

# *Crosswind dependent separations (CROPS)*

*Wakenet 3 Europe  
London, 8-9 February 2011*

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# Agenda

- High-level generic concept of operations for:
  - Cross Wind Operations
- Benefit assessment
- Update on safety assessment
  - Wind thresholds – initial results
- Open issues or research subjects

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# High-level concept of operations

## Crosswind

- Based on CREDOS & ATC-WAKE concepts
- Procedure change only, with limited system support
- Authorise on the runway, during initial climb and on a final approach reduction or suspension of wake turbulence separation (time or distance) between WT pairs (as per ICAO Doc 4444)
- Conditional application – only in specific crosswind conditions

# Separation reduction

- *Departures:*
  - *Suspension of WT separation, resulting into spacing of 60-100 sec (depending on SID layout and selection)*
- **Arrivals:**
  - **Reduction by 0.5 NM**

## Required wind conditions

- Surface crosswind component wind is equal to or stronger than X kt
- Wind forecast confirms favourable wind speed and directions for winds aloft for the entire planning period (duration of this period will be shorter for departures = X min and larger for arrivals = Y min)
- No significant MET situations are forecasted
  - Unfavourable MET conditions need to be defined, e.g. thunderstorms, wind shear.

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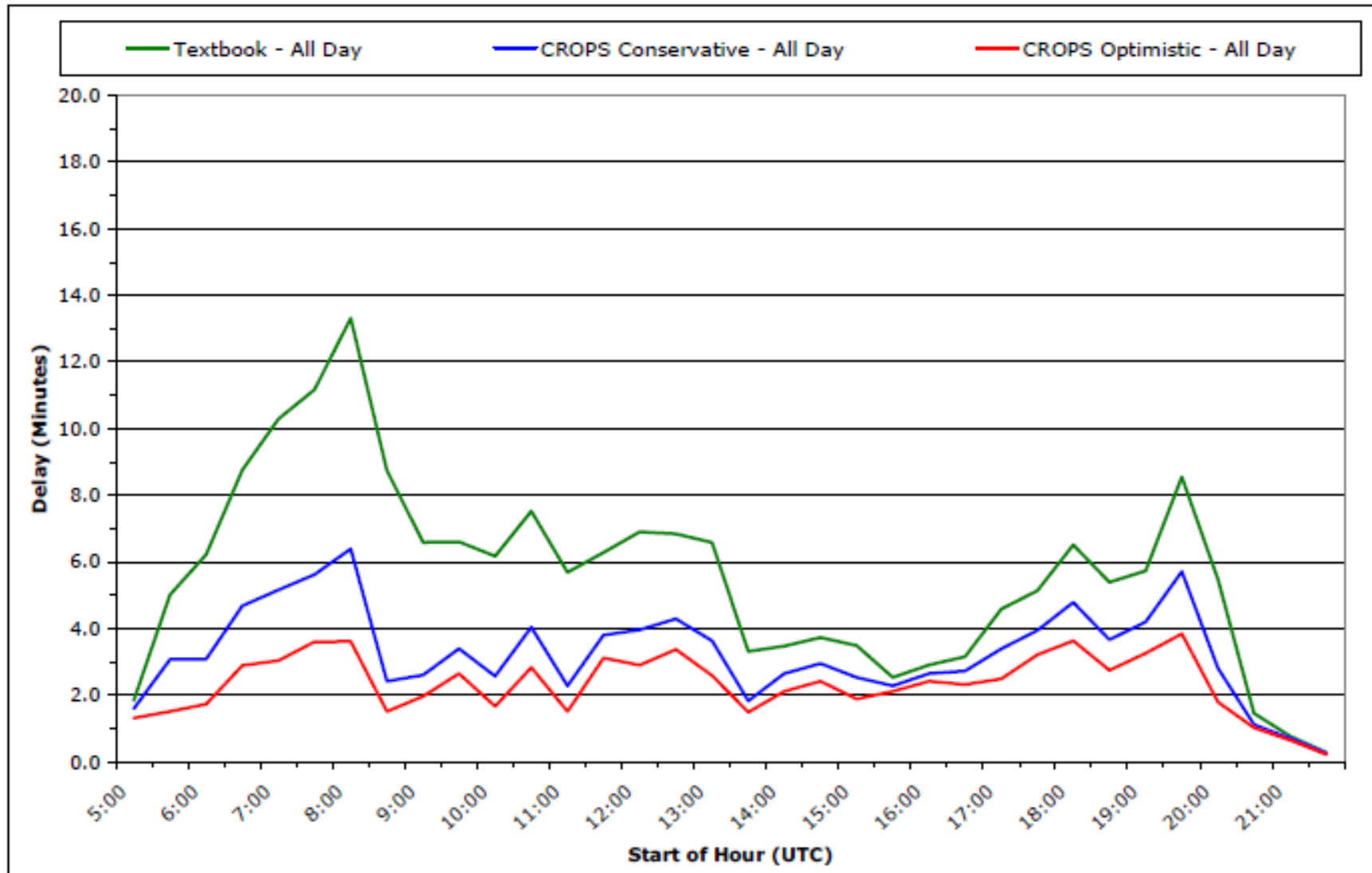
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## HERMES simulations for LHR (Crosswind)

- HERMES\* = Heuristic Runway Movement Event Simulation
- Based on LHR traffic demand from 2009
- Baseline using textbook separations as per MATS Part I and II
- Conservative scenario:
  - 0.5 Nm reduction for arrivals
  - 30 sec reduction for departures
- Optimistic scenario:
  - 1 Nm reduction for arrivals
  - 60 sec reduction for departures
- MRS = 3 Nm

# CROPS arrivals – delay reduction

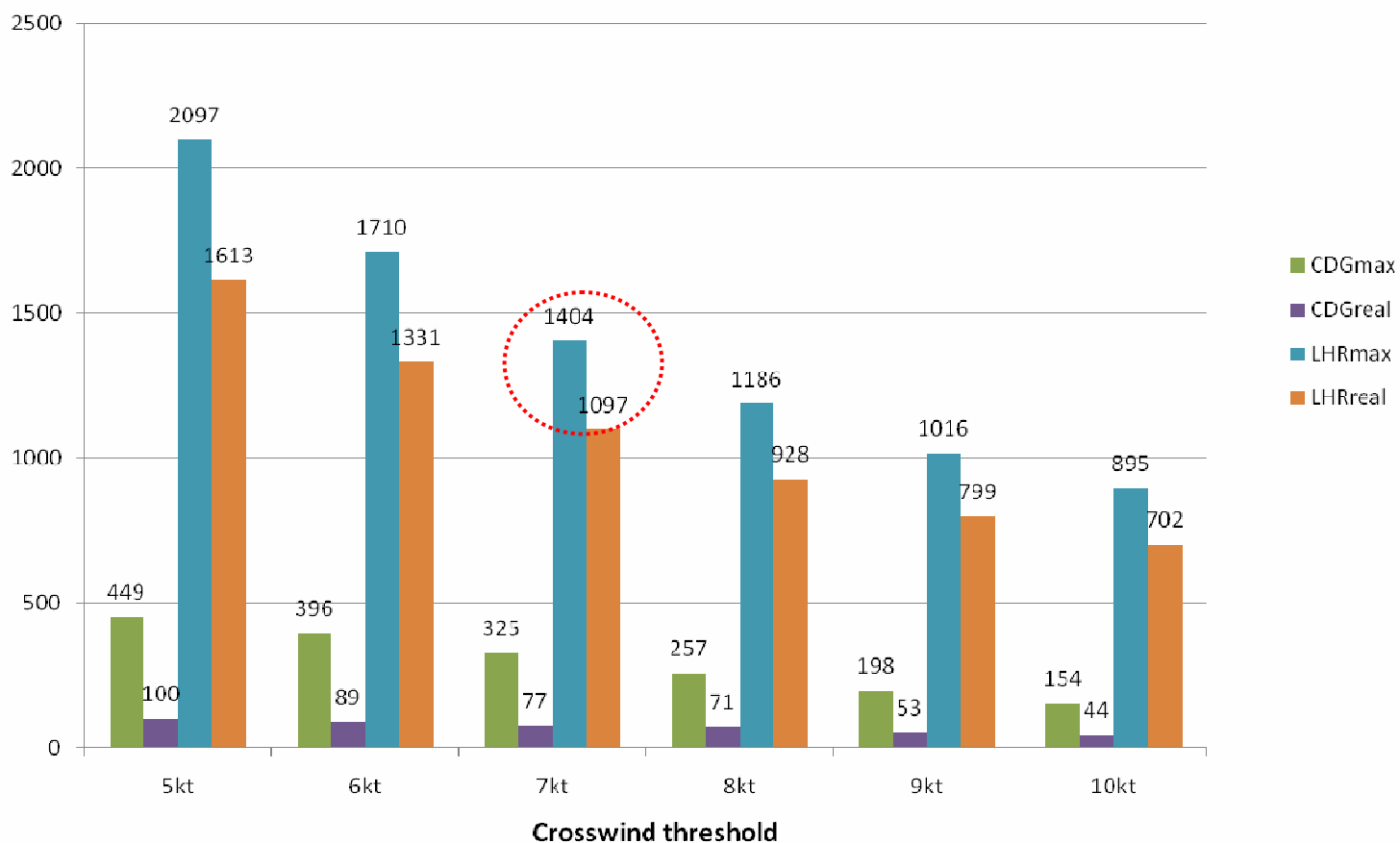


## Results from analytical modelling for LHR and CDG airports

- WT reduction by 0.5 & 1.0 NM for H-H and H-M pairs only
- Arrivals only
- OPS data correlated with one year of RWY anemometer data for crosswind criteria from 5 to 10 kt
- Two groups of benefits assessed:
  - Real – only taking into account H-H and H-M pairs separated close to ICAO separation (+20 seconds max)
  - Max – taking into account all H-H and H-M pairs with full distribution of separations
- Sum of total separations saved – converted to potentially gained movements => **tactical benefit only => resulting in reduction of airborne delay if wind conditions are met**
- Required wind stability not taken into account (leads to overestimation of benefits)

## Potentially gained movements in 1 year per one RWY (0.5 Nm reduction)

Number of potentially gained movements in 1 year per one arrival runway with CROPS operations (0.5Nm reduction)



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# Safety criteria

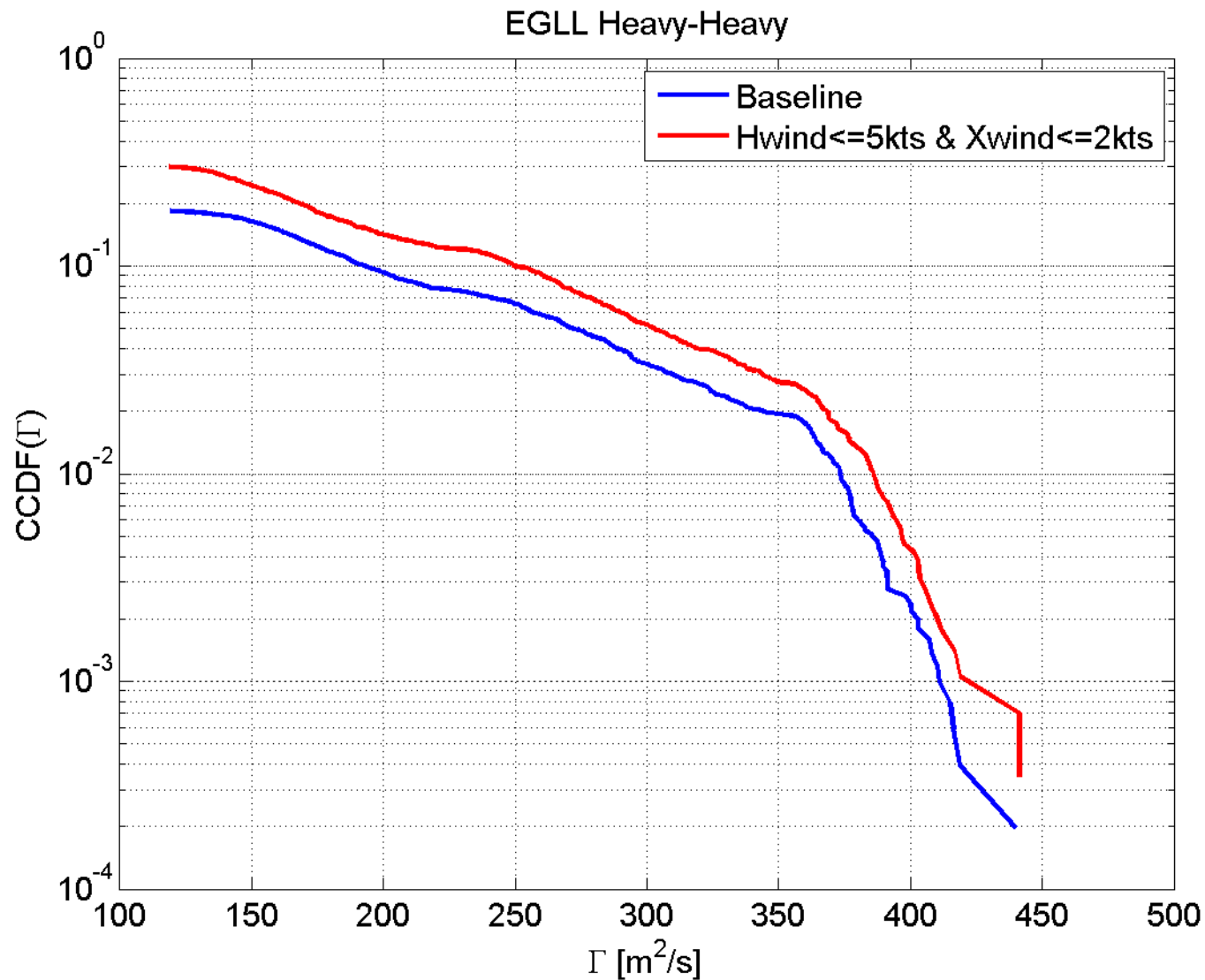
- Relative risk assessment criteria is proposed:
  - **Risk per approach** of an accident due to wake turbulence when reduced distance based separation minima are applied to an aircraft on final approach **in crosswind conditions** (as proposed by CROPS) **shall not be greater than the risk per approach** of an accident due to wake turbulence when ICAO provisions for wake turbulence are applied **in low wind conditions (<5kt)**.

## Frequency & Severity assessment – initial results

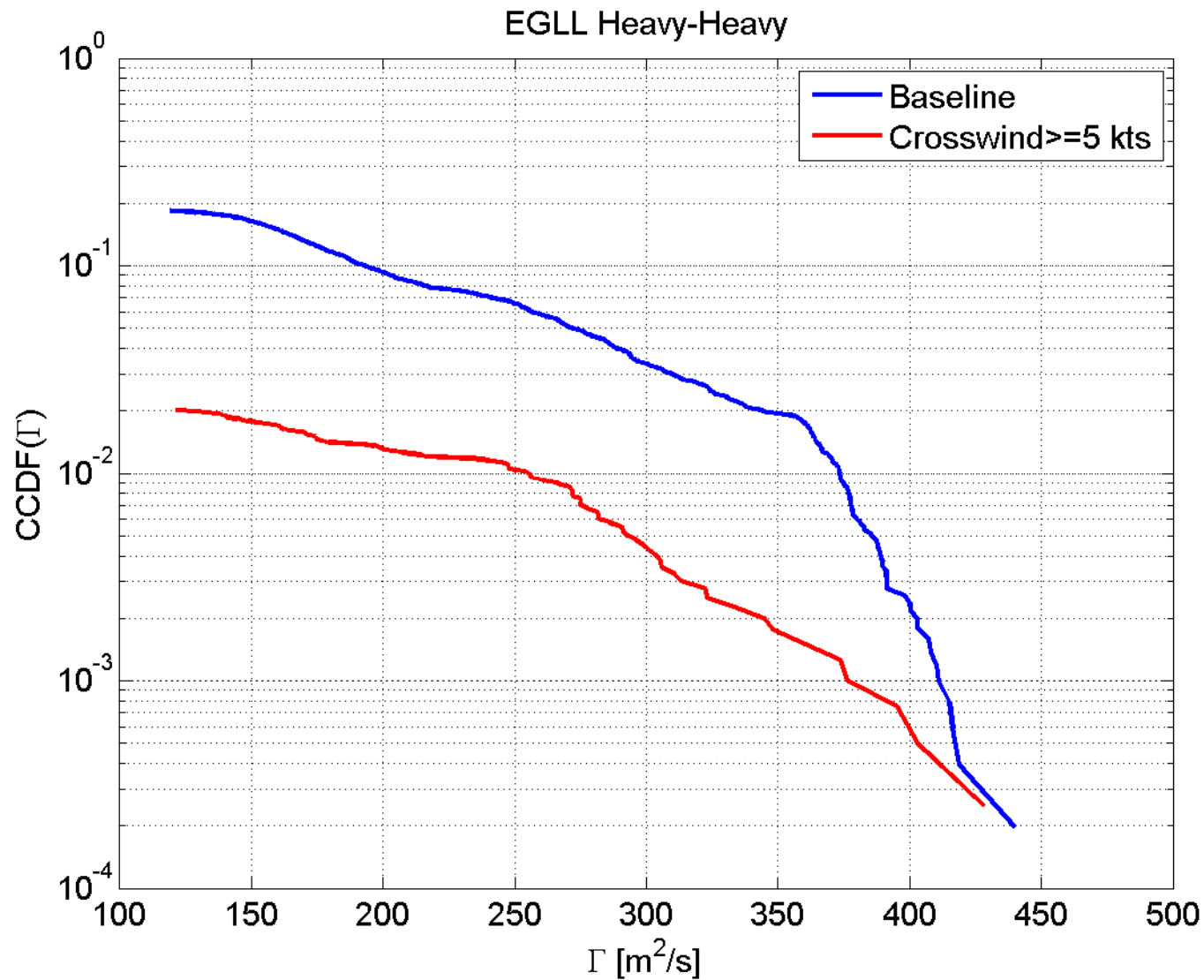
- WV risk curves: cumulative distribution of frequency of each strength (circulation) value
- Lateral corridor: +/- 75m (150 m total)
- Total wind & Headwind from RWY anemometers, Crosswind from LIDAR and WV tracks from LIDAR
- Baseline:
  - ICAO separations in calm wind: Total wind  $\leq 5$ kt
- Check case (0.5 NM reduction):
  - HW  $\leq 5$ kt
  - XW  $\leq 2$ kt
- CROPS (0.5 NM reduction):
  - HW  $\leq 5$ kt
  - XW  $\geq 5,6,7,8,9,10$ kt
- P-TBS (0.5 NM reduction):
  - XW  $\leq 2$ kt
  - HW  $\geq 5-15$ kt (per 1kt)
- **Initial results available only for H-H and H-M pairs!**



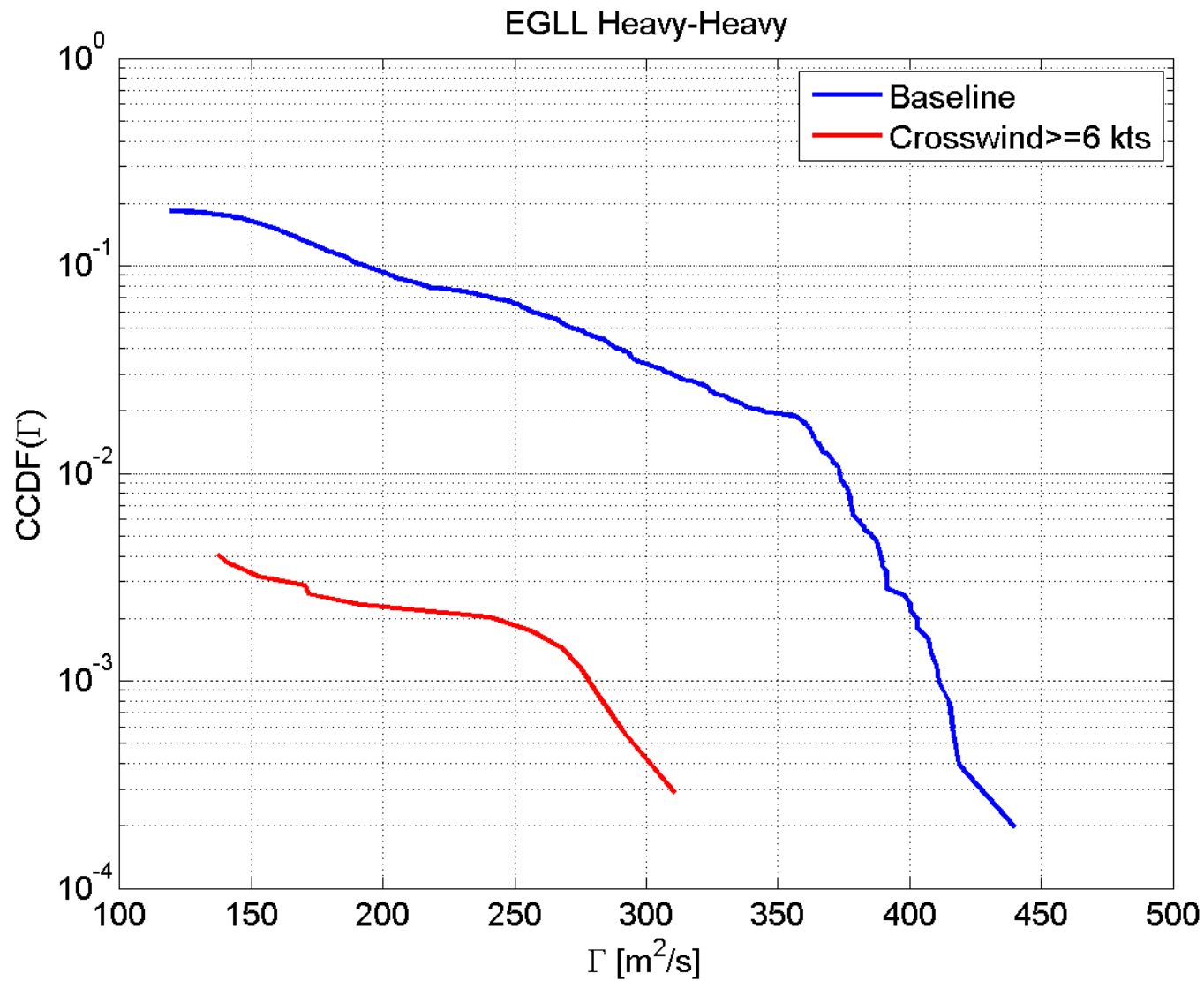
# Initial SA results – H-H pair – 0.5 NM reduction – calm wind conditions (CROPS)



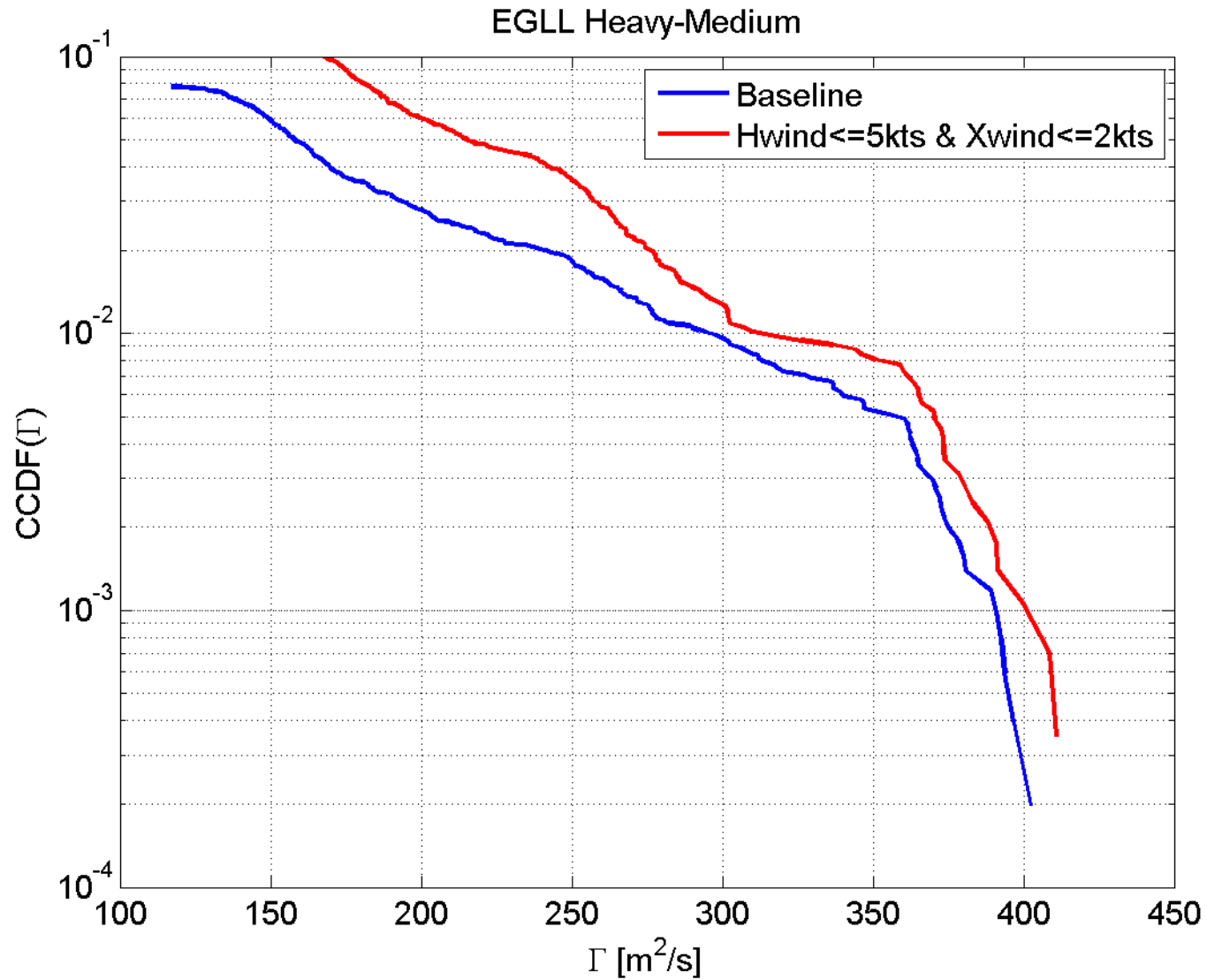
# Initial SA results – H-H pair – 0.5 NM reduction – Xwind $\geq$ 5kt



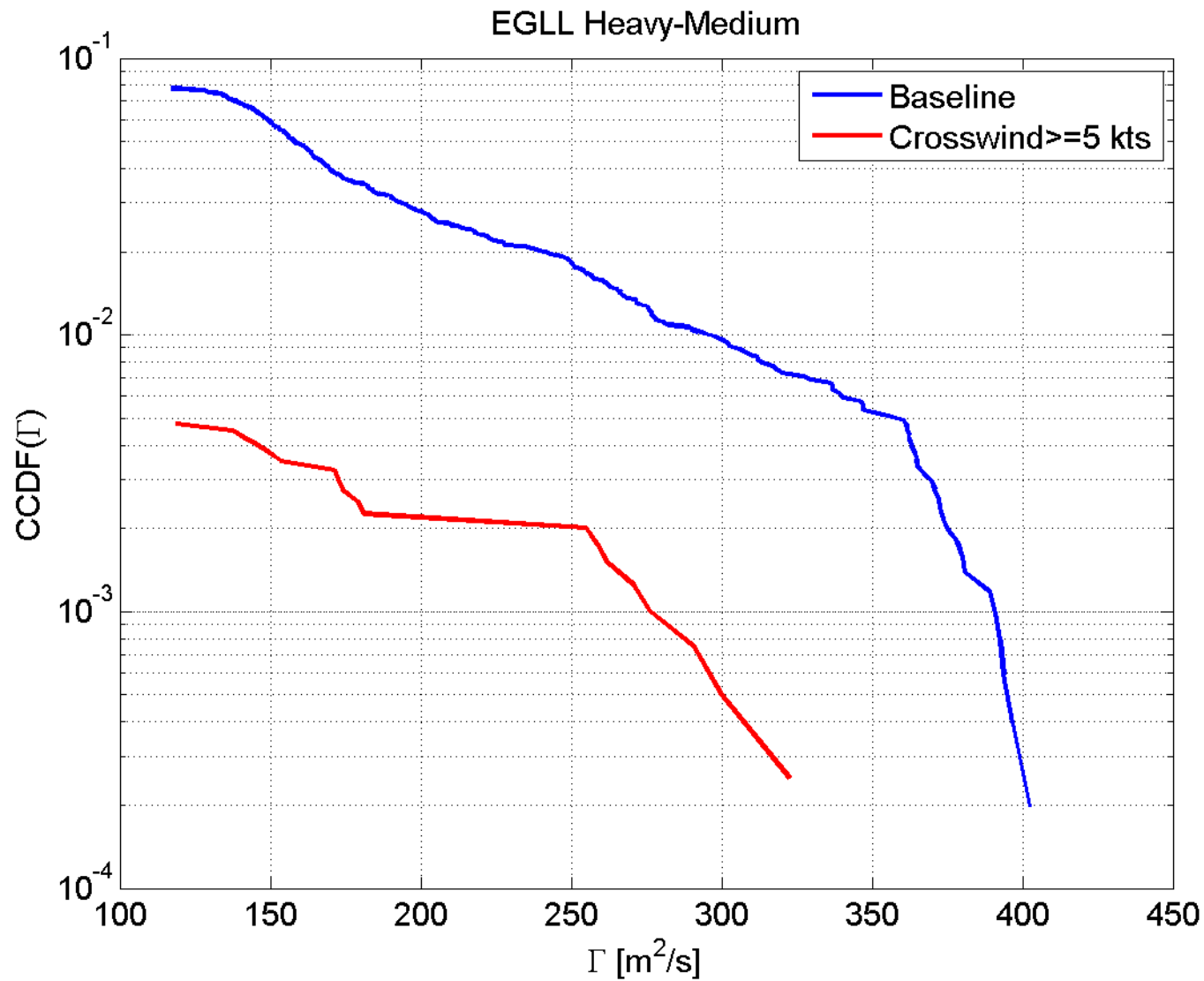
# Initial SA results – H-H pair – 0.5 NM reduction – Xwind $\geq$ 6kt



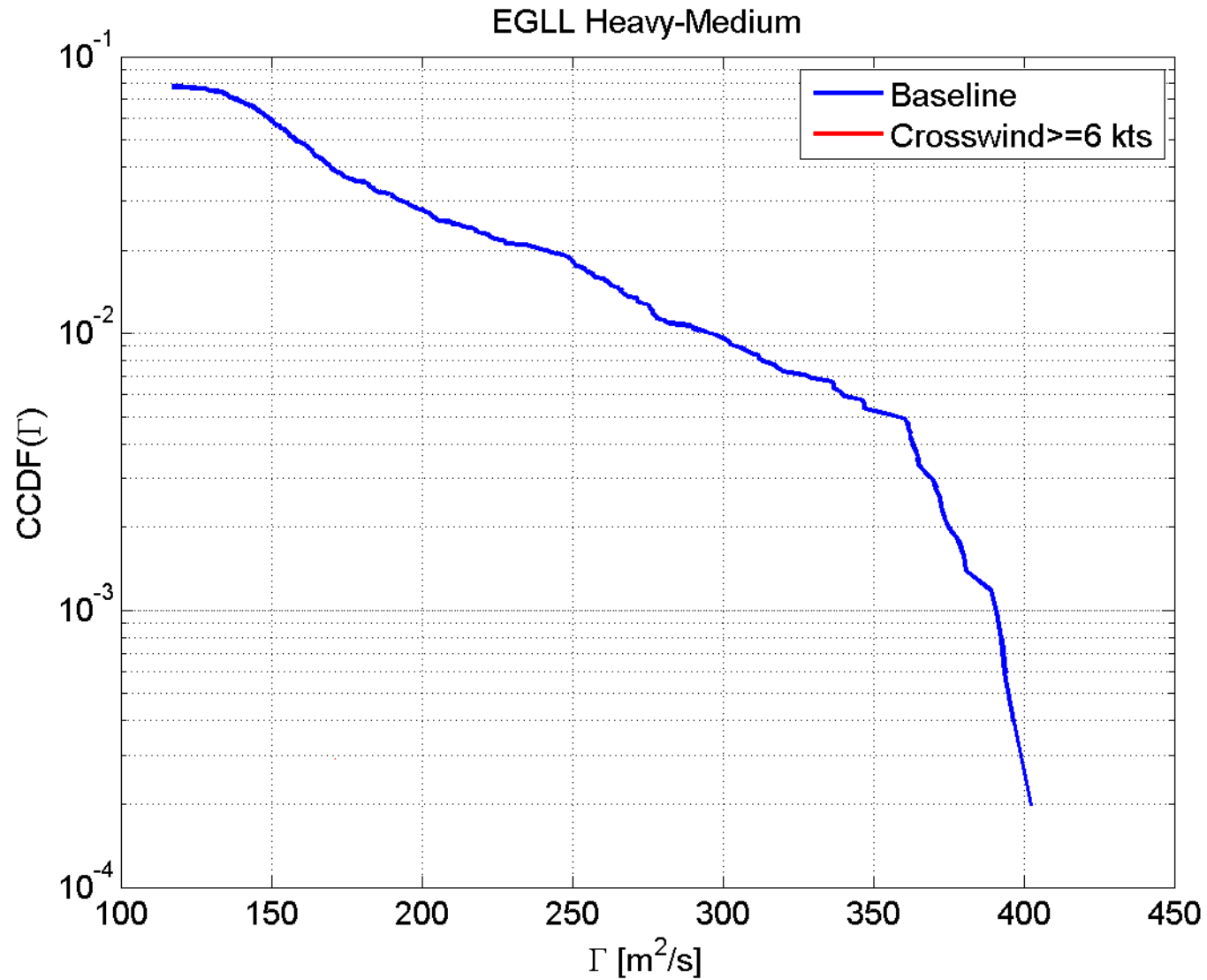
# Initial SA results – H-M pair – 0.5 NM reduction – calm wind conditions



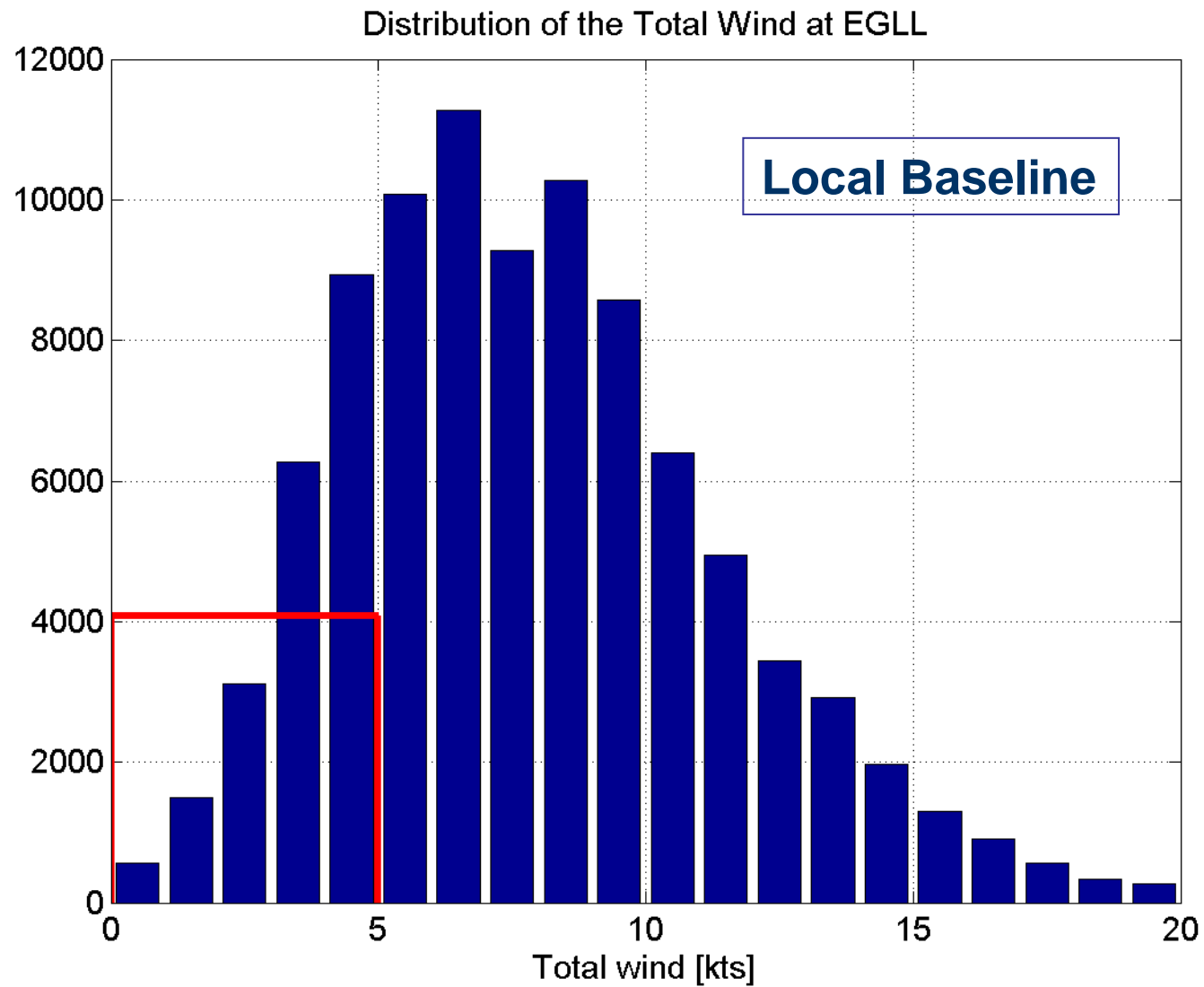
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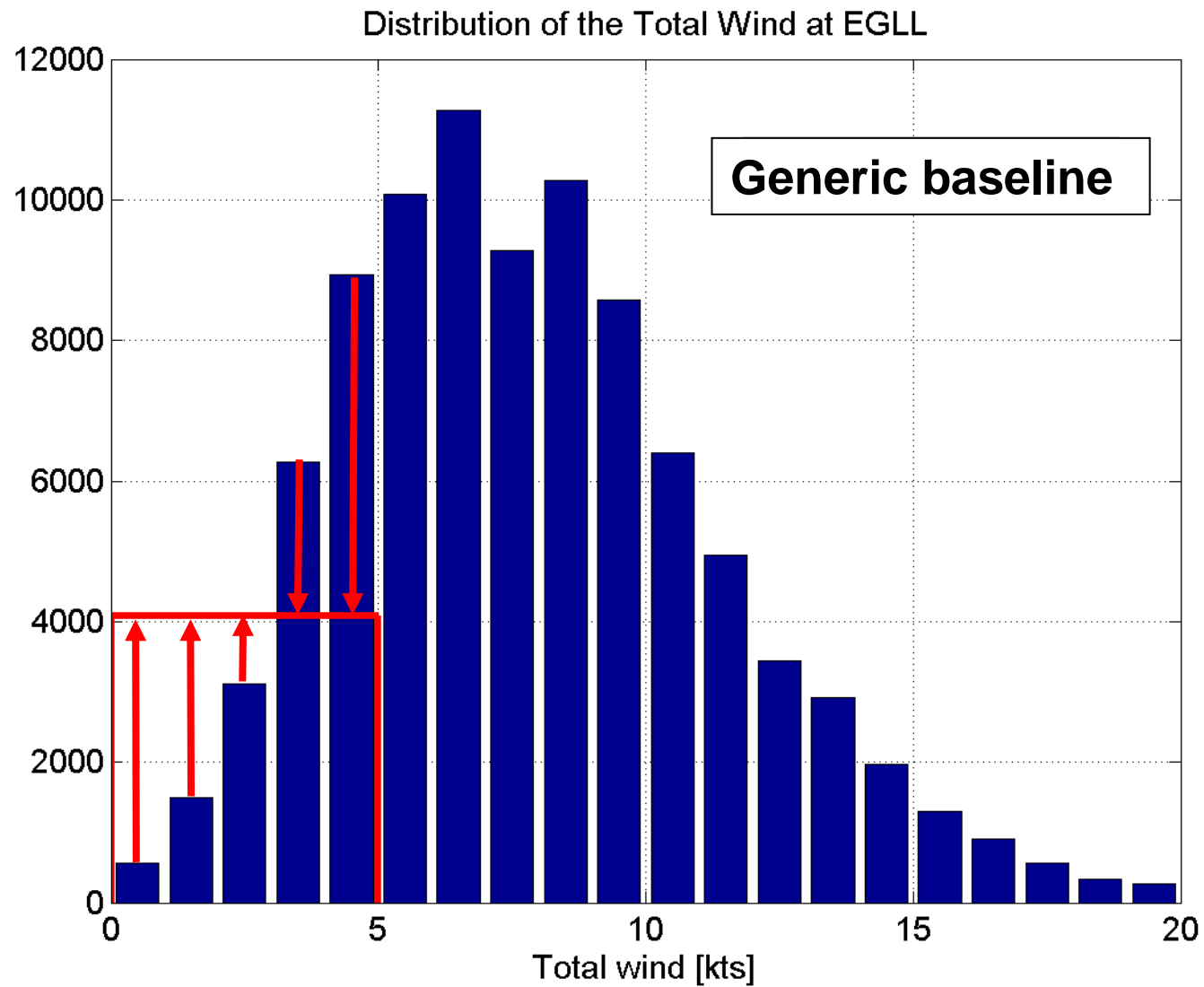
# Initial SA results – H-M pair – 0.5 NM reduction – Xwind $\geq$ 6kt



# Generalisation of the WVE risk assessment results

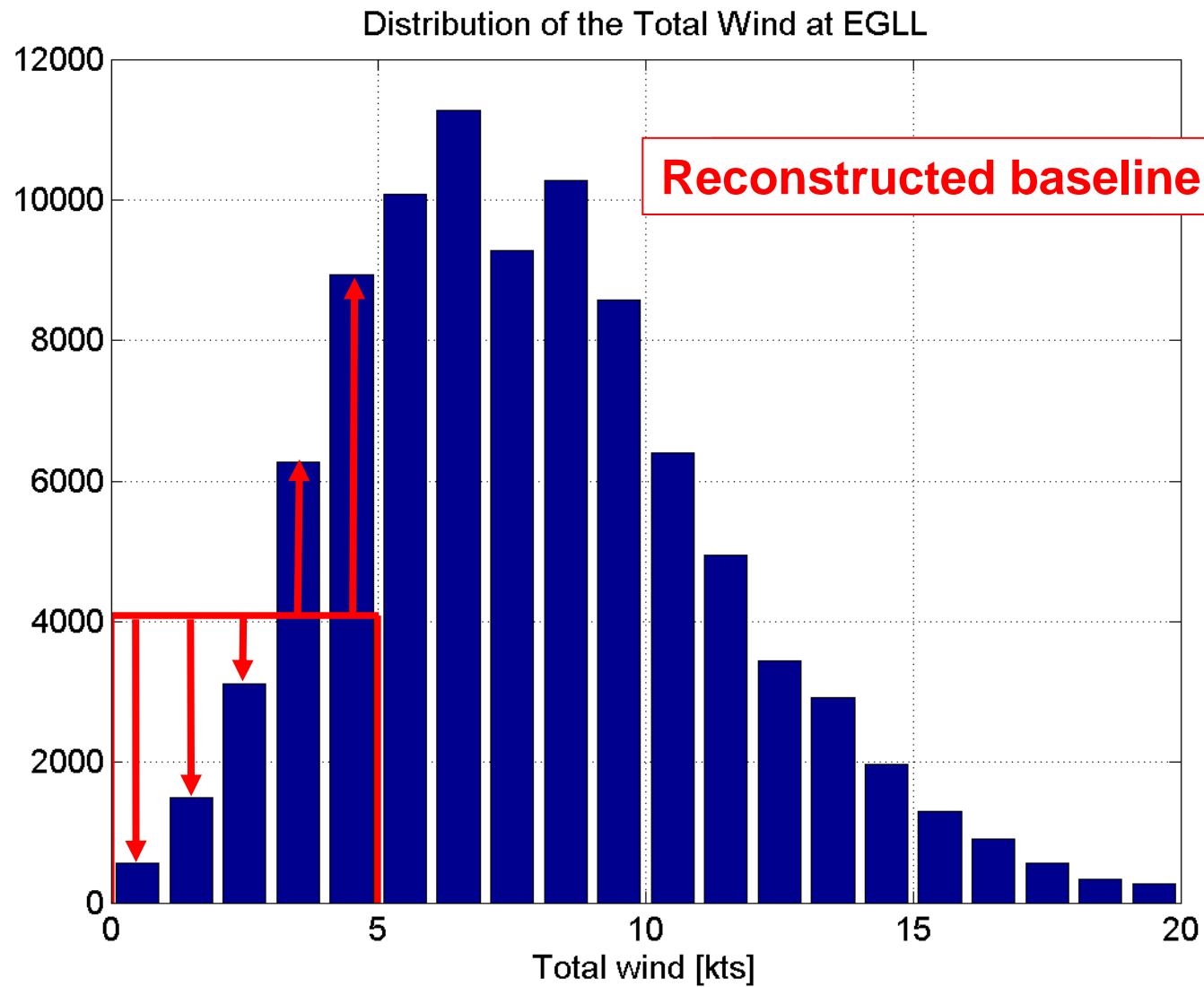


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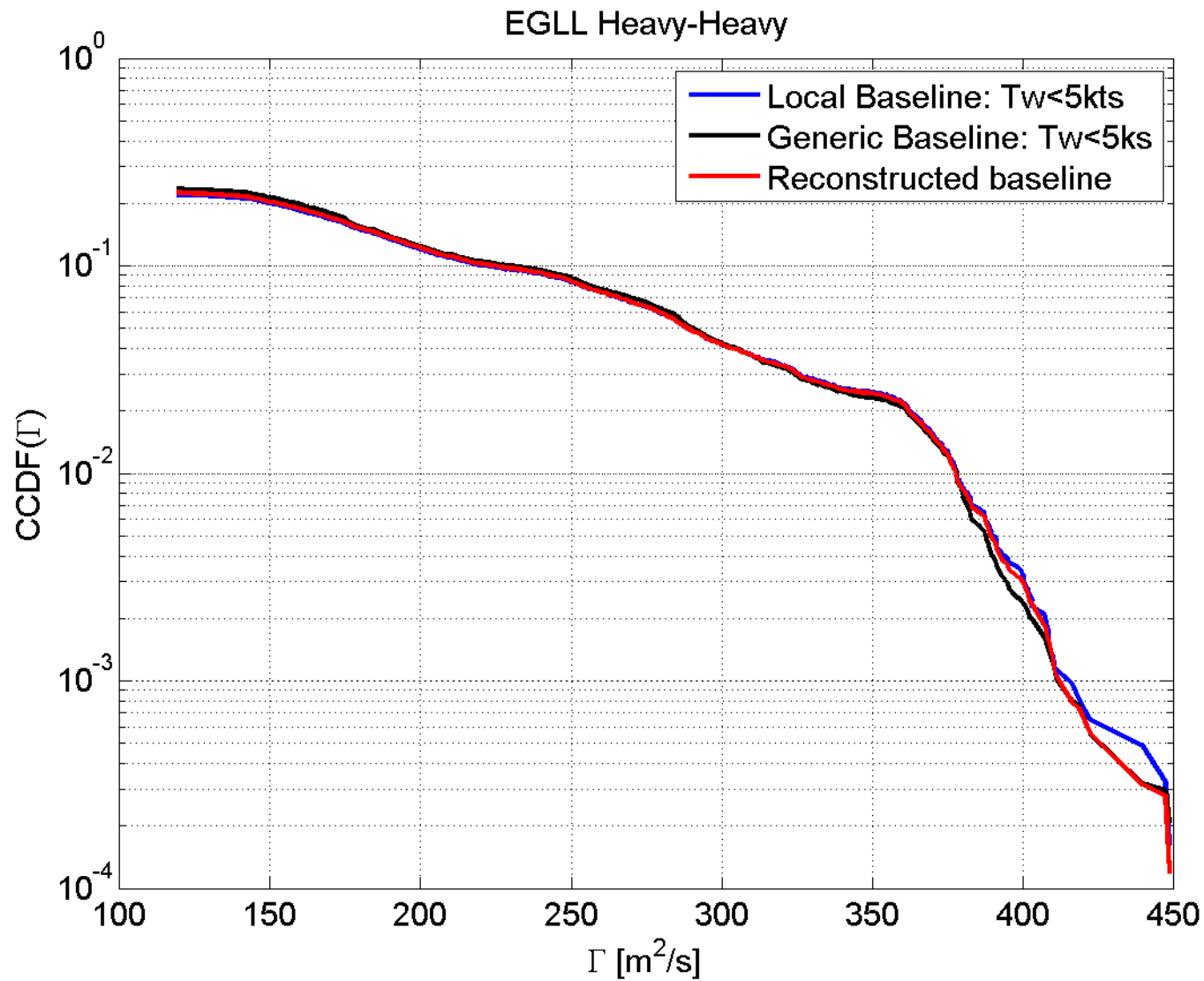




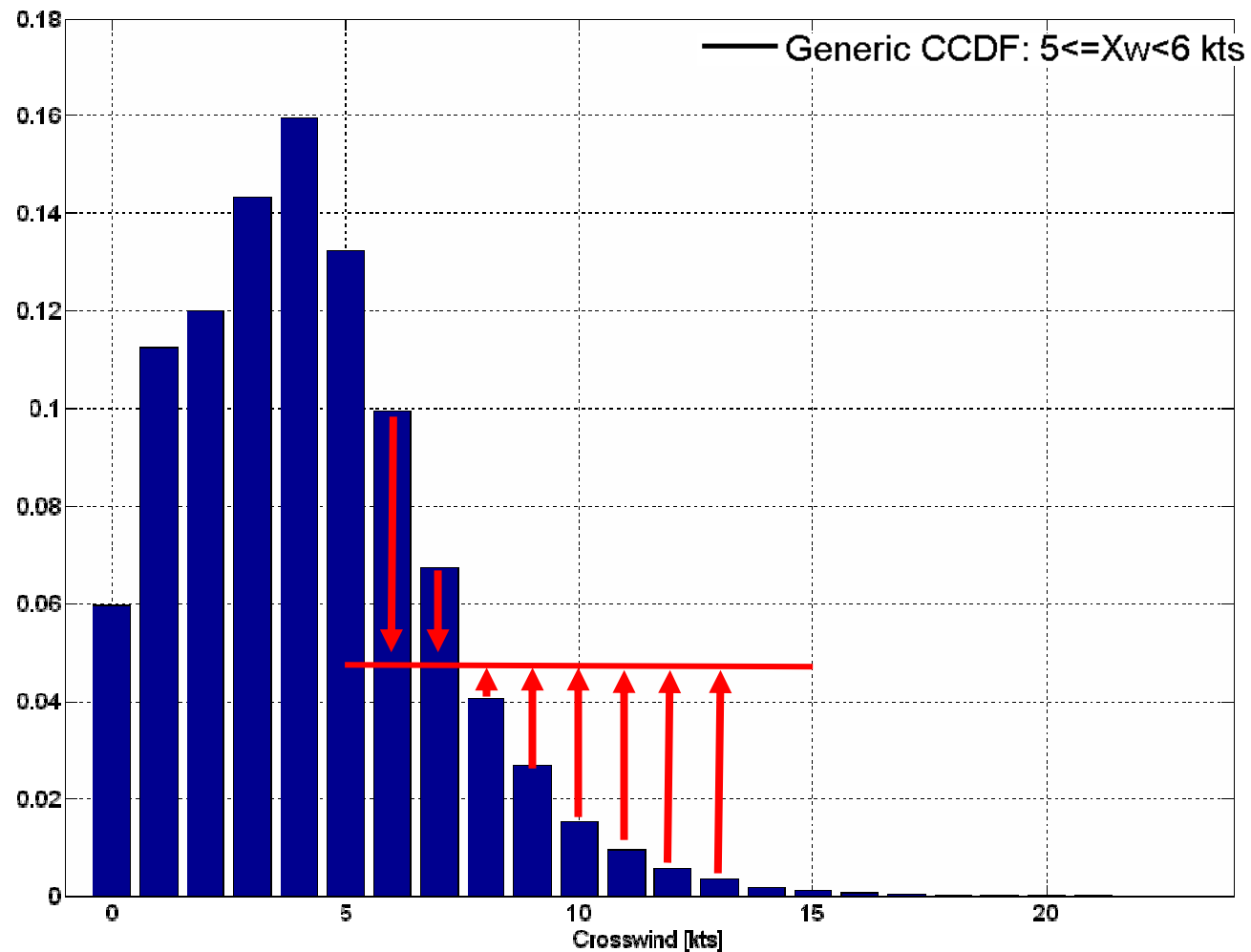
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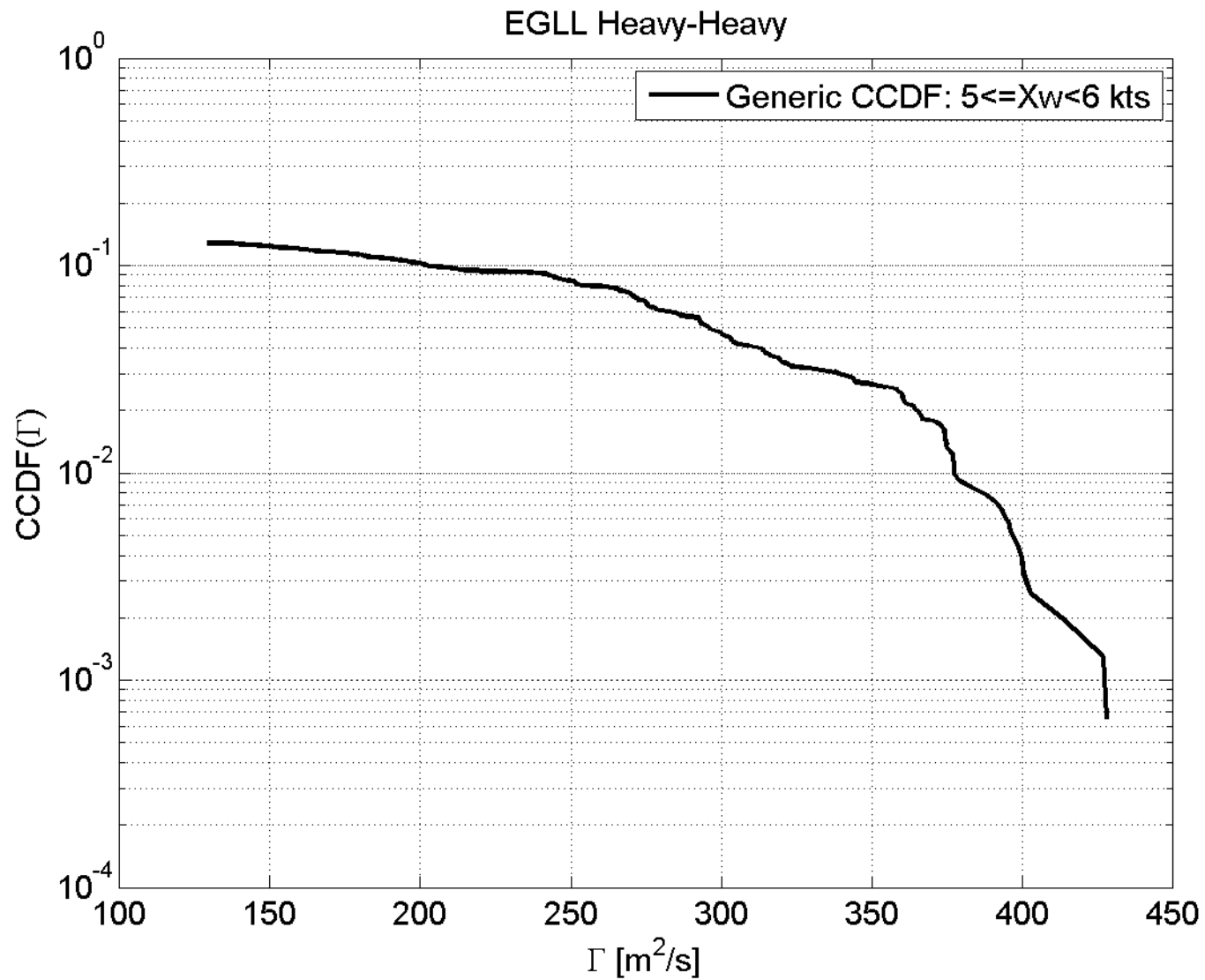
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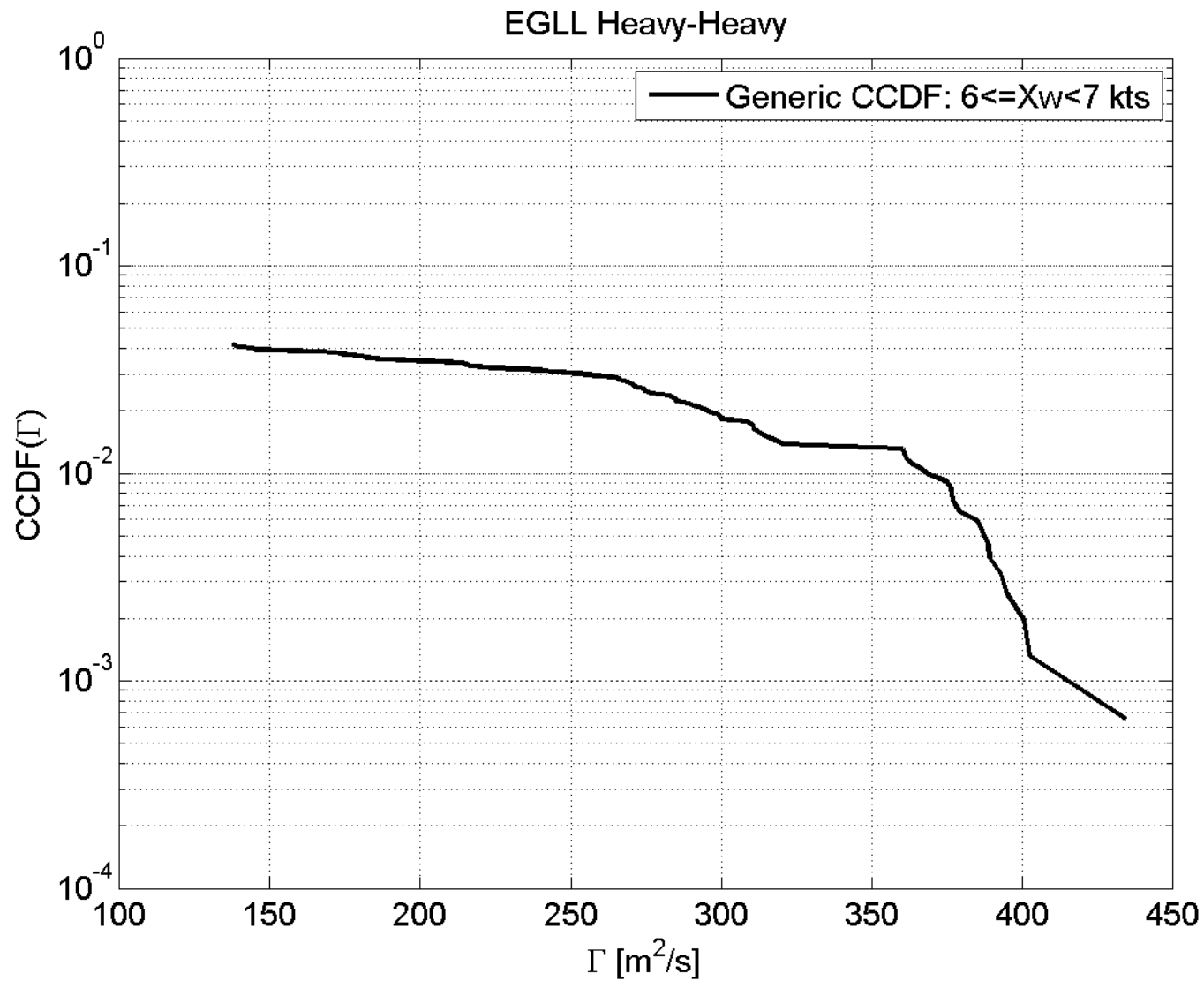
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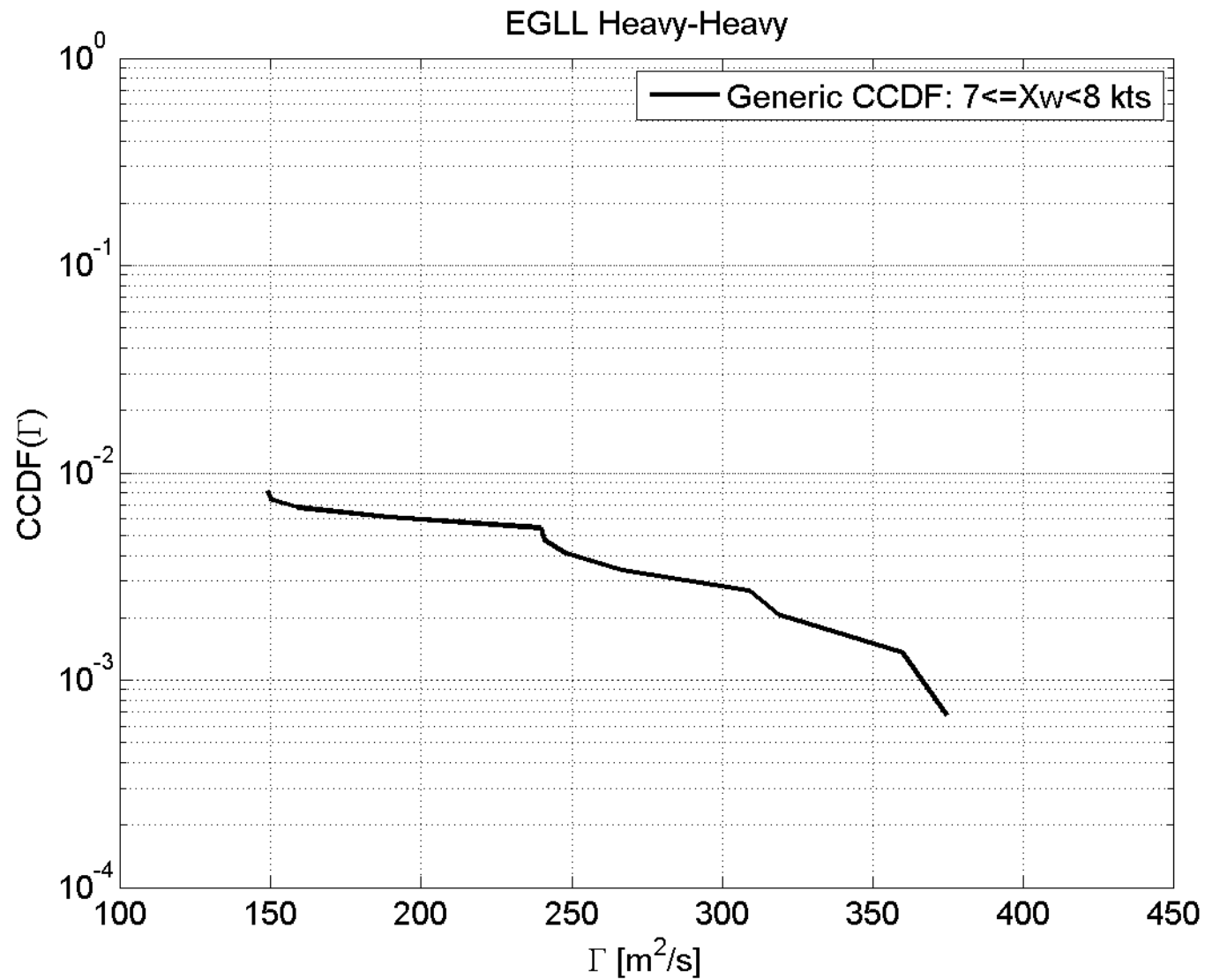
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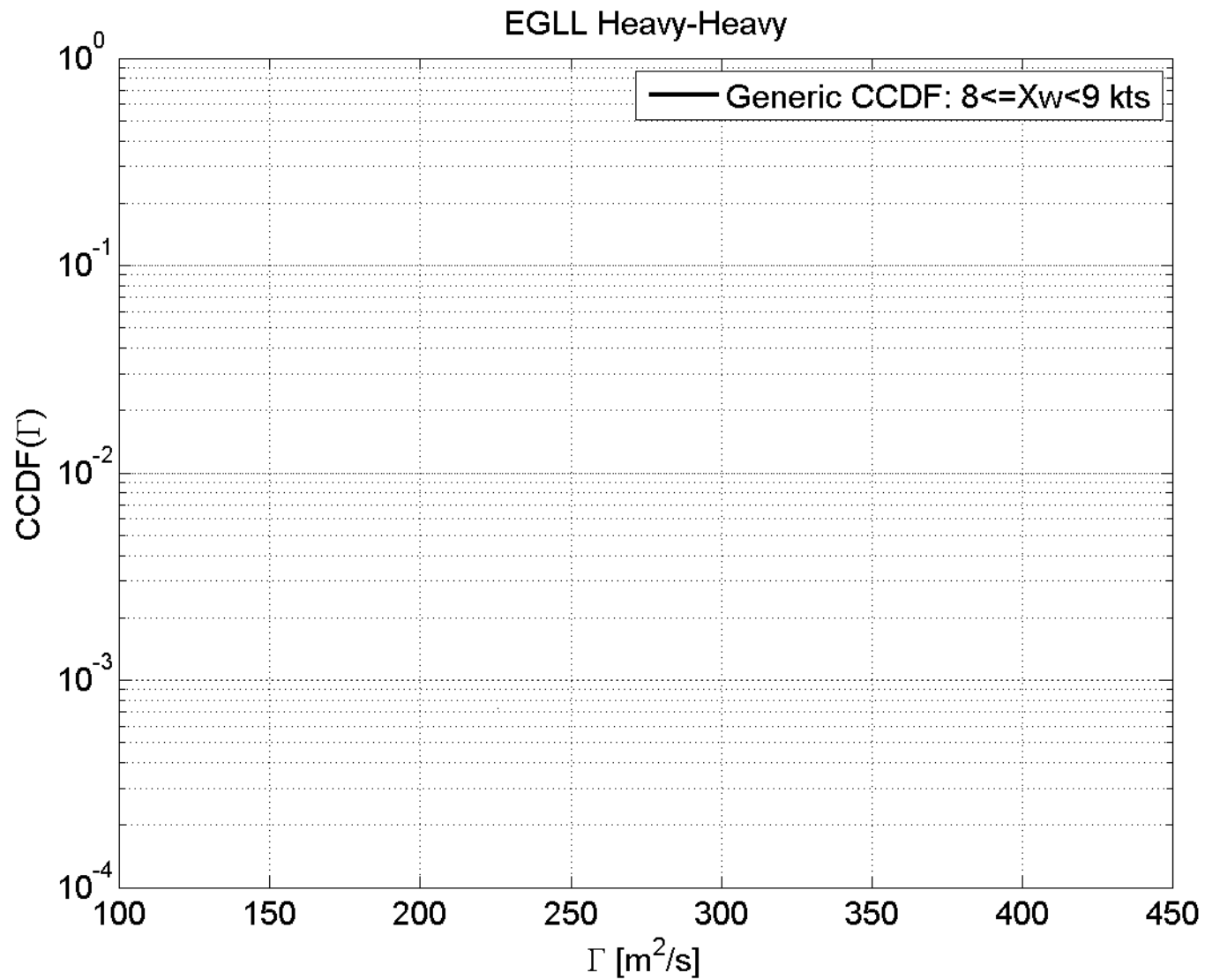
# Generalisation of the WVE risk assessment results



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# Generalisation of the WVE risk assessment results



## Initial wind thresholds for application of CROPS & P-TBS (0.5 NM separation reduction for arrivals)

- So far based only on analysis of H-H and H-M pairs, arrivals only
- Initial CROPS wind threshold:
  - Minimum surface crosswind component
    - 5/6 knots + design buffer (depending on accuracy of local wind info)
- Initial P-TBS wind threshold:
  - Minimum surface headwind component
    - 10 knots + design buffer (depending on accuracy of local wind info)
- *Initial “Total Wind concept” threshold:*
  - *Minimum total surface wind (with 180 degrees limitation)*
    - *X knots + design buffer*



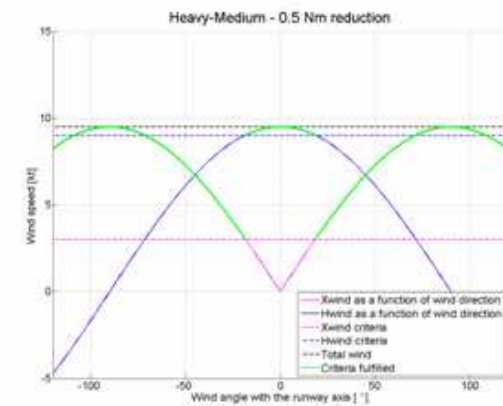
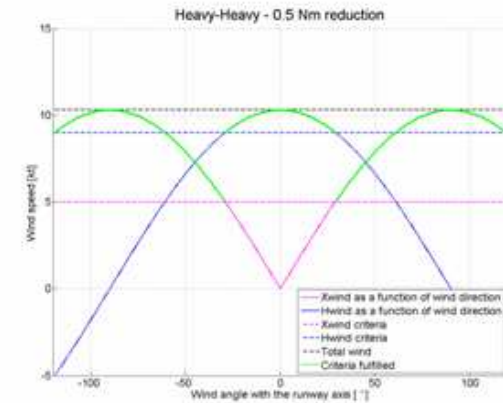
# Initial “Total Wind concept” threshold

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

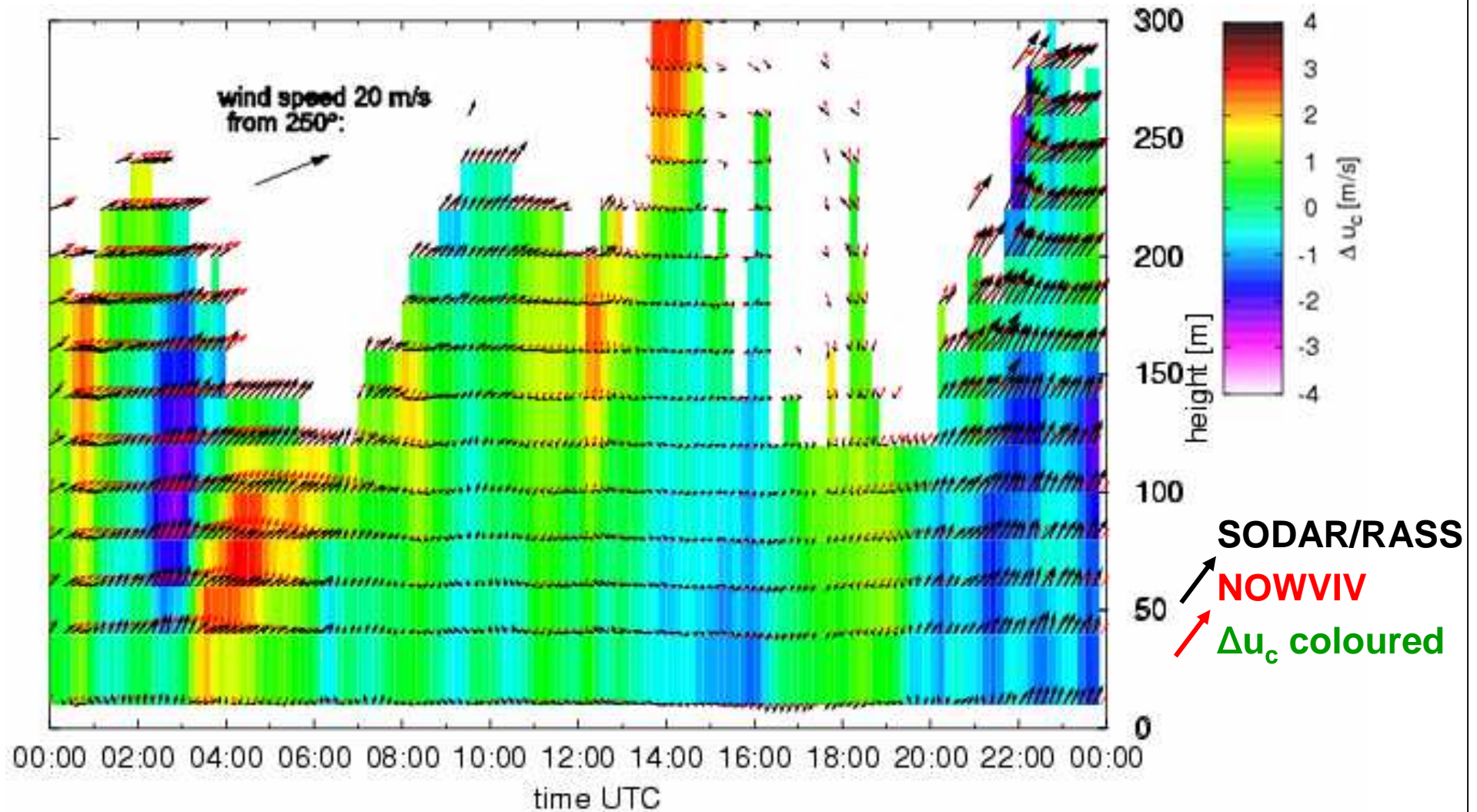
Total wind criteria:  
10,3kt

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

Total wind criteria:  
9,5kt



# WSV: prediction skill on 15.01.07 – DLR



## Open issues or research subjects

- Do we need to adapt the concept for increasing portability and benefit on other airport or to provide toolkit and method for local customisation?
- Analysis and trade-off for defining the wind thresholds
- Acceptability of the safety argument (baseline)?
- How to operationally deal with wind forecasting in today environment?
- How to deal with the lost of awareness for the pilot in today environment?
- Merging of P-TBS and CROPS in a total wind concept

Thank you for your attention!

# Backup slides