Interdisciplinary Centre for Mathematical and Computational Modelling (ICM), University of Warsaw

Airport capacity imbalance problem

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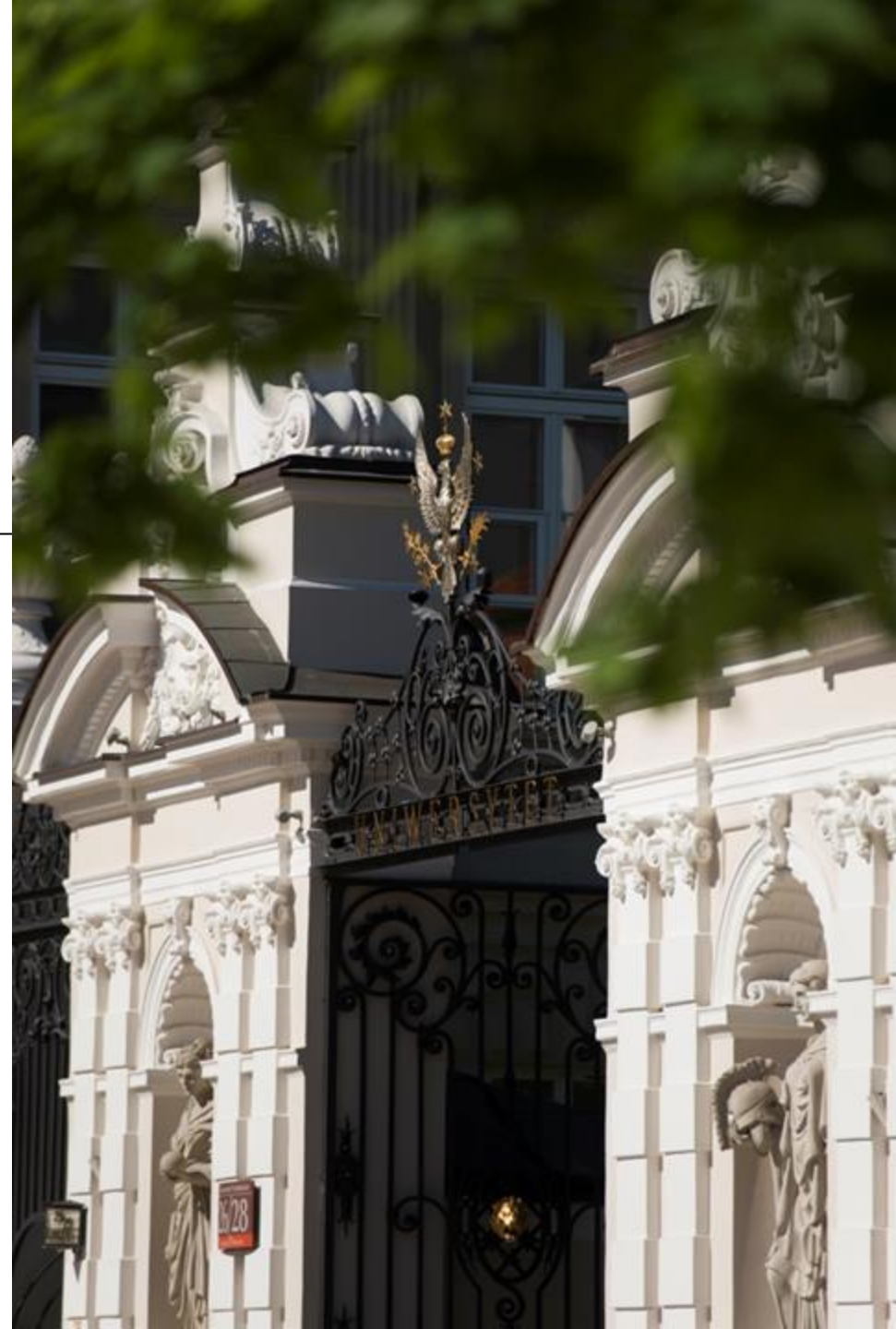

Graduated from Faculty of Aeronautics of Warsaw Technical University. Has been working on various experts', managerial and advisory positions in the Aviation Industry, including Airplane Manufacture, Airline, Airport and Civil Aviation Authority Enterprises. From the beginning of 90s, as a performance/operations Engineer completed various professional courses and was directly involved in the replacement of LOT Polish Airlines fleet by Boeing and ATR aircraft. In 1999 completed Doctoral studies on “Methods of evaluation of airline schedule reliability” at Transportation Faculty of Warsaw Technical University. As Director of LOT Network Planning in the year 2000, implemented Warsaw Hub operations concept which required total slot and schedule rearrangement. In the year 2003 as Director of Airport Department of Polish CAA introduced ICAO Airport’s certification process. During the period 2005-2010 as a GM for Airport Safety and SMS was leading the safety supervision during Warsaw Airport expansion construction works.

Subsequently chaired Airport Runway Safety Team and Airport Incidents Investigation Team for Warsaw Chopin Airport. With professional presentations he has been contributing to the international ICAO, IATA, AGIFORS, EUROCONTROL, EASA, ACI symposiums and meetings. Is the author of several SESAR project concepts within the scope of ICM-NASP PANSA partnership. Lecturer on “Transport System Dynamics”, “Aviation Safety” and “Airport Operations” at University of Warsaw, Interdisciplinary Centre for Mathematical and Computational Modelling (ICM), Lazarski, Cracow and Silesia Technical University and other Aviation Training Centres.

Recently held the position of Airport focal point as a member of EuroControl Performance Review Commission.

Currently leads the most advanced aviation projects at the ICM, University of Warsaw, including the join ICAO-ICM development of Global Air Transport Analytics.

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Airport capacity planning process is a complex issue which requires to be perform and tune in a permanent feedback with **performance results**.

It requires the consideration and correlation of several factors:

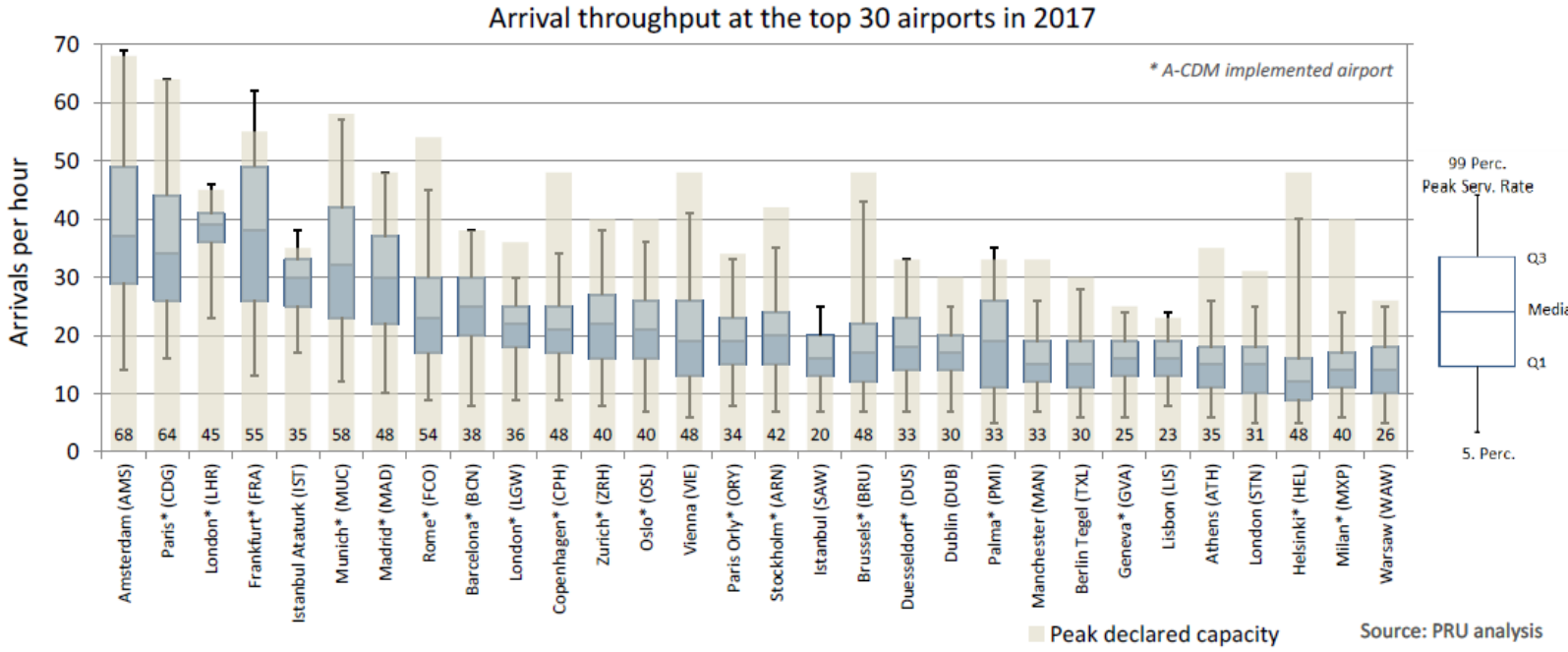
- airport layout
- weather (**wind rouse,** LVC,….)
- regulations (inlc environment), procedures & organization
- automation, technology and support

It is multi stakeholder's (ATC, Airport Operator, Airport Users, Ground Handling, etc.) influenced who act within A-CDM framework.

Lack of capacity symmetry (same value for all RWY in use configurations) may lead to substantial throughput imbalance.

As a consequence it has a crucial influence on punctuality and regularity of operations, which propagates into the overall operating network.

PRR compares the declared peak arrival capacities in ideal conditions (brown bars) to actual throughput dispersion degree



Operations during strong crosswind may affect safety and result in miss approaches or necessity to divert to an alternate airport

Photo: Lars Tretau

≈10.3m/s

- Recommended max. crosswind for contaminated runways:

reported braking action	reported runway friction coefficient	maximum crosswind	equivalent runway condition
good good/medium	≥ 0.40 0.39 -0.36	25 kt 20 kt	dry, damp, wet
medium medium/poor	0.35 - 0.30 0.29 - 0.26	15 kt 10 kt	slush, dry snow
poor	≤ 0.25	5 kt	dry snow, wet snow, standing water with risk of hydroplaning

Source: Airbus – 320 QRH

Probably none of us would like to be on board of these planes

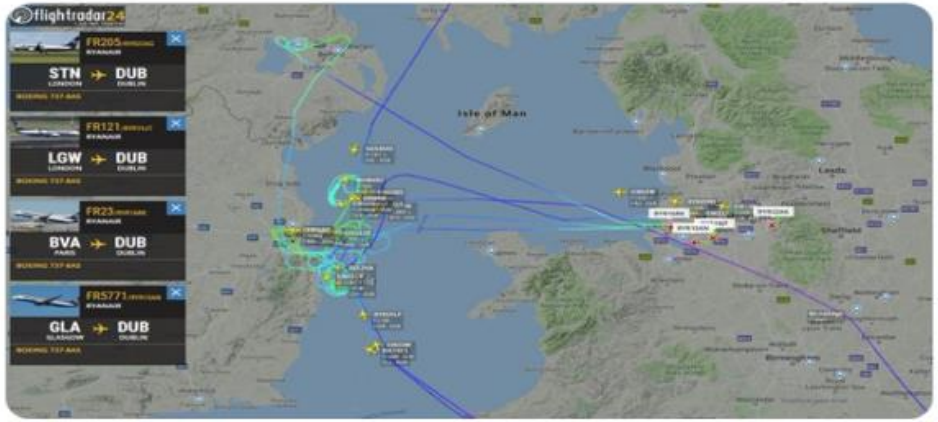
Sun 10 Feb 2019

Emirates confirms London flight was diverted due to 'high winds'

The A380 aircraft twice attempted to land at Gatwick Airport, but was unable to do so safely due to treacherous weather

Flightradar24 @flightradar24 · 19 wrz 2018

4 Dublin-bound Ryanair flights just diverted to UK. #FR23 from Beauvais tried to divert to Belfast first, but finally diverted to Liverpool.



20 aircraft could not land at Kolkata airport on Friday evening due to a crosswind. From 5 pm to 6.30

Let’s introduce the following metrics
which apply for a particular A/D :

$C_{imb}(Prob)[\%]=\{(C_{decl}-C_{min})/C_{decl}\}*100$

where

$C_{imb}(Prob)[\%]$ - Capacity imbalance as a percentage of lack of capacity in reference to declared capacity, which can occur with probability *Prob*

Prob - Probability of the existence of unfavorable wind conditions which prevent takeoffs and landings (due to crosswind limitations) on RWY in use corresponding to declared capacity configuration

C_{decl} – Declared capacity with favorable wind conditions

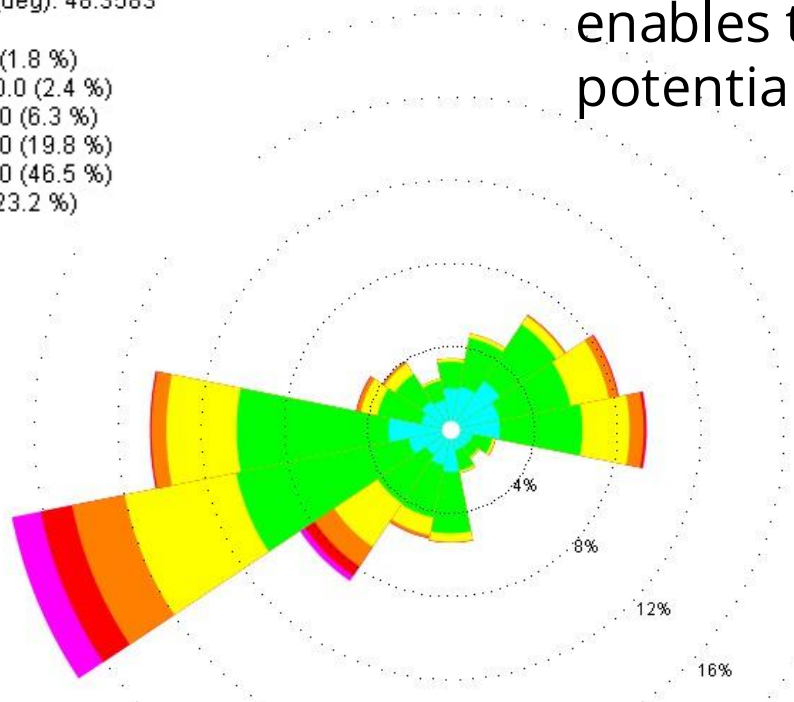
C_{min} – Minimum capacity with unfavorable wind conditions
/limited RWY in use configuration/

CASE STUDIES

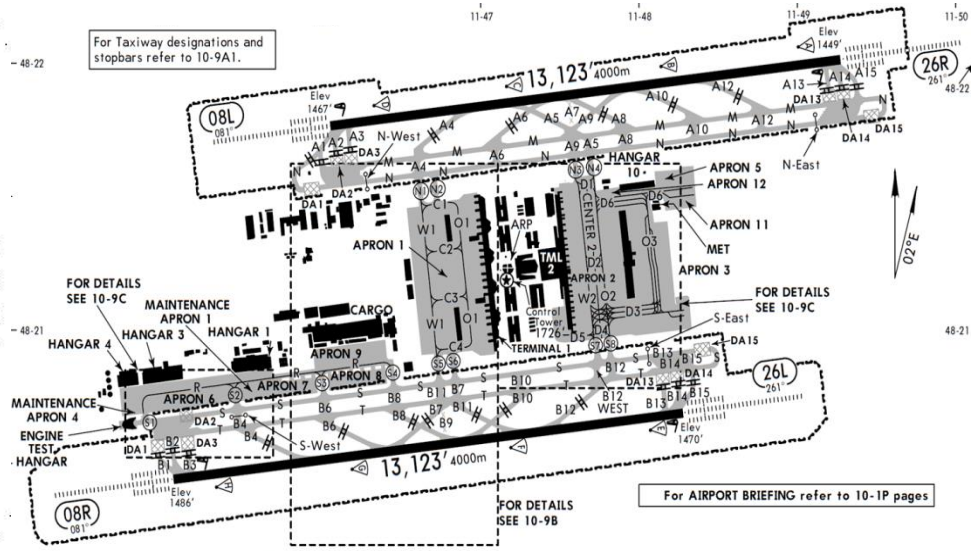
EDDM 2016

Max speed (m/s): 16.0
Total number of data (-): 17498
Events in chart (-): 14409
Calm (%): 1.6
Longitude (deg): 11.8092
Latitude (deg): 48.3583

- > 10.0 (1.8 %)
- 8.0 - 10.0 (2.4 %)
- 6.0 - 8.0 (6.3 %)
- 4.0 - 6.0 (19.8 %)
- 2.0 - 4.0 (46.5 %)
- < 2.0 (23.2 %)



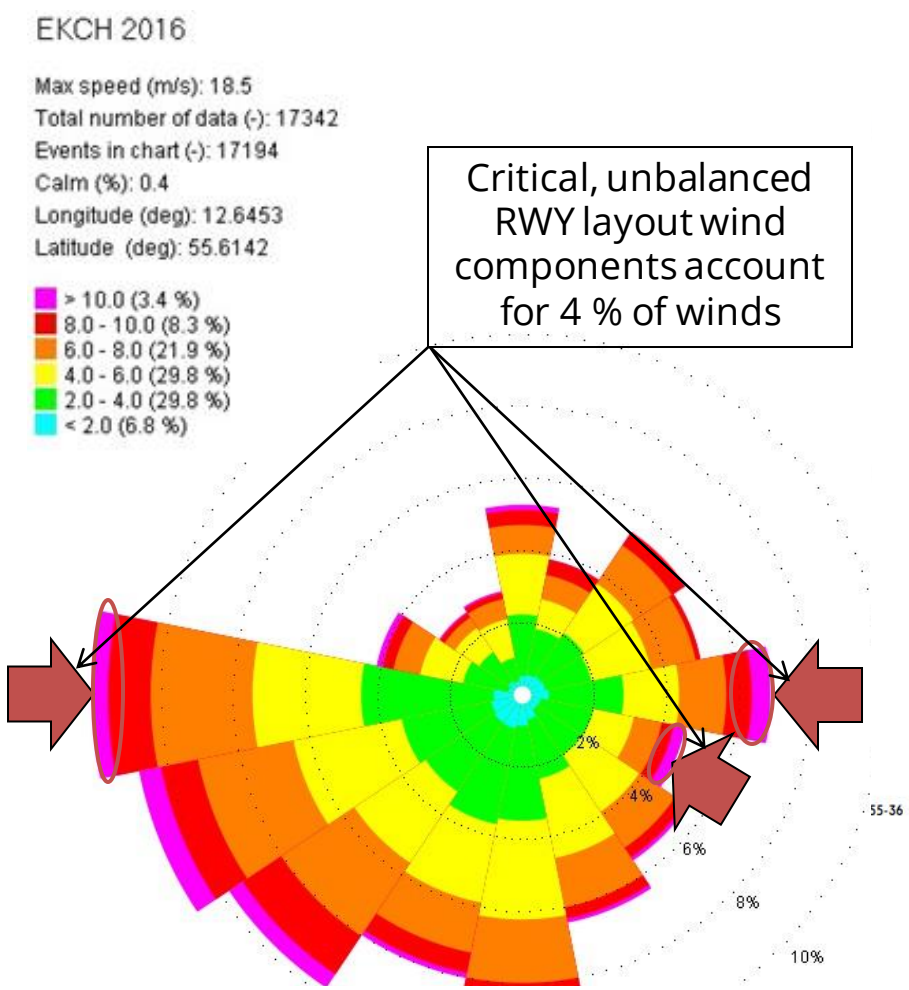
Wind rouse is a very FUNDAMENTAL airport layout planning factor (mainly for RWYs directions, TWYs, RETs, de-icing platforms etc.) and ATC procedures which in respond enables the same capacity level for all limiting potential crosswind directions.



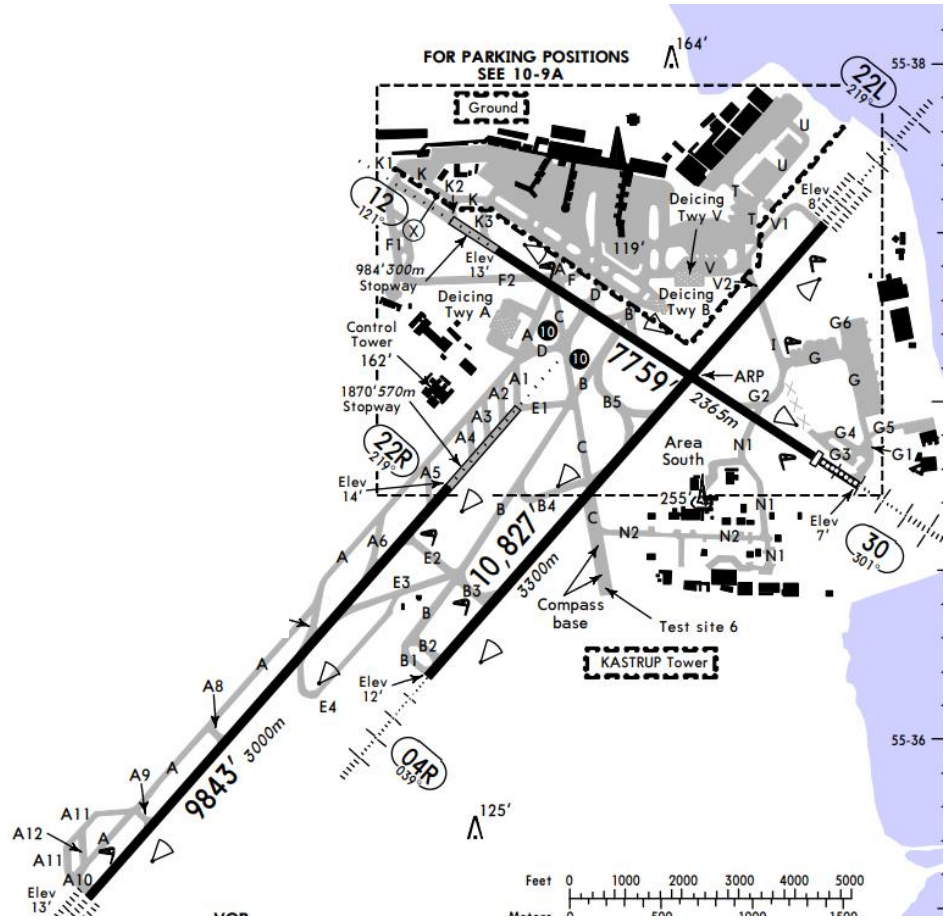
Capacities for different runway configurations

Runway Configuration	Max Arrivals (movements/hour)	Max Departures (movements/hour)	Global (movements/hour)	Optimum
08L & 08R, mixed mode ops	58	58	90	Yes
26L & 26R, mixed mode ops	58	58	90	Yes

As a consequence => $C_{imb}=0$ **NO Capacity imbalance exist**



Critical, unbalanced RWY layout wind components account for 4 % of winds



Capacities for different runway configurations

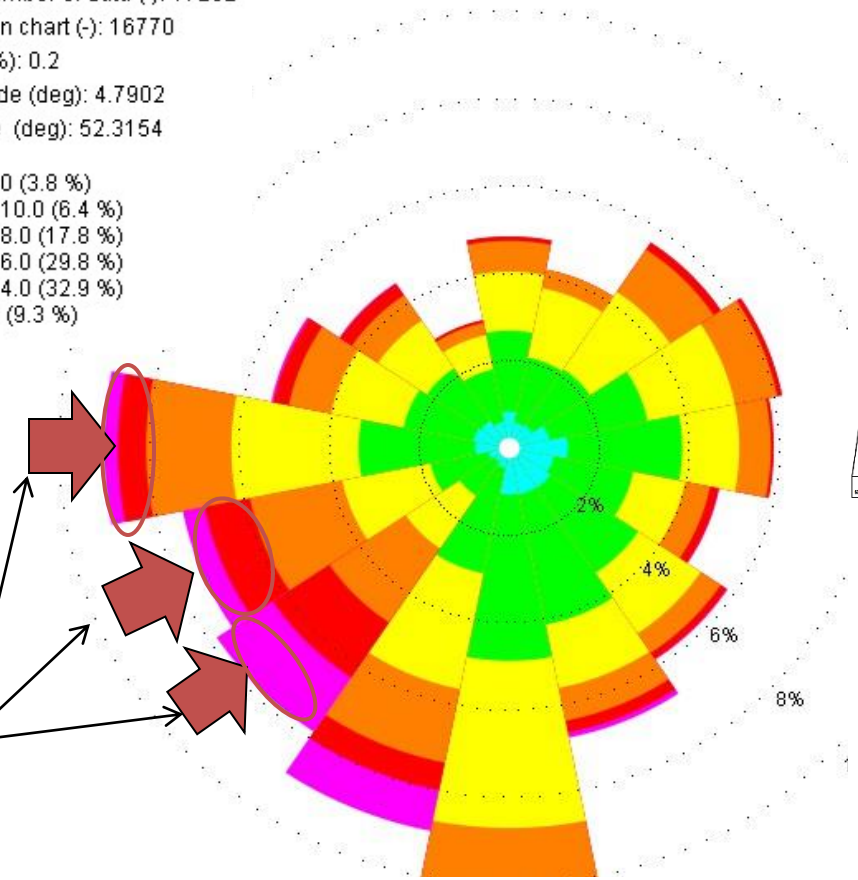
Runway Configuration	Max Arrivals (movements/hour)	Max Departures (movements/hour)	Global (movements/hour)	Optimum
22L/R	48	48	83	Yes
04L/R	48	48	83	Yes
12/30 + 22R/04L	48	48	83	No
12/30	20	20	36	No

$$C_{imb}(4)=\{(83-36)/86\}*100 = 55\ \%$$

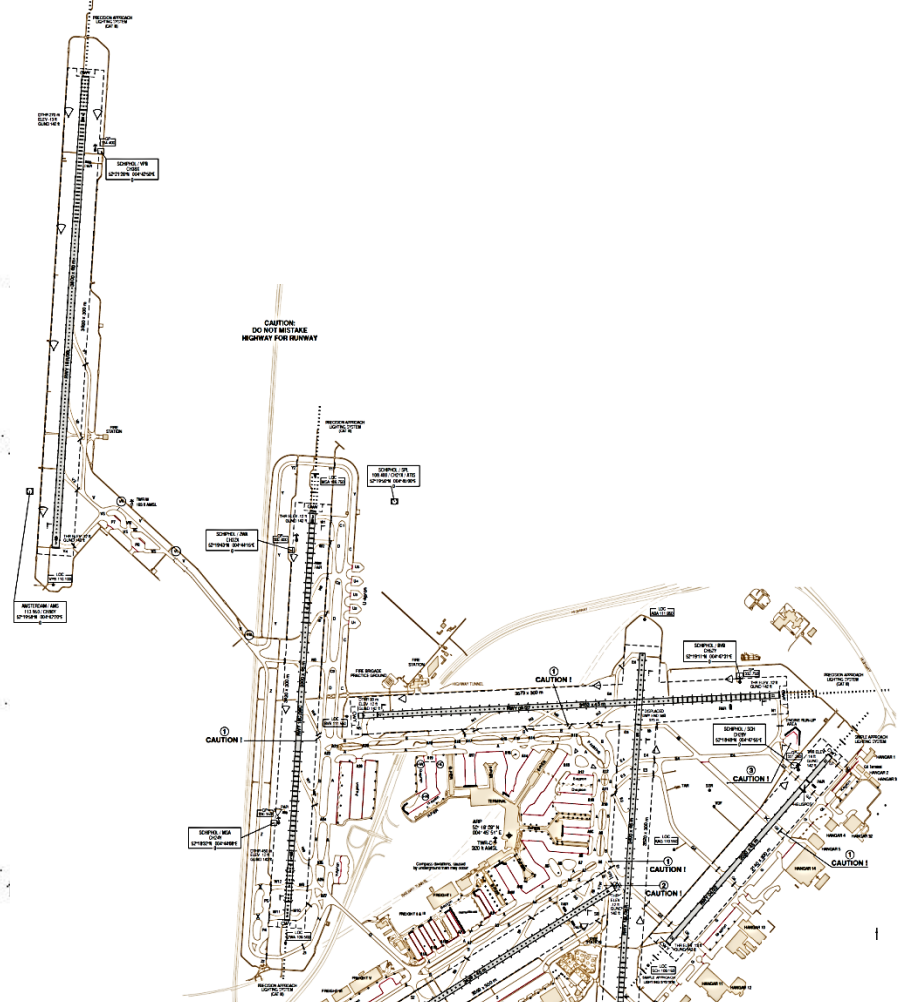
EHAM 2016

Max speed (m/s): 20.1
Total number of data (-): 17282
Events in chart (-): 16770
Calm (%): 0.2
Longitude (deg): 4.7902
Latitude (deg): 52.3154

- > 10.0 (3.8 %)
- 8.0 - 10.0 (6.4 %)
- 6.0 - 8.0 (17.8 %)
- 4.0 - 6.0 (29.8 %)
- 2.0 - 4.0 (32.9 %)
- < 2.0 (9.3 %)



Critical, unbalanced RWY layout wind components account for 6,5 % of winds



Capacities for different runway configurations

Runway Configuration	Max Arrivals (movements/hour)	Max Departures (movements/hour)	Global (movements/hour)	Optimum
Off peak	38	40	78	No
Inbound peak	68	40	108	No
Outbound peak	38	74	112	Yes
Night	24	25	49	No

? RWY config inconsistency

$$C_{imb}(6,5)=\{(112 - 78)/112\}*100 = 30\ \%$$

EHAM Schedule example case

4 arrivals & 7 departures **at 12:15 (11 ops in 5 mins)**

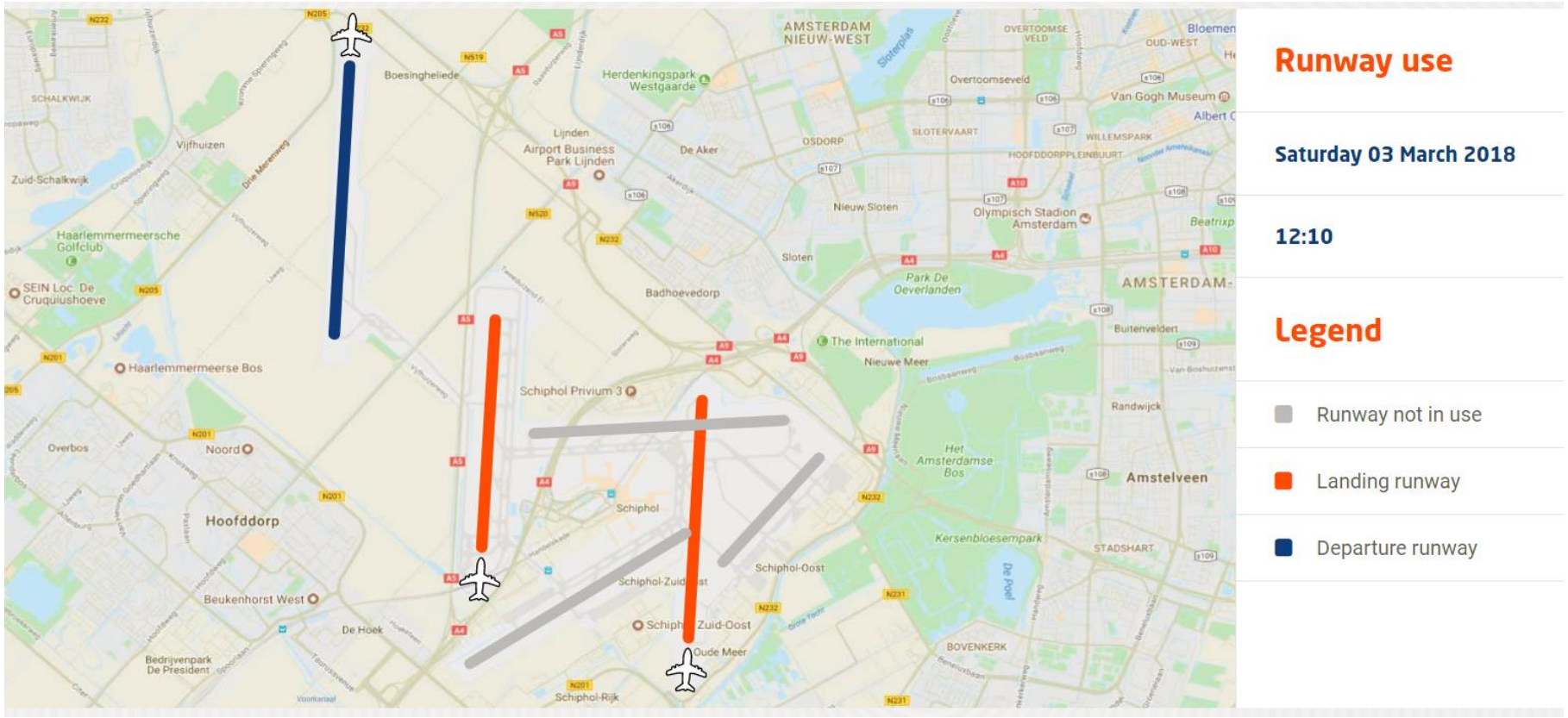
•Arrivals

12:10		Vancouver (YVR)	AF 8377 DL 9369 9W 8822 KL 0682	Air France Delta Air Lines Jet Airways KLM
~~12:15~~	11:56	Cardiff (CWL)	SU 3337 AF 8344 MK 7731 AZ 3801 DL 9437 EY 7381 9W 8956 KL 1060	Aeroflot Air France Air Mauritius Alitalia Delta Air Lines Etihad Airways Jet Airways KLM
~~12:15~~	11:47	Oporto (OPO)	KL 2588 HV 6004	KLM Transavia
~~12:15~~	11:50	Naples (NAP)	KL 2654 HV 6412	KLM Transavia
12:15		Los Angeles (LAX)	AF 8455 DL 9645 9W 8812 KL 0604	Air France Delta Air Lines Jet Airways KLM
~~12:20~~	11:39	Sao Paulo (GRU)	G3 5500 KL 0792 MF 9926	Gol Transportes Aereos KLM Xiamen Airlines

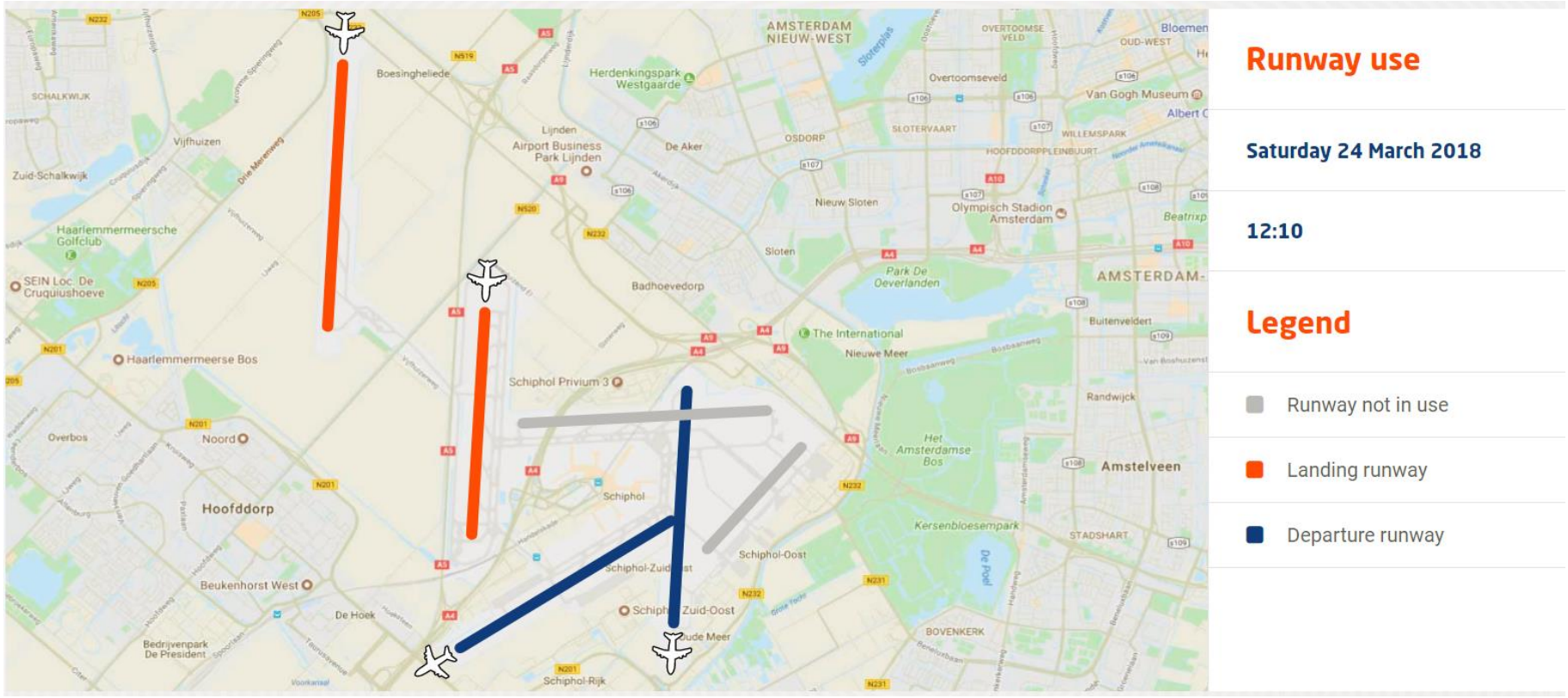
https://www.schiphol.nl/en/

•Departures

12:10	Toronto (YYZ)	AF 6798 DL 7535 9W 0234 KL 3817	Air France Delta Air Lines Jet Airways KLM
12:15	Stavanger (SVG)	SU 3320 AF 8217 DL 9513 KL 1201	Aeroflot Air France Delta Air Lines KLM
12:15	Dresden (DRS)	AF 8432 DL 9342 KL 1807	Air France Delta Air Lines KLM
12:15	Edinburgh (EDI)	SU 3224 BT 6021 CZ 7832 DL 9451 9W 8585 KL 1281 MF 9675	Aeroflot airBaltic China Southern Airlines Delta Air Lines Jet Airways KLM Xiamen Airlines
12:15	Valencia (VLC)	DL 7484 KL 2622 HV 6335	Delta Air Lines KLM Transavia
12:15	Aalborg (AAL)	SU 3368 DL 9481 KQ 1333 KL 1333 MF 9767	Aeroflot Delta Air Lines Kenya Airways KLM Xiamen Airlines
12:15	Gothenburg (GOT)	SU 3310 DL 9688 EY 7338 9W 8627 KL 1157 MF 9827	Aeroflot Delta Air Lines Etihad Airways Jet Airways KLM Xiamen Airlines
12:15	Bari (BRI)	KL 2565 HV 5819	KLM Transavia



https://en.lvnl.nl/environment/questions-about-runway-use



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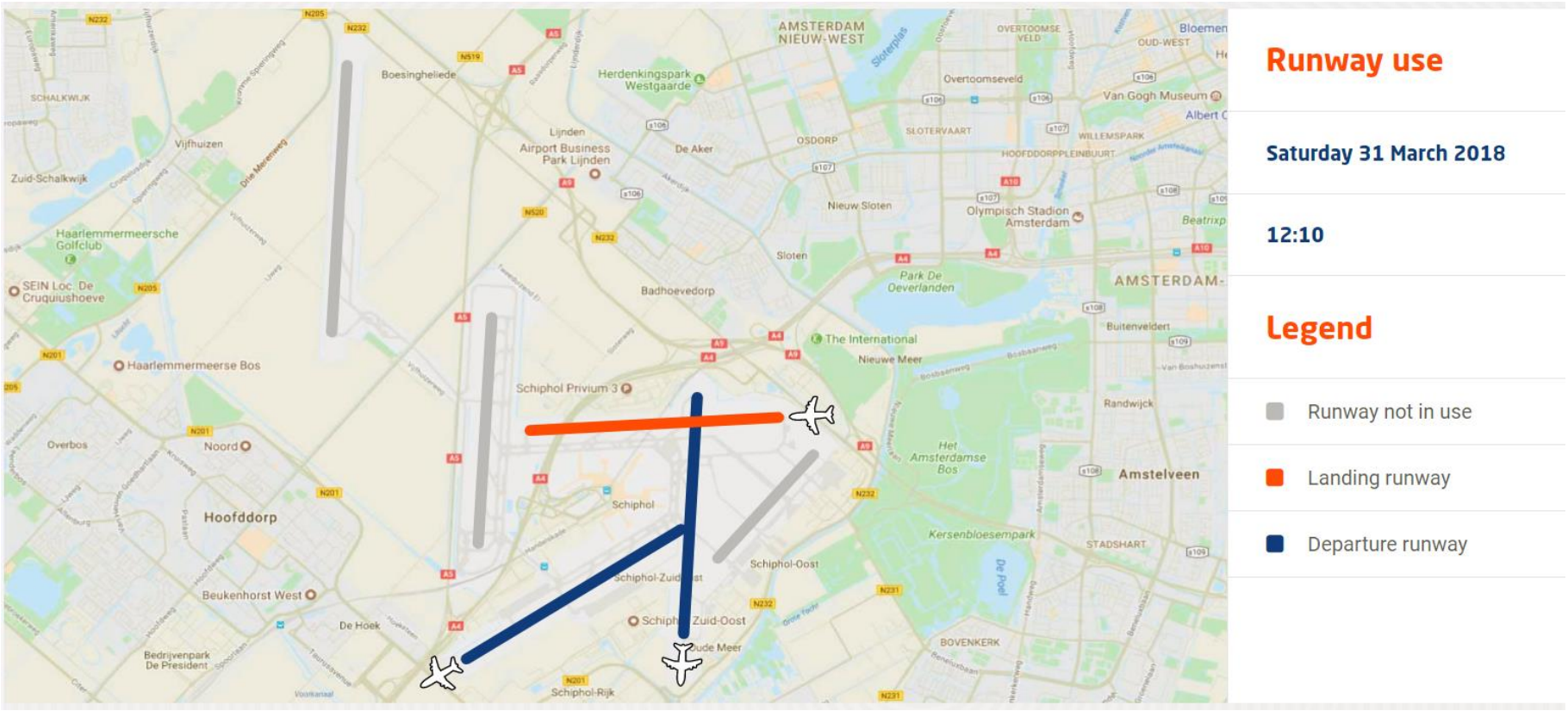

https://en.lvnl.nl/environment/questions-about-runway-use

Conclusion

1/Airport capacity imbalance metrics (additionally to the Base Load Index & Peak Load Index) as a delay/cancelation risk assessment input have significant potential to be used by stake holders:

- Slot coordinators
- ATCs
- Airports
- Airlines
- Airport Development Planners

specially for airport operations monitoring & optimization process.

2/ This novel approach value consist in simultaneous expression of performance metric related to the probability of its occurrence and would be consider as an initiative to EASA/ICAO new A/D development standard.

3/ Similar methodology can be apply for other airport variable performance issues like night curfew limitations or Low Visibility constrain limitations.

Further research work

Focused on the short term (knowcasting), precise determination of the period when it is impossible to served airports due to weather conditions, as well as the critical operations destinations.

It will also be necessary define the time buffers and take them into account in the Slot distribution process.

Procedures development aimed at minimizing the inconvienceses for passengers who lose their connections in case of flight cancelations or delays.

Many thanks for your kind attention

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References:

- Wind roses – www.enviroware.com
- Airport maps – AIP
- Airport capacity data - https://ext.eurocontrol.int/airport_corner_public