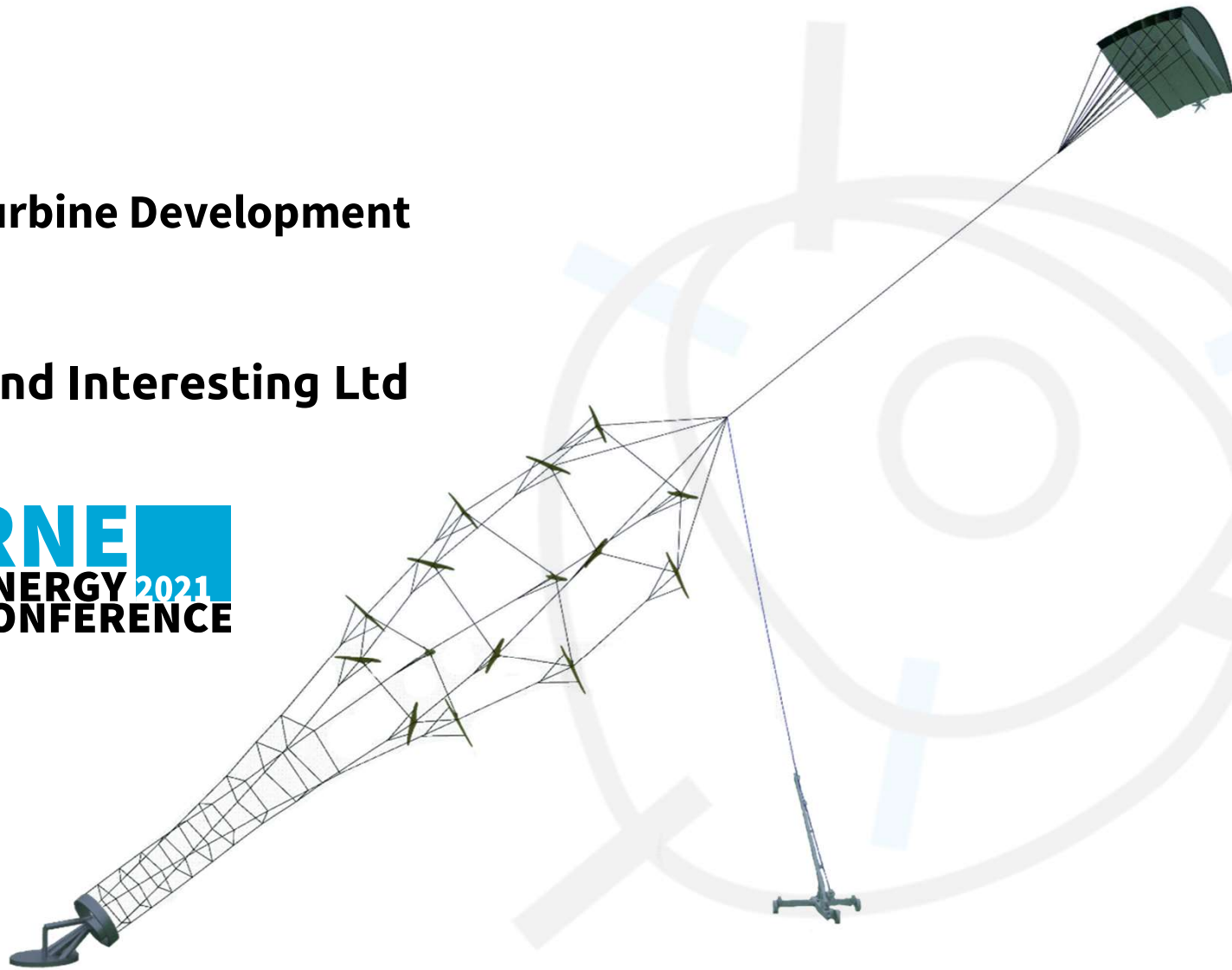


Rotary Kite Turbine Development

Roderick Read

Windswept and Interesting Ltd

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CONFERENCE

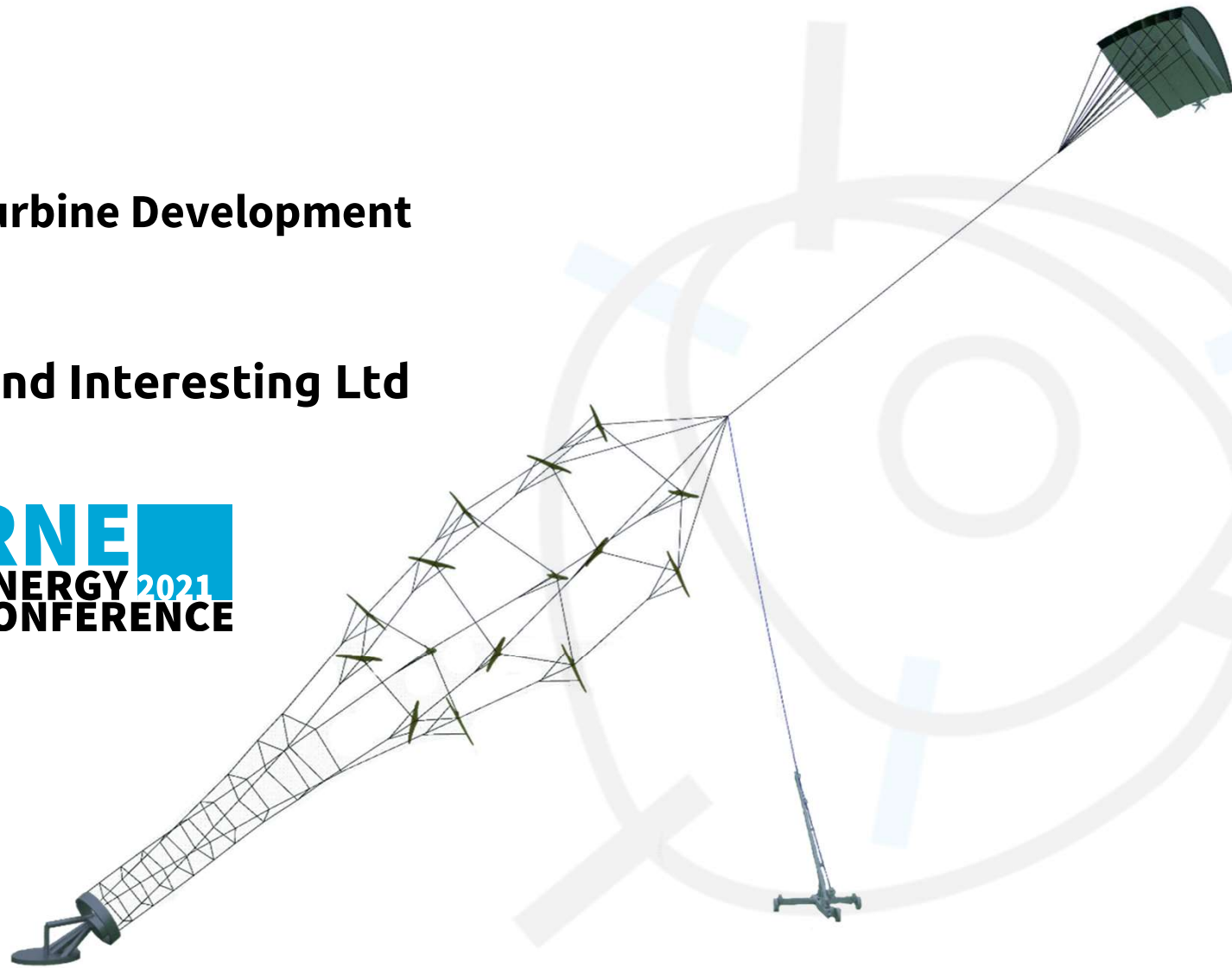


Rotary Kite Turbine Development

Roderick Read

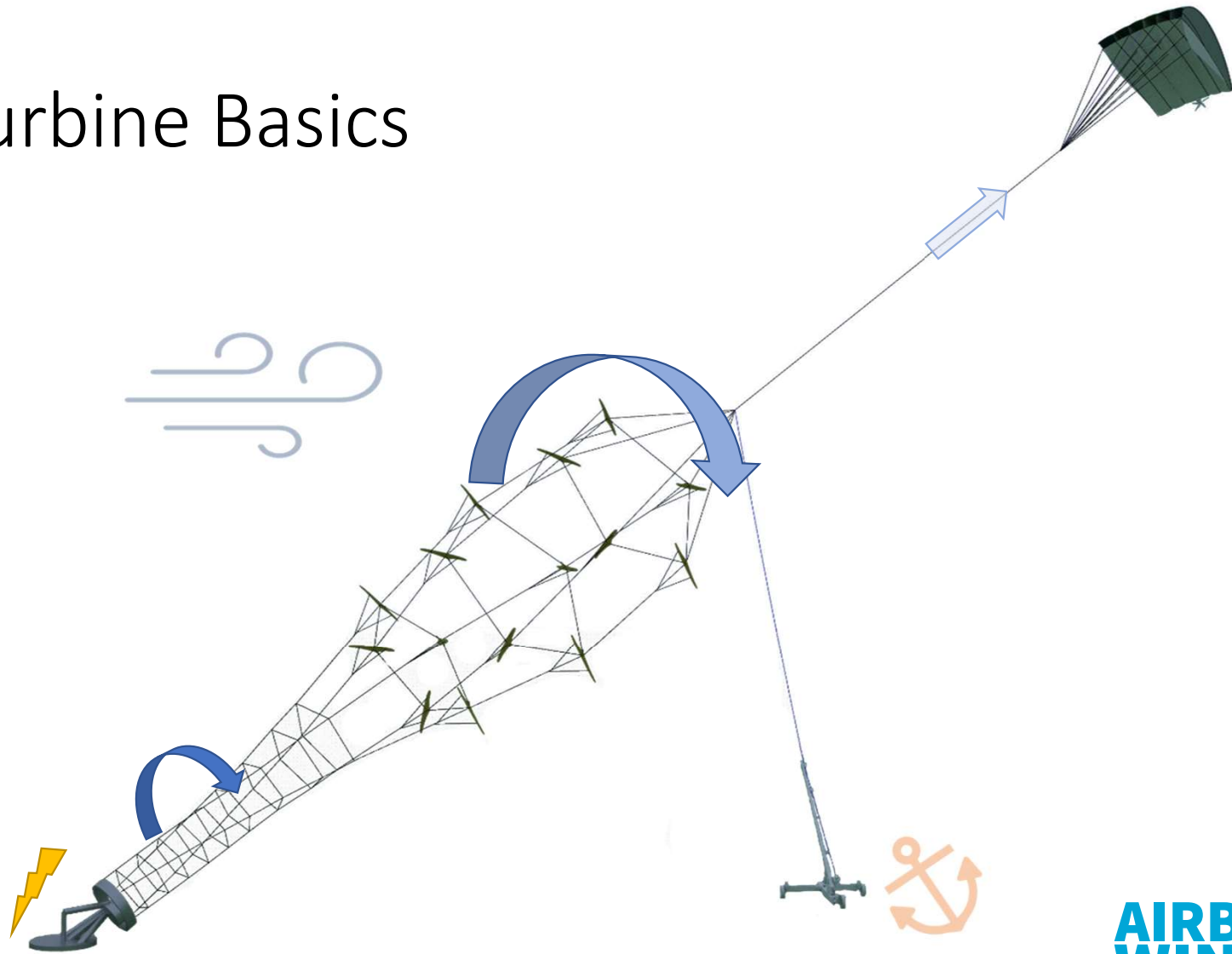
Windswept and Interesting Ltd

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Kite Turbine Basics



Project Partners



Shell
GameChanger



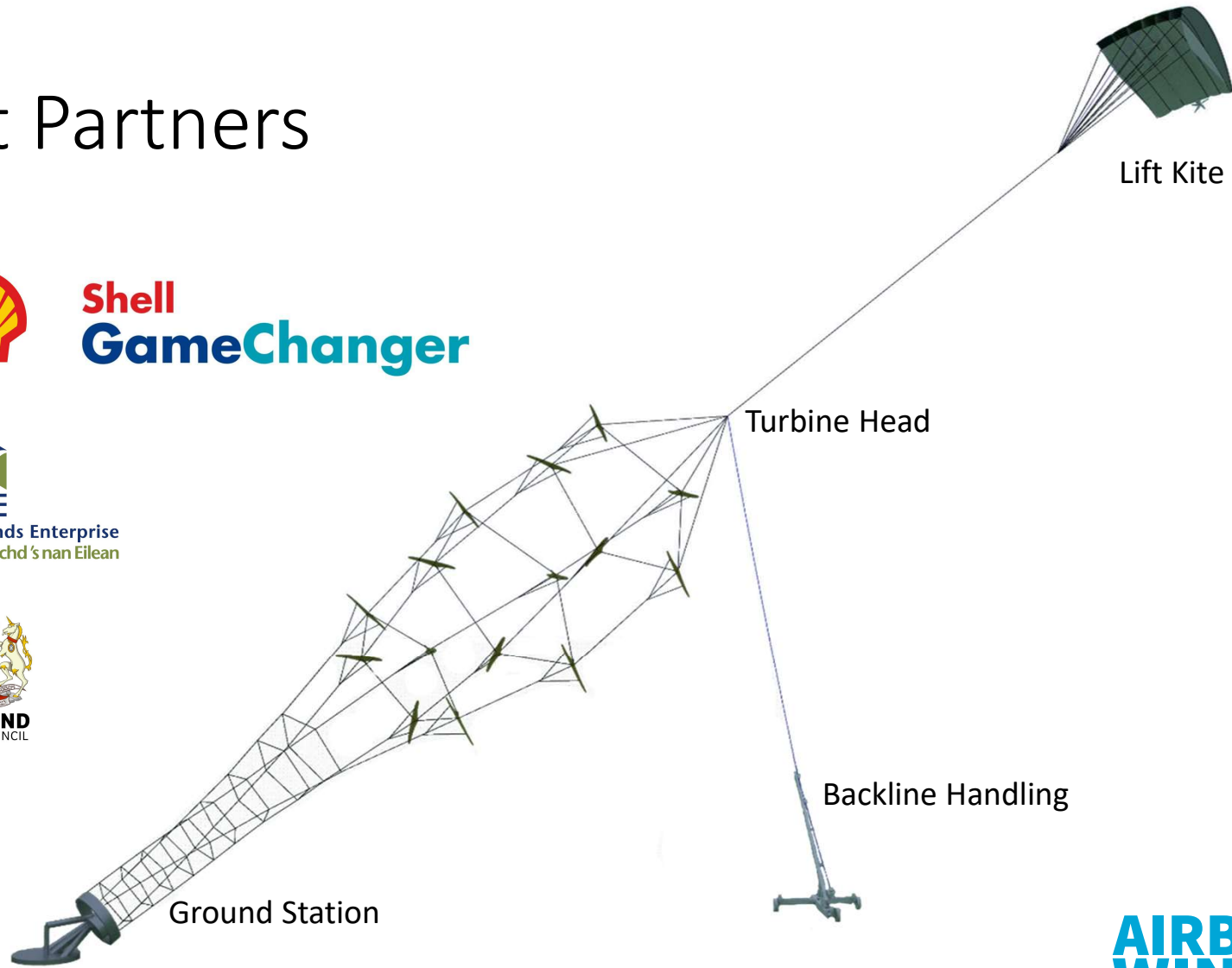
HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd's nan Eilean



SHETLAND
ISLANDS COUNCIL



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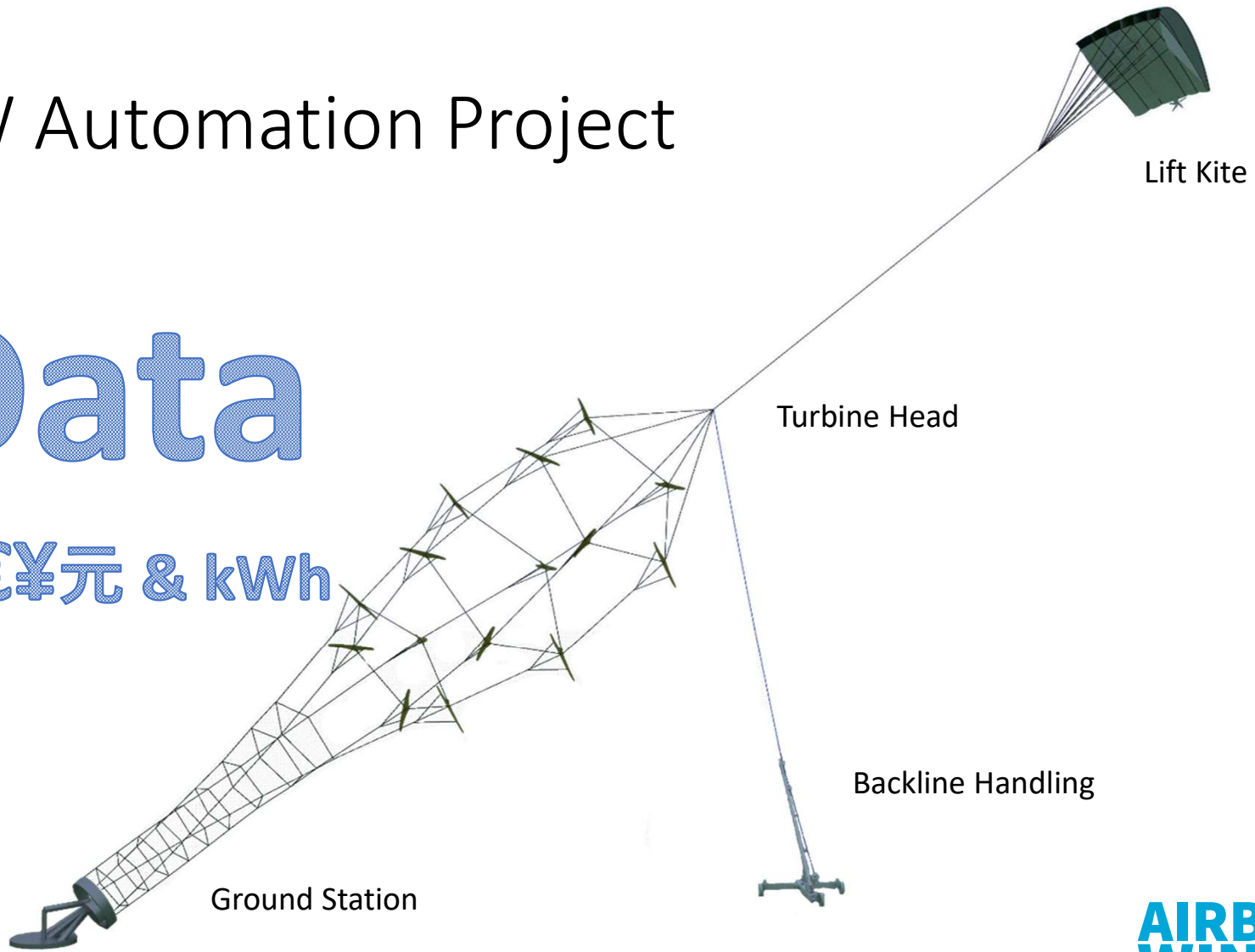


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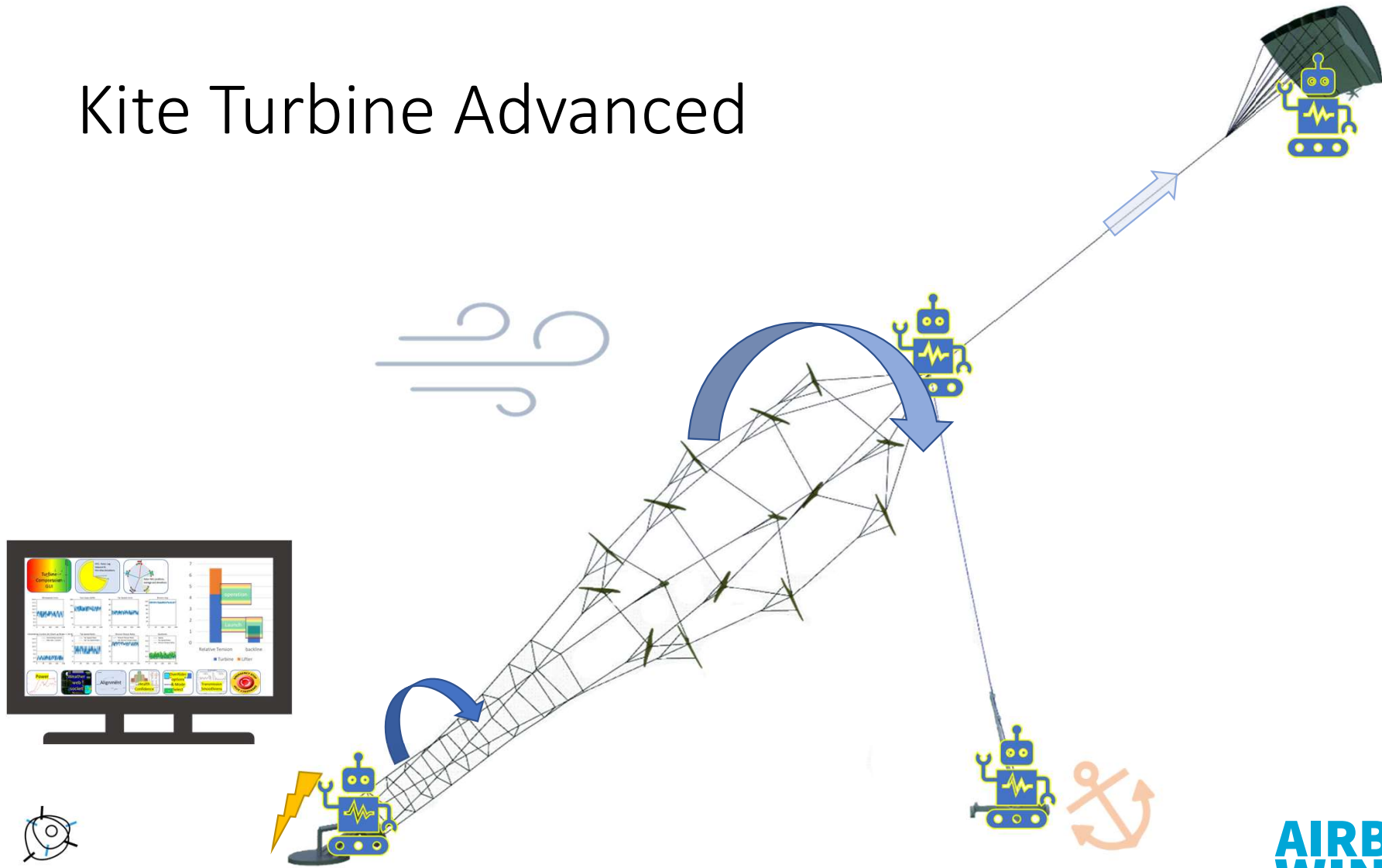
10kW Automation Project

Data

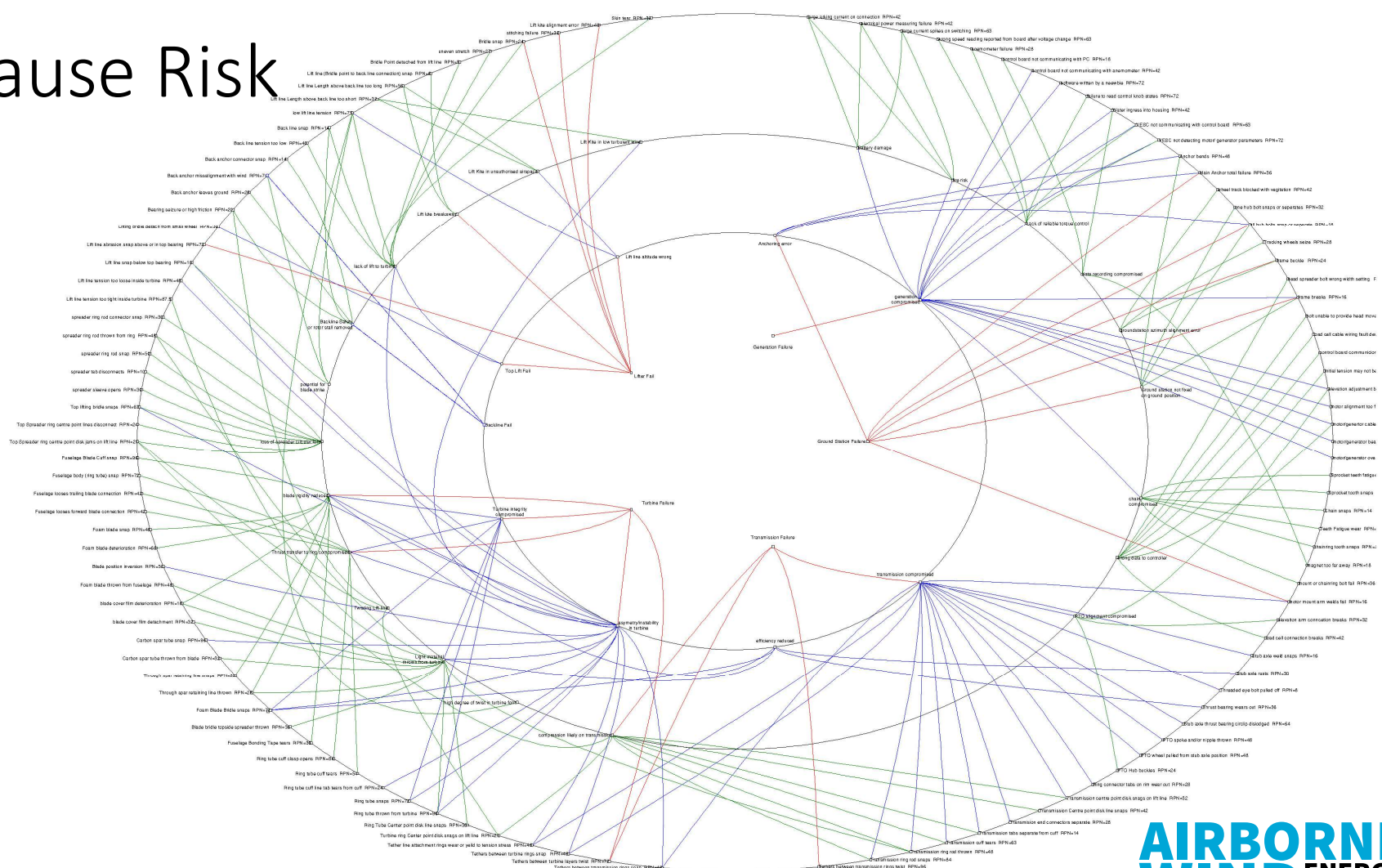
£\$€¥元 & kWh



Kite Turbine Advanced

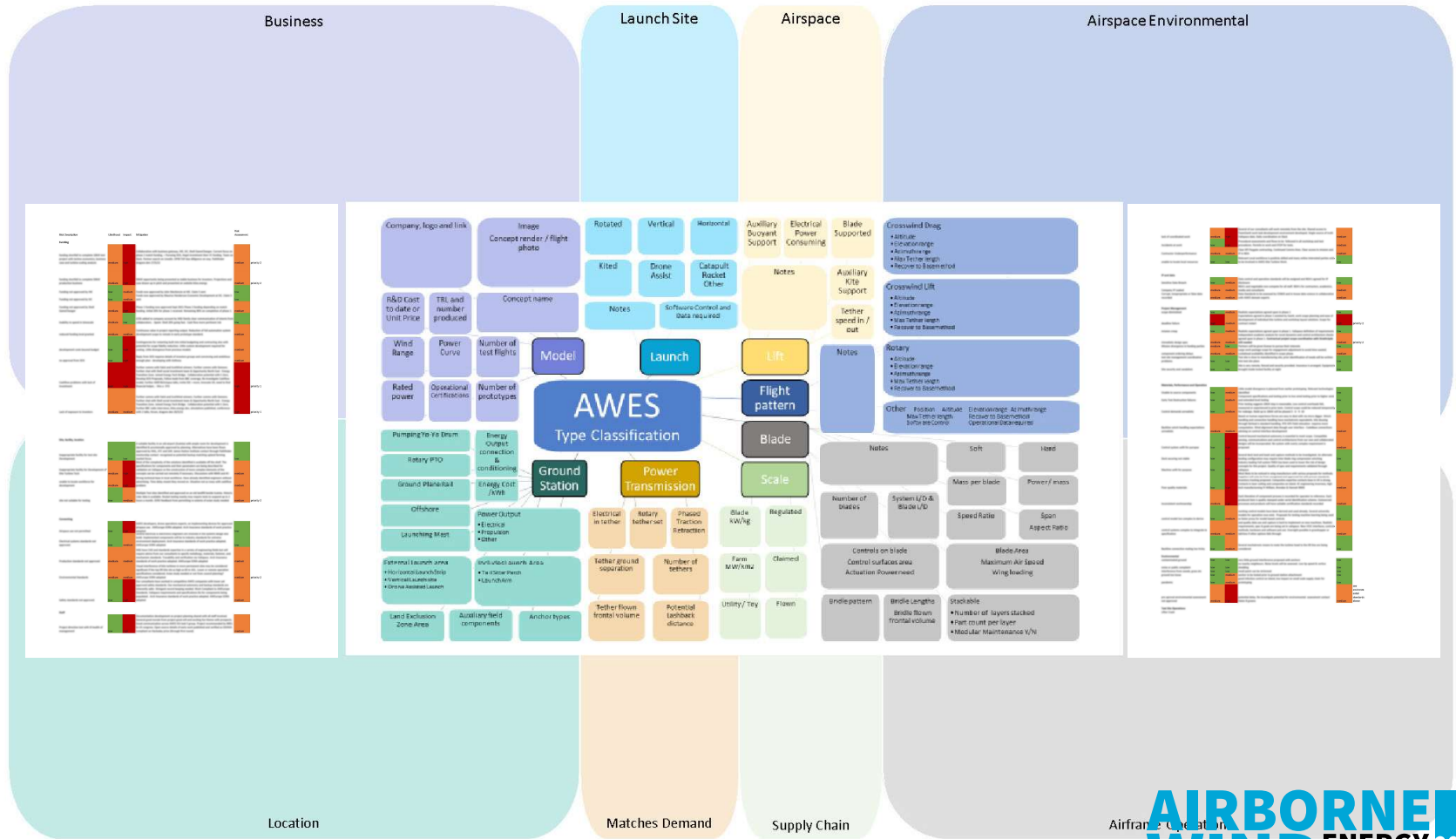


Because Risk



Risk

Extrinsic Factors



Risk



In accordance with our Shell General Business Principles and Group Code of Conduct, we seek to work with contractors and suppliers who contribute to sustainable development and are economically, environmentally and socially responsible.

We will develop and strengthen relationships with contractors and suppliers who are committed to the principles set out below or to similar standards through their own activities and the management of their own suppliers and sub-contractors.

Contractors and suppliers should provide workers with a dedicated whistle-blowing mechanism where grievances related to below topics can be logged confidentially.

1. Business Integrity

Contractors and suppliers comply with all applicable laws and regulations.

Contractors and suppliers should not tolerate, permit or engage in bribery, corruption or unethical practices.

Contractors and suppliers support fair competition. Conflicts of interest are avoided.

2. Health, Safety, Security, Environment and Social Performance

Contractors and suppliers have a systematic approach to HSSE & SP management, designed to ensure compliance with all applicable laws and regulations and to achieve continuous performance improvement.

Contractors and suppliers:

- are committed to protect the environment in compliance with all applicable environmental laws and regulations.

- use energy and natural resources efficiently.
- continually look for ways to minimise waste, emissions and discharge of their operations, products and services.
- respect their neighbors and contribute to the societies in which they operate.
- manage the social impacts of their activities carefully and enhance the benefits to local communities.
- recognize that regular dialogue and engagement with stakeholders is essential. In interactions with employees, business partners and local communities, seek to listen and respond to them honestly and responsibly.

3. Labour and Human Rights

Contractors and suppliers conduct their activities in a manner that respects human rights as set out in the UN Universal Declaration of Human Rights and the core conventions of the International Labour Organization (ILO) including ensuring:

- no use of child labour;
- no use of forced, prison or compulsory labour;
- no payment of recruitment fees by workers;
- compliance with all applicable laws and regulations on freedom of association and collective bargaining.
- a safe, secure and healthy workplace and not tolerating discrimination, harassment or retaliation;
- compliance with all applicable laws and regulations on working hours; and
- providing wages and benefits that meet or exceed the national legal standards.

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Risk

Airborne Wind Europe

An introduction to the Specific Operations Risk Assessment (SORA) for Airborne Wind Energy

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Document Version Control

Date	Version	Author	Description
2019.05	V1.0	Corey Houle (TwingTec)	Initial document for release to WG for feedback.
2021.01.25	V1.1	Kristian Petrick (Airborne Wind Europe)	Reviewed by Kristian Petrick (Airborne Wind Europe) and Joep Breuer (Kitepower). Earlier comments and responses by Corey Houle have been integrated by Kristian Petrick, mainly in footnotes (25 January 2021).

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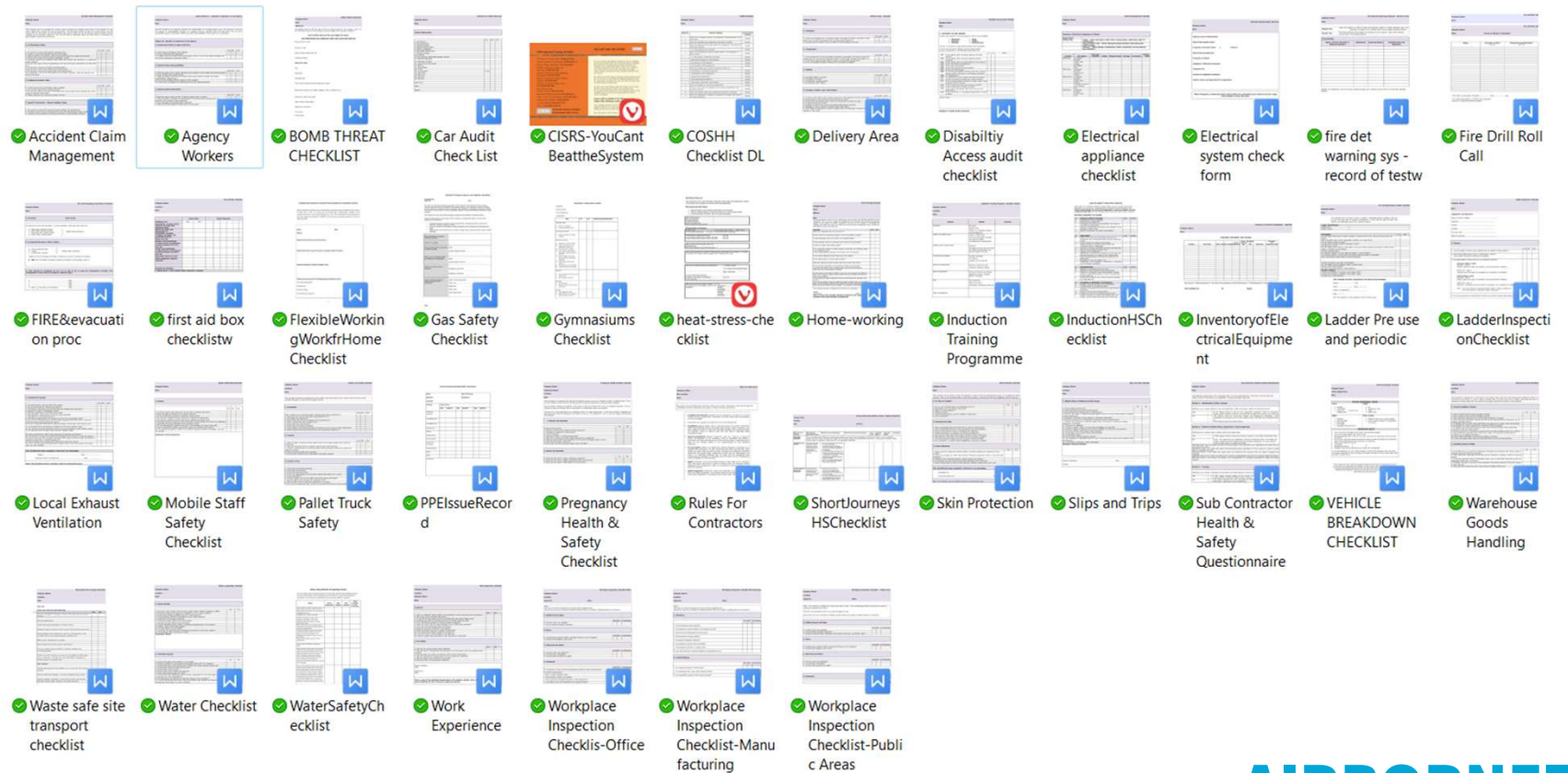
1

Inputs to AWE Technical Guidelines: Operational Risk Assessment

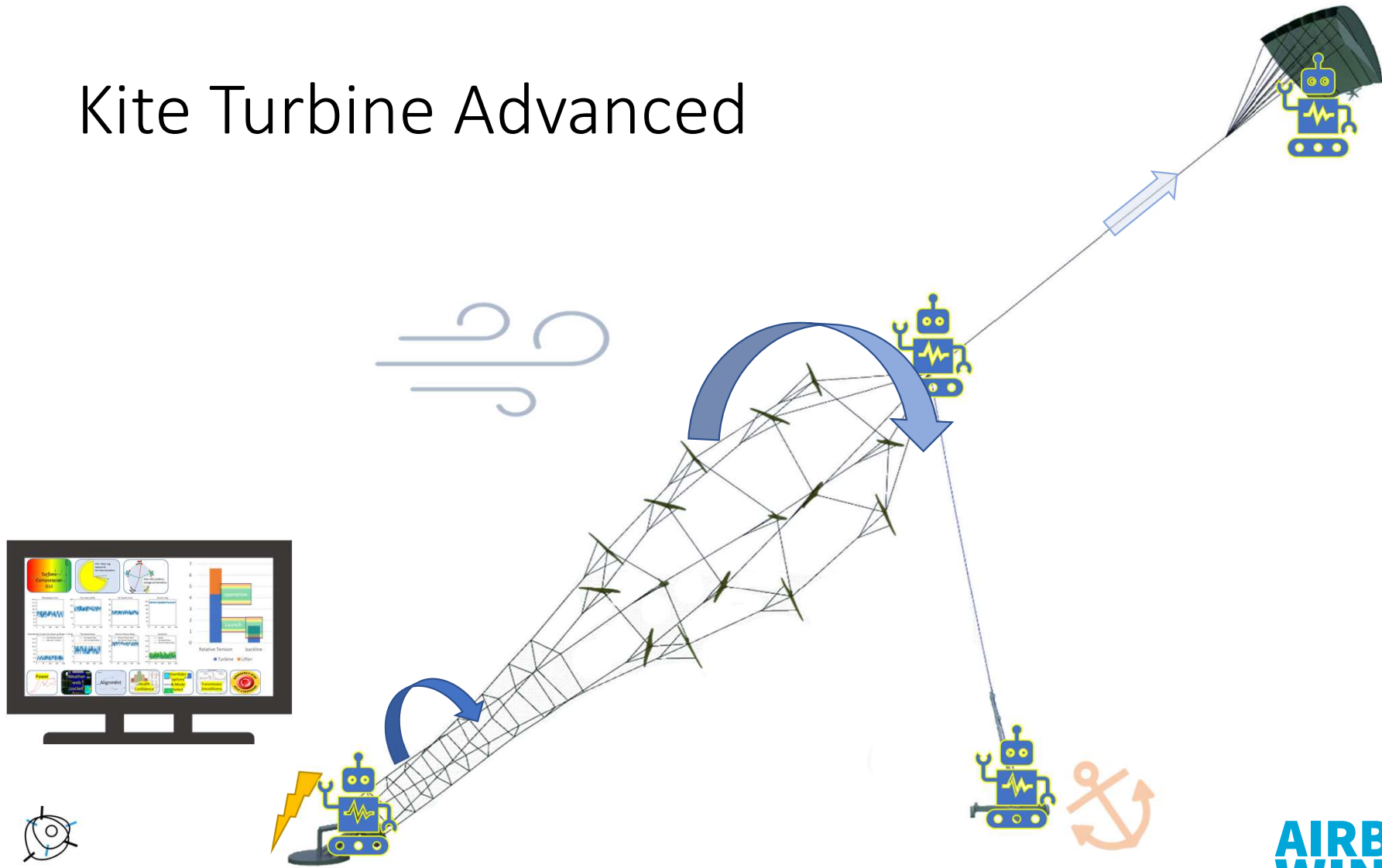
Airborne Wind Europe

Airborne Wind Europe

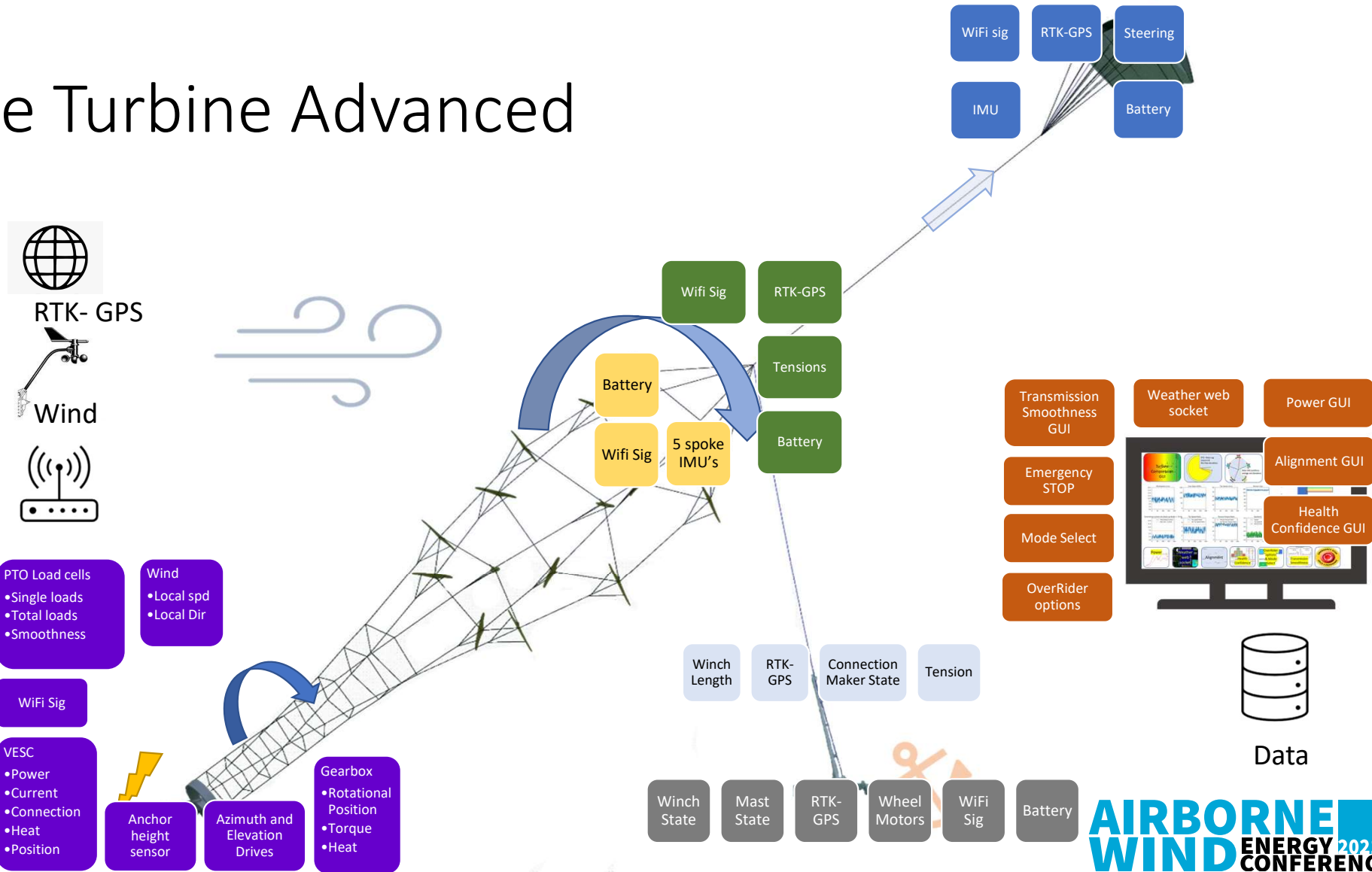
Risk



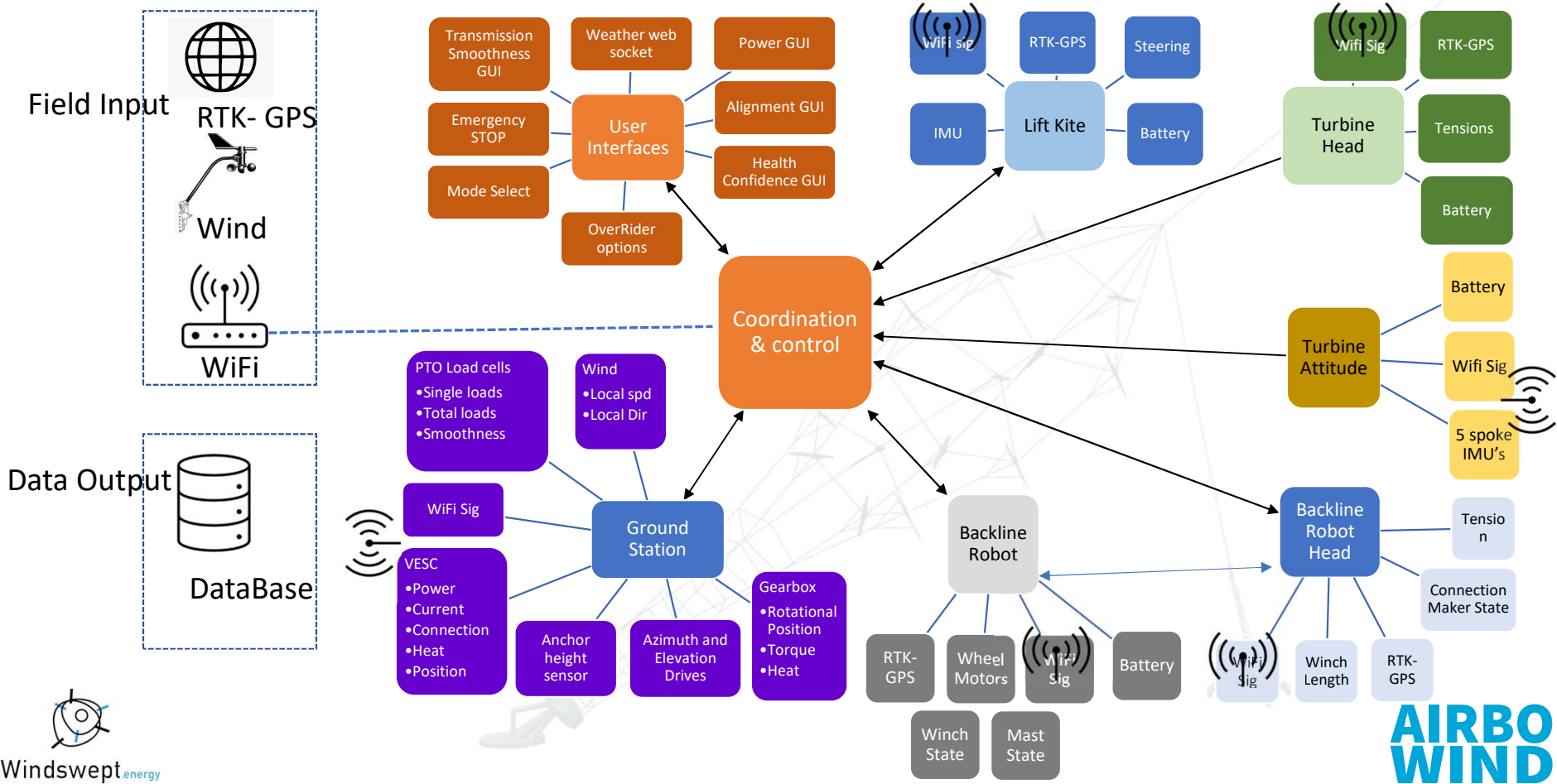
Kite Turbine Advanced



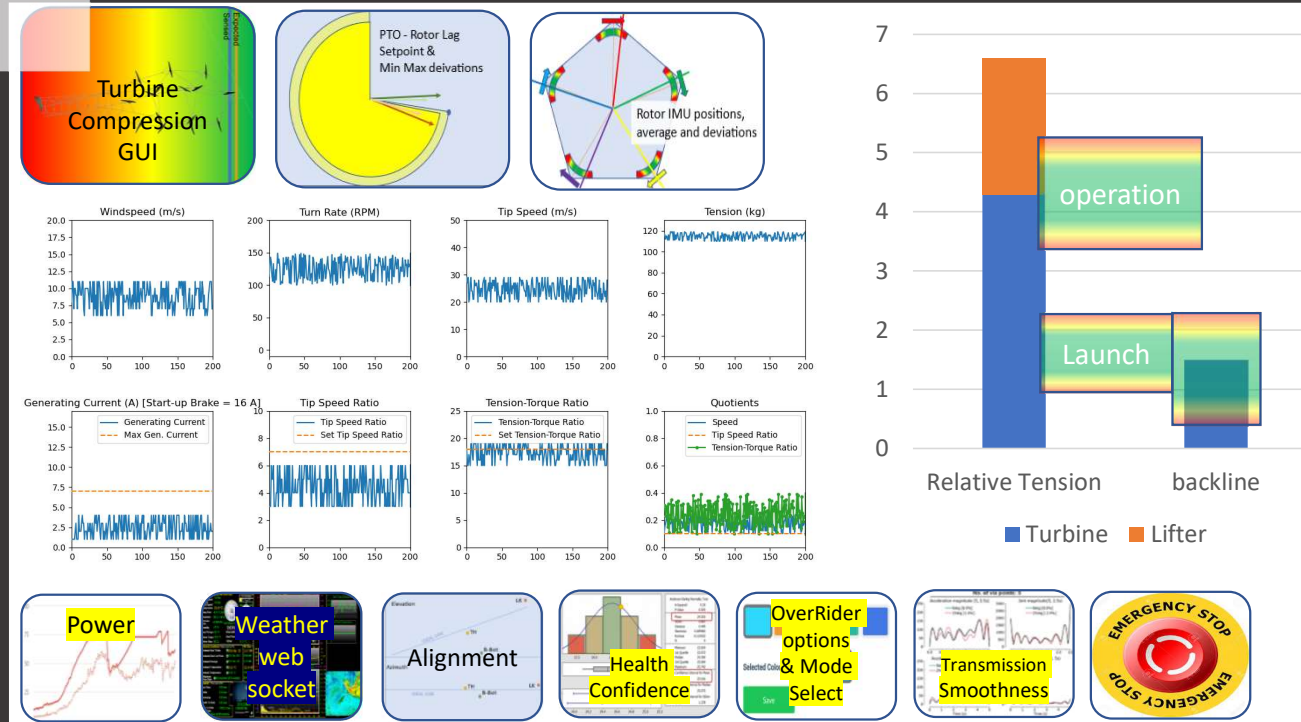
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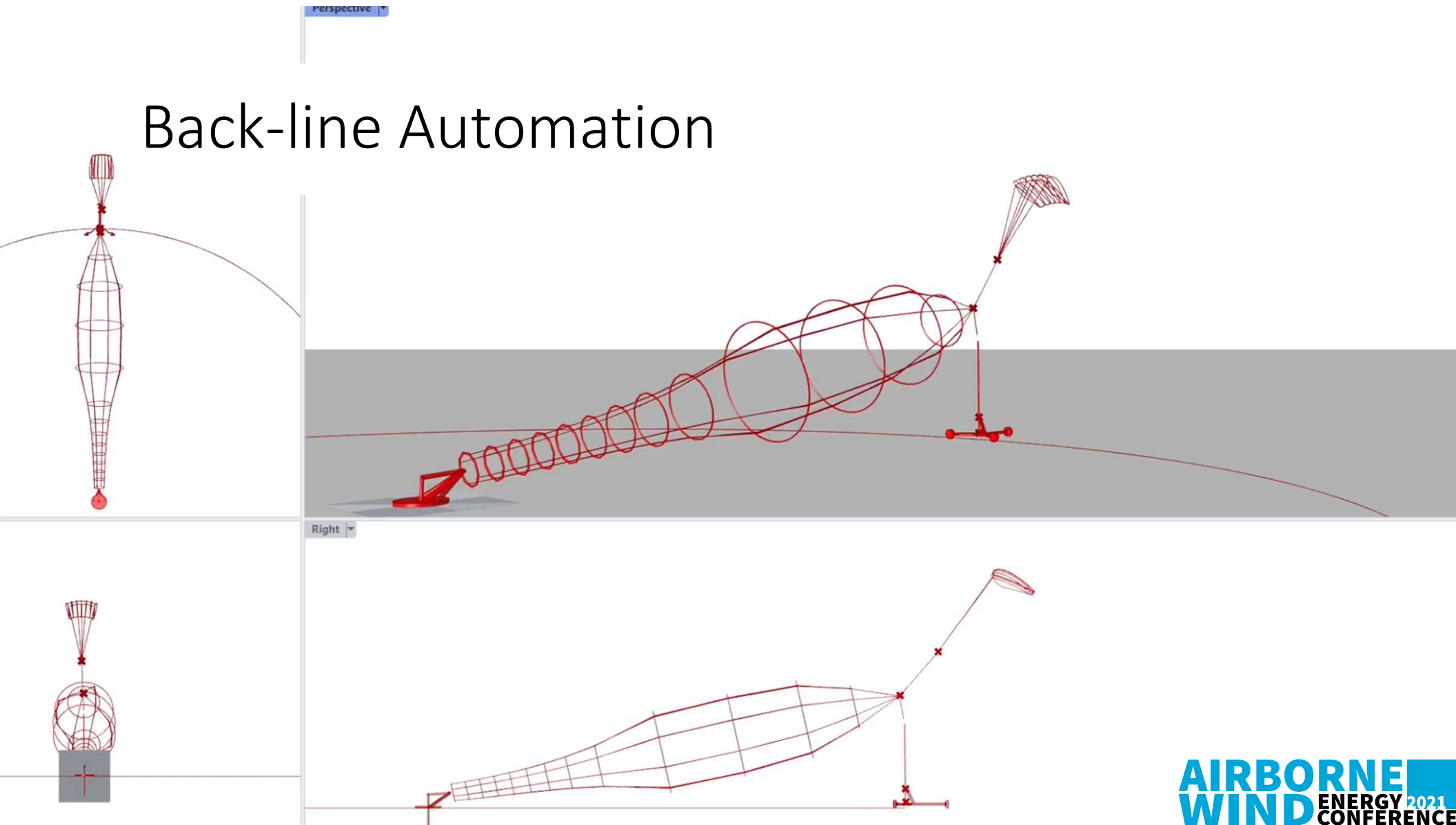
Systems



Control



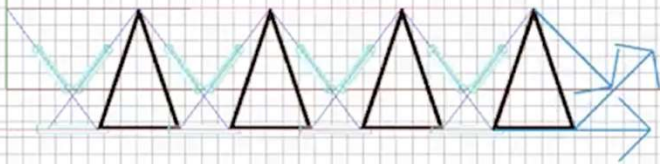
Back-line Automation



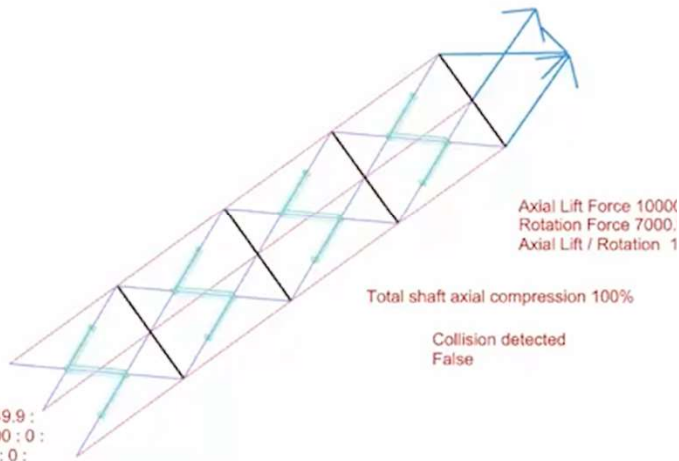
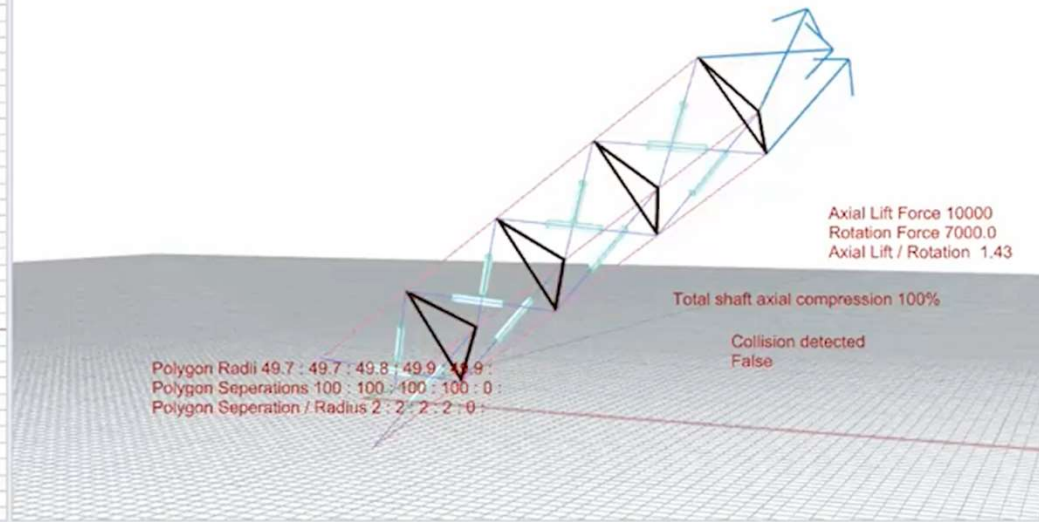
TRPT Lag Control

Lift Force 10000
 on Force 7000.0
 Lift / Rotation 1.43
 100%

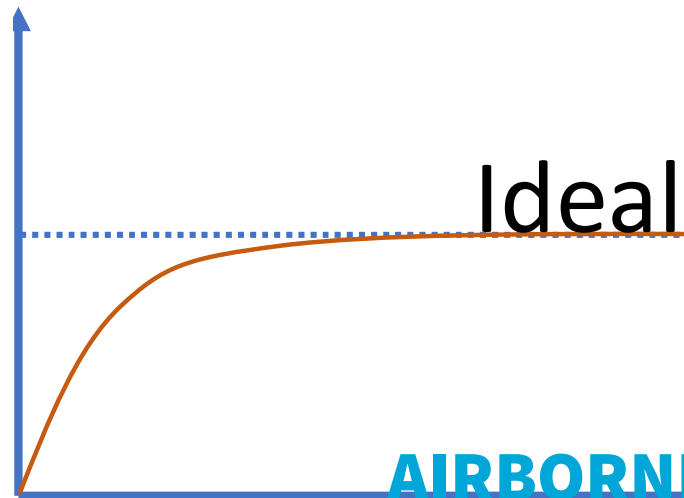
Collision detected
 False



Perspective

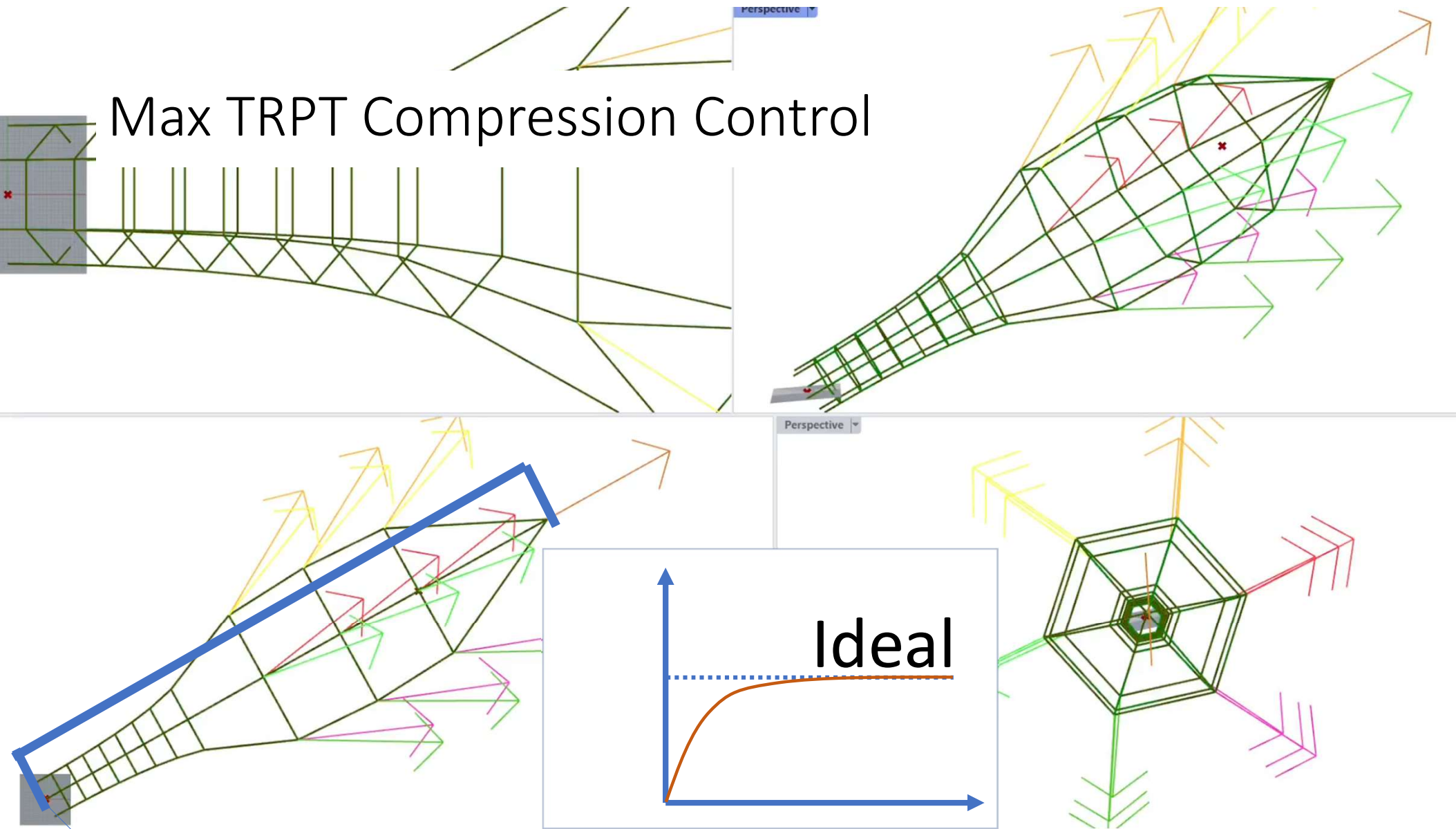


PTO vs
 Rotor
 Lag

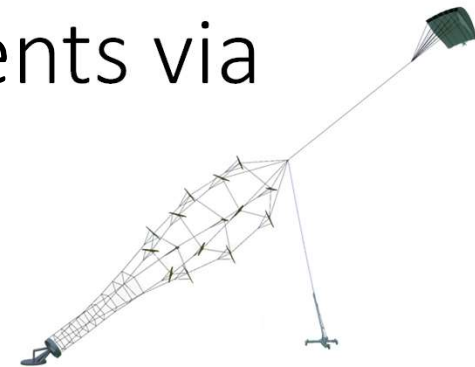


Polygon Radii 49.7 : 49.7 : 49.8 : 49.9 : 49.9 :
 Polygon Separations 100 : 100 : 100 : 100 : 0 :
 Polygon Separation / Radius 2 : 2 : 2 : 2 : 0 :

Max TRPT Compression Control



Validation of Performance Requirements via Test Standards



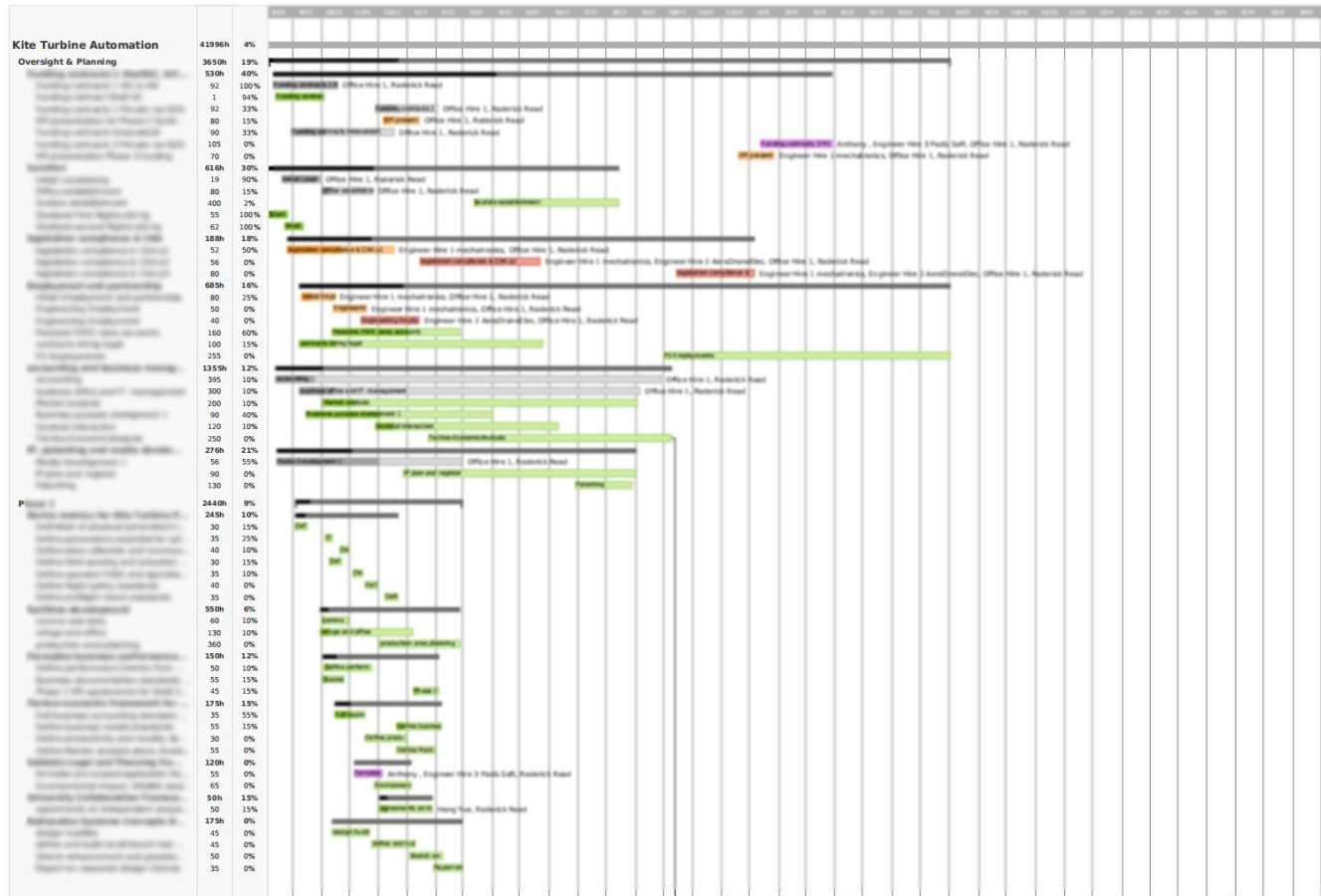
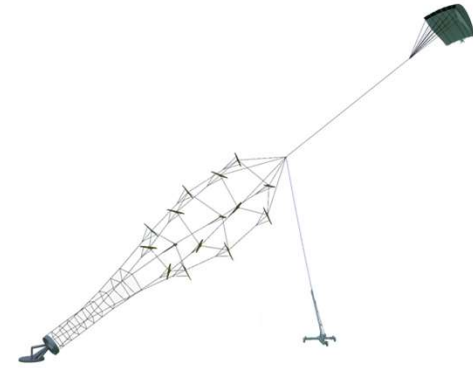
#	COMPONENTS	DESCRIPTION
1	Field	The Outside Areas where all the testing and wind is
2	Office_Business	Organisation Level Components and Systems
3	Kite_Turbine	Spins round in the air converting wind flow into mechanical rotation Top is h
3.1	Transmission_TRPT	A TRPT Tensile Rotary Power Transmission is a horn shaped cylindrical net, made fr
3.4.1	Polygon_Rods_Bars	The basic polygon form of a TRPT layer is made up of 5/6/7 polygon rods/bars
3.4.2	Torque_Tethers	A polar array of tethers to hold the kite turbine and allow it to spin Each tethe
3.4.3	Compression_wrap	Where Knuckles are compressed to hold the polygon rods (Bars) to knuckle nodes
3.4.4	Knuckles	A tightening node point to hold the ends of Rod/Bar elements of the TRPT polygons
3.4.5	Ring_below_turbine	At most positions of TRPT a ring is used for standard polygon elements
3.4.6	Center_point_disk_and_lines	Lines connecting the nodes of the polygon to the centre of the polygon help to hold t
3.2	Oversight_controller	A capable field computer station Runs software to determine what operation
3.2.1	EMERGENCY_STOP_Physical_button	Large red button to cut power from systems in event of emergency
3.2.2	HMI_and_Control_Software	Human Machine Interface will have an interactive screen of controls (See attached fi
3.2.2.1	Emergency_STOP_Button_Screen	Large red button on screen to cut power from systems in event of emergency
3.2.2.2	PTO_Turbine_Jag_GUI	A display which shows the difference in rotary yaw between the rotor IMU and PTO I
3.2.2.3	Relative_tension_GUI	See file for example. We display the current data within operating bars safe range fo
3.2.2.4	refresh_speed	The controller and HMI must have fast refresh speeds. Control data from the IMU or
3.2.2.5	Health_Confidence_GUI	Simple indication of how overall confident we are in a safe working setup having cor
3.2.2.6	Turbine_Compression_interface	Compute the Length of the RTK GPS separation from PTO to Turbine Head
3.2.2.7	Weather_Forecast_Screen	Location specific weather data to trigger a warning if parsed data is outwith operatic
3.2.2.7.1	Weather_Data	Location specific weather data to trigger a warning if parsed data is outwith operatic
3.2.2.7.2	Wind_Conditions	Wind direction and speed data from on the field

Parts

REQUIREMENTS	TEXT
Lifter_Mass	the maximum mass of th...
Lift_Line_tensile_Strength	40000.00.N=(5*0.55.kg)
windspeed	must cope with launchin...
Blade_cover_spec	Must keep the blade seal...
BBot_Data	A reliable comms link fro...
SMD02	The organization uses 'in...
SMD01	A safety management sy...
weekly_Maintenance	Must look at and inspect ...
L_L_Req1	By factor of safety over ...
Max_Wing_loading	Wing Loading has to be ...
Winching_Speed	Winch maximum line spe...
Backline_tension_accuracy	The backline bot should ...
Line_Length	A count of the amount of...
Line_Length-002	An accurate identificatio...
Winching_Force	Should be less than ult...
Locationing	Must be able to have loc...

Spec

Planning



Validation Metrics



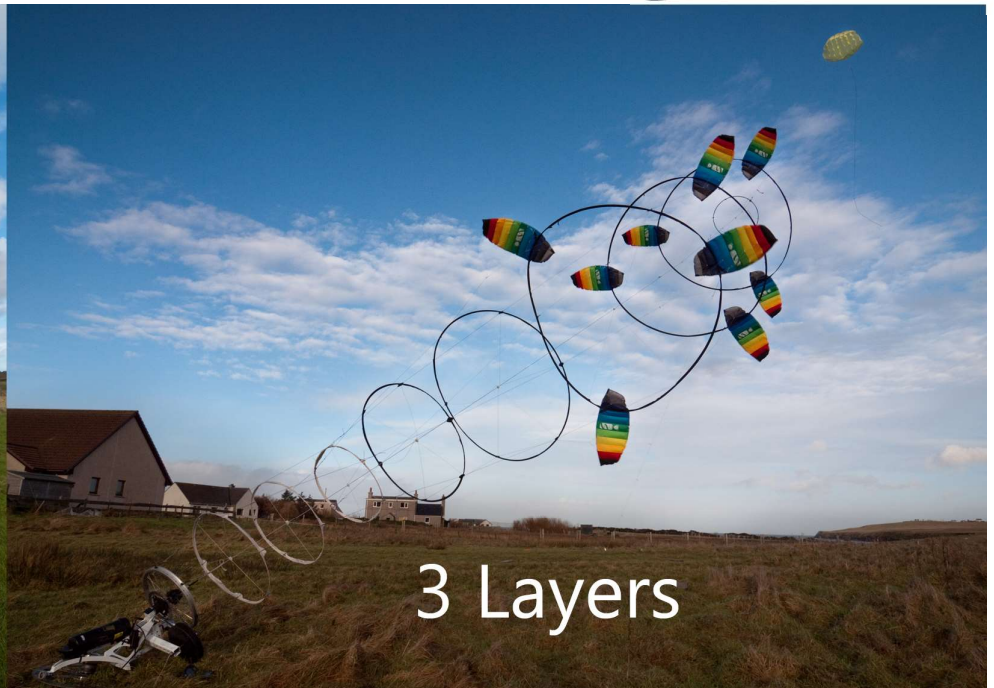
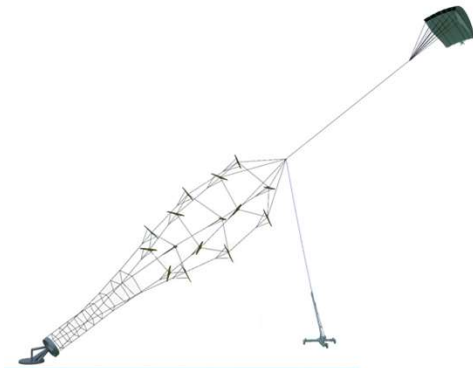
Airborne Wind Europe 

IEA Wind Task 48 AWE Performance Assessment Criteria WP5 Architectures

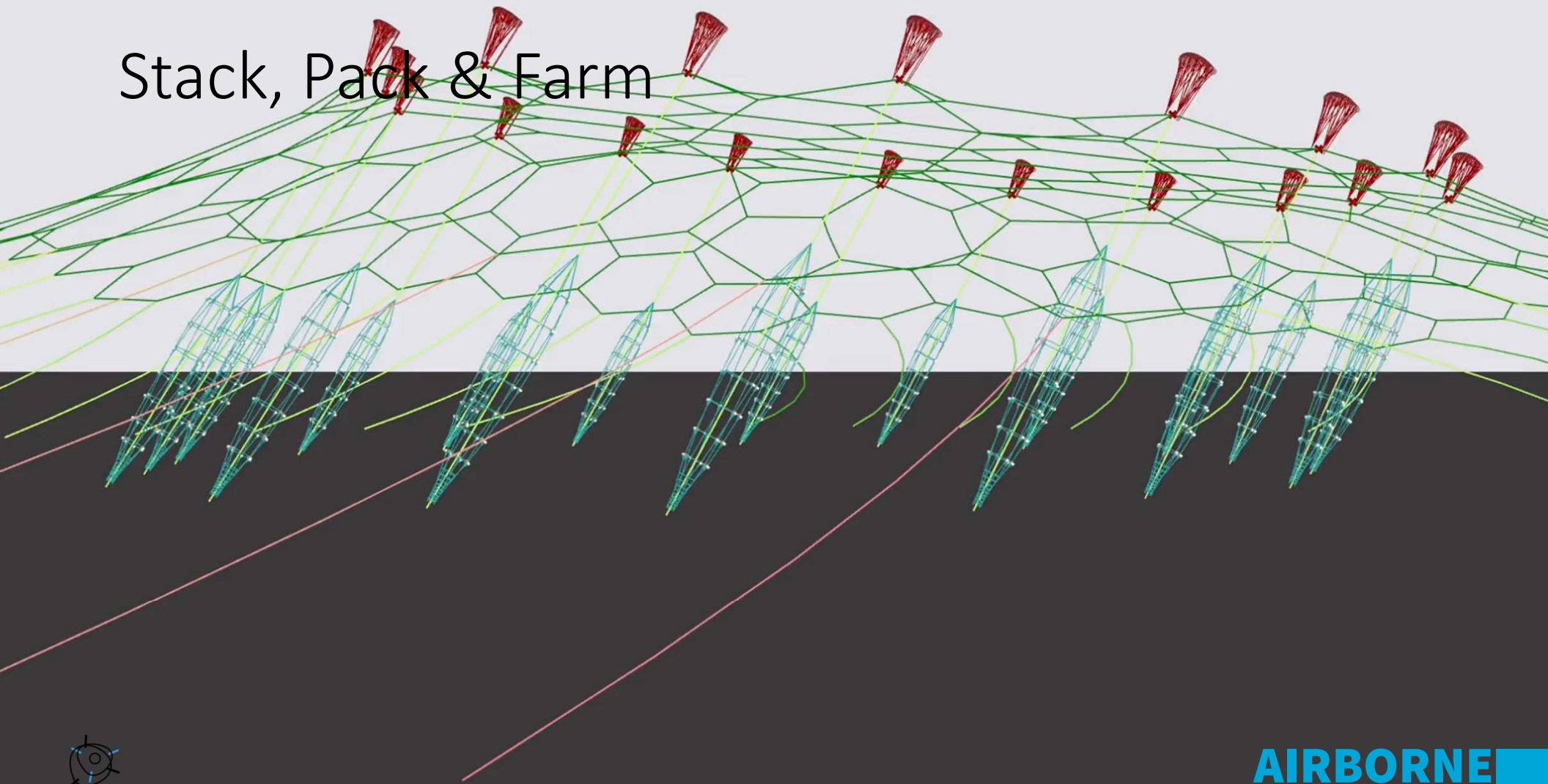
<u>1.1</u>	<u>Efficiency</u>
<u>1.2</u>	<u>Reliability</u>
<u>1.3</u>	<u>Availability</u>
<u>1.4</u>	<u>Complexity</u>
<u>1.5</u>	<u>Automatability</u>
<u>1.6</u>	<u>Scalability</u>
<u>1.7</u>	<u>Airborne Mass</u>
<u>1.8</u>	<u>Durability</u>
<u>1.9</u>	<u>Ductility</u>
<u>1.10</u>	<u>Safety</u>
<u>1.11</u>	<u>Potential</u>
<u>1.12</u>	<u>Cost</u>
<u>1.13</u>	<u>Investability</u>



10kW 3 stack x 5 blade rotors



Stack, Pack & Farm

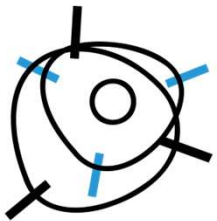


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