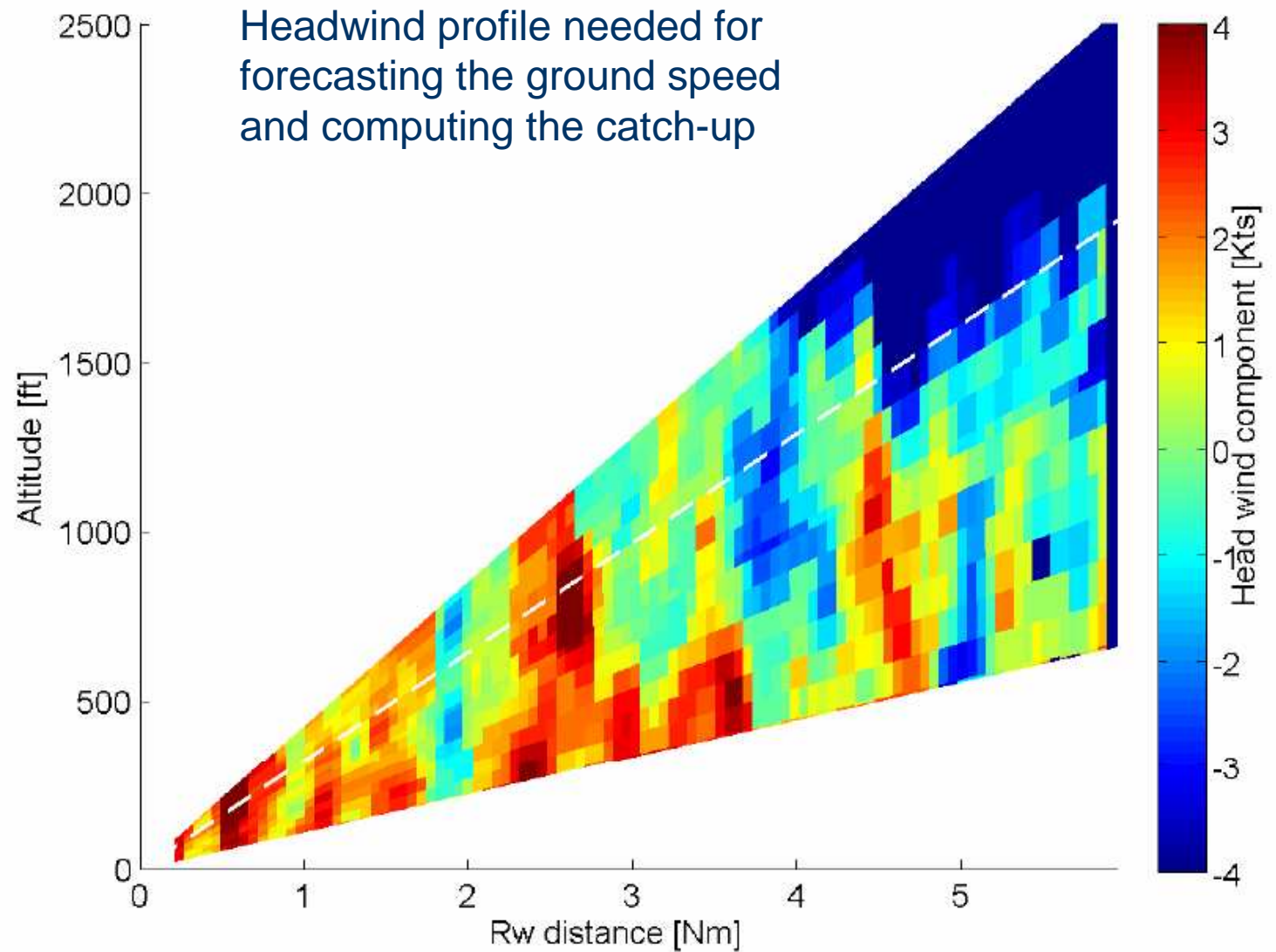
D_Sep
D_CatchUp

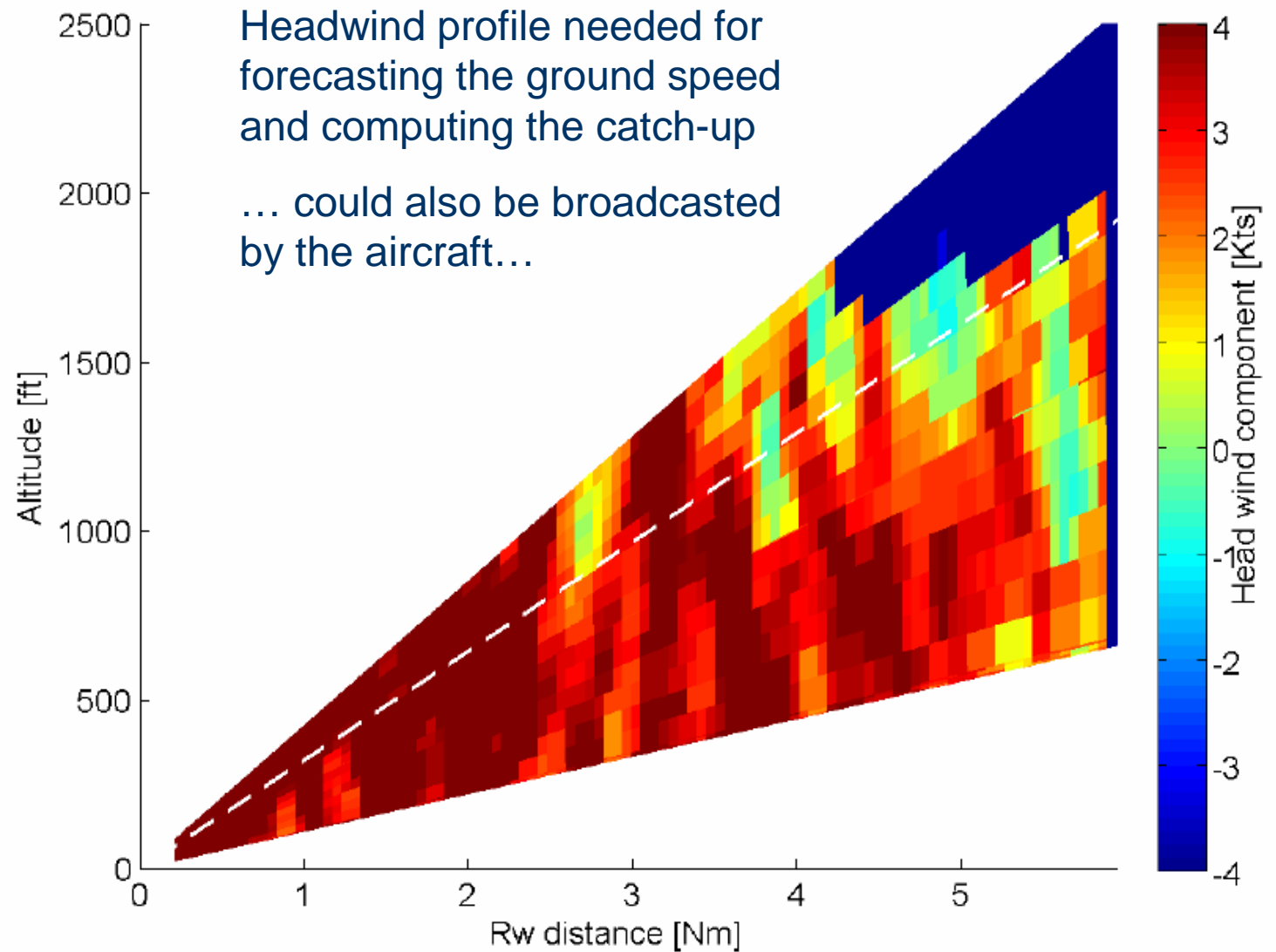
Runway
capacity

Spacing mode
planning









Task 5 - Detailed TBS OSED Definition (preliminary)

Sequence CMP				Landing List 161			
A	N	CALLSIGN	A	P	RTA	N	CALLSIGN
1	8	VLL2200	N	N	10:33	26	ETH8725
2	7	DH0428	N	N	10:32	25	ETH8725
3	6	SWR1760	N	N	10:31	24	ETH8725
4	5	MAS15	N	N	10:29	23	AZA483
5	4	AZA437	N	N	10:28	22	SWR1760
6	3	AZA191	N	N	10:26	21	MAS15
7	2	SAS681	N	N	10:24	20	SWR1760
8	1	BRU885	F	N	10:23	19	AZA437
9	1	BRU885	F	N	10:21	18	AZA293
10	1	BRU885	F	N	10:20	17	AZA191
11	1	BRU885	F	N	10:19	16	BAW1830
12	1	BRU885	F	N	10:17	15	AZA571
13	1	BRU885	F	N	10:16	14	AFR1604
14	1	BRU885	F	N	10:15	13	ISL433
15	1	BRU885	F	N	10:13	12	ADH591
16	1	BRU885	F	N	10:11	11	ETE781

Advanced arrival
sequence manager

OR

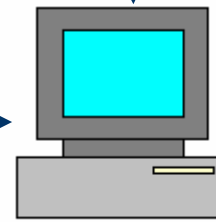
Aircraft
downlink

Aircraft
TAS
profile

3.0 RUS reduction		Heavy-Medium															
Weight/Weight	Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

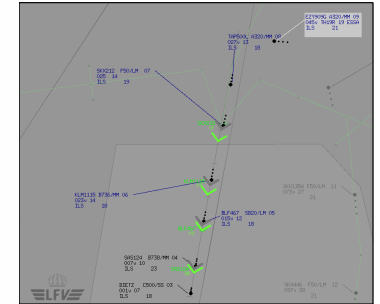
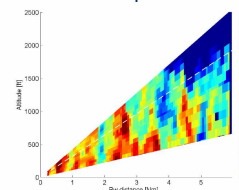
Validation of the
new separations

T_Sep



Separation
definition

Headwind
profile

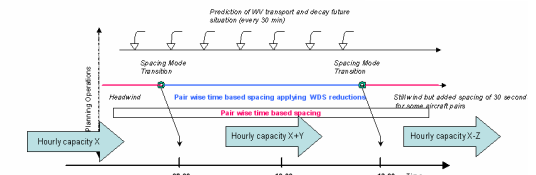


Controller
separation tool

D_Sep
D_CatchUp

Runway
capacity

Spacing mode
planning



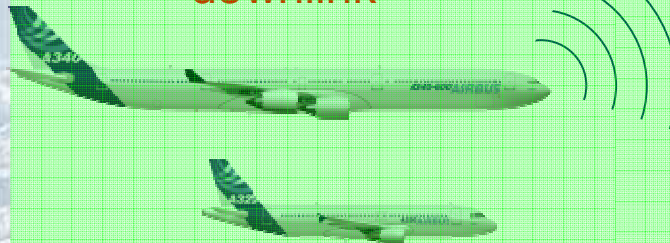
Task 5 - Detailed TBS OSED Definition (preliminary)

Sequence CMP				Landing List 101			
A	N	CALLSIGN	A	P	RTA	N	CALLSIGN
1	6	VLT2009	N	N	10:33	26	N
2	7	DVDA208	N	N	10:32	25	ETH9725
3	6	SNR5768	N	N	10:31	24	RIJ5628
4	5	MAS15	N	N	10:29	23	AZA481
5	4	AZA437	N	N	10:28	22	SNR5768
6	3	AZA191	N	N	10:26	21	MA315
7	2	SAS681	N	N	10:24	20	SVA162
8	1	BURMS	F	N	10:23	19	AZA437
9					10:21	18	AZA263
10					10:20	17	AZA191
11					10:19	16	BAW1030
12					10:17	15	AZA371
13					10:16	14	ATK1684
14					10:15	13	ISS433
15					10:13	12	ADH591
16					10:11	11	OTZ81

Advanced arrival
sequence manager

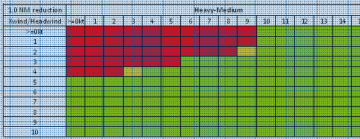
OR

Aircraft
downlink



P12.2.2

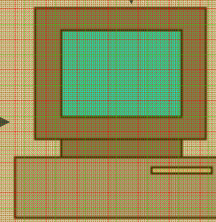
Aircraft
TAS
profile



Validation of the
new separations

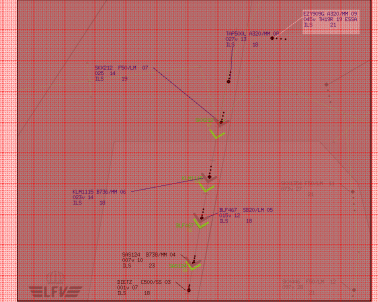
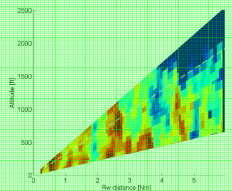
P6.8.1

T_Sep



Separation
definition

Headwind
profile



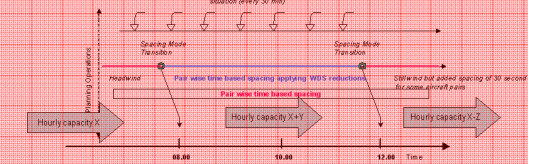
Controller
separation tool

D_Sep
D_CatchUp

Runway
capacity

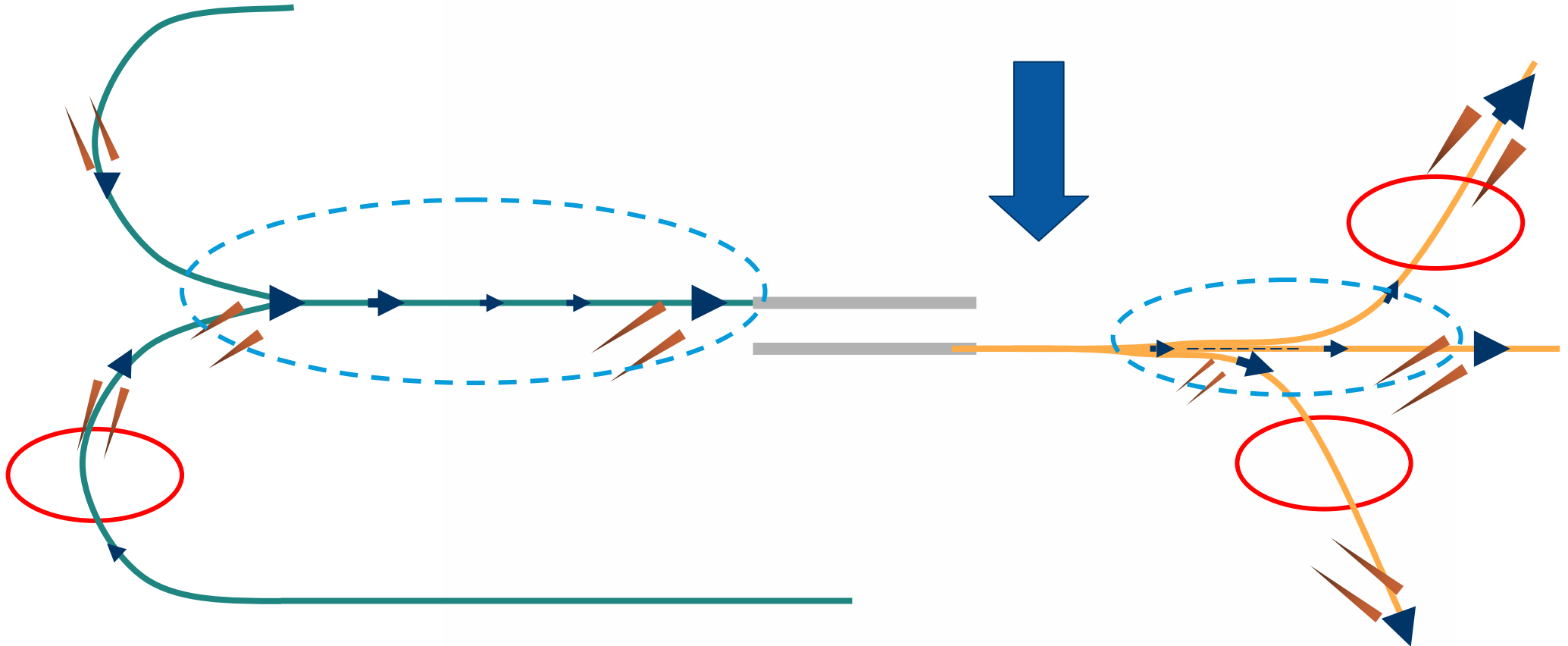
P10.4.4

Spacing mode
planning



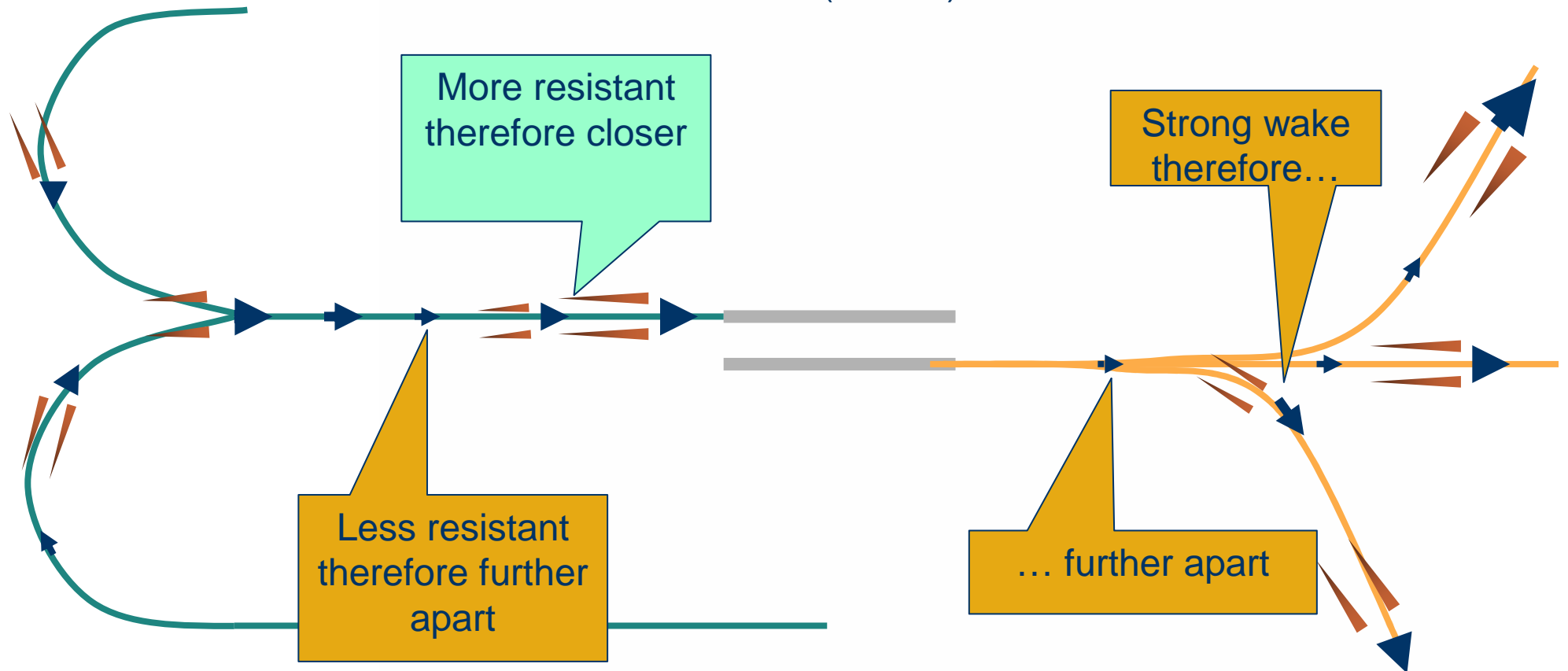
Key enabler:

- Weather forecasting and monitoring capabilities (Sys WPs)
- WV databases for validation (Task 9)



Key enabler:

- Validated metric for characterising WT risk (Task 8)
- WV databases for validation (Task 9)



Approach: Derive “simple” models for roll axis disturbance

- Sufficiently simple for generalization (any aircraft type)
- Sufficiently accurate to include relevant characteristics of the generator and follower aircraft, incl. new systems

(1) Wake-induced max. static roll acceleration on follower A/C:

$$\dot{p}_{wv} = \frac{4\rho V_f}{GM_f R_{xf}^2 (\Lambda_f + 4)} \Gamma(t) C_{wv,c} \left(\lambda_f, \frac{b_v}{b_f}, \frac{r_c}{b_f} \right)$$

(2) Maximum bank angle upset on follower A/C:
(to include controllability aspects of follower aircraft)

$$\Phi_{\max, WV} \sim (\dot{p}_{wv} + \dot{p}_p + \dot{p}_\xi)$$

Static wake-induced
roll acceleration

Roll damping

Roll control

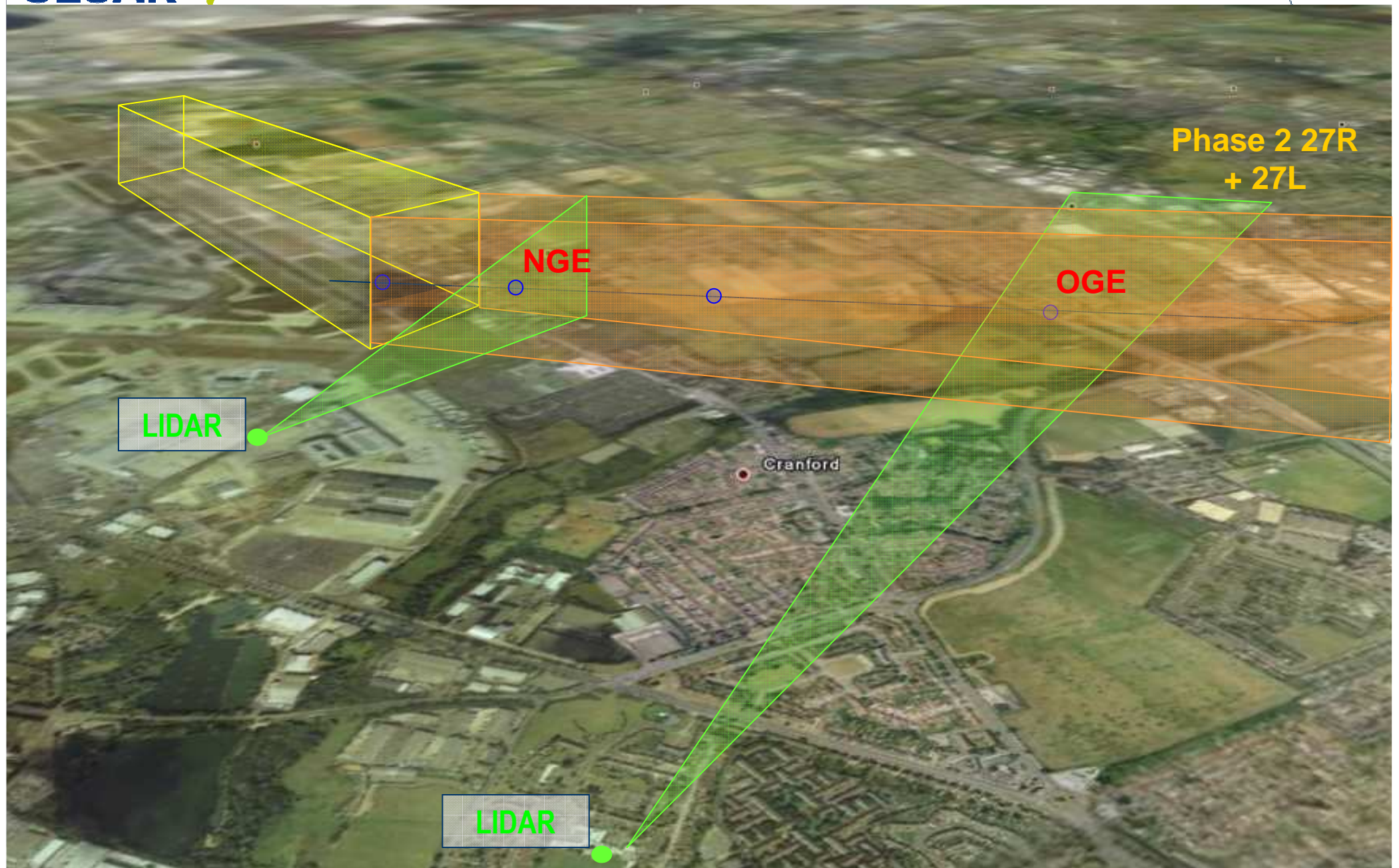
LIDAR and Aircraft data correlated for first 21 months of measurements

85 028 vortex tracks from Oct '08 until Sep '10

- A380 ~ 600 tracks
- Heavy ~ 46,000 tracks
- Upper Medium ~ 4,600 tracks
- Lower Medium ~ 60,000 tracks
- Small ~ 500 tracks
- Light ~ 10 tracks

METAR & Wind data processed

- RWY anemometers
- LIDAR headwind data along the glide slope
- LIDAR cross- and head-wind data reconfigured (scan elevation from 3 to 15 degrees between the two runway centrelines)
- Correlation of vortex and MET data



Open issues or research subjects

- Usability of the proposed HMI logic (catch-up management)?
- Availability of wind information broadcasted by aircraft
- Conditional separation reductions (with human in the loop) vs real time adaptation of separations (system based)
- Can we go below today MRS?
- How to deal with the up-wind SID concept?
- How to deal with the lost of awareness for the pilot especially for PWS?
- Acceptability of new severity metric?
- Need for more wake measurement campaigns?

QUESTIONS?

