Airbus Defence and Space

Signature technology group

Influences of wind farms on modern ASR Radarsytems with consideration of multi-level doppler filter procedures

(The possibilities for the reduction of WT effects on digital atc radars
-Results from own projects and several current measurements-)

Dr.-Ing. A. Frye, Labor für Signaturtechnik
öffentlich bestellter und vereidigter Sachverständiger für Hochfrequenz- und Signaturtechnik
Tel. +049-421-538 -2719
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Airbus Defence and Space GmbH
Abt. Signaturtechnik, Dr. A. Frye
Airbusallee 1
28199 Bremen

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Signaturtechnik Bremen, Dr. - Ing. A. Frye
andreas.frye@airbus.com Tel. 0421 /538 -2719

Presentation:

1. Open questions for the WT- influence on digital ATC-radars

2. The technical possibilities we have today
   a. at the radar ?
   b. at the WT / at the wind farm ?

3. Results / Overview

Signaturtechnik Bremen, Dr. - Ing. A. Frye
andreas.frye@airbus.com Tel. 0421 /538 -2719

1. Open questions for the WT- influence on digital ATC - Radars

WTs (Wind Turbines) will reduce the detection of overflying aircrafts for modern civil and military multi level doppler filter ATC -Radars

- **How strong is the influence of the Windfarm –Layout or Windfarm-Size ?**
- **How strong is the influence of the Aircraft path ?**
- **How strong is the influence of the wind direction ?**
- **How good is a „switch-of"- possibility for the ATC ?**
- **Can we realise a „direction control" at the WT ?**
- **How good is the influence of „low reflection" rotorblades ?**
- **Can we combine some of these options ?**

Signaturtechnik Bremen, Dr. - Ing. A. Frye
andreas.frye@airbus.com Tel. 0421 /538 -2719

2. The technical possibilities do we have today

a. at the radar ?

b. at the WT / at the wind farm ?

At the radar:
- * Remote switch-of possibility for severals Wind turbines
- * Remote switch-of possibility for a complete Windfarm

At the WT :
- * Direction control of the WT / No directions with strong reflections are given
- * use of the direction charakteristics of the WT
- * take the main wind direction into account
- * use of low reflecting rotorblades

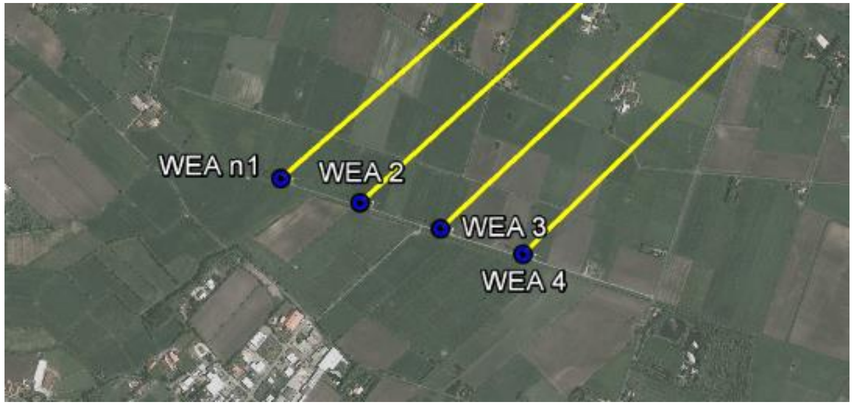
Signaturtechnik Bremen, Dr. - Ing. A. Frye
andreas.frye@airbus.com Tel. 0421 /538 -2719

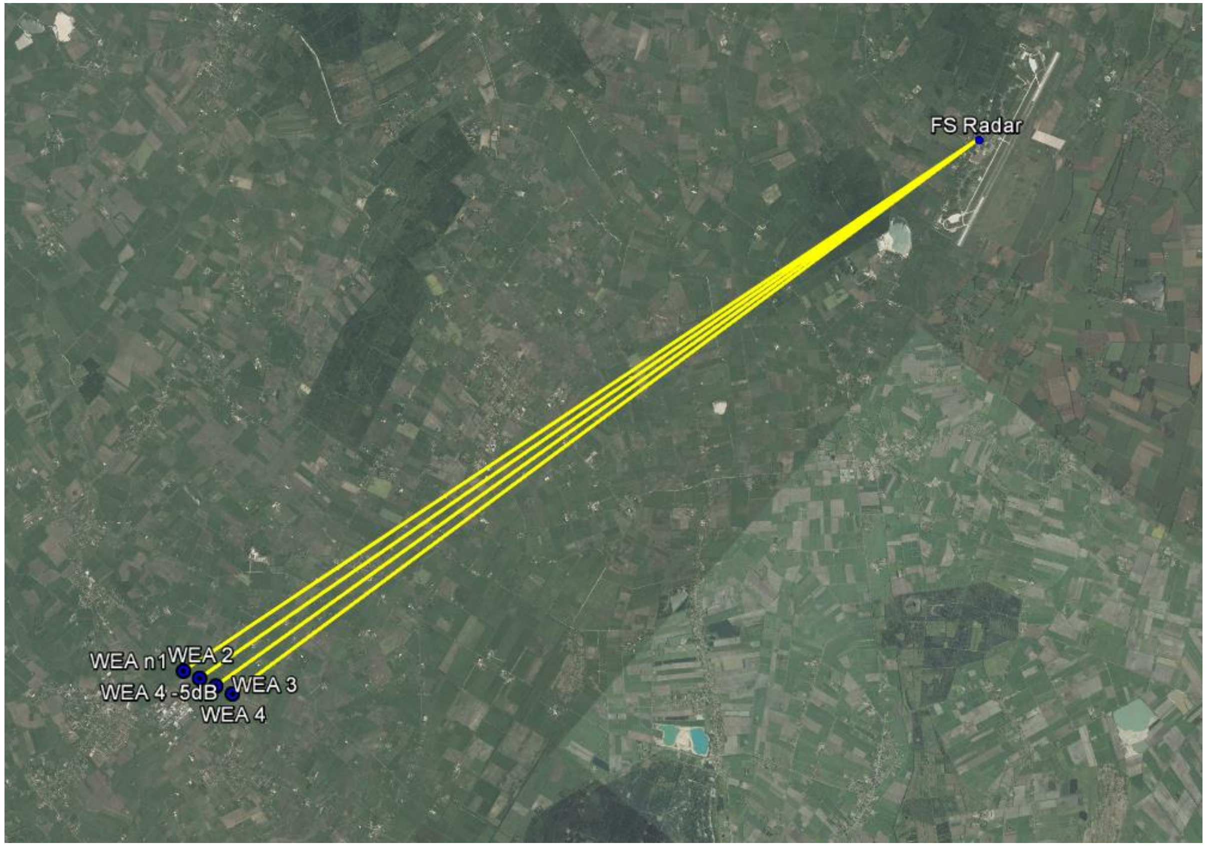
Introduction

Many data recordings / many measurement at modern radars are made in the last few years

Large distance from the atc- radar

Example windfarm:
4 Wind turbines in a row





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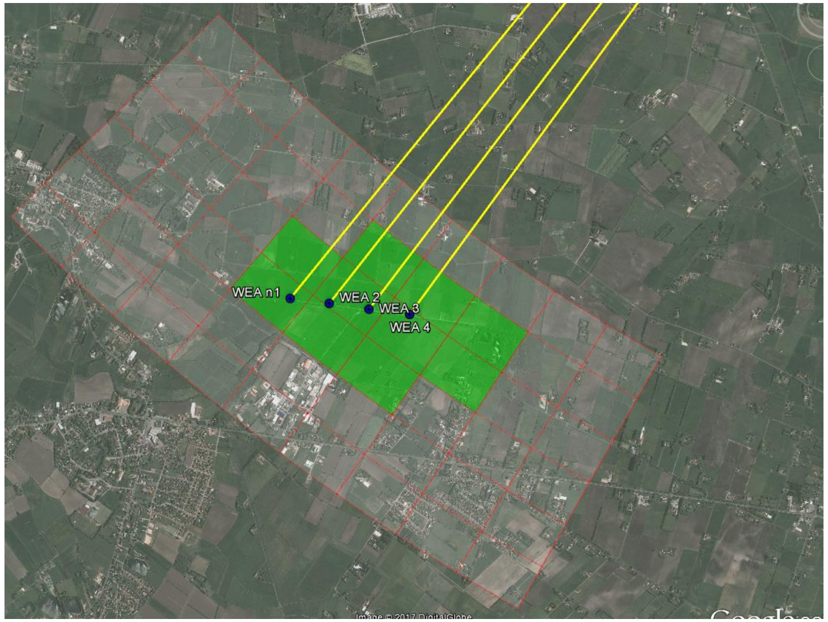

The DCM-Map will be updates ongoing and indicates a average level for each cell.

Ground-Clutter Map (fading out of fixed targets):

The cells show, where an „influence“ by the WEA will be possible.

Digital-Clutter Map (Fading out of moving targets : WTs, traffic, etc.):

The colour of the cells show, where a smart / middle/ strong influence from the Wind turbines on the detection on overflying aircraft can be expected

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andreas.frye@airbus.com Tel. 0421 /538 -2719

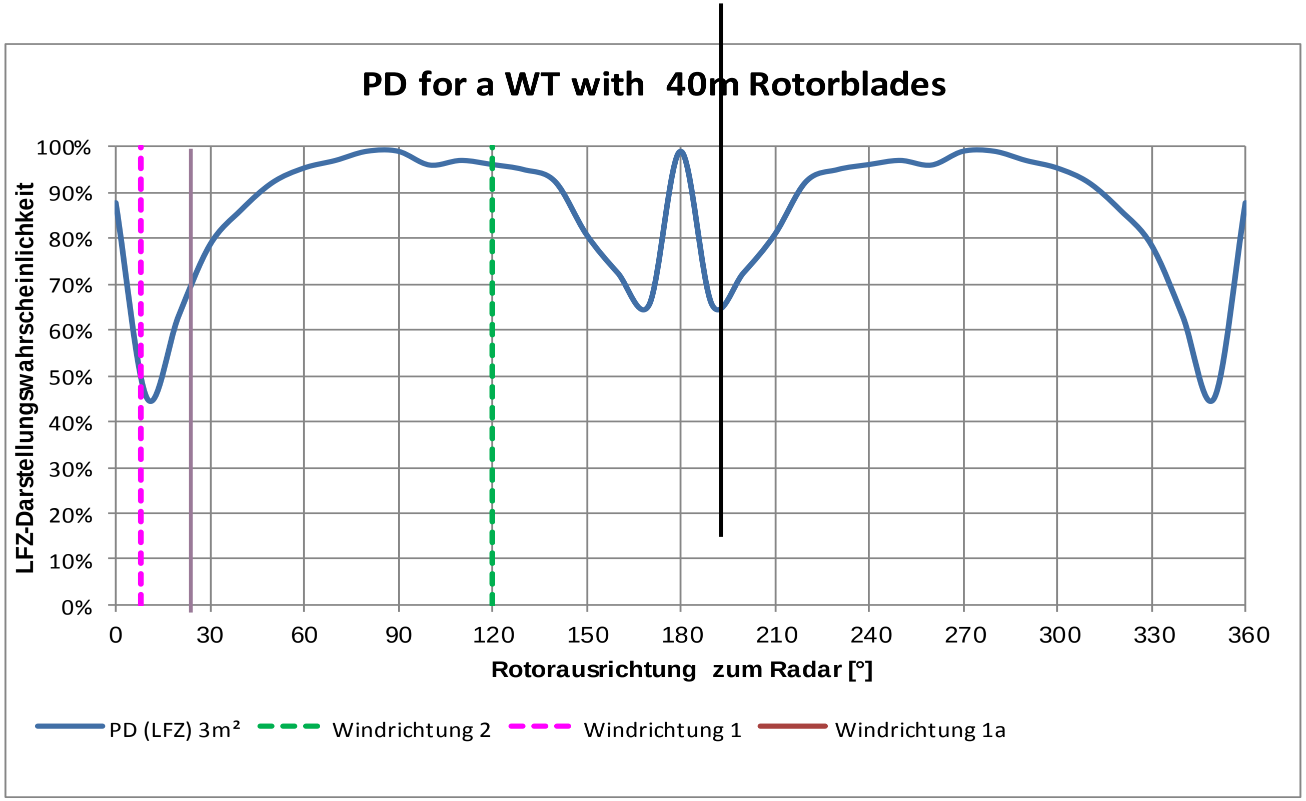
2. The technical possibilities we have today
a. at the Radar ?

- **Direction control of the WT / No directions with strong reflections are given**
- **take the main wind direction into account**
- **use of low reflecting rotorblades**

Typical Reflection characteristic of a wind turbine and Pd of an overflight aircraft:

Rotoraxis direction vs. reflexion characteristics (RQS_{dyn} vs. direction)

Data basic: **analysis of the signal processing unit of an radar manufacturer with an 8-step doppler-filter algorithm**



At 180° : Rotoraxis is orientated to the radar (here we don‘t have an aircraft loss) Chance of the aircraft-detection => 100%)

At 120° : Low Influence on the overflight aircraft detection rate => 95% (Winddirection 2)

At 10° : Clear influence on the overflight aircraft detection rate => 45% (Winddirection 1)

At 20° : Strong influence on the overflight aircraft detection rate => 67% (Winddirection 1a)

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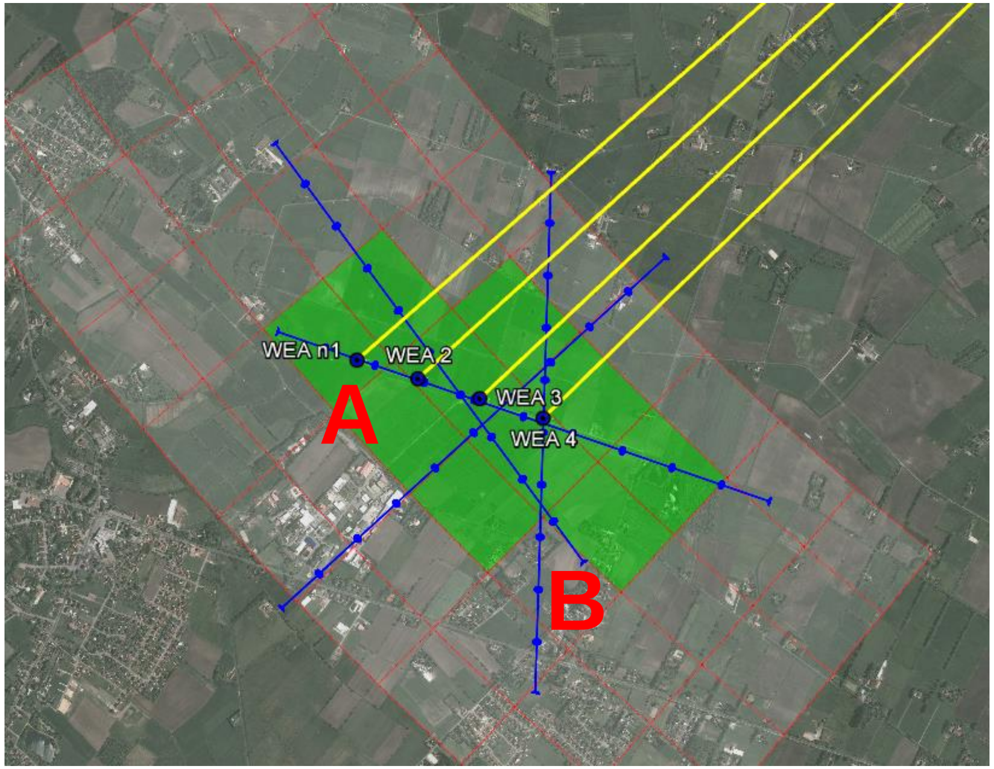
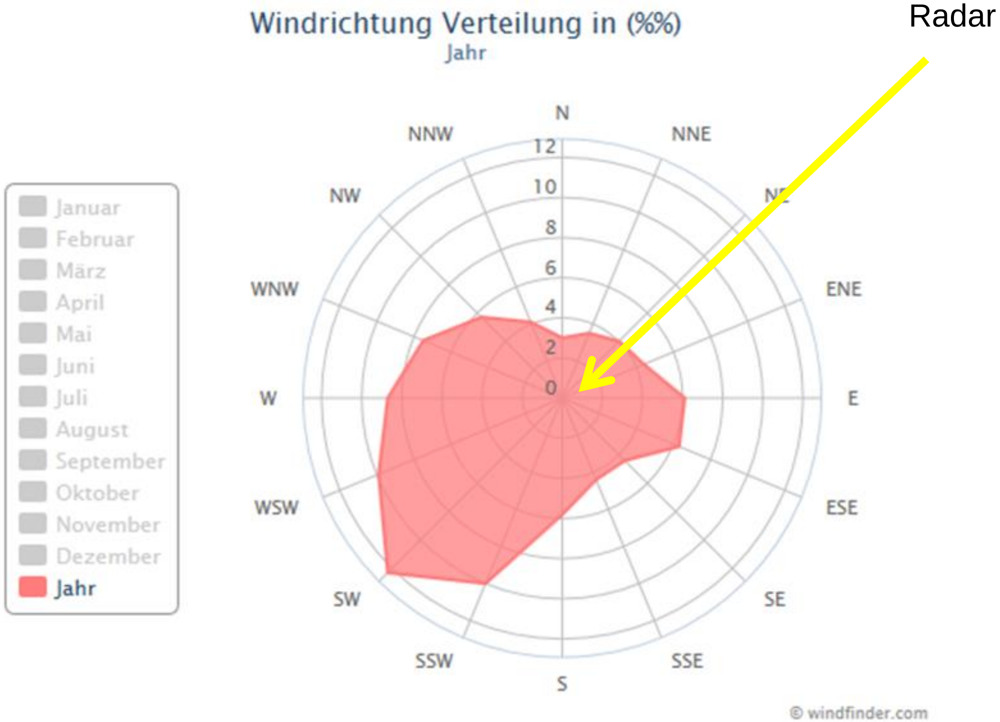
andreas.frye@airbus.com Tel. 0421 /538 -2719

2. The technical possibilities do we have today ?
a. at the radar ?

All wind turbines are orientated in the main wind direction; here 180° to the radar



wind direction distribution



For the main wind direction all cells are green

=> not or very low influence
for flightpath A or B

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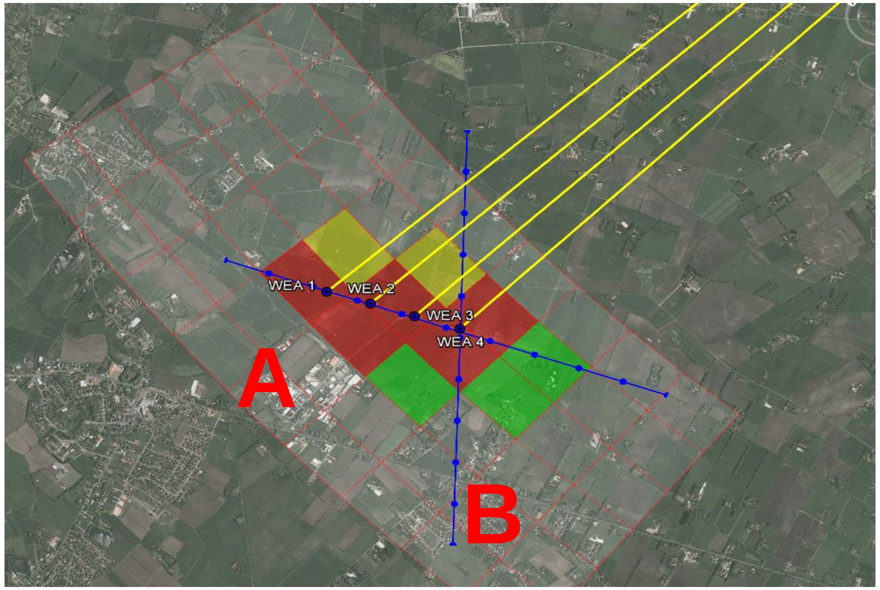
2. The technical possibilities do we have today ?
a. at the radar ?

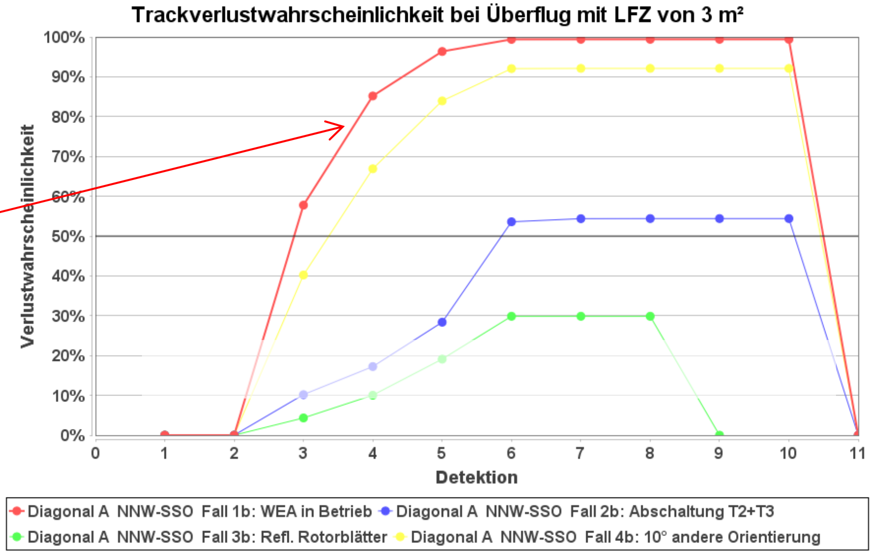
Situation: **all WT operating**
Winddirection 1



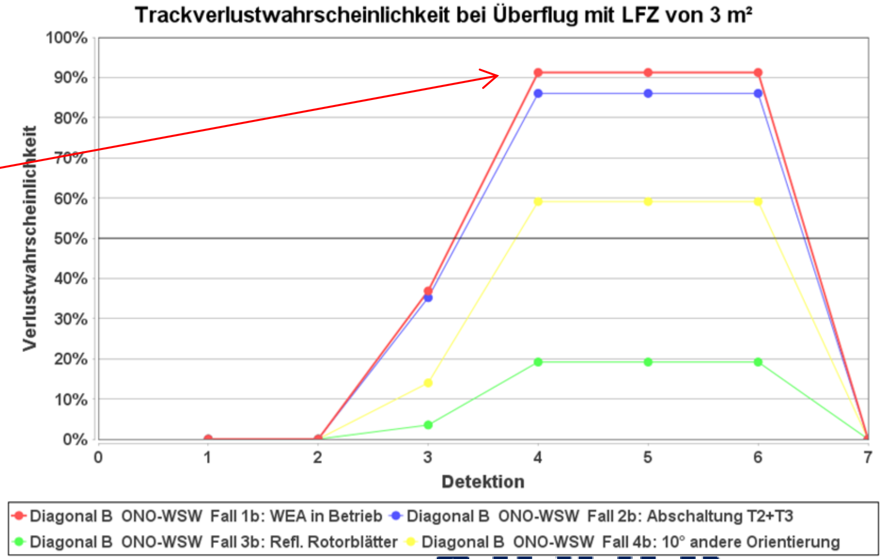
Flight path A
Detection loss rate:
8 detections with ca. 95%

Flight path B
Detection loss rate:
3 detections with ca. 90%

A



B



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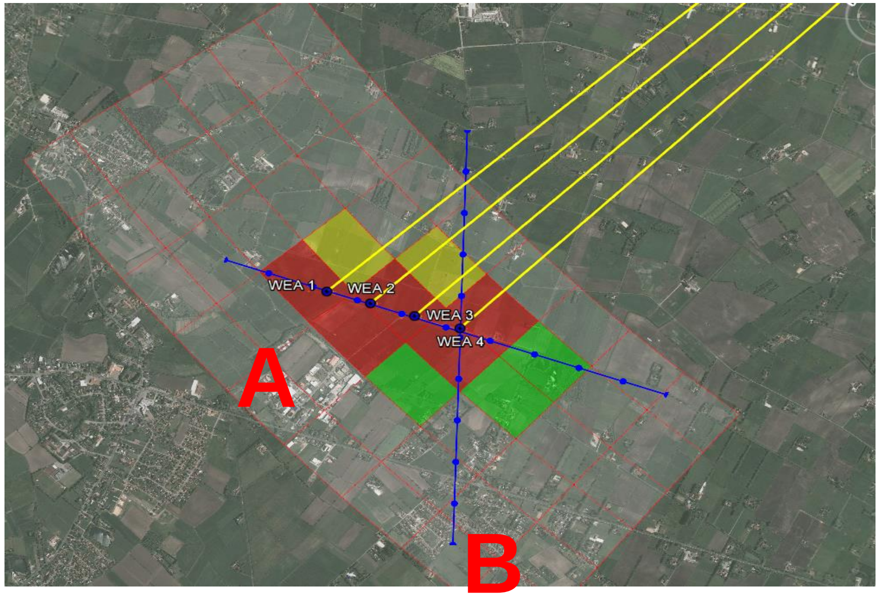
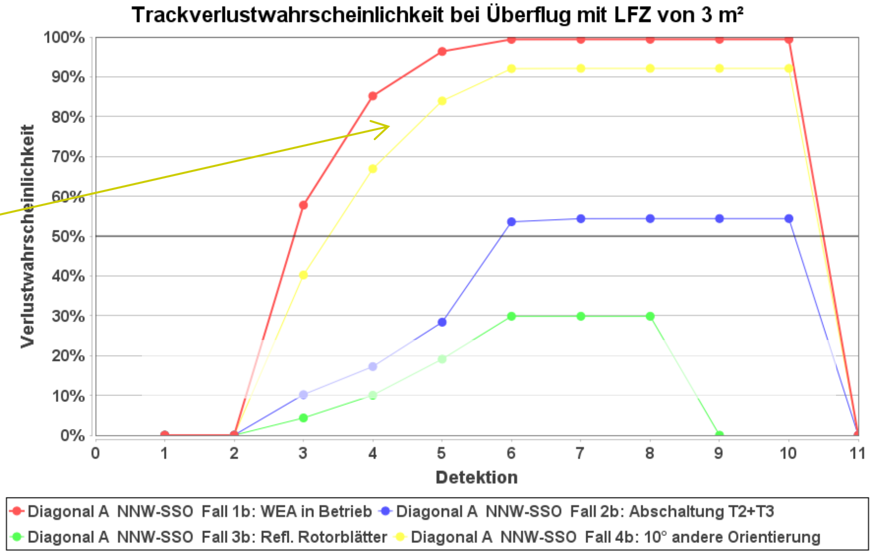
andreas.frye@airbus.com   Tel. 0421 /538 -2719

2. The technical possibilities we have today
a. at the radar ?

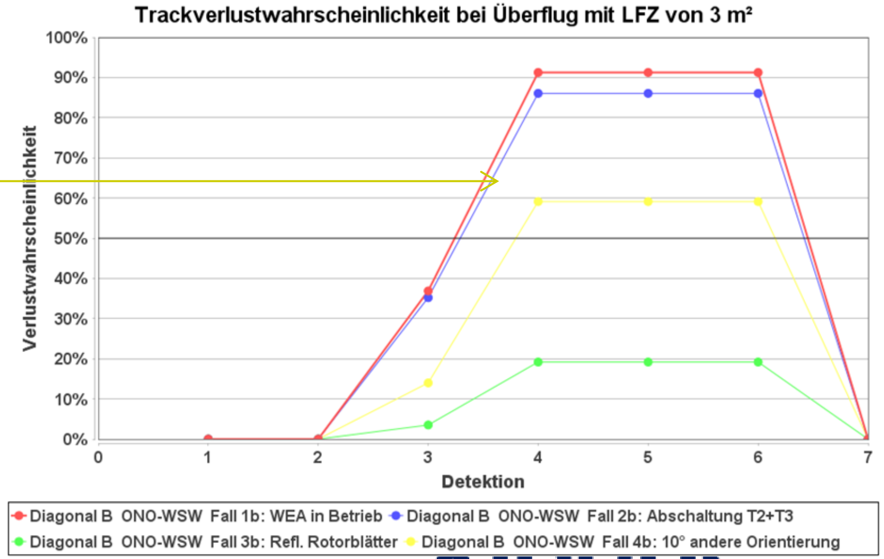
Situation: **all WT operating**
Winddirection 1a



A



B



Flight path A
aircraft track loss for
7 Detektions with ca.93%

Flight path B
aircraft track loss for
3 Detektions with ca.60%

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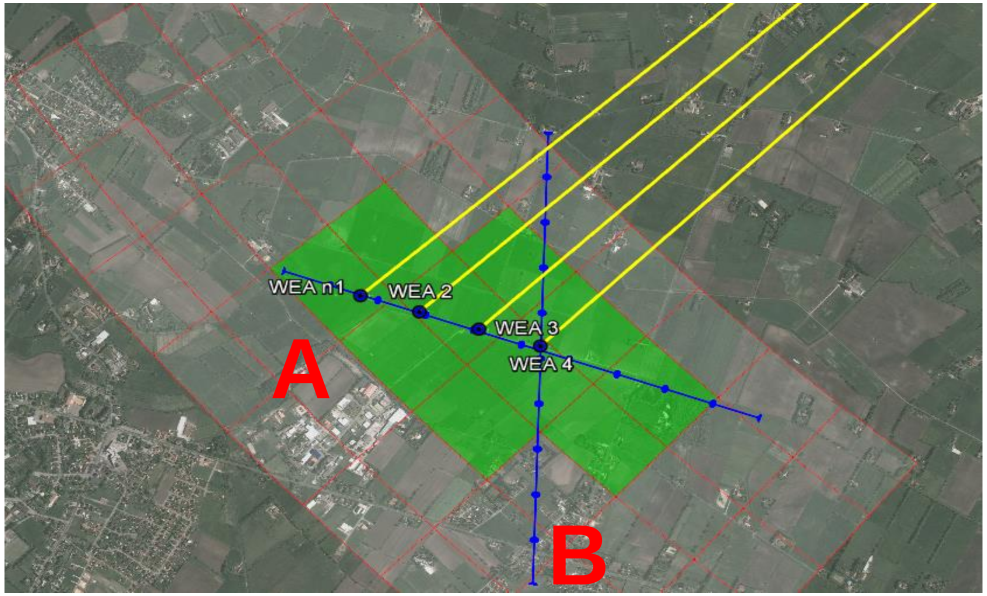
andreas.frye@airbus.com Tel. 0421 /538 -2719

2. The technical possibilities we have today
a. at the radar ?

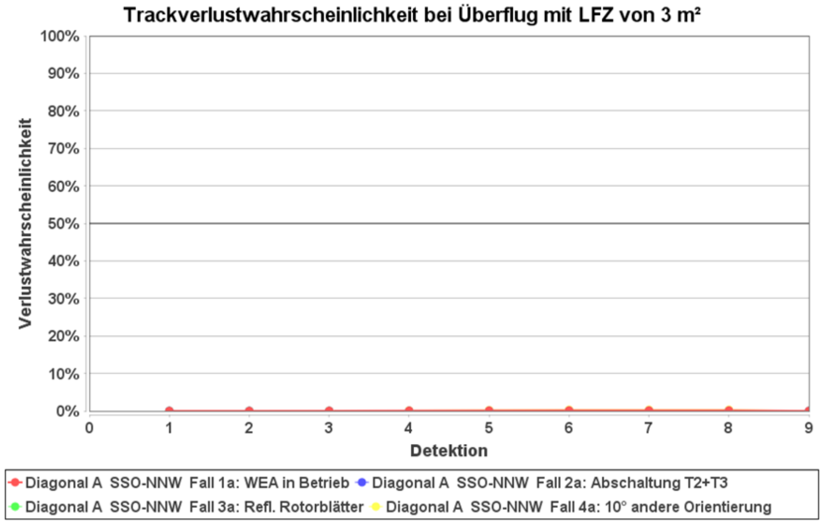
Situation: **all WT operating**
Winddirection 2



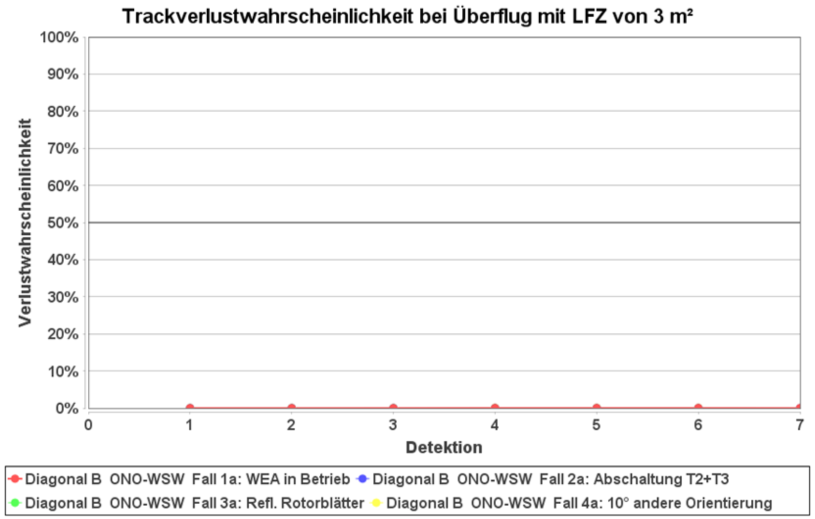
Flight pathA
No aircraft track loss

Flight pathB
No aircraft track loss

A



B



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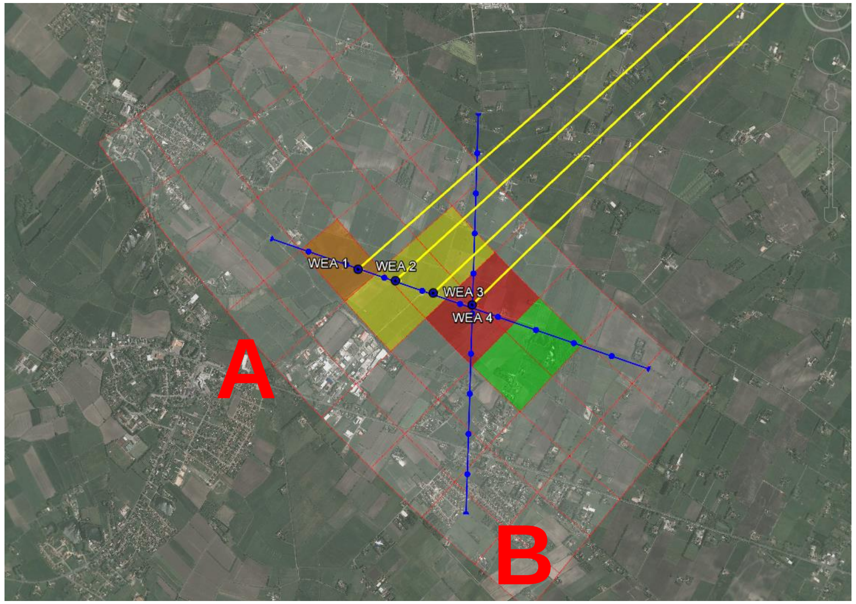
andreas.frye@airbus.com Tel. 0421 /538 -2719

2. The technical possibilities we have today
a. at the radar ?

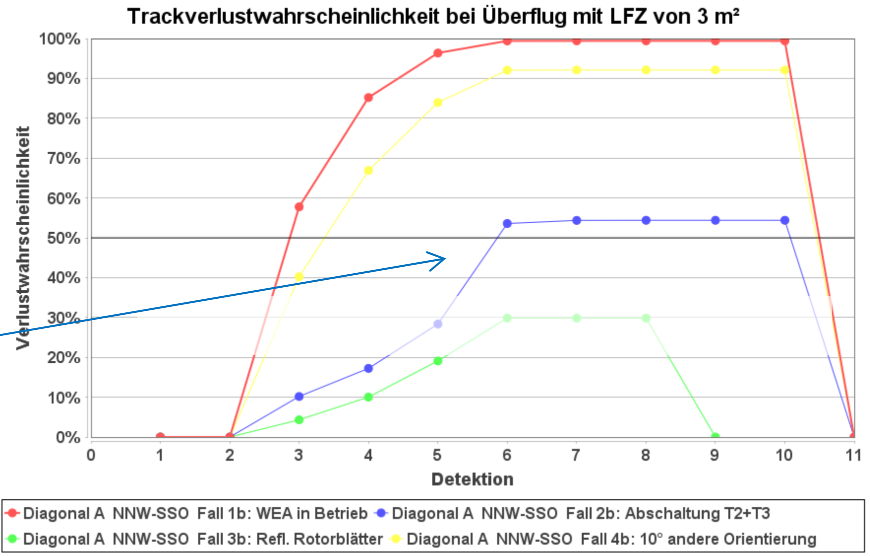
Situation: **WT 2 und 3 not in operation by remote Winddirection 1**



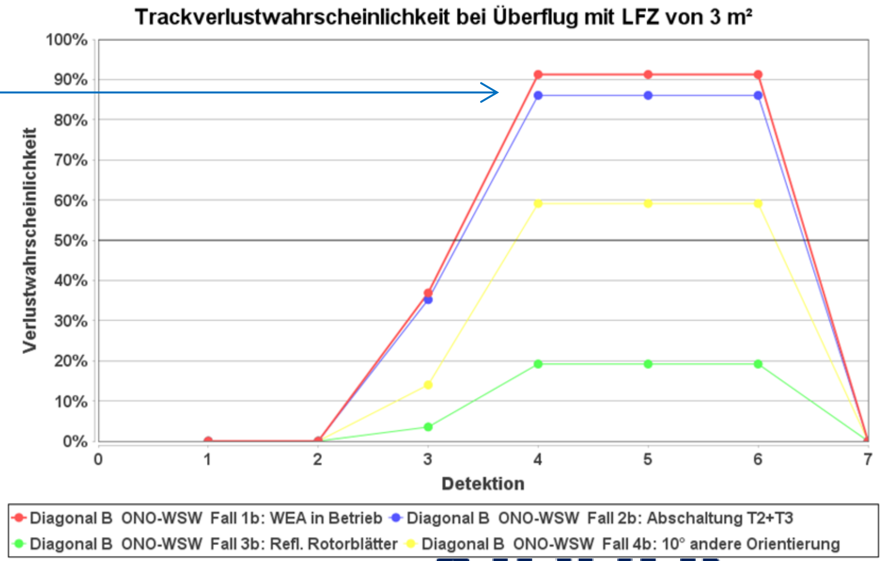
Flight pathA
aircraft track loss for
5 Detektions with ca.55%

Flight path B
aircraft track loss for
3 Detektions with ca.88%

A



B



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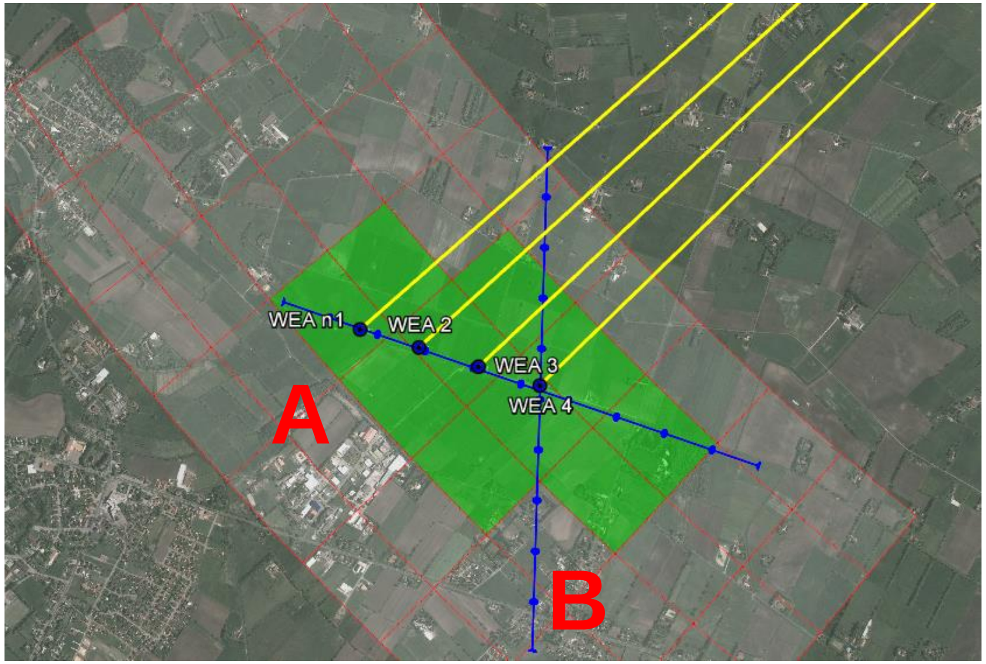
andreas.frye@airbus.com Tel. 0421 /538 -2719

2. The technical possibilities we have today
a. at the radar ?

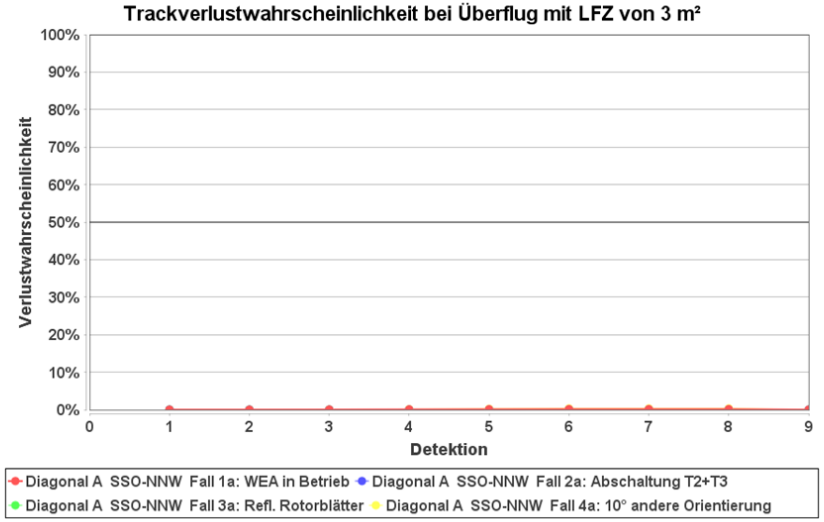
Situation: **WT 2 and 3 not in operation**
(by remote)
Winddirectiong 2



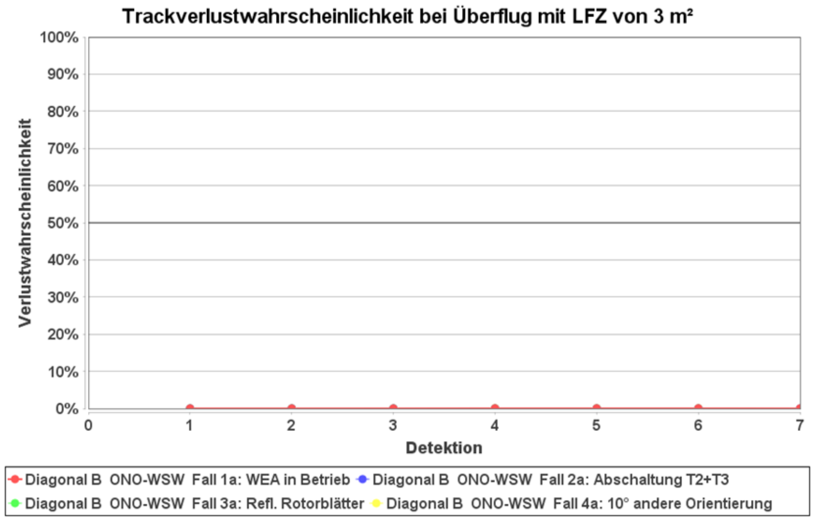
Flight path A
No aircraft track loss

Flight path B
No aircraft track loss

A



B



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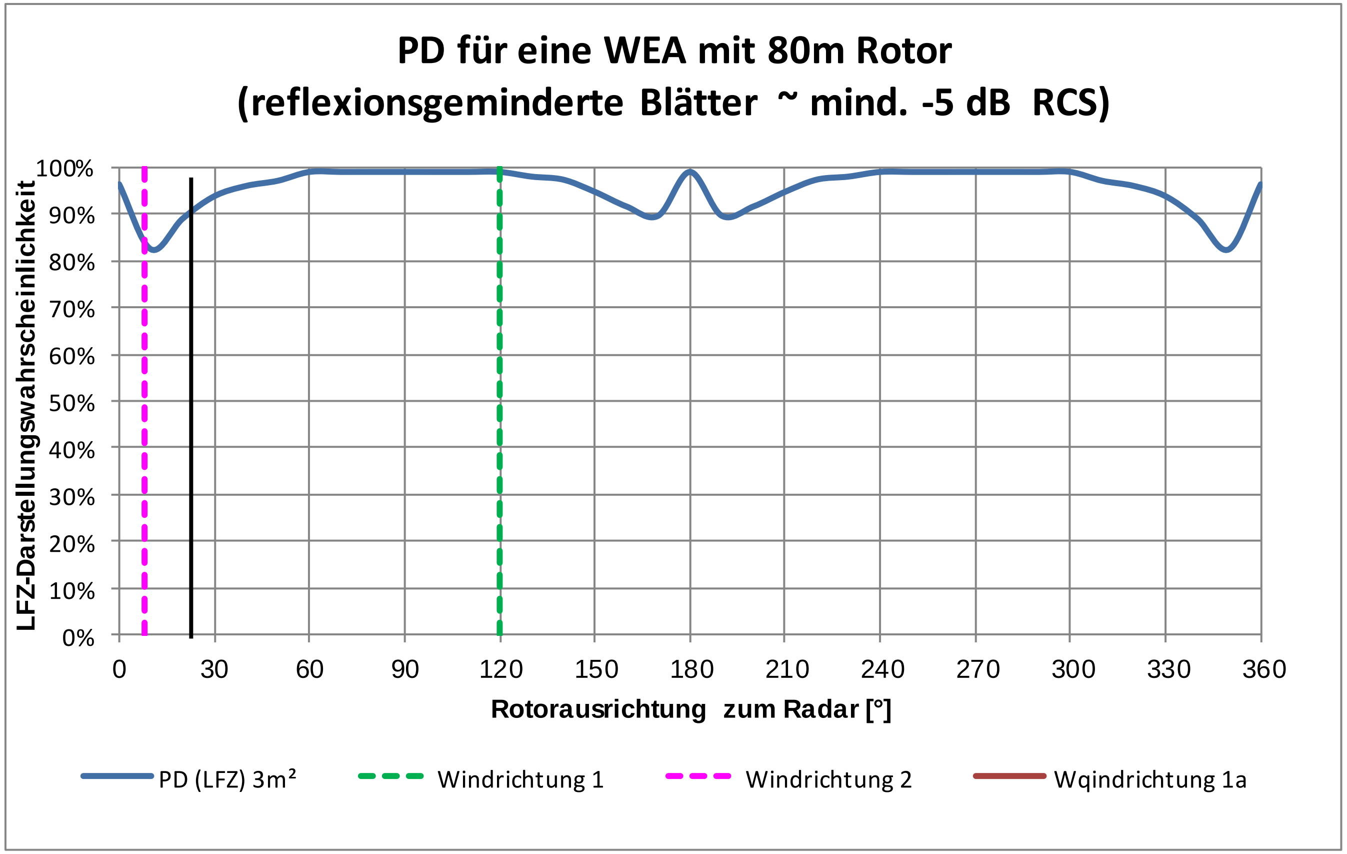
andreas.frye@airbus.com Tel. 0421 /538 -2719

2. The technical possibilities we have today
b. at the WT ?

Low reflecting blades of a wind turbine: **Rotoraxis direction vs. RCS (RQS_{dyn} vs. direction)**



Rotoraxis is orientated to the radar
(here we don't have an aircraft loss)
Chance of the aircraft-detection
=> 100%)

At 120° : Low Influence on the overflight
a/c detection rate => 96%
(Winddirection 2)

At 10° : Clear influence on the overflight
a/c detection rate => 82%
(Winddirection 1)

At 20° : Strong influence on the overflight
a/c detection rate => 89%
(Winddirection 1a)

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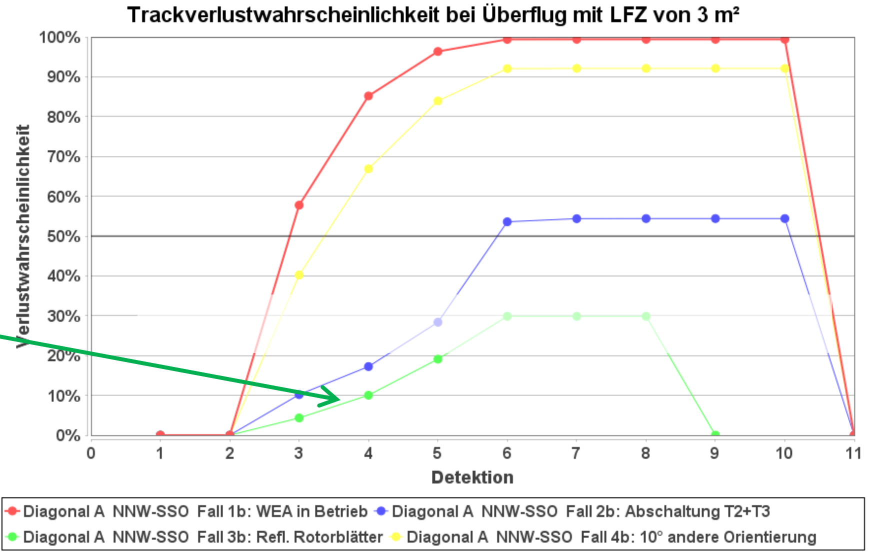
andreas.frye@airbus.com Tel. 0421 /538 -2719

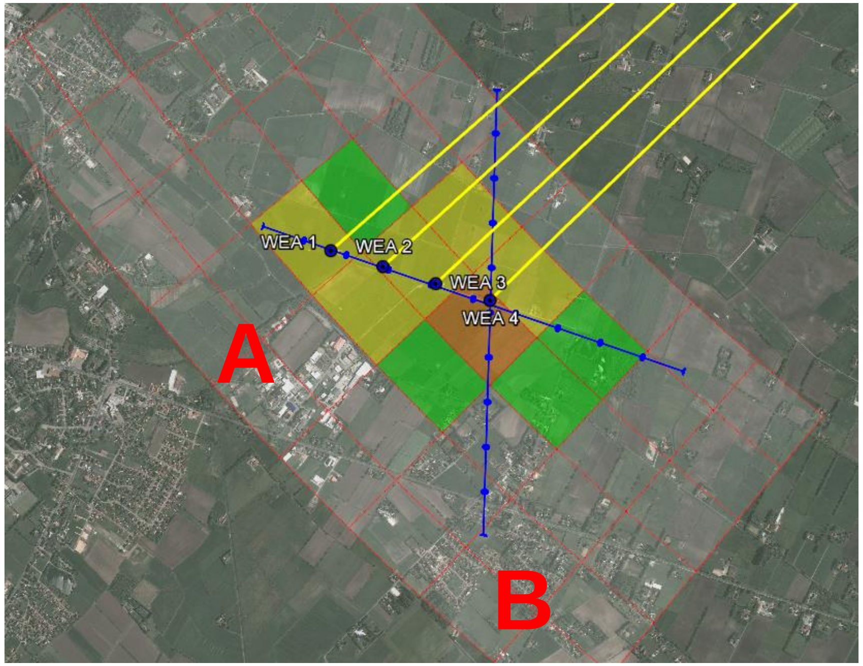
2. The technical possibilities we have today

b. at the WT ?

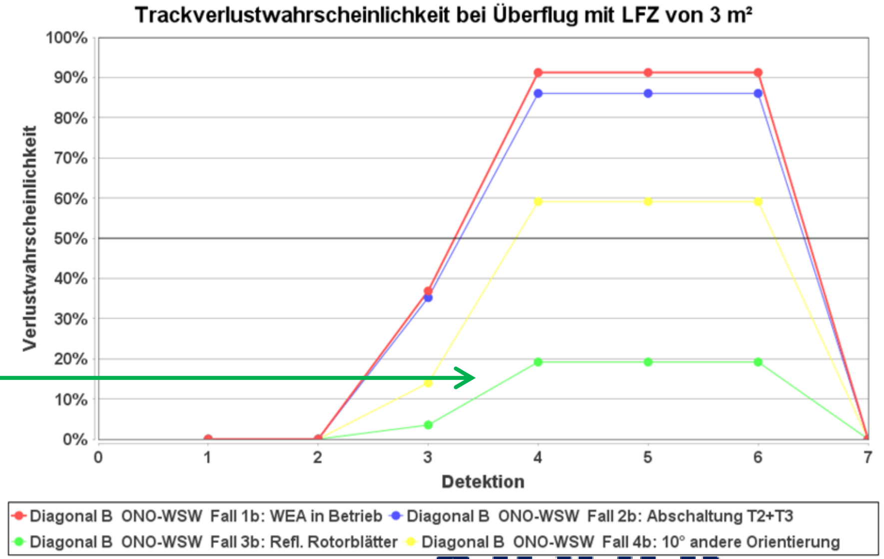
Situation: **all WT operating**
low reflecting blades
Winddirection 1

A





B



Flight path A
No aircraft track loss
(under 30%)

Flight path B
No aircraft track loss
(unter 20%)

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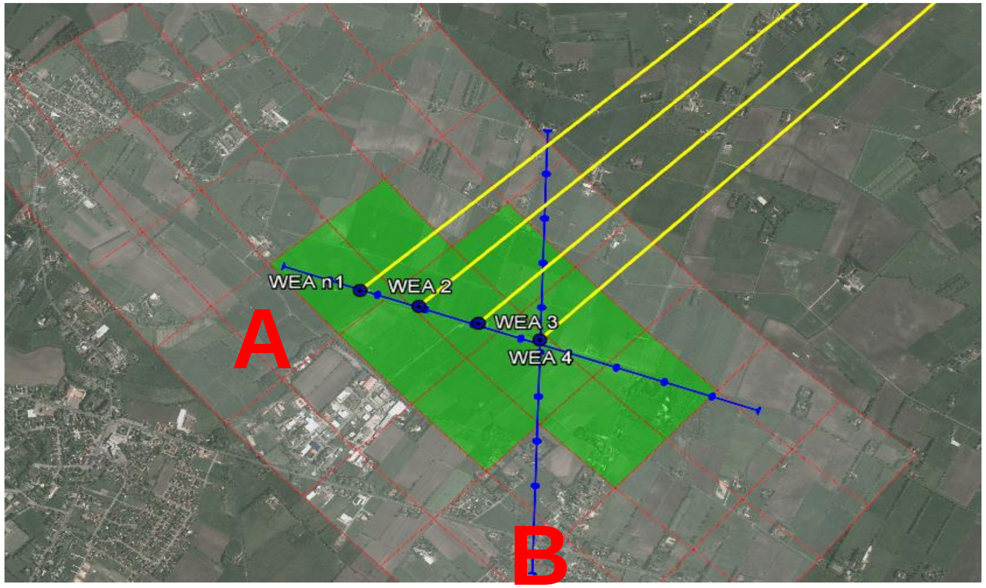
andreas.frye@airbus.com Tel. 0421 /538 -2719

2. The technical possibilities we have today

b. at the WT ?

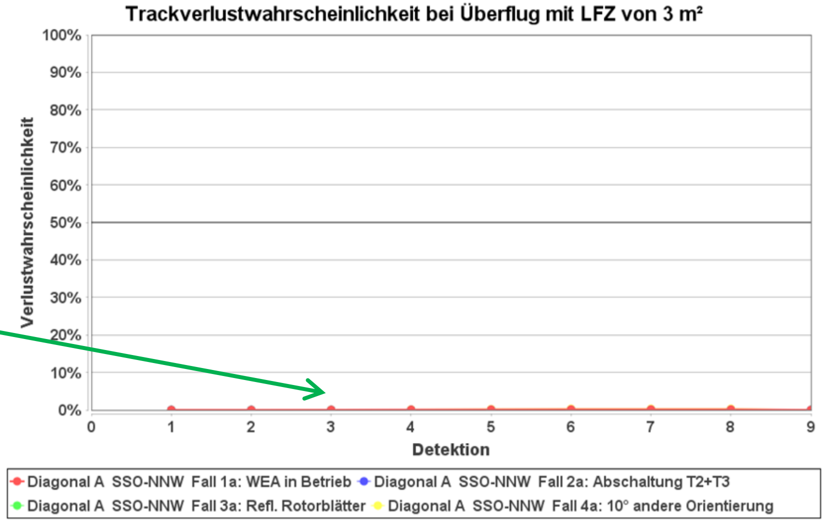
Situation: **all WT operating**
low reflecting Blades
Winddirections 1a and 2



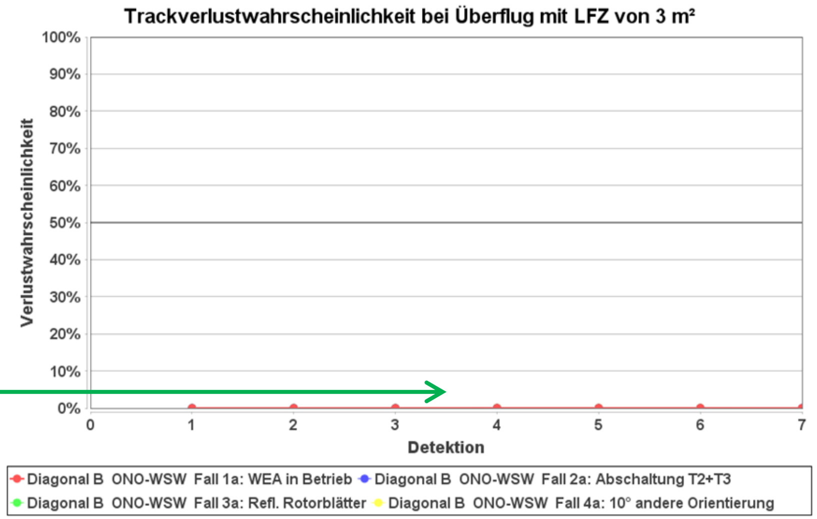
Flight path A
No aircraft track loss

Flight path B
No aircraft track loss

A



B



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andreas.frye@airbus.com Tel. 0421 /538 -2719

3. Summary

Option:	Flightpath A	Flightpath B
All WT operating (Winddirection 1) (Winddirection1a) (Winddirection 2)	8 Detectionen with 95%(40 sek.) 7 Detektionen with 93% (35 sek.) track loss	5 Detektionen with 90% (25 sek.) 3 Detektionen with 60% (15 sek.) track loss
Wt 2 +3 remote Switch off (Winddirection 1) (Winddirection 2)	5 Detections with 55%(25sek.) track loss	3 Detections with 88% (15sek.) track loss
All WT operating (Low reflecting blades) (Winddirection 1) (Winddirection 2)	6 Detections with 30% no track loss	4 Detections under 30% no track loss
All WT operating (no critical WT orientations & low reflecting blades) (Winddirection 1a) (Winddirection 2)	All Wind directions: Detections under 30% = no track loss	All Wind directions: Detectiones under 10% = no track loss

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Danke für Ihre Aufmerksamkeit

Thank you for your attention