

An airport view on wake vortex separation at FRA and its affect on capacity – today and in future

*09th February 2011,
WakeNet-3 Europe Concepts Workshop at NATS, London Heathrow*

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Fraport AG*



Video



Wirbelschleppen.mp4

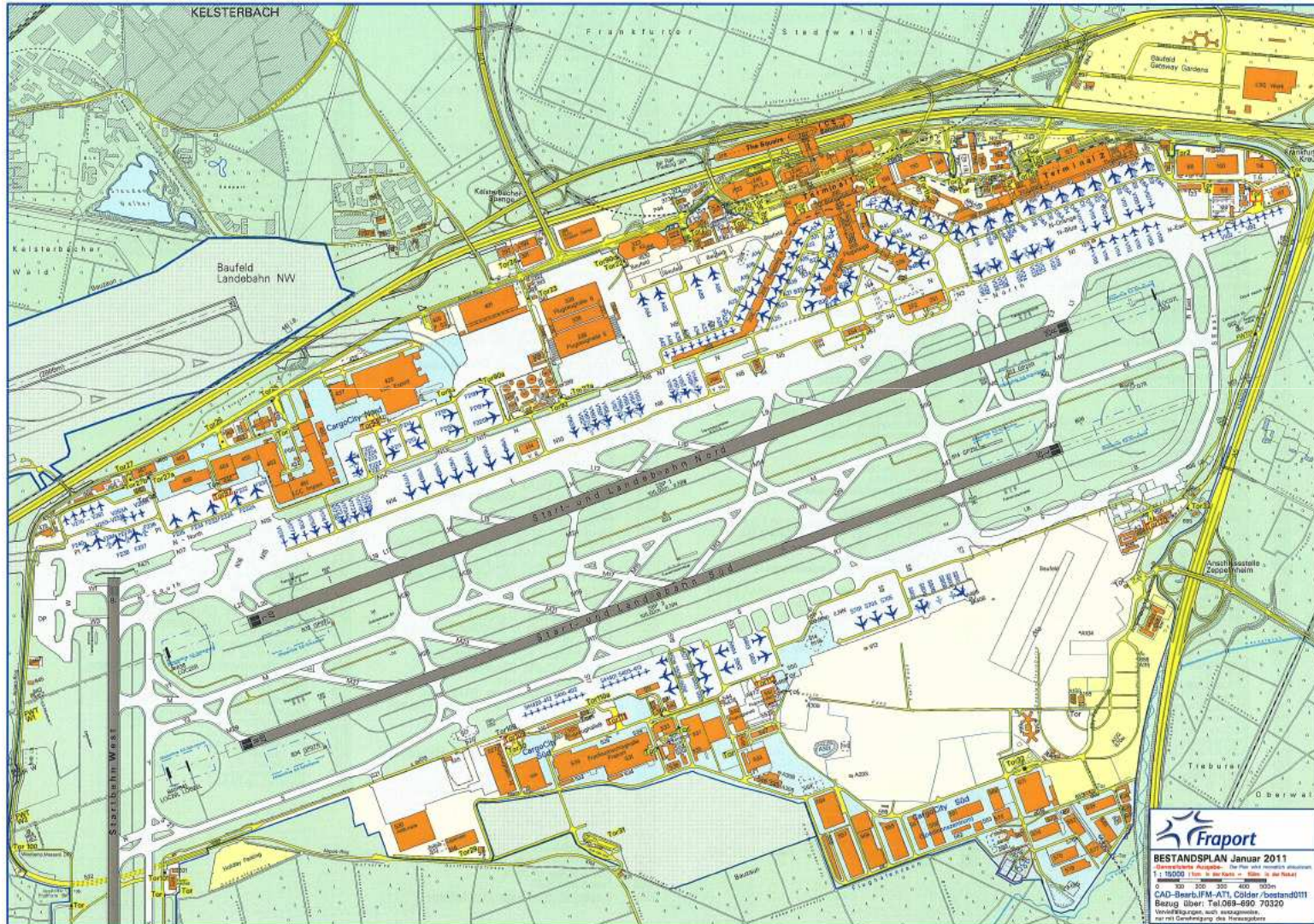
Don't judge a book by its cover ...

... hence I will try to open the book of “operational view on separation minimas” a little bit and start – but not finish! – reading.

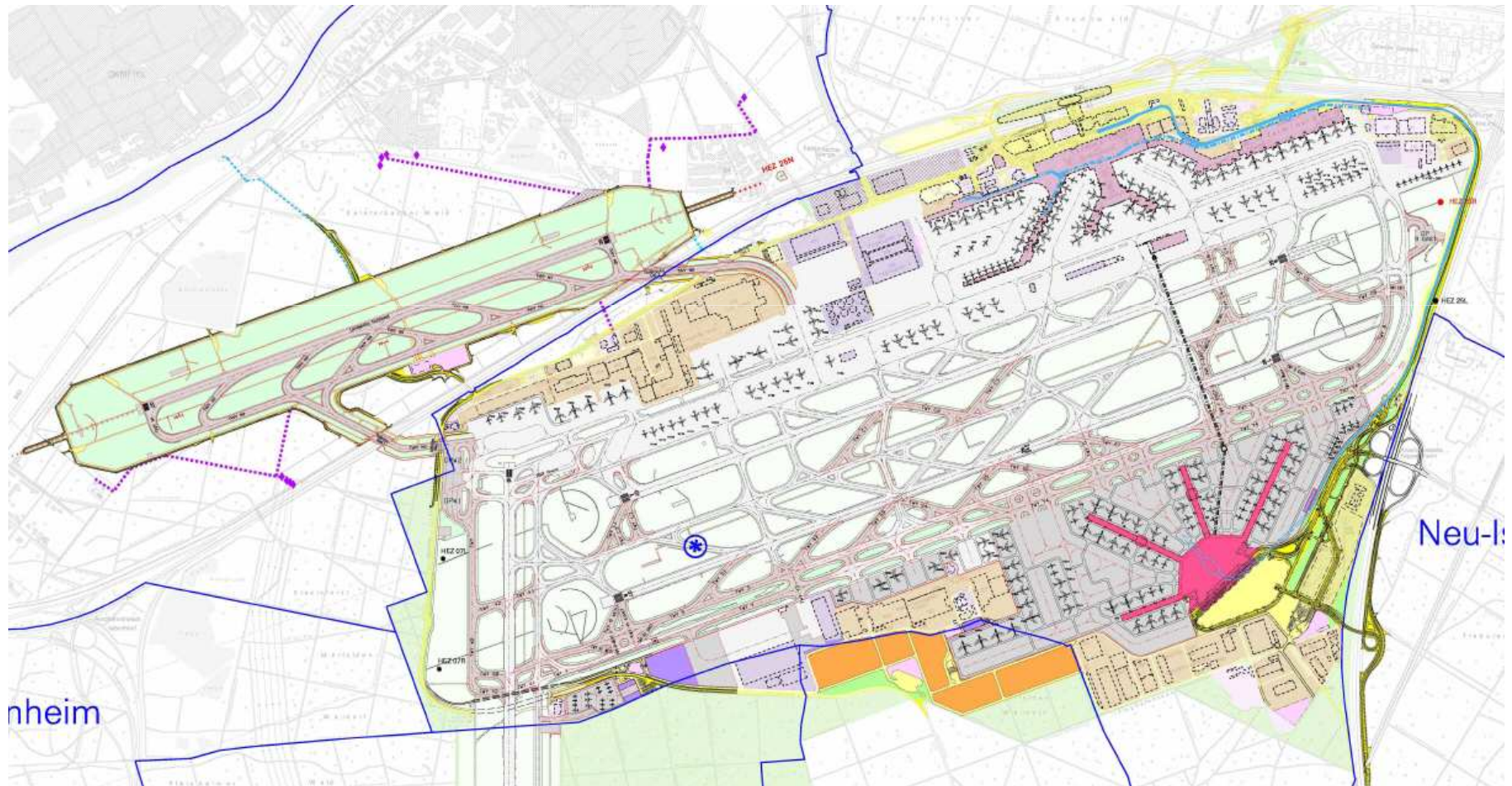
Content

- **EDDF infrastructure – today and tomorrow**
- **EDDF procedures – today**
- **EDDF (r&d) projects concerning wakevortex separation (in the past)**
- **EDDF procedures - future**
- **(draft) EDDF results for RECAT / PTBS / CROPS**
- **Conclusion**

EDDF infrastructure – today



EDDF infrastructure – future (2020)



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EDDF procedures – ICAO Annex 14 („THE“ textbook – or better: bible ?)

ICAO Annex 14, Volume I:

Minimum distance between parallel runways

3.1.11 Recommendation

Where parallel instrument runways are intended for simultaneous use subject to conditions in the PANS-ATM (Doc 4444) and the PANS-OPS (Doc 8168), Volume I, the minimum distance between their centre lines should be:

- 1 035 m for independent approaches;
- 915 m for dependent parallel approaches;
- 760 m for independent parallel departures;
- 760 m for segregated parallel operations;

- ⇒ EDDF today: 518 m (1.700ft) spacing between arr-rwys
- ⇒ EDDF future: 1.918 m (6.300ft) spacing between arr-rwys

EDDF procedures – ICAO Doc 9643 (textbook no.2)

SOIR – ICAO Doc 9643:

2.2 Independent parallel instrument approaches (mode 1)

2.2.1 Requirements and procedures

2.2.1.1 Independent parallel approaches may be conducted to parallel runways provided:

- a) the runway centre lines are spaced by the distance specified in Annex 14, Volume I, and:
 - 1) where runway centre lines are spaced by **less than 1 310 m** (4 300 ft) **but not less than 1 035 m** (3 400 ft), suitable SSR equipment, with a minimum azimuth accuracy of 0.06 degrees (one sigma), an **update period of 2.5 seconds** or less and a high resolution display providing position prediction and deviation alert is available; or
 - 2) where runway centre lines are spaced by **less than 1 525 m** (5 000 ft) **but not less than 1 310 m** (4 300 ft), SSR equipment with performance specifications other than the foregoing may be applied, provided they are equal to or better than those stated under 3) below, and when it is determined that the safety of aircraft operation would not be adversely affected; or
 - 3) where runway centre lines are spaced by **1 525 m** (5 000 ft) or more, suitable surveillance radar with a minimum azimuth accuracy of 0.3 degrees (one sigma) or better and an **update period of 5 seconds** or less is available; [...]

EDDF procedures – ICAO Doc 4444 (textbook no.3 – „THE“ operational bible)

PANS ATM – ICAO Doc 4444:

8.7.4.4. The following wake turbulence radar separation minima shall be applied to aircraft in the approach and departure phases of flight in the circumstances given in 8.7.4.4.1

Aircraft category		
Preceding aircraft	Succeeding aircraft	Wake turbulence radar separation minima
HEAVY	HEAVY	7.4 km (4.0 NM)
	MEDIUM	9.3 km (5.0 NM)
	LIGHT	11.1 km (6.0 NM)
MEDIUM	LIGHT	9.3 km (5.0 NM)

8.7.4.4.1

The minima set out in 8.7.4.4 shall be applied when:

- an aircraft is operating directly behind another aircraft at the same altitude or less than 300 m (1 000 ft); or
- both aircraft are using the same runway, or parallel runways separated by less than 760 m; or
- an aircraft is crossing behind another aircraft, at the same altitude or less than 300 m (1 000 ft) below.

EDDF procedures – BA-FVK – German ATC (another textbook – coming closer to our reality)

**BA-FVK (Manual of operations – Air traffic control services)
– Aerodrome control procedures:**

327 REDUCTION OF SEPARATION

...

327.2 In other cases, the separation minima may be reduced in the vicinity of aerodromes if :

.21 adequate separation can be provided by the aerodrome controller when each aircraft is continuously visible to this controller;

or

.22 each aircraft is continuously visible to pilots-in-command of the other aircraft concerned and the pilots thereof report that they can maintain their own separation;

or

.23 in the case of one aircraft following another, the pilot of the succeeding aircraft reports that he has the other aircraft in sight and can maintain separation.

EDDF procedures – BA-FVK – German ATC (another textbook – coming closer to our reality)

**BA-FVK (Manual of operations – Air traffic control services)
– Aerodrome control procedures:**

„328 WAKE TURBULENCE SEPARATION

328.1 In order to minimize the hazards of wake turbulence - for flights for which an obligation to provide separation exists - the following radar separation minima shall be applied if the prescribed separation minima are lower :

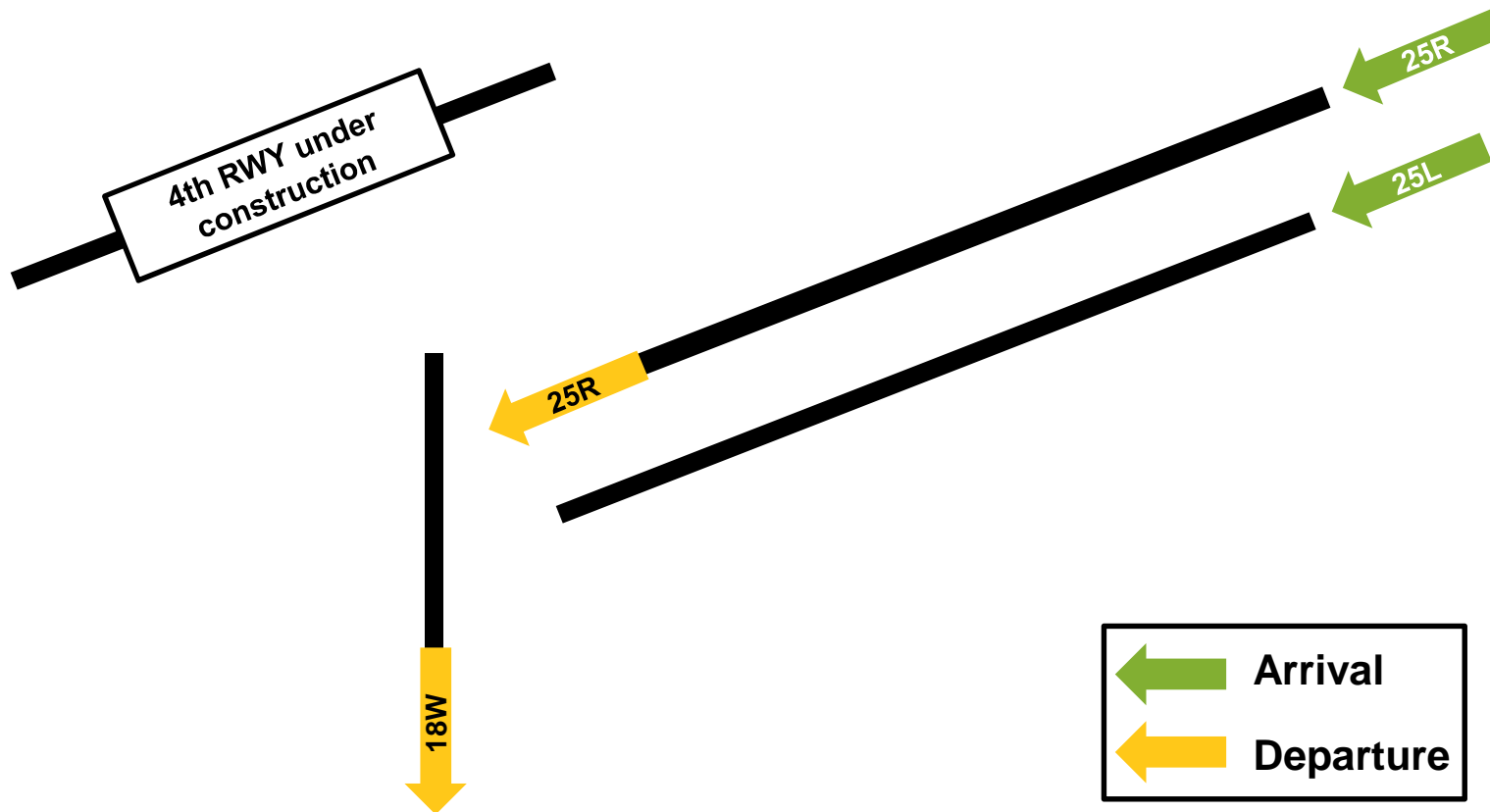
Preceding Aircraft	Succeeding Aircraft	Separation Minima
HEAVY	HEAVY	4 NM
HEAVY	MEDIUM	5 NM
HEAVY	LIGHT	6 NM
MEDIUM	LIGHT	5 NM

[...]

328.3 The **separation minima mentioned above do not need to be applied, if :**

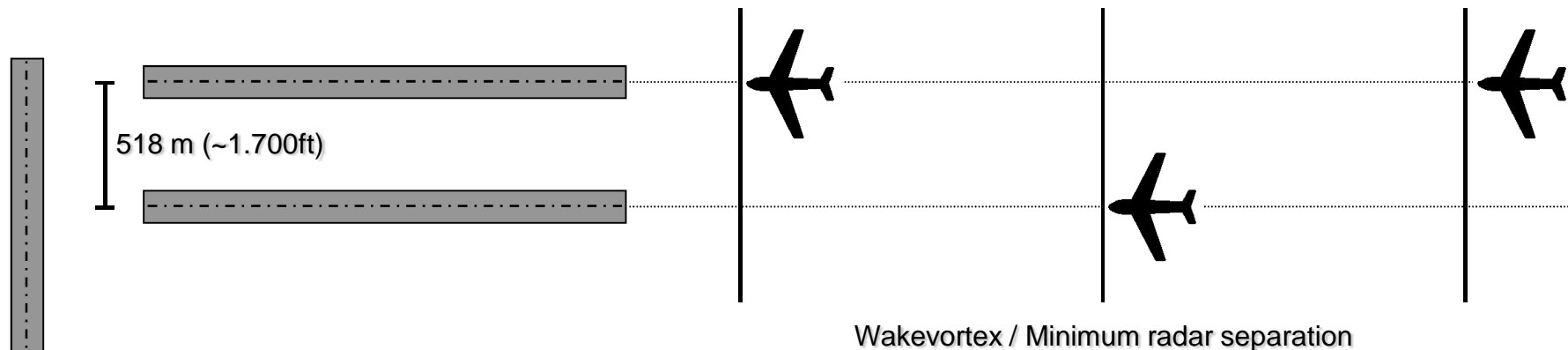
- .31 the pilot of an aircraft has declared that he has the preceding aircraft in sight and will attend to an appropriate distance himself;
- .32 the pilot of an aircraft renounces wake turbulence separation;
- .33 the area within which wake turbulence is expected will not be penetrated.”

EDDF procedures – today (rwy dir 25)



Today's EDDF procedures (closely spaced parallel rwys) required reductions in wake vortex / minimum radar separation (looking in the textbook)

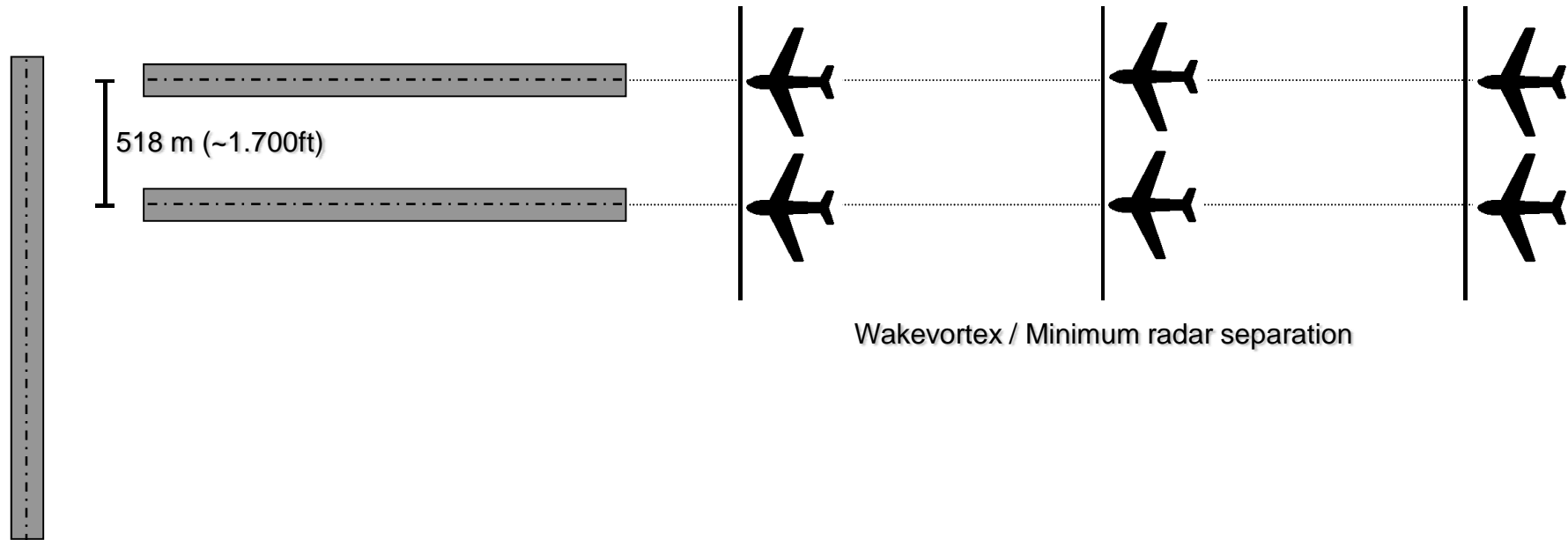
< 1 035 m for dependent approaches



Two closely spaced parallel runways (4000 m -- spacing 518 m / 1.700 ft); one intersecting runway for take-off only (4000 m)

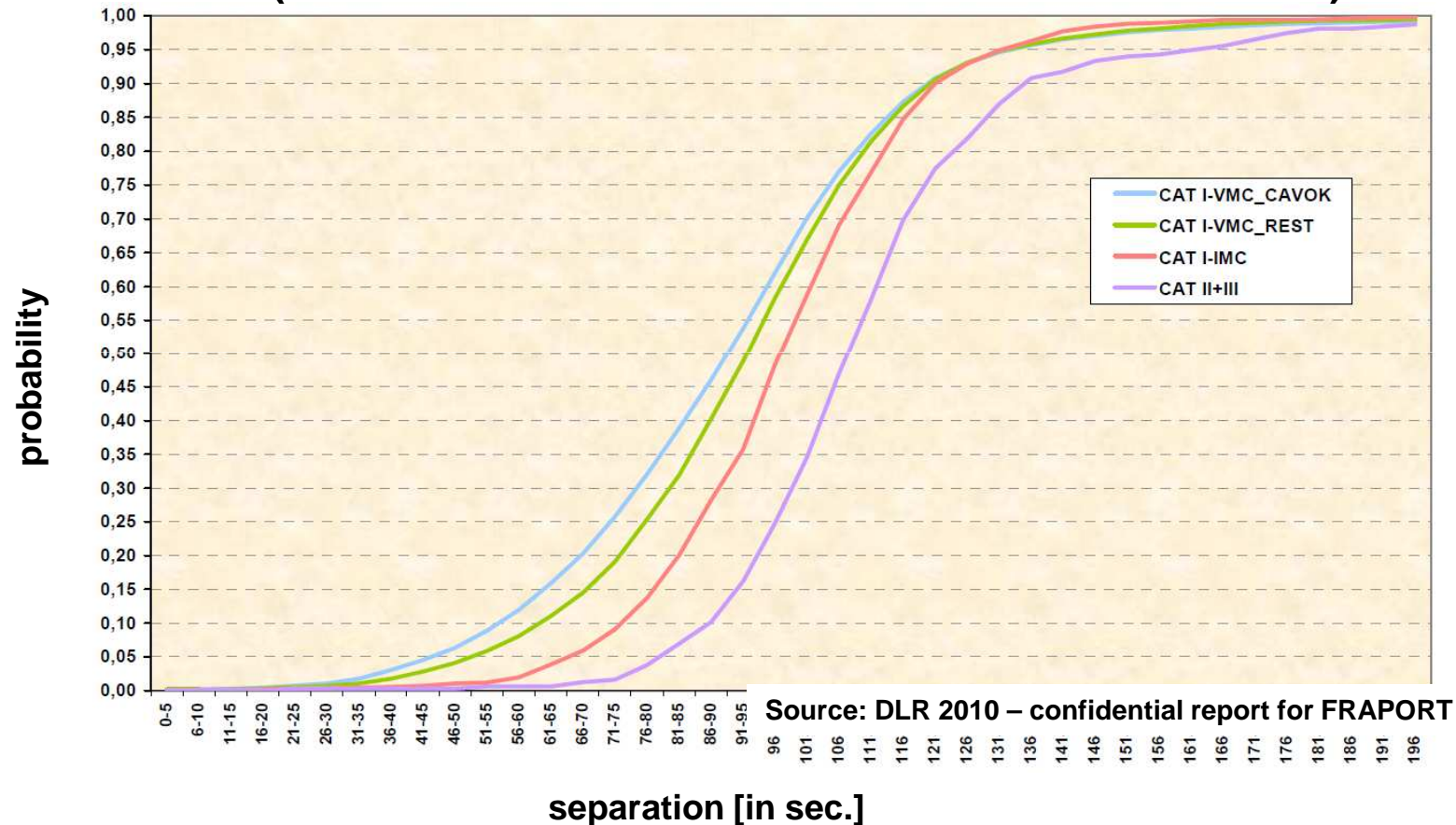
=> No parallel approaches on runways 25 L/R and 07 L/R possible

EDDF procedures – today's reality ?



EDDF procedures – today's reality

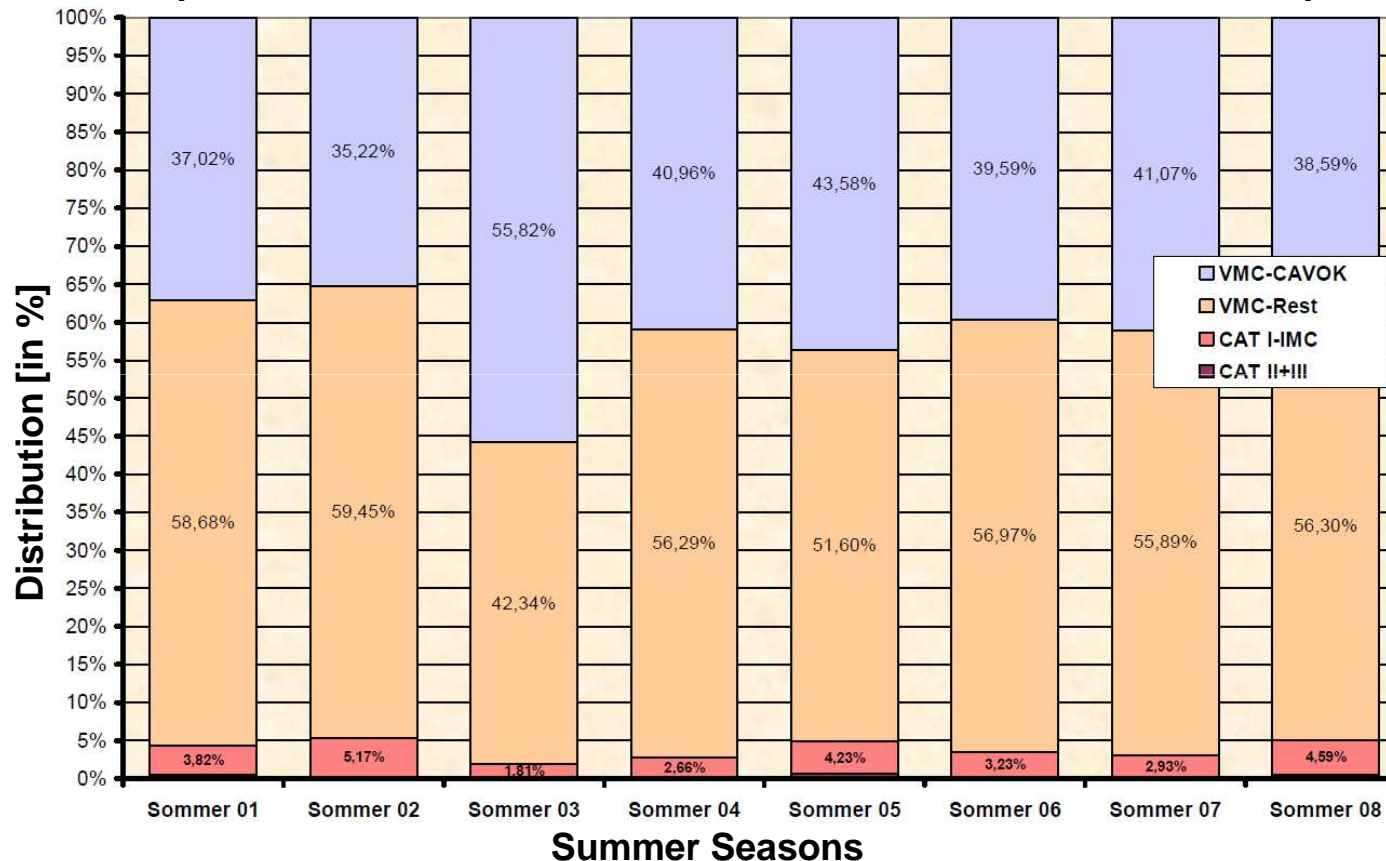
**ARR-ARR separations (Hvy<->Hvy) – 4NM – staggered –
(summer seasons 04/2005 – 10/2008 – 05:00-23:00)**



**=> ATC-controllers & pilots save about 5-10 sec [~0.35NM] on average
during good weather-conditions in staggered (and intrail) mode**

EDDF procedures – today's reality

**Distribution of VMC/IMC CATI/CAT II/III
(summer seasons 04/2005 – 10/2008 – 05:00-23:00)**



Source: DLR 2010 – confidential report for FRAPORT

=> EDDF has >95% VMC during summer seasons

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"Once bitten twice shy."

The past - r&d project (concerning wakevortex)

I) WVWS - Wake Vortex Warning System

History

- **1992-1994:** First studies and operational concept (by DLR, IABG and DWD on behalf of DFS)
- **1995:** Installation of anemometer masts

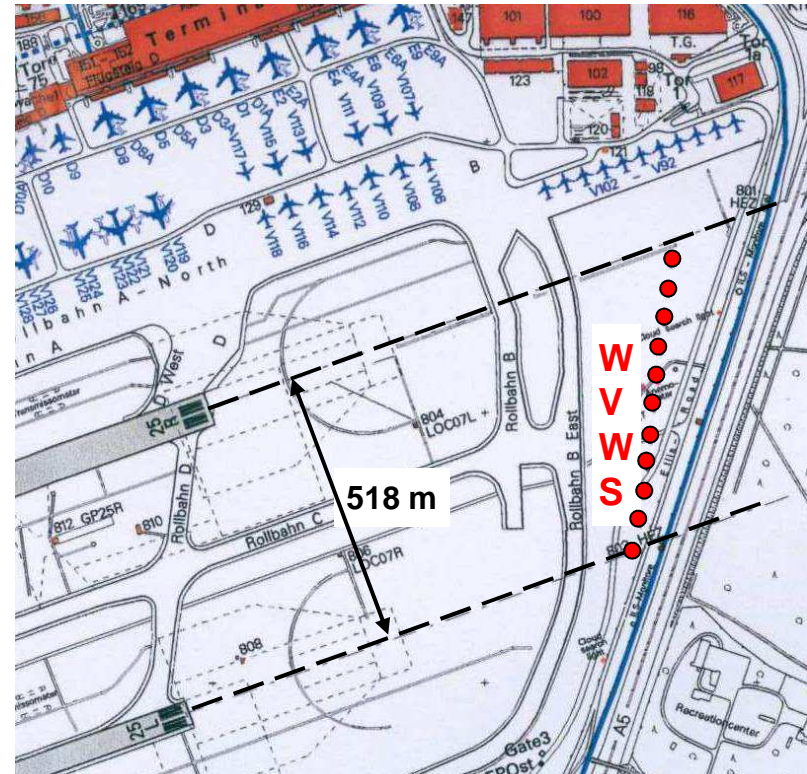
Targets

Increasing the approach capacity at FRA:

- Predict the occurrence of wake vortices
- Reduction of existing minima for diagonal separation based on this prediction

Problems

- German Pilots Unit (VC) judged the system insufficient for reduction of separation
- Measurement and prediction has to be valid for total approach path to reduce separation



The past - r&d project (concerning wakevortex)

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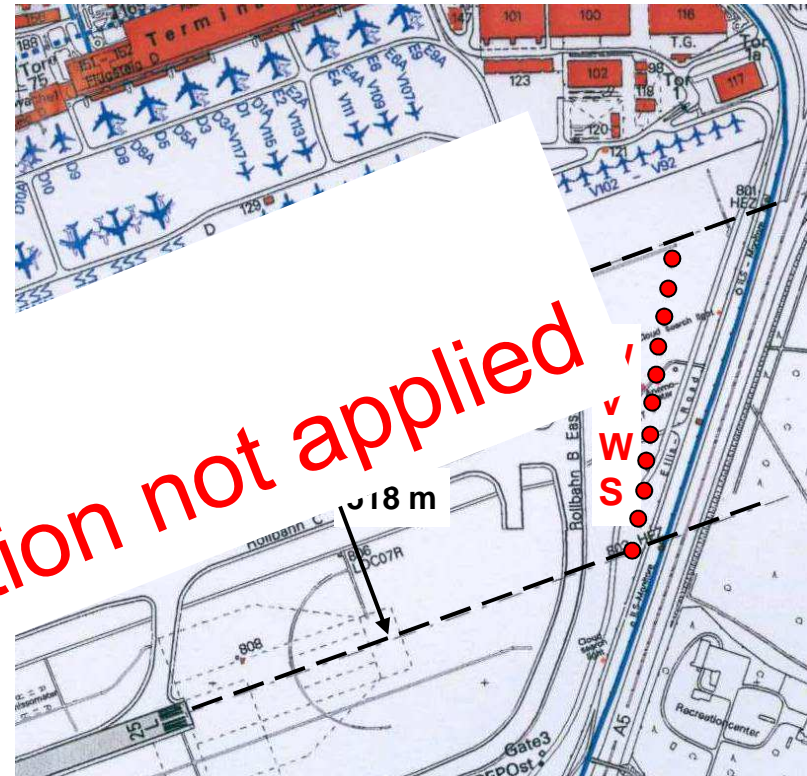
Targets

Increasing the approach capacity at

- Predict the occurrence of wake
- Reduction of existing separation

Problem

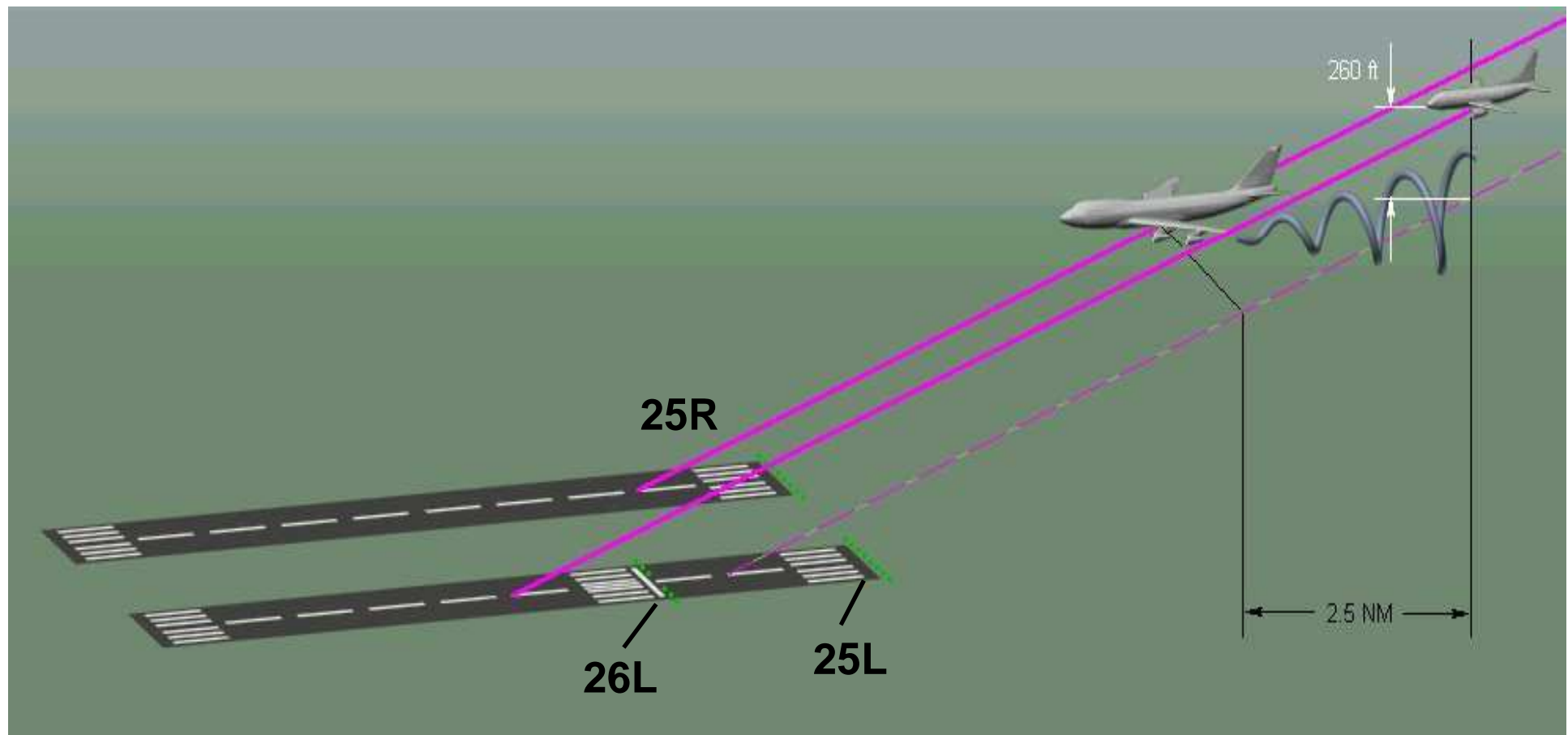
- Gern (VLC) judged the system insufficient for reduction of separation
- Measurement and prediction has to be valid for total approach path to reduce separation



The past - r&d project (concerning wakevortex)

II) HALS & HALS/DTOP

(High Approach Landing System; Dual Threshold Operations)



The past - r&d project (concerning wakevortex)

II) HALS & HALS/DTOP

History

- **1999:** Operational trial period (I)
- **2001-2004:** Operational trial period (II)
- **2009:** Deinstallation (THR26L)

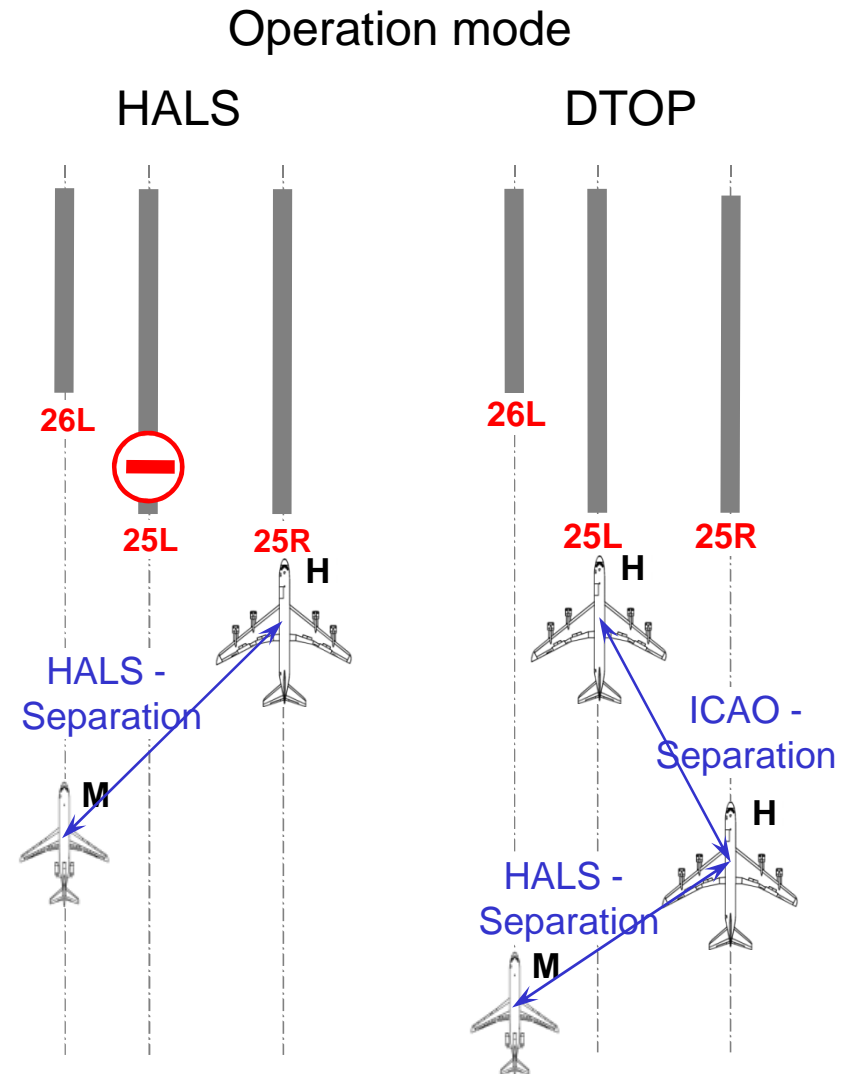
Targets

Increasing the approach capacity at FRA:

- Avoid wake vortex encounters
- no higher risk regarding wake vortex at reduced HALS-separation (2,5 NM) than at recommended ICAO separation (5NM)
- reduction of existing minima for diagonal separation

Problems

benefits of HALS/DTOP not achieved due to several reasons



The past - r&d project (concerning wakevortex)

II) HALS & HALS/DTOP

History

- **1999:** Operational trial period (I)
- **2001-2004:** Operational trial period (II)
- **2009:** Deinstallation (THR26L)

Targets

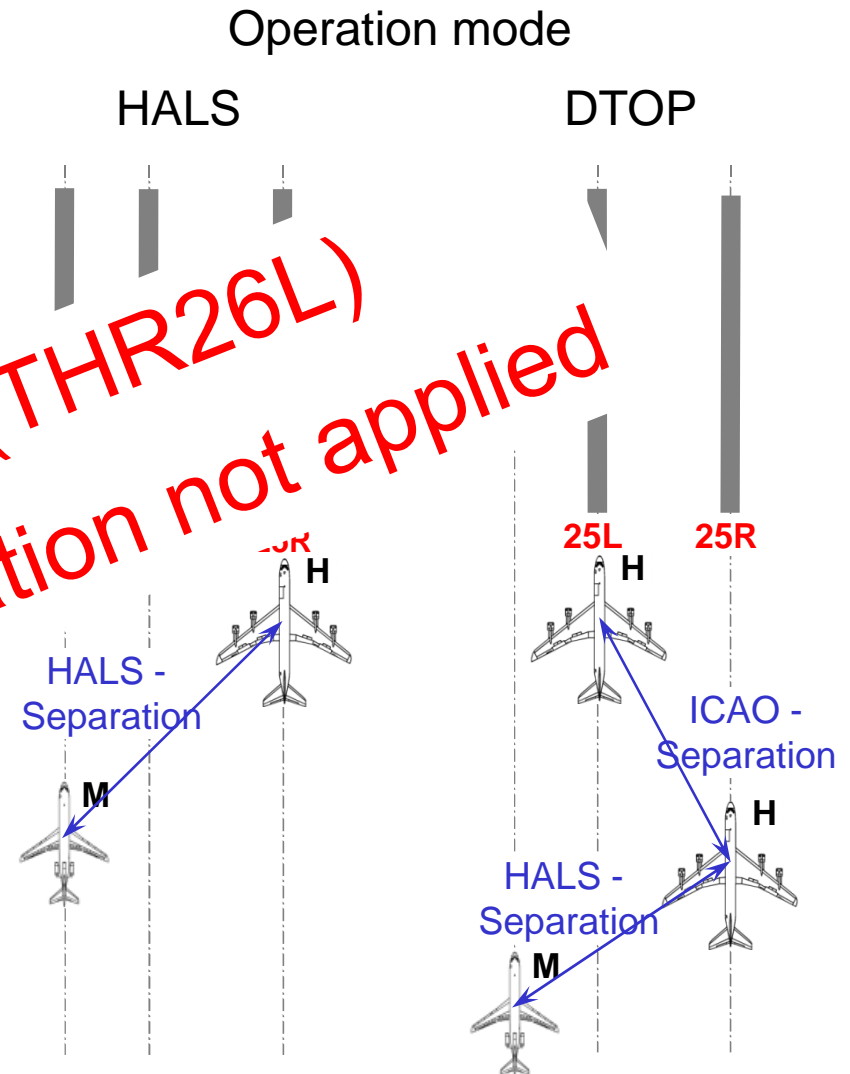
Increasing the approach capacity at

- Avoid wake vortex encounter
- no higher risk reduction at reduced separation
- reduced separation

Problem

benefits of HALS/DTOP not achieved due to several reasons

2009: Deinstallation (THR26L)
=> Reduced separation not applied



The past - r&d project (concerning wakevortex) III) 80+ (with DFS, DLH, Hessian ministry & DLR)

History

- **Late 199x:** Definition of different “packages”, to reduce wake vortex separations, e.g.
 - Further development of WVWS
 - Onboard identification of wake vortices
 - Reduction of wake vortices at the a/c
 - Recategorization of wake vortex categories
 - Further development of HALS/DTOP

Targets

Increasing the approach capacity at FRA:

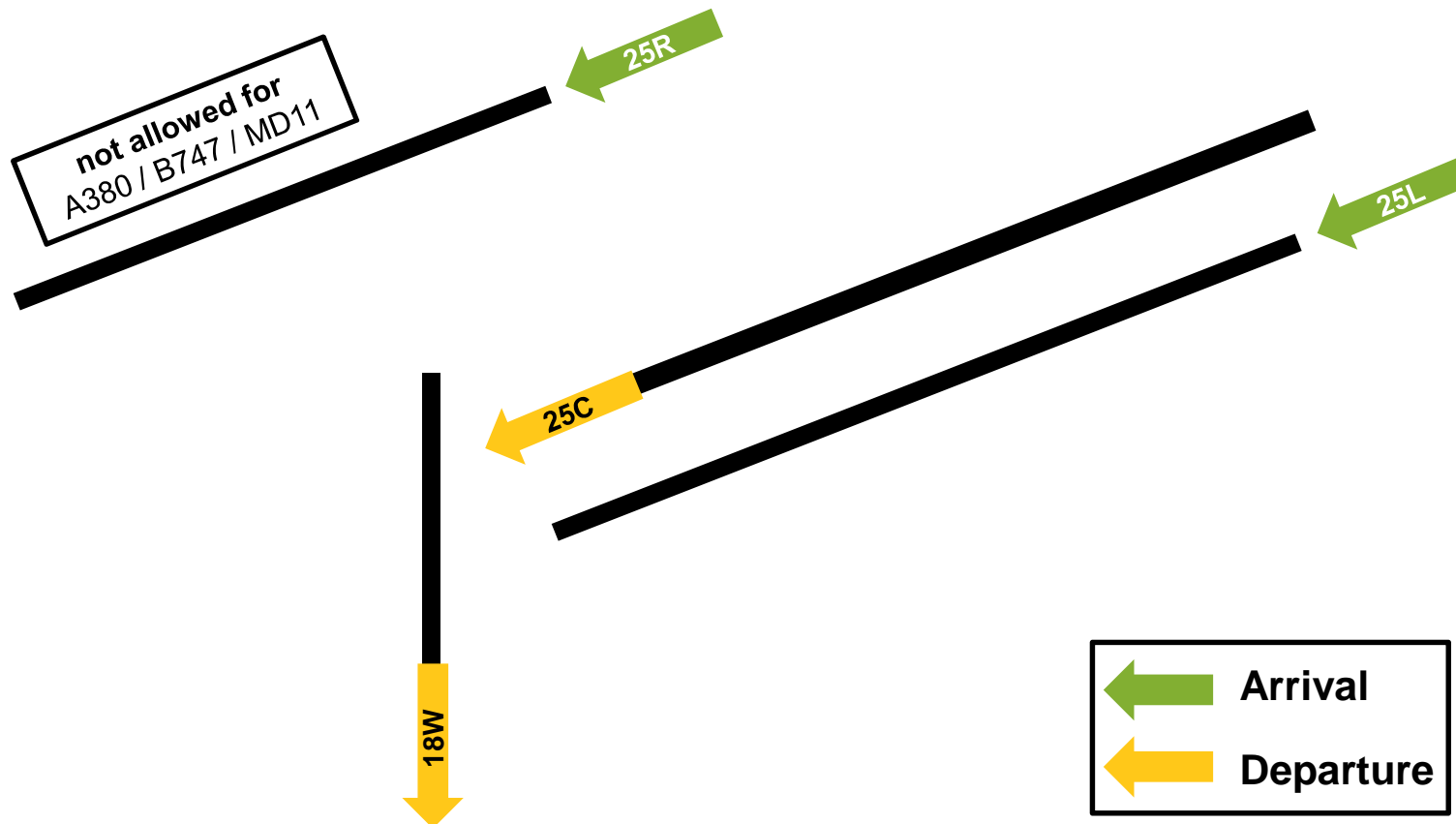
- by reducing wake vortex separations

2011: no benefits achieved yet

Content

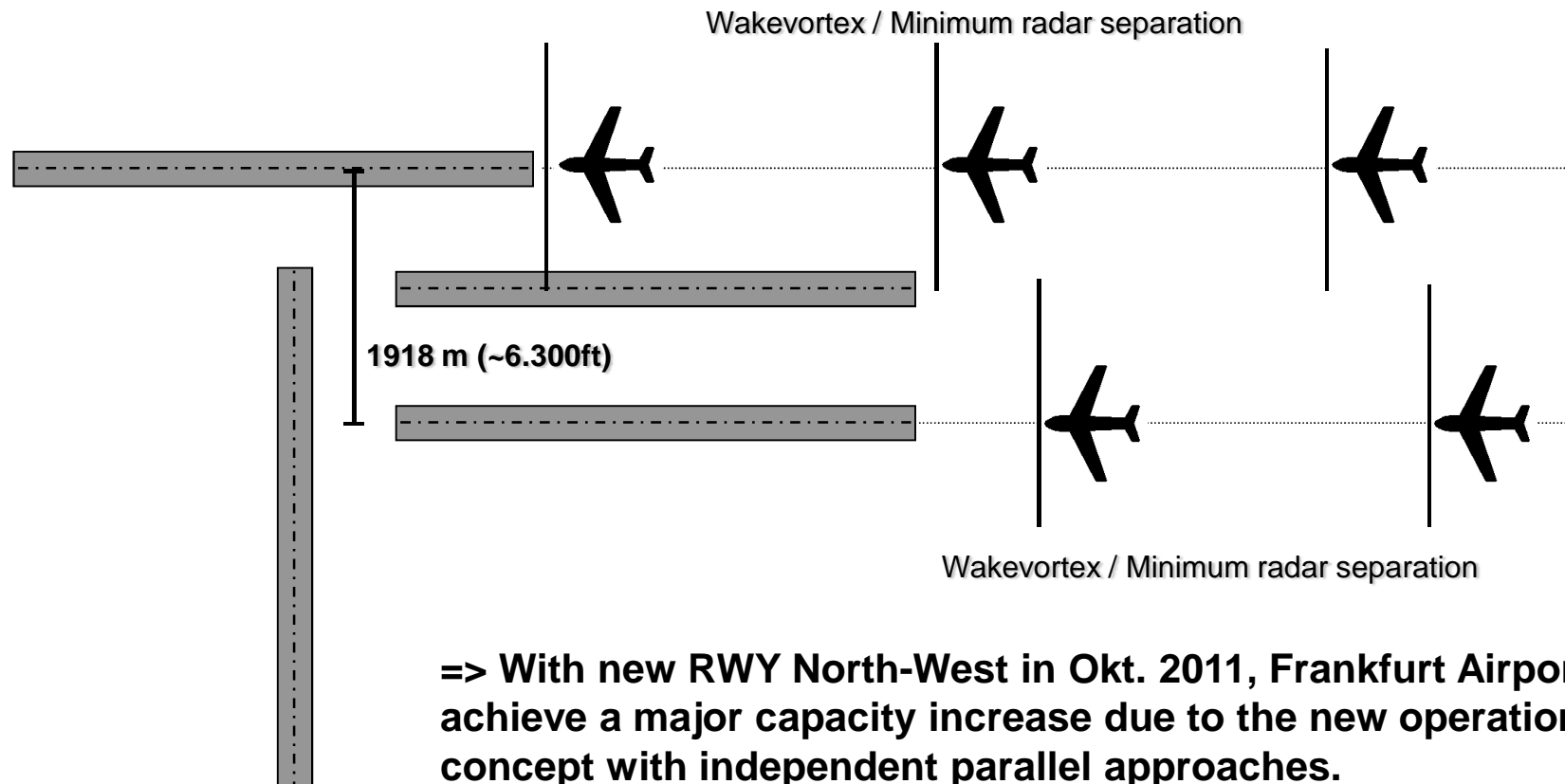
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EDDF procedures – the future (standard operational concept – rwy dir 25)



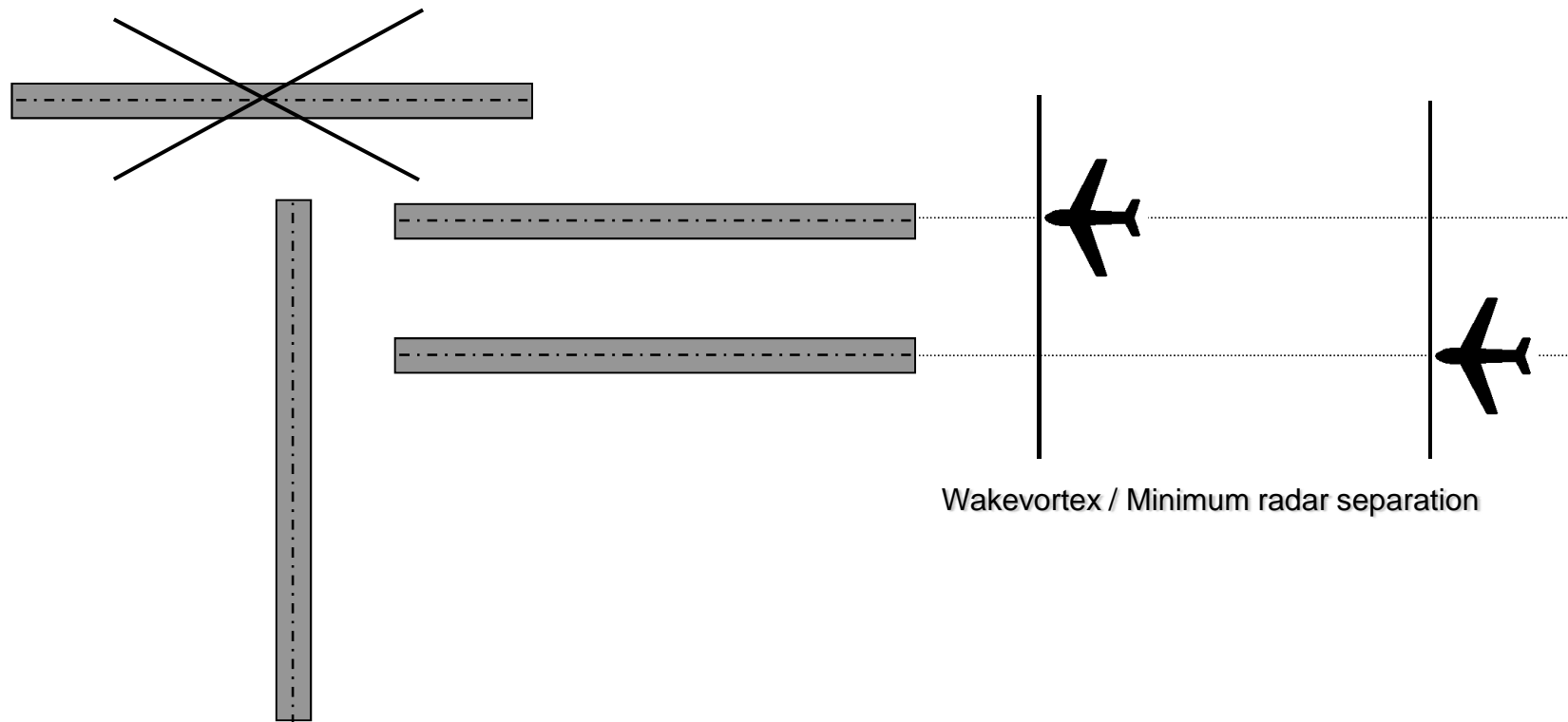
The (near) future EDDF procedures (Oct 2011) allows indepent parallel approaches in the standard operational concept ...

> 1 035 m for independent approaches

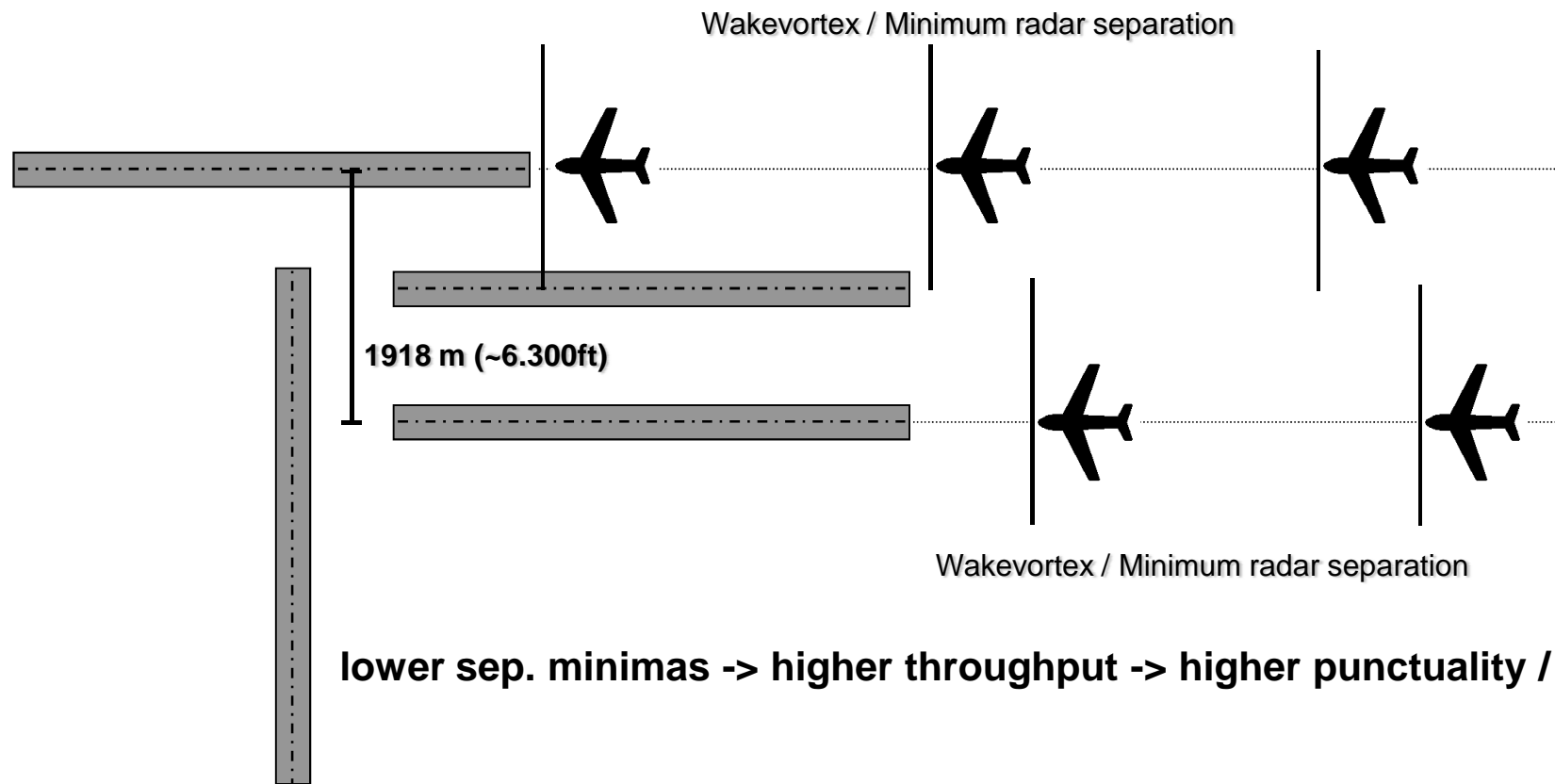


=> With new RWY North-West in Okt. 2011, Frankfurt Airport will achieve a major capacity increase due to the new operational concept with independent parallel approaches.

... but nevertheless EDDF needs for non-standard operations low separation minimas to keep capacity/punctuality high during those periods ...

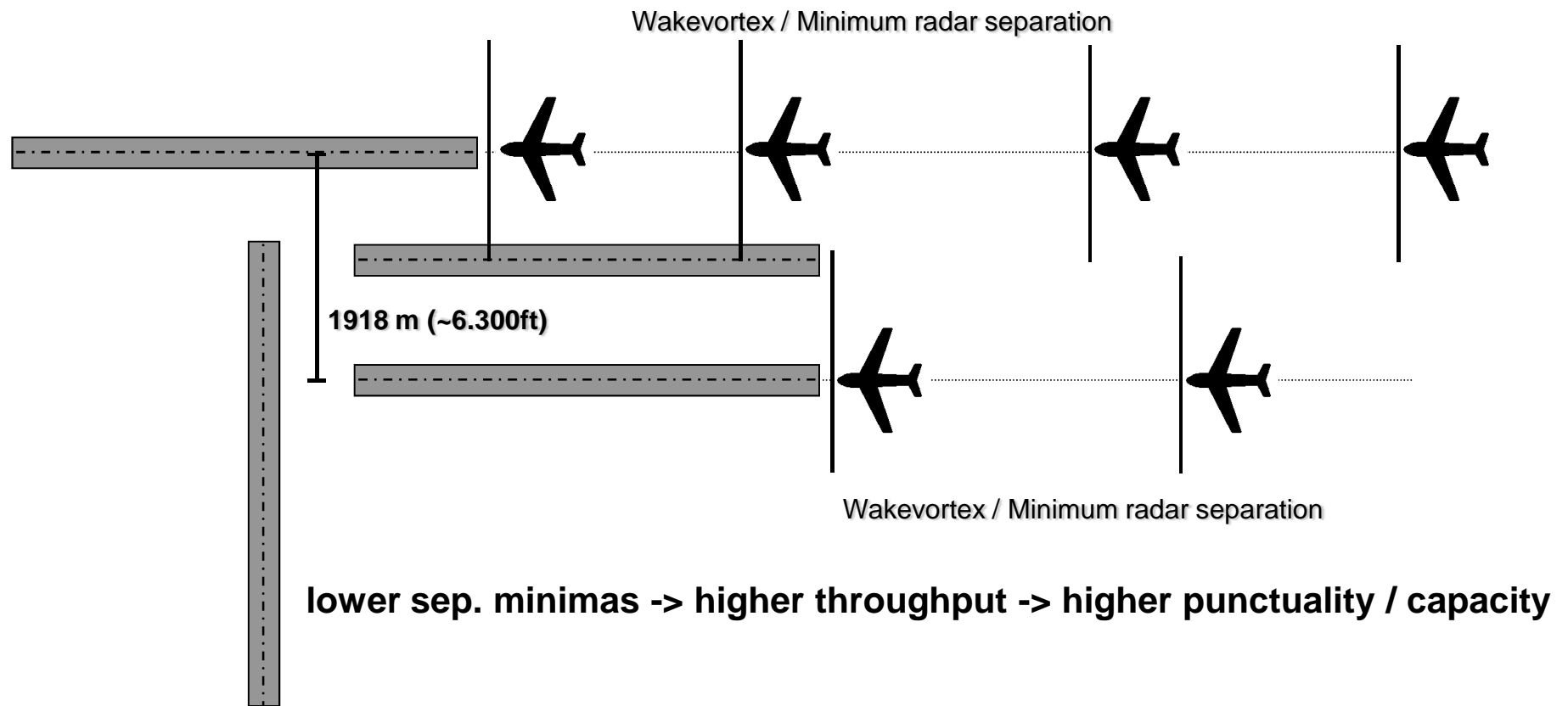


... and - of course - for standard operations EDDF welcomes low (intrail) separation minimas to increase capacity/punctuality ...

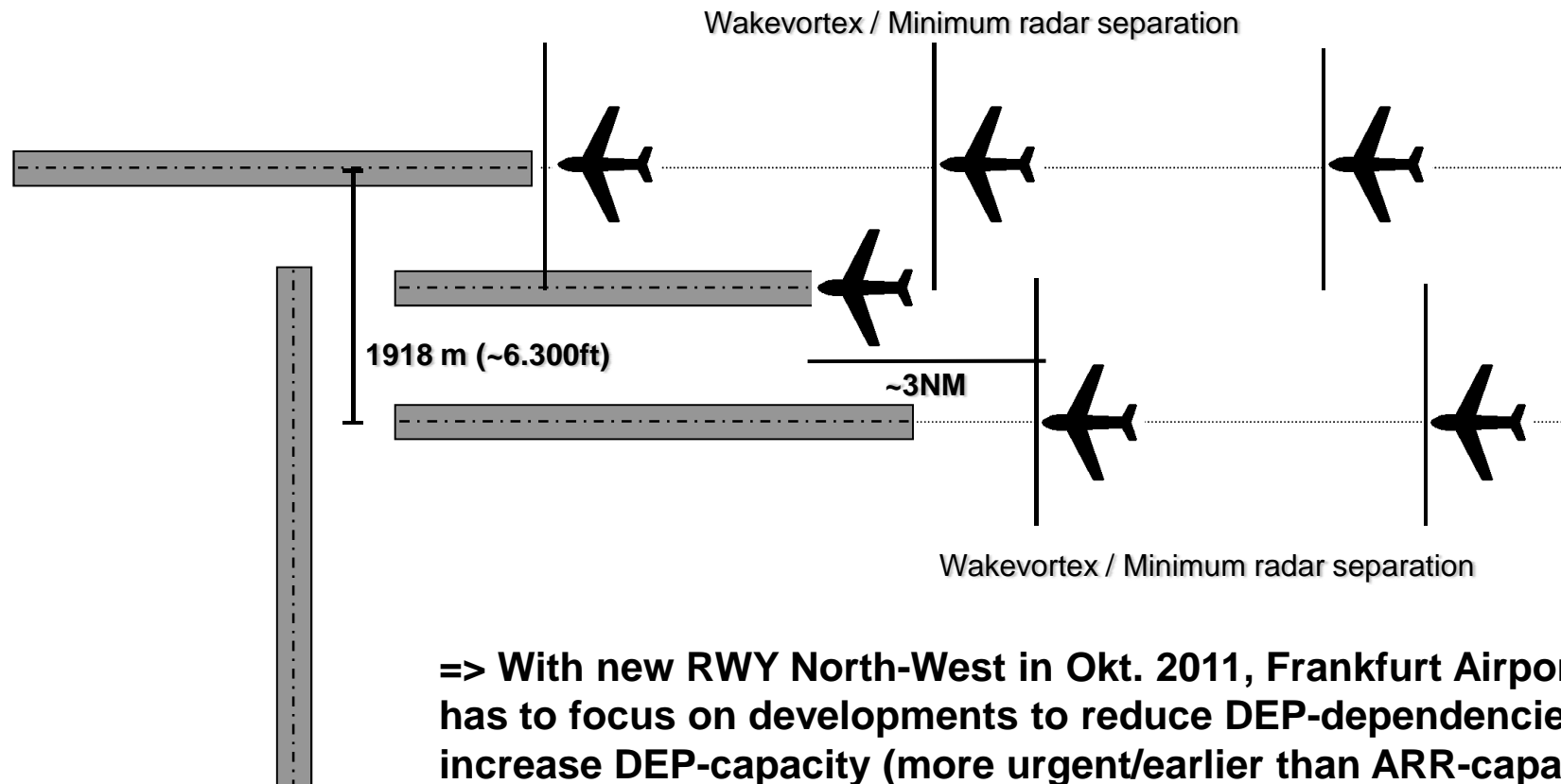


lower sep. minimas -> higher throughput -> higher punctuality / capacity

... and - of course - for standard operations EDDF welcomes low (intrail) separation minimas to increase capacity/punctuality ...



... but due to ARR/DEP dependencies on the existing parallel rwys the DEPs needs enough ARR-gaps, to be cleared for take-off.



A (further) reduction of A380-separations would allow higher capacity / punctuality if amount of A380 ops increase at EDDF.

		TRAIL (suc)				ARRIVAL								
LEAD (pre)	[NM]	25R				25C				25L				
		S	H	M	L	S	H	M	L	S	H	M	L	
ARRIVAL	25R	S	3,0	6,0	7,0	8,0	-	-	-	-	-	-	-	-
		H	4,0	4,0	5,0	6,0	-	-	-	-	-	-	-	-
		M	3,0	3,0	3,0	5,0	-	-	-	-	-	-	-	-
		L	3,0	3,0	3,0	3,0	-	-	-	-	-	-	-	-
	25C	S	-	-	-	-	3,0	6,0	7,0	8,0	3,0	6,0	7,0	8,0
		H	-	-	-	-	4,0	4,0	5,0	6,0	4,0	4,0	5,0	6,0
		M	-	-	-	-	2,5	2,5	2,5	5,0	2,0	2,0	2,0	5,0
		L	-	-	-	-	2,5	2,5	2,5	2,5	2,0	2,0	2,0	2,0
	25L	S	-	-	-	-	3,0	6,0	7,0	8,0	3,0	6,0	7,0	8,0
		H	-	-	-	-	4,0	4,0	5,0	6,0	4,0	4,0	5,0	6,0
		M	-	-	-	-	2,0	2,0	2,0	5,0	2,5	2,5	2,5	5,0
		L	-	-	-	-	2,0	2,0	2,0	2,0	2,5	2,5	2,5	2,5

EDDF procedures -- Videos

- **Videos showing EDDF procedures**
 - **today and in the**
 - **future**

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Topics / ideas concerning EDDF (draft) results

**„The lie often goes further
than the truth“**

**„We want to know, which side
one's bread is buttered on“**

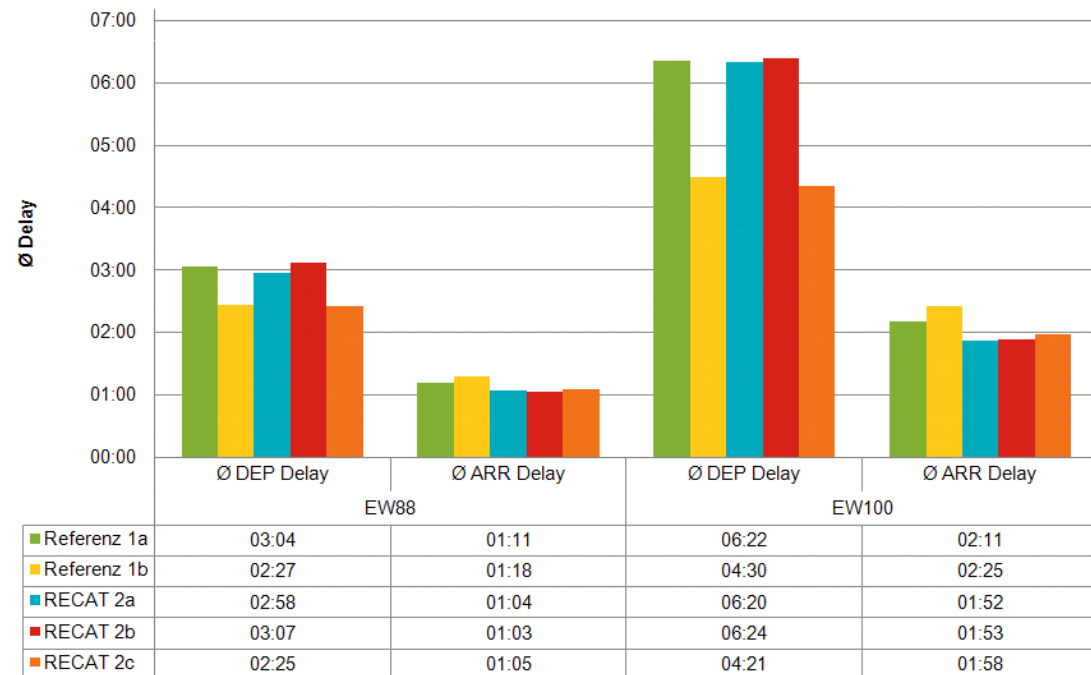
A recategorization of wake vortex categories seems to increase arr capacity / punctuality (slightly), but RECAT should keep its potential influence on dep capacity in mind

1. Baseline scenario

- ICAO separation
- increased radar separation to facilitate dep's

2. RECAT scenario (2.5NM)

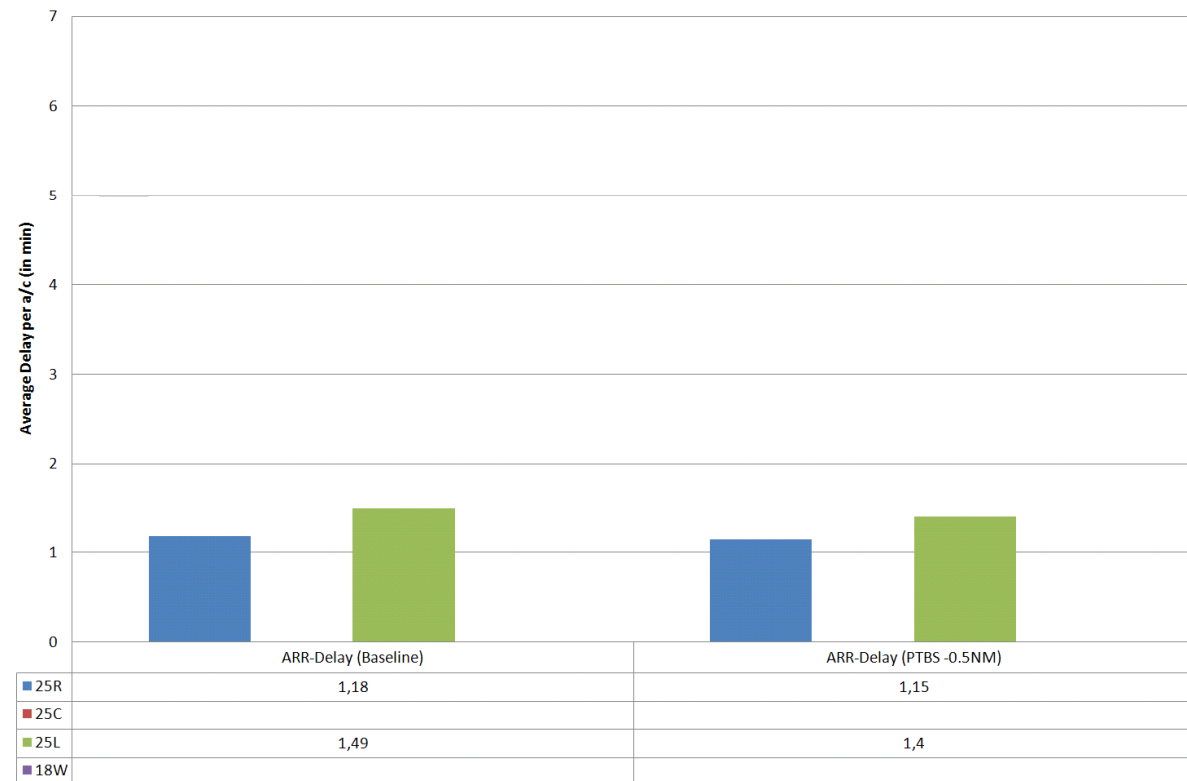
- RECAT on RWY 25L & 25R
- RECAT on RWY 25R, ICAO on RWY 25L
- RECAT on RWY 25R, increased ICAO on RWY 25L (see 1-b)



(draft) EDDF RECAT fast-time-simulation results

A reduction of wake vortex separation by 0.5NM due to P-TBS / CROPS seems to increase arr capacity / punctuality, but it should keep its potential influence on dep capacity in mind ...

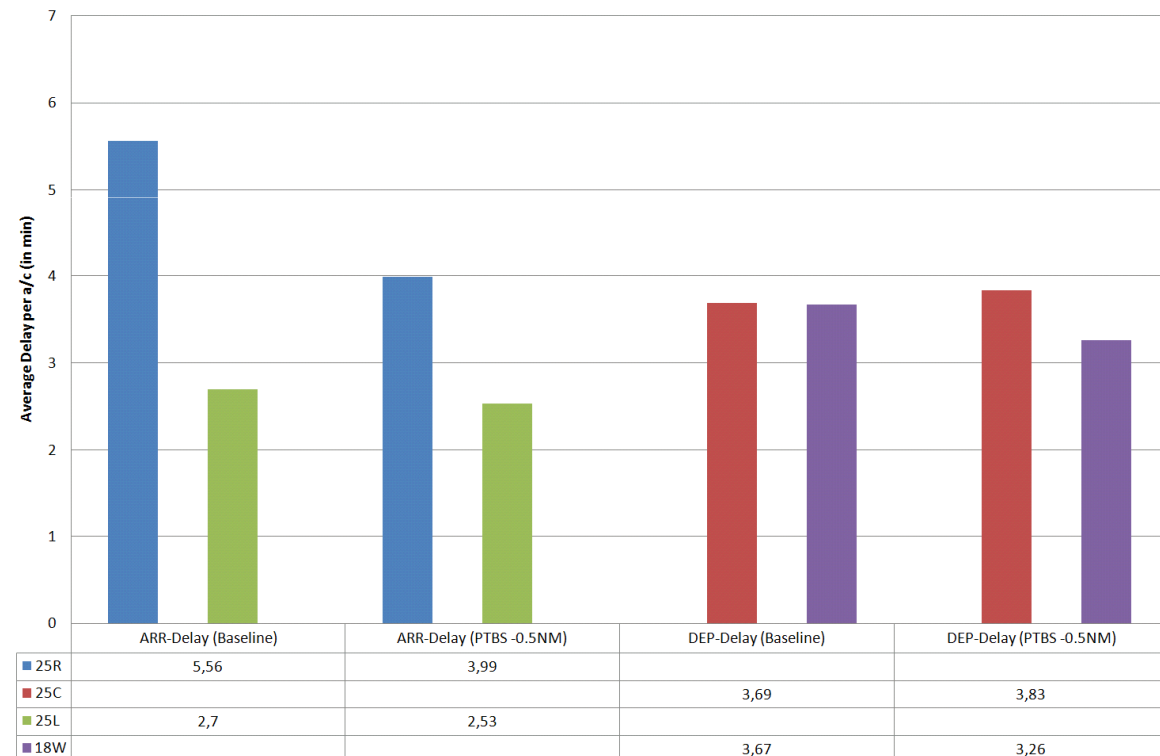
1. Baseline scenario
 - a. ICAO separation
2. PTBS scenario (-0,5NM)
 - a. WS -0.5NM



(draft) EDDF PTBS fast-time-simulation results
(demand in year 2012 – ~90 mov/h)

A reduction of wake vortex separation by 0.5NM due to P-TBS / CROPS seems to increase arr capacity / punctuality, but it should keep its potential influence on dep capacity in mind ...

1. Baseline scenario
 - a. ICAO separation
2. PTBS scenario (-0,5NM)
 - a. WS -0.5NM



(draft) EDDF PTBS fast-time-simulation results
(demand in year 2020 – 126 mov/h)

... and it should be mentioned, that even based only on METAR data P-TBS couldn't be used the whole year.

- ⇒ If headwind ≥ 5 kts -- approx. 105 days / year useable in main rwy dir 25 (261 days p.a.)
- ⇒ If headwind ≥ 10 kts -- approx. 31 days / year useable in main rwy dir 25
- ⇒ further reduction of useability will occur due to different wind directions on final approach by a (roughly estimated) factor of ~3 (?)
 - => only 10-30 days applicable !?

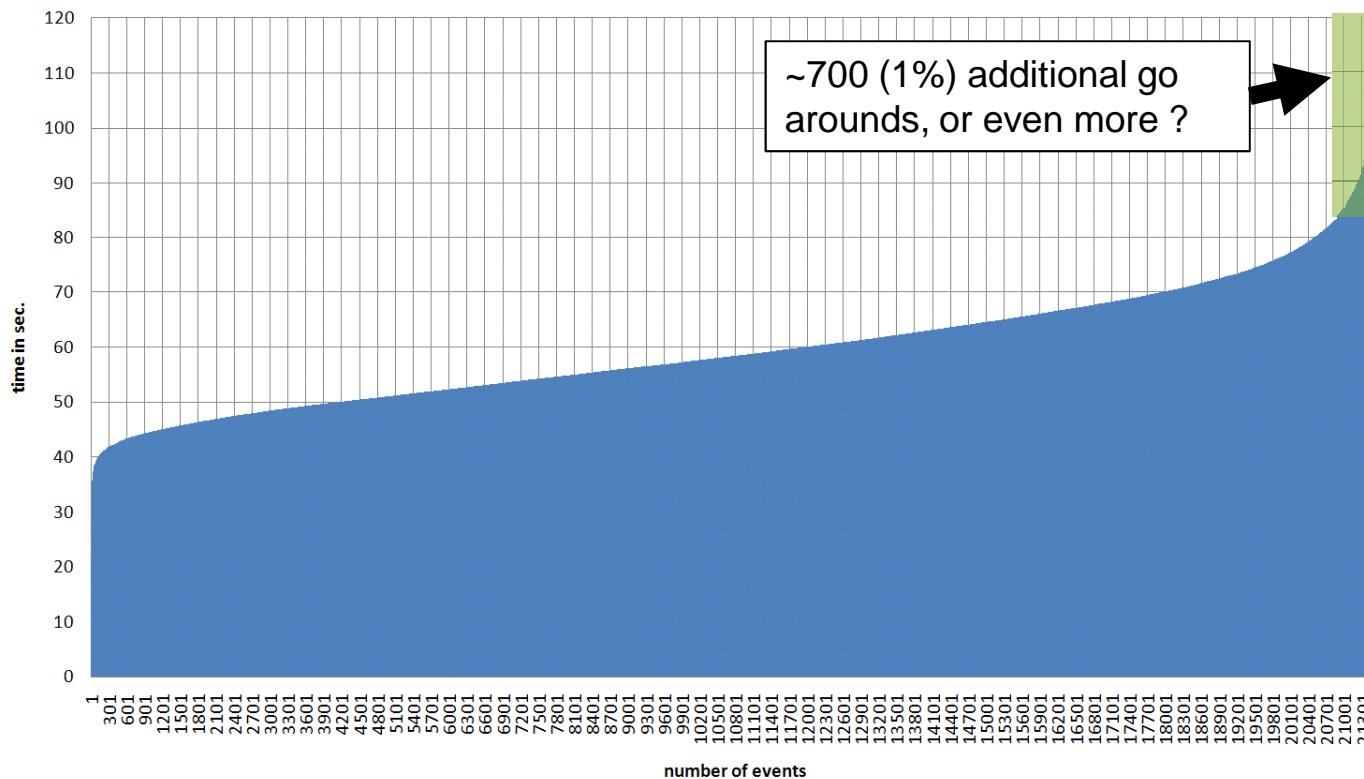
[illegible]

(draft) EDDF METAR data analysis – year 2006

Further on, the rwy occupancy time as a lower boundary for separation minimas shouldn't be forgotten.

- Hvy-Hvy-Separation of 4NM means ~100 secs between two arrivals
- Reducing Separation by 0.5 NM => ~85 secs

RWY occupancy time (only Hvy a/c - all RWYs - 2008)



(draft) EDDF ROT data analysis – (parts of) year 2008
sample size H+M+L = 85.000

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Conclusion

- **EDDF needed methods to increase ARR-capacity in the last years due to the dependent close parallel rwy system**
- **Unfortunately most of r&d did not bring the expected gains on ARR-capacity**
- **EDDF will have a major increase in ARR-capacity by opening the 4th (ARR-only) RWY in October 2011**
- **Due to the dependencies in the 4-RWY-system, EDDF needs methods to increase DEP-capacity more urgent than for ARR-capacity**
- **All changes to reduce separation minimas (e.g. wake vortex separation) are welcomed ...**
- **... but the influence by changing ARR-separation on the DEP-capacity and the ROT has to be taken into account.**
- **Don't compare the benefits by looking in the „textbook“ – compare against reality – and that's even more complex as it seems at the first glance (not only in EDDF)...**

One man's meat is another man's poison.

Hence be aware to have the right antidote available.

‘cause prevention is better than cure.

Any Questions ?

The Fraport logo is displayed in the top right corner of the contact card. It features a stylized graphic of four curved lines forming a star-like shape, followed by the word "Fraport" in a bold, sans-serif font.

Steffen Wendeborg

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*Thank you for your patience
and attention ;-)*

