CYBERHAWK

Aerial Inspection and Surveying Specialists

WTG Blade Inspection & Asset Management Using Drones

Contents

About CYBERHAWK

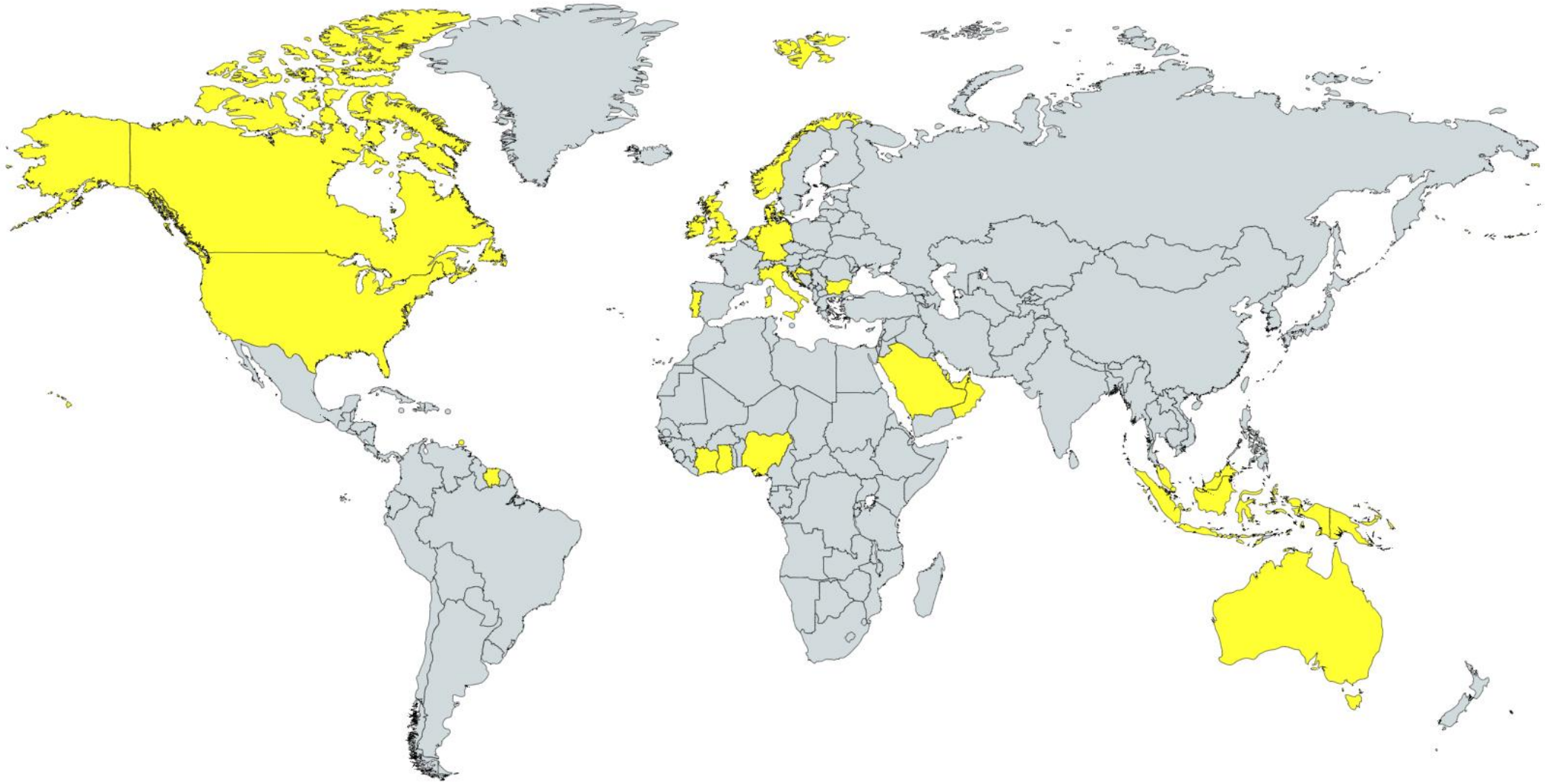
Cyberhawk At A Glance

- World Leaders
  - UAV inspection, survey & visual asset management
  - Sectors: Wind , Oil and Gas, Utilities, Infrastructure

- Safe and Proven
  - Founded in 2008
  - >30,000 commercial flights safely executed


CYBERHAWK Team
>50 Members of Staff
>15 Operational Field Teams
Pilots
Inspection Engineers
Surveyors
Software Developers

Global Experience



Selected Clients

Our Experience

Offshore Wind Farms

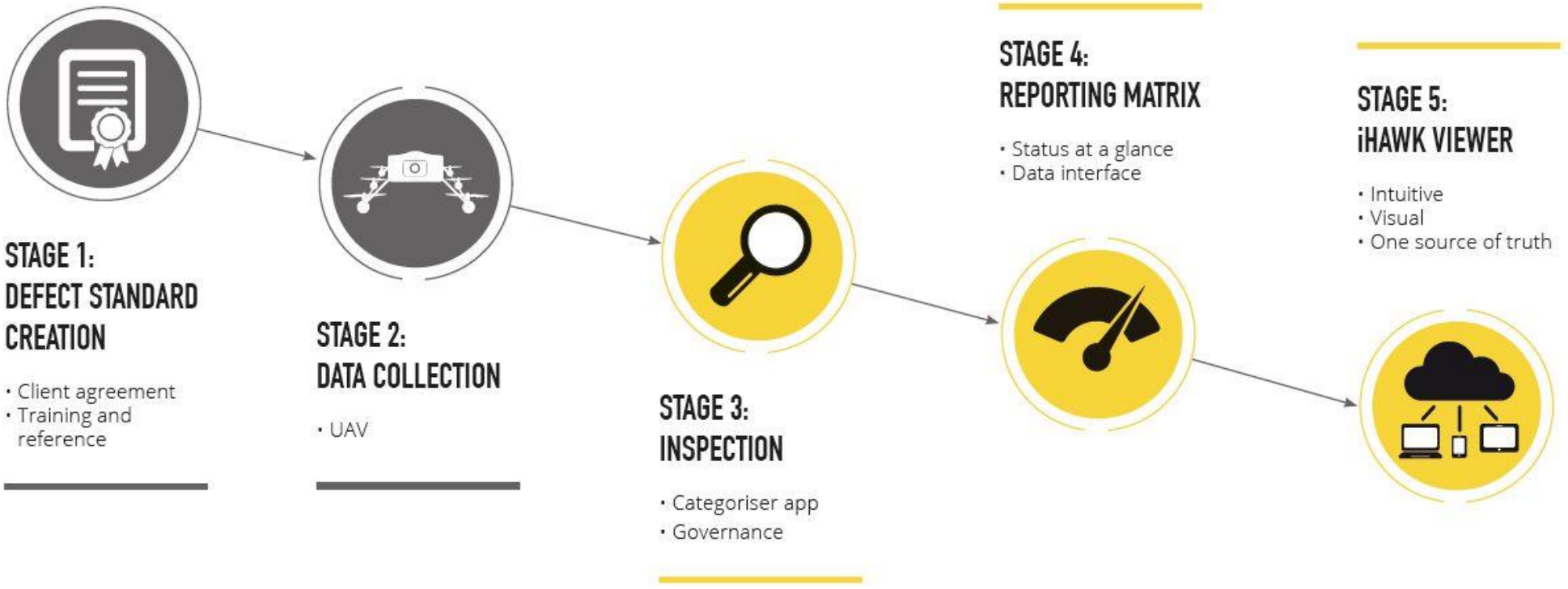
- Anholt
- BorWin
- Docking Shoal
- Dogger Bank
- Greater Gabbard
- HelWin
- Lincs
- Moray
- Race Bank
- Rhyl Flats
- Robin Rigg
- SylWin
- Teesside
- Trianel
- West of Duddon Sands

Onshore Wind Farms

- Scotland
- Republic of Ireland
- Northern Ireland
- England
- Denmark
- Germany
- Croatia
- Turkey

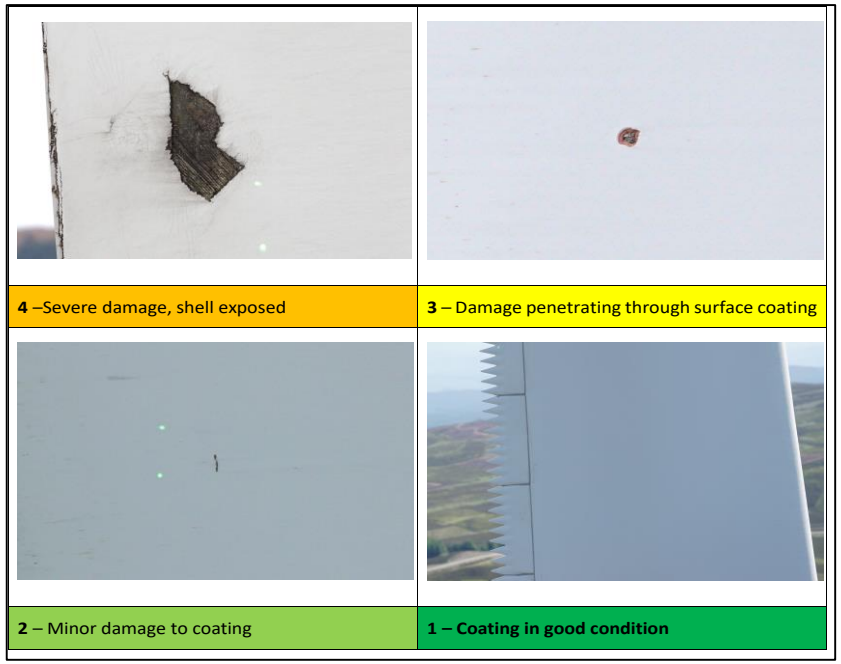
UAV Blade Inspection

Cyberhawk Blade Inspection Process



- A ‘Defect Standard Manual’ is created and agreed with the client
- The manual has condition ratings from 1-5 (1 = good condition, 5 = bad condition) or to the client's specification
- The manual includes an example image against each condition for each component to remove subjectivity

1	Good Condition
2	Superficial Damage
3	Functional Damage
4	Structural Damage: May Cause Turbine Stoppage
5	Substantial Structural Damage – Stop Turbine



Defect Standard | Data Collection | Inspection | Reporting Matrix | iHawk Viewer

- 1 x Pilot, 1 x Inspector + UAV equipment for on site data collection
- 100% image coverage for every blade
- Average onshore collection speed 4-10 turbines per day

- 2 Person Team = Pilot & Blade Inspector
- Pilot
  - CAA Pilot Qualification
  - Trained to fly fully manually to increase safety
- Inspector
  - Engineer who ensures correct images captured
  - Identifies safety critical defect before detailed inspection at office
- Drone
  - 8 independent rotors to ensure redundancy & safety
  - Light and small = 2kg & 1m

- Inspection engineers and in-house developed software used for inspection
- Accurate defect measurement and positioning:
  - +/-5mm on defect sizing
  - +/-0.5m on defect location from root
- Quality Assurance process to ensure inspection accuracy

Defect Standard | Data Collection | Inspection | Reporting Matrix | iHawk Viewer

- Categorised and approved data summarised into a “traffic light” RAG status Summary Reporting Matrix for each site
- High level overview of the site condition can be seen at a glance

WTG Data			Rotor Blades											
			Blade - SGL-0538				Blade - SGL-0540				Blade - SGL-0541			
WTG No	Inspection Date	WGS 84– Lat/Long	Pressure Side	Suction Side	Leading Edge	Trailing Edge	Pressure Side	Suction Side	Leading Edge	Trailing Edge	Pressure Side	Suction Side	Leading Edge	Trailing Edge
WTG 1	28-06-2016		3	3	3	2	3	3	3	1	3	2	3	3
WTG 2	28-06-2016		2	1	4	2	2	2	3	2	2	1	3	2
WTG 3	29-06-2016		2	2	4	1	2	2	3	2	3	3	3	2
WTG 4	06-09-2017		3	2	4	2	2	3	3	3	1	3	4	2
WTG 5	06-09-2017		1	3	4	2	4	2	4	2	1	2	4	3
WTG 6	05-09-2017		3	1	3	4	3	2	4	1	4	1	4	2
WTG 7	05-09-2017		1	2	4	3	4	2	4	1	1	2	4	1
WTG 8	05-09-2017		4	2	4	2	1	3	4	2	2	2	4	2
WTG 9	06-09-2017		3	3	4	2	2	3	4	1	3	2	4	2
WTG 10	29-06-2016		3	3	3	1	3	3	3	2	3	3	3	1
WTG 11	06-09-2017		2	2	3	2	3	3	4	2	2	2	3	2
WTG 12	06-09-2017		4	1	4	3	1	2	4	2	2	1	4	3
WTG 13	24-08-2017		3	2	3	3	3	2	3	2	3	2	3	3
WTG 14	29-06-2016		2	2	3	2	2	2	4	2	2	2	4	2
WTG 15	29-06-2016		3	3	4	2	3	3	3	2	3	2	3	2
WTG 16	30-06-2016		3	3	3	2	3	3	3	2	2	3	3	1
WTG 17	24-08-2017		4	2	4	2	3	1	3	2	4	2	4	2
WTG 18	30-06-2016		3	3	3	3	3	3	4	1	3	3	4	3
WTG 19	30-06-2016		3	3	3	2	3	2	4	1	3	3	3	3
WTG 20	01-07-2016		3	3	3	1	3	3	4	1	3	3	3	1

- A Detailed Reporting Matrix for each blade is then provided
- 1000's of inspection findings and high definition images of a wind farm captured for an "at a glance" status
- Defect trends easily visible
- Maintenance priorities clearly identified

			Leading Edge									Trailing Edge									Pressure Side									Suction Side									
Blade	Inspection Date	WGS 84 - Lat/Long	Deformation	Bonding deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Aerodynamic Aids	Surface contamination	Other	Deformation	Bonding Deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Aerodynamic Aids	Surface contamination	Other	Deformation	Bonding deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Surface contamination	Balance Weight	Other	Deformation	Bonding Deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Surface contamination	Drain Hole	Aerodynamic Aids	Balance Weights	Other
SGL-0486	05-09-2017		1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1

Defect Standard | Data Collection | Inspection | Reporting Matrix | iHawk Viewer

i HAWK
BY CYBERHAWK

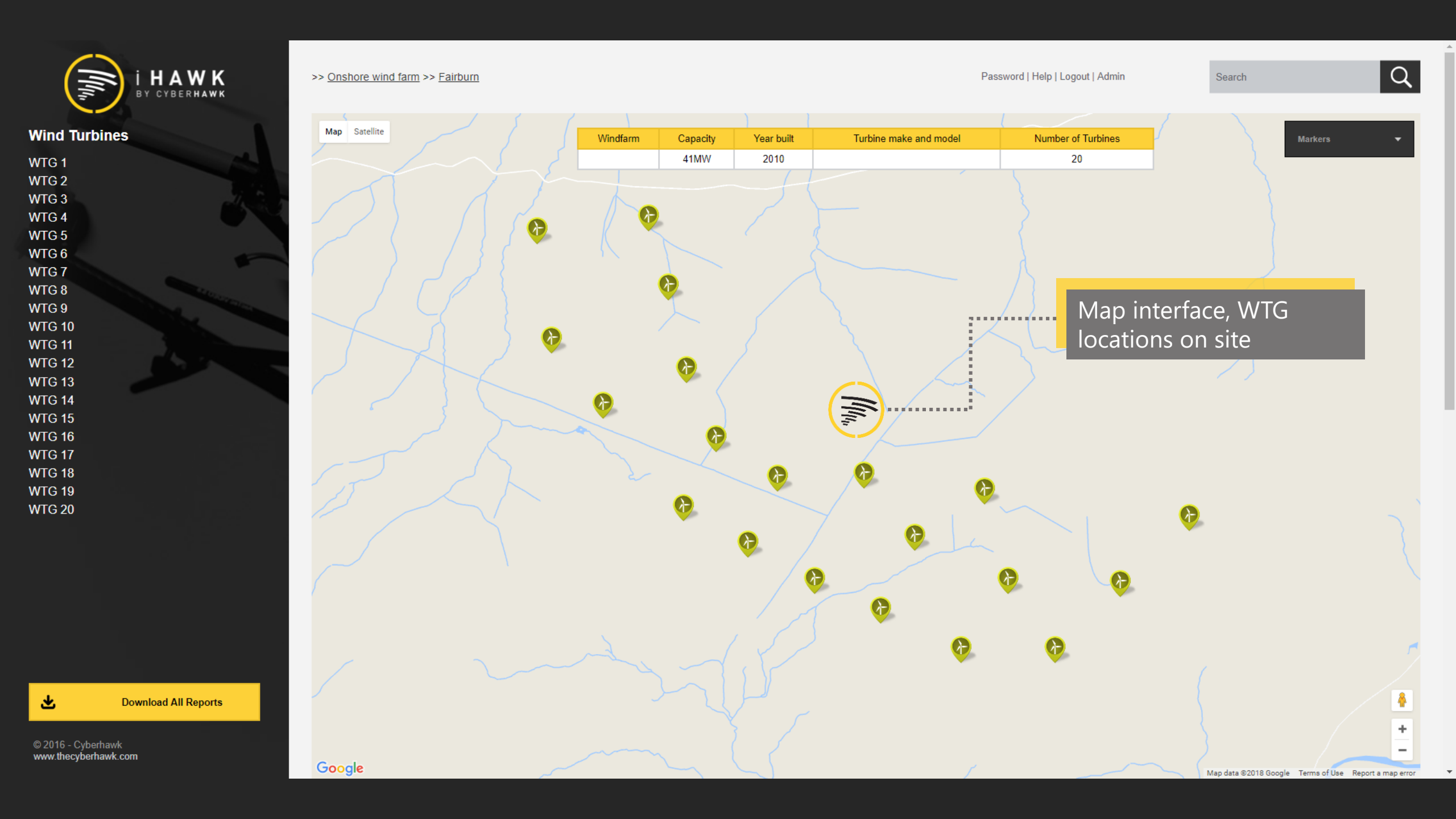
Wind Farms

>> Onshore wind farm

Password | Help | Logout | Admin

Search

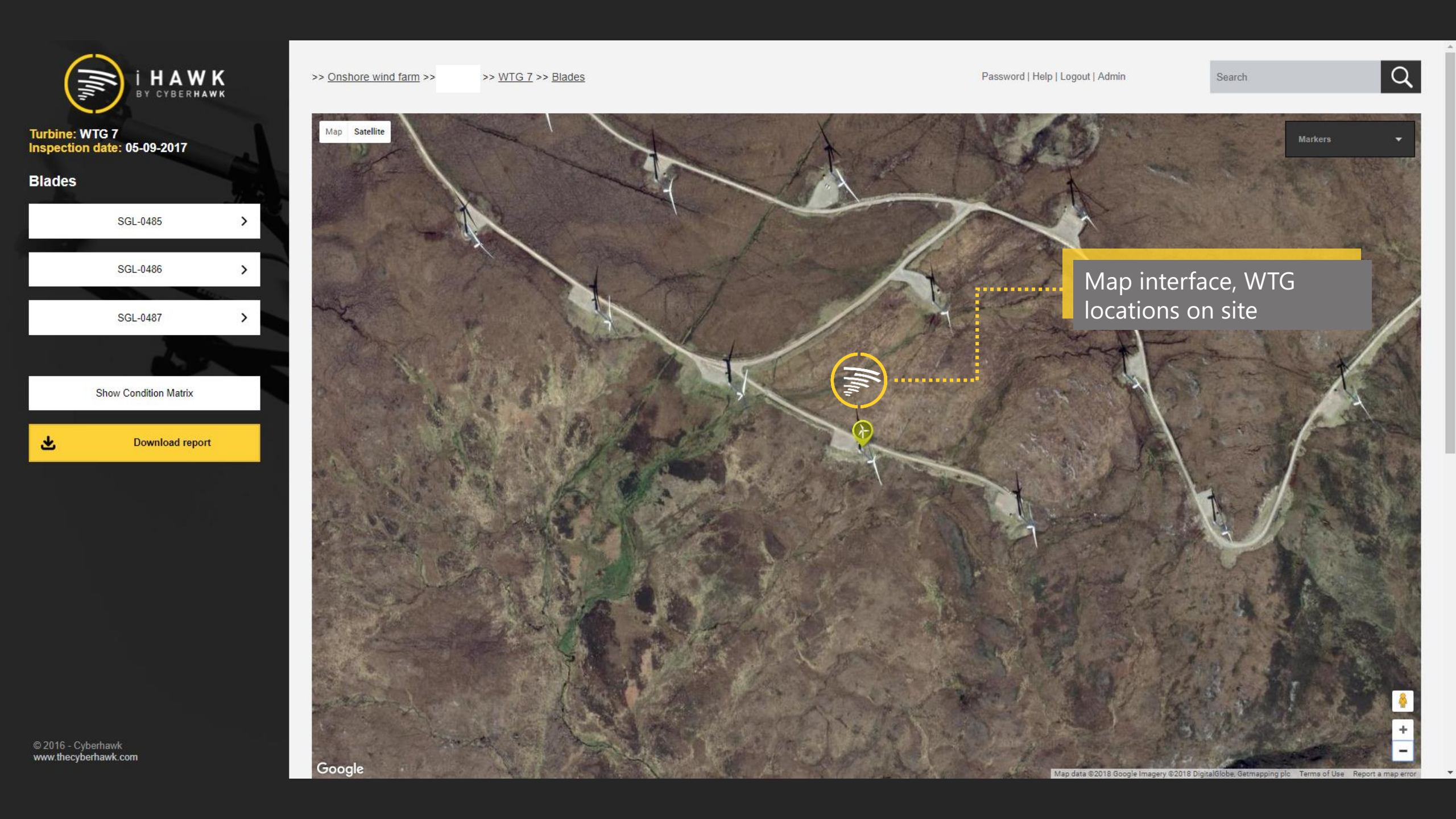
Map interface, wind farm locations


i HAWK
BY CYBERHAWK
Wind Turbines
WTG 1
WTG 2
WTG 3
WTG 4
WTG 5
WTG 6
WTG 7
WTG 8
WTG 9
WTG 10
WTG 11
WTG 12
WTG 13
WTG 14
WTG 15
WTG 16
WTG 17
WTG 18
WTG 19
WTG 20
Download All Reports
© 2016 - Cyberhawk
www.thecyberhawk.com
>> Onshore wind farm >> Fairburn
Password | Help | Logout | Admin
Search
Map
Satellite
Windfarm
Capacity
Year built
Turbine make and model
Number of Turbines
41MW
2010
20
Markers
Map interface, WTG locations on site
Google
Map data ©2018 Google
Terms of Use
Report a map error

WTG Data			Rotor Blades											
			Blade - SGL-0538				Blade - SGL-0540				Blade - SGL-0541			
WTG No	Inspection Date	WGS 84- Lat/Long	Pressure Side	Suction Side	Leading Edge	Trailing Edge	Pressure Side	Suction Side	Leading Edge	Trailing Edge	Pressure Side	Suction Side	Leading Edge	Trailing Edge
WTG 1	28-06-2016		3	3	3	2	3	3	3	1	3	2	3	3
WTG 2	28-06-2016		2	1	4	2	2	2	3	2	2	1	3	2
WTG 3	29-06-2016		2	2	4	1	2	2	3	2	3	3	3	2
WTG 4	06-09-2017		3	2	4	2	2	3	3	3	1	3	4	2
WTG 5	06-09-2017		1	3	4	2	4	2	4	2	1	2	4	3
WTG 6	05-09-2017		3	1	3	4	3	2	4	1	4	1	4	2
WTG 7	05-09-2017		1	2	4	3	4	2	4	1	1	2	4	1
WTG 8	05-09-2017		4	2	4	2	1	3	4	2	2	2	4	2
WTG 9	06-09-2017		3	3	4	2	2	3	4	1	3	2	4	2
WTG 10	29-06-2016		3	3	3	1	3	3	3	2	3	3	3	1
WTG 11	06-09-2017		2	2	3	2	3	3	4	2	2	2	3	2
WTG 12	06-09-2017		4	1	4	3	1	2	4	2	2	1	4	3
WTG 13	24-08-2017		3	2	3	3	3	2	3	2	3	2	3	3
WTG 14	29-06-2016		2	2	3	2	2	2	4	2	2	2	4	2
WTG 15	29-06-2016		3	3	4	2	3	3	3	2	3	2	3	2
WTG 16	30-06-2016		3	3	3	2	3	3	3	2	2	3	3	1
WTG 17	24-08-2017		4	2	4	2	3	1	3	2	4	2	4	2
WTG 18	30-06-2016		3	3	3	3	3	3	4	1	3	3	4	3
WTG 19	30-06-2016		3	3	3	2	3	2	4	1	3	3	3	3
WTG 20	01-07-2016		3	3	3	1	3	3	4	1	3	3	3	1

5	Substantial Structural Damage
4	Structural Damage
3	Functional Damage
2	Superficial Damage
1	Good working condition

Wind farm summary reporting matrix


i HAWK
BY CYBERHAWK
Turbine: WTG 7
Inspection date: 05-09-2017
Blades
SGL-0485
SGL-0486
SGL-0487
Show Condition Matrix
Download report
© 2016 - Cyberhawk
www.thecyberhawk.com
>> Onshore wind farm >> >> WTG 7 >> Blades
Password | Help | Logout | Admin
Search
Map
Satellite
Markers
Map interface, WTG locations on site
Google
Map data ©2018 Google Imagery ©2018 DigitalGlobe, Getmapping plc
Terms of Use
Report a map error

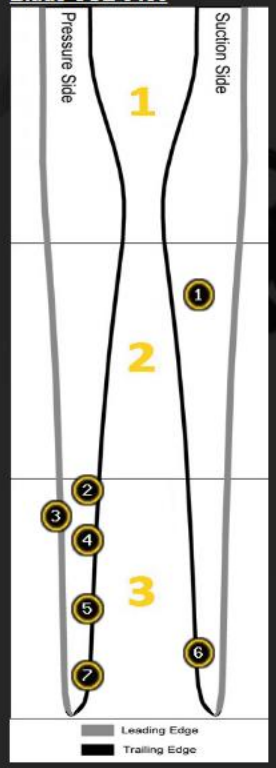
iHAWK BY CYBERHAWK

>> Onshore wind farm >> [redacted] >> WTG 7 >> Blades >> SGL-0486

Password | Help | Logout | Admin

Search

Turbine: WTG 7
Inspection Date: 05-09-2017
Blade SGL-0486



LE
TE
PS
SS
LE
TE
PS
SS
LE
TE
PS
SS

Defects on blade schematic & access to all images

Previous Finding

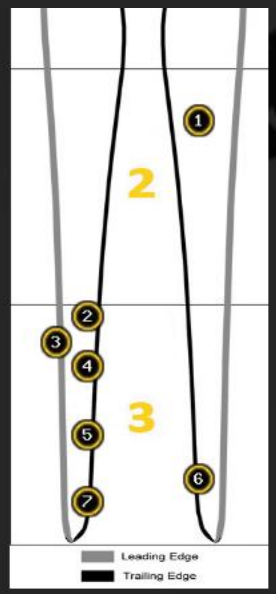
Image 2 of 4

Next Finding

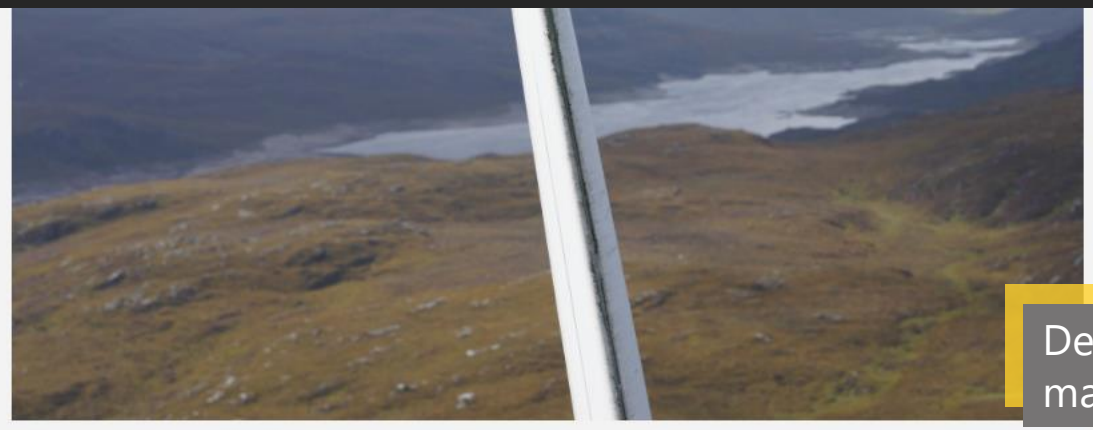
Finding no	7	Distance from root (m)	39.1	Defect Class	4
Finding Type	Coating Damage	Distance from LE (m)	0	Condition	Structural Damage
Comment	LE heavy erosion on bond line.				

Gallery

All images sorted by *Distance from Root*



SS | LE | TE | PS | SS | LE | TE | PS | SS



Detailed blade defect matrix

Previous Finding

Image 2 of 4

Next Finding

Finding no	7	Distance from root (m)	39.1	Defect Class	4
Finding Type	Coating Damage	Distance from LE (m)	0	Condition	Structural Damage
Comment	LE heavy erosion on bond line.				

Gallery

All images sorted by *Distance from Root*

All Findings | All Images | Defect 3 or 4

			Leading Edge									Trailing Edge									Pressure Side									Suction Side										
Blade	Inspection Date	WGS 84 - Lat/Long	Deformation	Bonding deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Aerodynamic Aids	Surface contamination	Other	Deformation	Bonding Deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Aerodynamic Aids	Surface contamination	Other	Deformation	Bonding deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Surface contamination	Balance Weight	Other	Deformation	Bonding Deficiencies	Transportation or impact damage	Coating Damage	Cracks/Fractures	Lightning Damage	Surface contamination	Drain Hole	Aerodynamic Aids	Balance Weights	Other
SGL-0486	05-09-2017		1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1

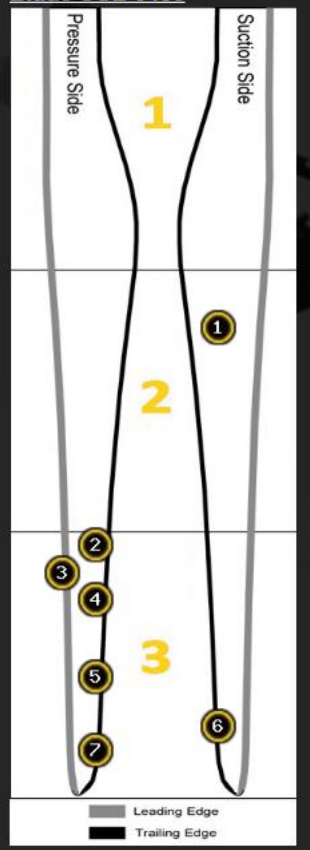
i HAWK
BY CYBERHAWK

>> Onshore wind farm >> [redacted] >> WTG 7 >> Blades >> SGL-0486

Password | Help | Logout | Admin

Search

Turbine: WTG 7
Inspection Date: 05-09-2017
Blade SGL-0486



LE
TE
PS
SS
LE
TE
PS
SS
LE
TE
PS
SS

Zoom into detail

Previous Finding

Image 2 of 4

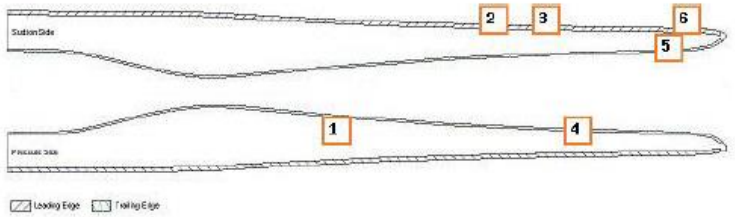
Next Finding

Finding no	7	Distance from root (m)	39.1	Defect Class	4
Finding Type	Coating Damage	Distance from LE (m)	0	Condition	Structural Damage
Comment	LE heavy erosion on bond line.				

Gallery

All images from section 3, Leading Edge - Sorted by *Distance from Root*

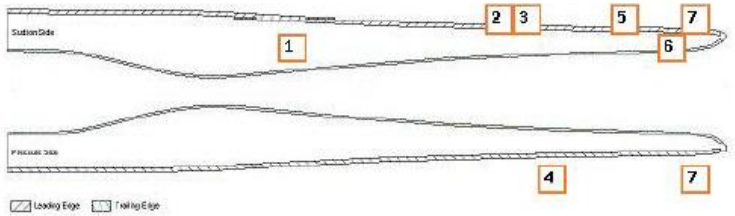
Findings Overview - Blade SGL-0485



#	Description	Cat.
1	TE surface contamination.	2
3	LE erosion.	3
5	Impact marks.	2

#	Description	Cat.
2	LE early stage erosion.	2
4	Possible TE crack.	3
6	LE erosion on bond line.	4

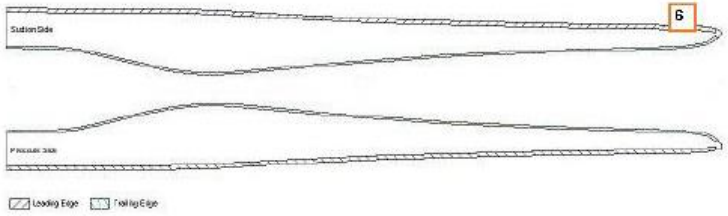
Findings Overview - Blade SGL-0486



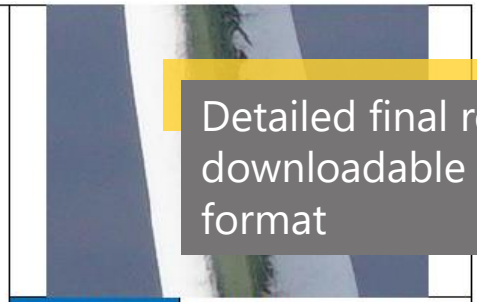
#	Description	Cat.
1	Surface contamination.	2
3	LE minor coating damage.	2
5	LE erosion.	3
7	LE heavy erosion on bond line.	4

#	Description	Cat.
2	LE early stage erosion.	2
4	Minor coating damage.	2
6	Minor coating damage.	2

Rotor Blade	SGL-0485	Finding no	6	Defect class	4	View
PS		SS		LE	X	TE	
Distance from root (m)	37.6			Distance from LE	0	
Finding description	LE erosion on bond line.					



Picture ref : DSC03054.JPG_tagged_report_1.jpg



Picture ref : DSC03054.JPG_tagged_report_2.jpg

Picture ref : DSC03051.JPG_tagged_report_1.jpg

Detailed final reports in downloadable PDF format

Onshore Inspection


~200 mm


~200 mm

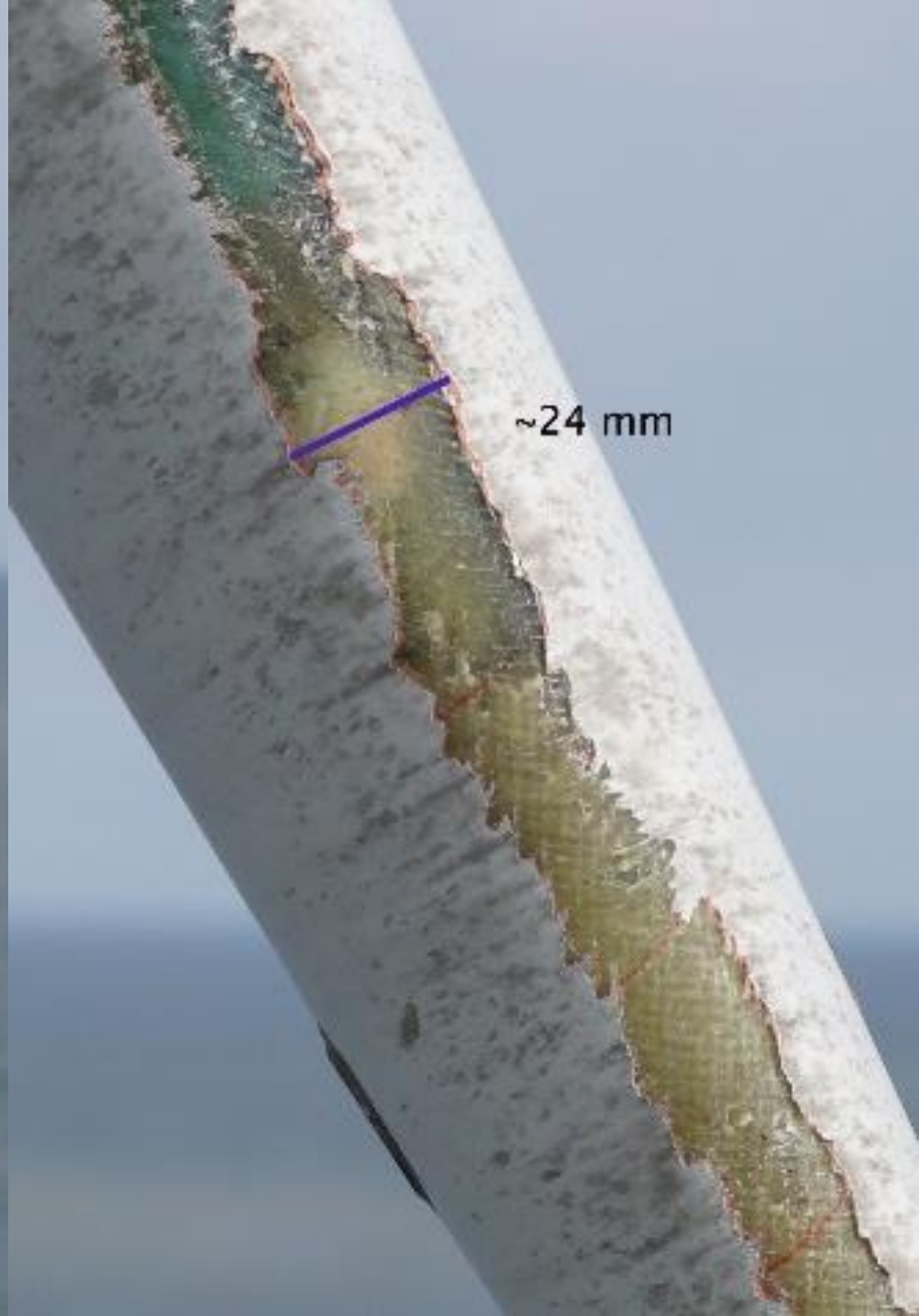

~200 mm


~ 37 mm


~530 mm
~ 100 mm

Offshore Inspection

Blade Inspection



Nacelle Inspection

Picture ref.:	DSC02120.JPG

Picture ref.:	DSC02120.JPG

Tower Inspection

Picture ref.:	DSC01815.JPG

Picture ref.:	DSC01815.JPG

Picture ref.:	DSC01837.JPG

Picture ref.:	DSC01837.JPG

Transition Piece Inspection

Picture ref.:	DSC01767.JPG

Picture ref.:	DSC01767.JPG

Splash Zone Inspection

Picture ref.:	DSC01759.JPG

Picture ref.:	DSC01759.JPG

Picture ref.:	DSC01759.JPG

Offshore Substation Inspection

CYBERHAWK
Aerial Inspection and Surveying Specialists

Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK
Aerial Inspection and Surveying Specialists

– Superstructure

West Elevation

Superstructure shell in good condition throughout with no signs of coating breakdown or deterioration.

Photo: DSC02830.jpg

Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK
Aerial Inspection and Surveying Specialists

– External Gangways

East Elevation

External walkway and support steelwork in good condition with no signs of coating breakdown and corrosion. No signs of damage or deformation.

Photo: DSC03520.jpg

Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK
Aerial Inspection and Surveying Specialists

– Crown Plates

Leg B2
View Looking South East

Crown plates in good condition with no obvious signs of cracks or deterioration to welded connections. All coatings in good condition throughout.

Photo: DSC00879.jpg

Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK
Aerial Inspection and Surveying Specialists

– Cable Access Tower

View Looking North West

Minor areas of coating breakdown at waterline however no signs of significant scaling and corrosion.

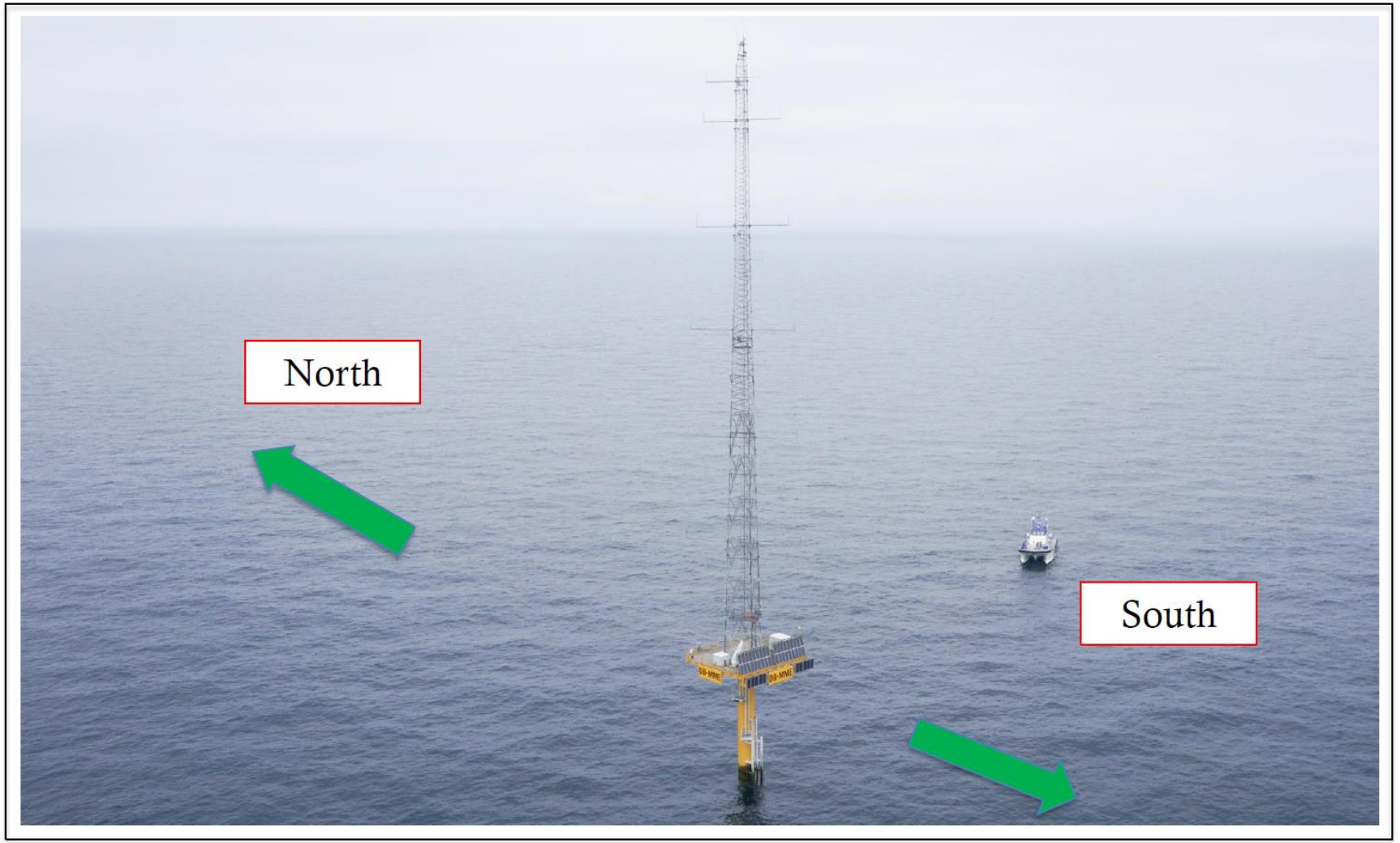
Photo: DSC00780.jpg

Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

Offshore Met Mast Inspection

CYBERHAWK
Aerial Inspection and Surveying Specialists

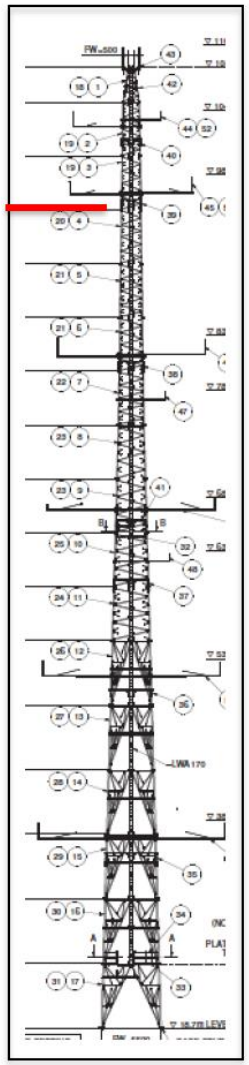
Metrological Mast XX MME (East)

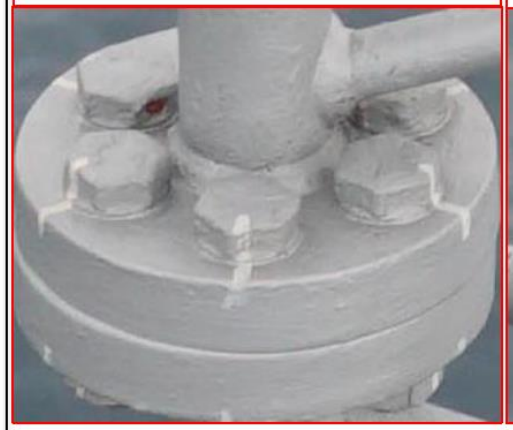
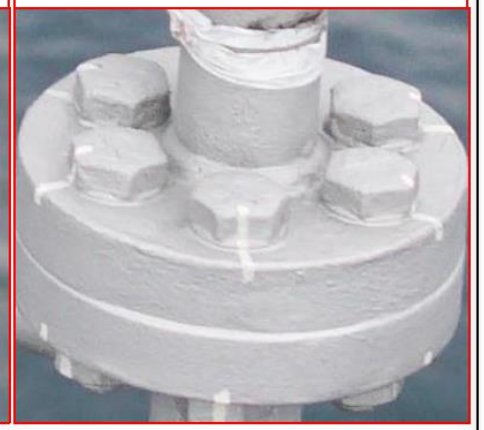


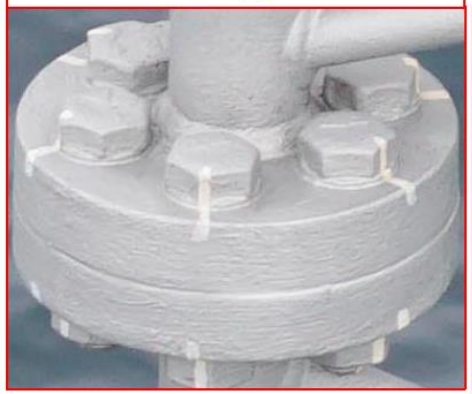
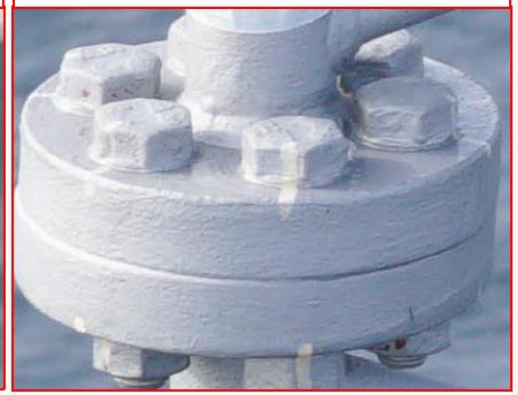
Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK
Aerial Inspection and Surveying Specialists

Module 10 – Flanges at 76m top



Flange A	Flange B	Flange C
		

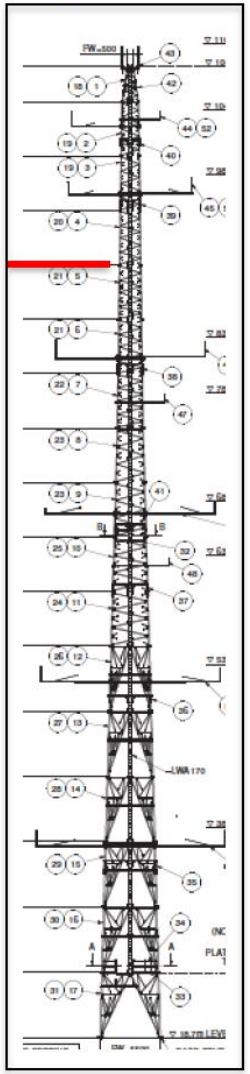
Flange A	Flange B	Flange C
		

Refer to page 7 for individual flange assessment and sketch on page 26 which explains the identification of each individual nut above

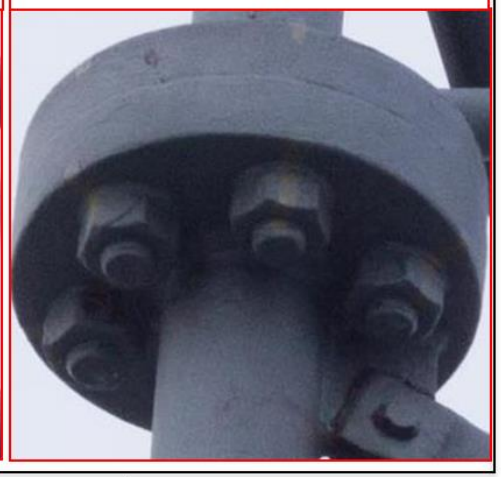
Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK
Aerial Inspection and Surveying Specialists

Module 11 – Flanges at 71m bottom



Flange A	Flange B	Flange C
		

Flange A	Flange B	Flange C
		

Refer to page 7 for individual flange assessment and sketch on page 32 which explains the identification of each individual nut above

Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK
Aerial Inspection and Surveying Specialists

Color Coded Flange Connections - XX MME

Elevation (m)	Top																		Bottom															
	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6
86	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
81	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
76	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
71	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
66	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
61	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
56	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
51	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
46	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N
41	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N	1	1	1	1	1	1	1	1	1	1	1	N
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N	1	N
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	N	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	2	1	1	1	1	1	2	1	1
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																		

1	We can see a paint mark clearly on the bolt / nut assembly and it aligns to the paint mark on the flange
2	The paint mark is poor but we can see alignment
3	Paint mark is clear but misaligned
4	Paint mark is poor and misaligned
N	There is a paint mark but cannot determine alignment or there is no paint mark
M	Technical miss - we can't see the connection due to Cyberhawk technical issues

Cyberhawk Innovations Ltd
Alba Innovation Centre, Alba Campus, Livingston, EH54 7GA
Tel: +44 (0) 1506 592187 info@thecyberhawk.com

CYBERHAWK

Aerial Inspection and Surveying Specialists

Presented by:
Phil Buchan
Commercial Director
Cyberhawk Innovations Limited

T: +44 (0) 1506 592187
E: philip@thecyberhawk.com
W: thecyberhawk.com
A: Innovation Centre | Alba Campus | Livingston | EH54 7GA | UK