Project Green Blade

Enabling radar friendly wind energy

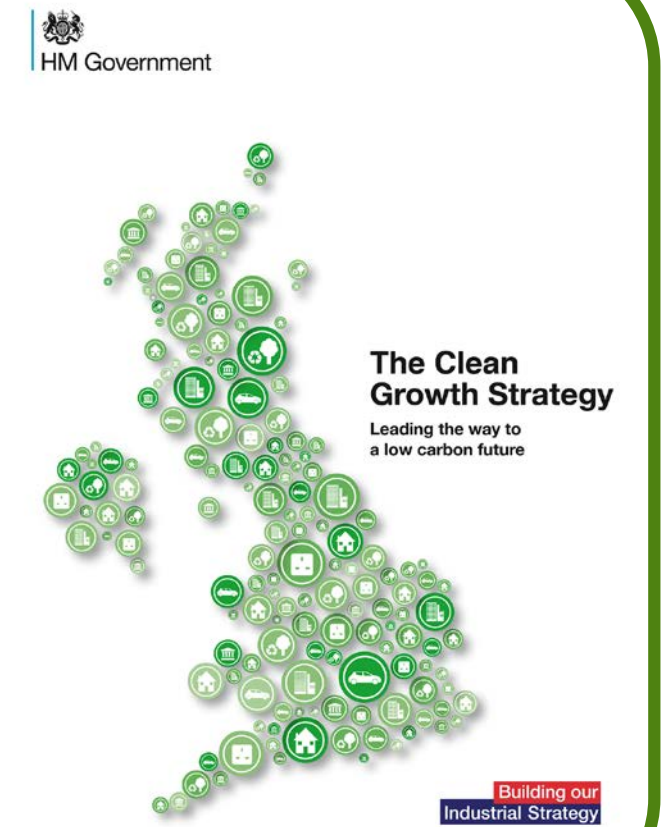
Farnborough July 2018

UK clean growth & industrial agenda

UK Clean Growth & Industrial Strategies

"Clean Growth means growing our national income while cutting greenhouse gas emissions … ensuring an affordable energy supply for businesses and consumers …"

Clean Growth Grand Challenge: "We will maximise the advantages for UK industry for the global shift to clean growth – through leading the world in the development, manufacture and use of low carbon technologies, systems and services …"



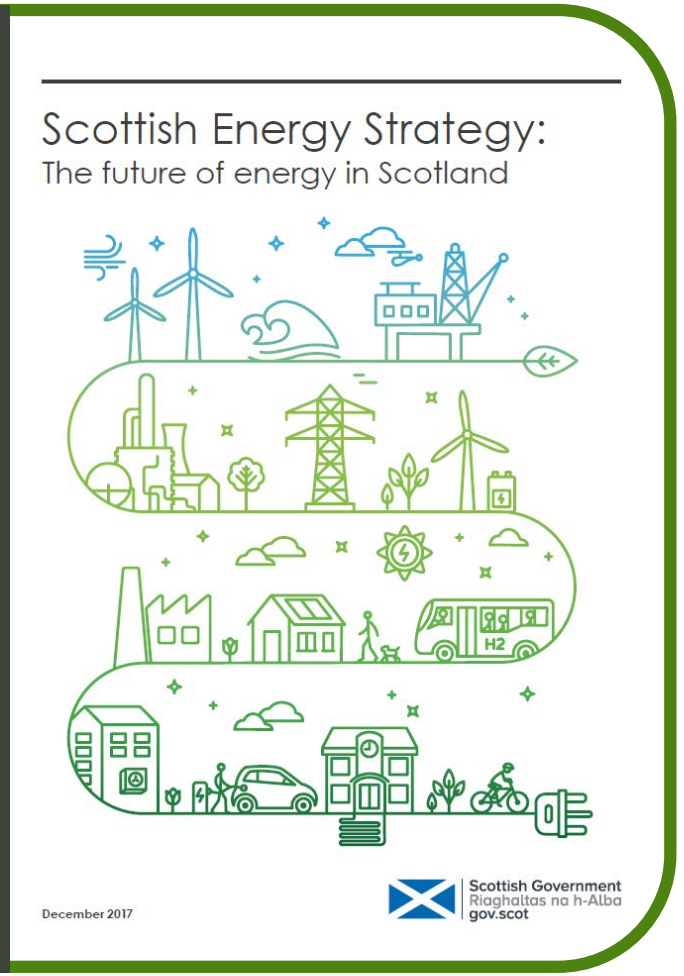
Scottish Government's energy ambitions

Scottish Government Energy Strategy and Onshore Wind Policy Statement

"Champion Scotland's renewable energy potential, creating new jobs and supply chain opportunities"

Sets 2030 Target of "the equivalent of 50% of energy for Scotland's heat, transport and electricity consumption to be supplied from renewable sources"

Acknowledging windfarms "are an established part of Scotland's landscape"



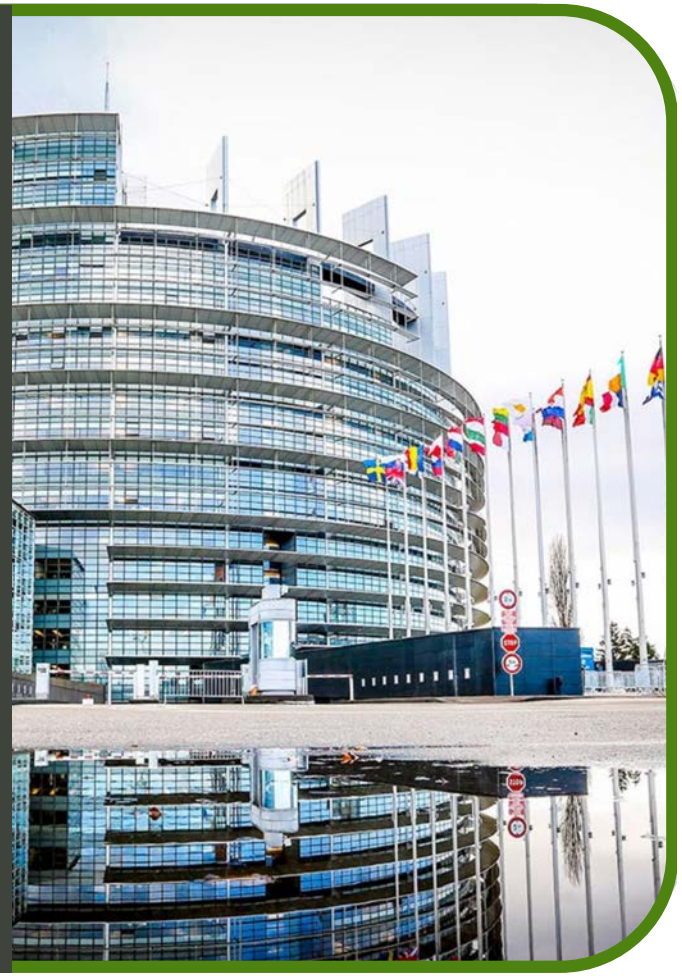
European Union Revised Renewable Energy Directive

Binding EU-wide renewable energy target for 2030 of 32%, clause for upwards revision by 2023

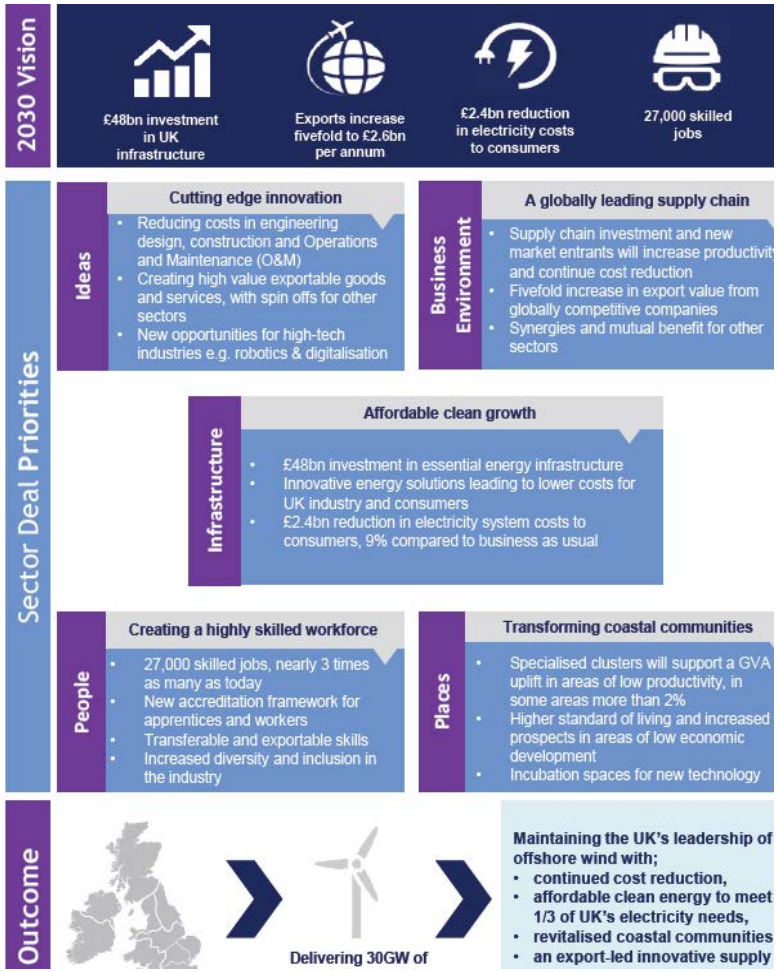
"Member States shall collectively ensure that the share of energy from renewable sources in the Union's gross final consumption of energy in 2030 is at least 32%."

Commissioner for Climate Action and Energy Miguel Arias Cañete, 14 June 2018:

"This new ambition will help us meet our Paris Agreement goals and will translate into more jobs, lower energy bills for consumers and less energy imports… The binding nature of the target will also provide additional certainty to the investors."



What the offshore wind industry believes it can deliver



Offshore Wind Sector Deal

30GW by 2030
50GW by 2050
UK infrastructure investment, exports, jobs, lower energy bills

Future offshore wind opportunities

The Crown Estate and **Crown Estate Scotland** pursuing additional leasing rounds to secure UK's clean energy future

The Power of Onshore Wind

Onshore wind

- **cheapest form of low carbon & lowest cost form of new-build electricity generation available in UK today**
- **forecast to be cheaper than wholesale energy price from 2023**
- **delivering the Industrial Strategy's five foundations of productivity, including significant UK content of c70%**

- **13GW of onshore wind currently operational in UK**
- **With appropriate Contract for Difference support, additional 5GW by 2025, >20GW by 2030**
- **Life extension and repowering opportunities of 8GW from 2027 – taller turbines on existing sites**

Industrial Strategy: Onshore wind delivers on the five foundations of productivity

People	Infrastructure	Ideas	Business Environment	Places
Good jobs and greater earning power for all	A major upgrade to the UK's infrastructure	The world's most innovative economy	The best place to start and grow a business	Prosperous communities across the UK
Onshore wind creates highly skilled and long-term jobs for the operational life of a wind farm.	*Onshore wind provides new low carbon generating capacity, increasing the UK's security of electricity supply.*	*Onshore wind is a proven technology and the lowest cost form of new generating capacity in the UK. It is developed within a technology-driven industry with a strong culture of innovation and cost reduction.*	*Onshore wind supports new supply chain businesses and is an increasingly attractive industry in which to invest.*	*Onshore wind creates local employment opportunities in areas where new economic opportunities are welcomed*

Five 1GW Contract for Difference auctions could deliver

18,000 jobs during peak construction, and 8,500 long term skilled jobs supporting the operation of the wind farms	**£6 billion of investment in** new clean generation	A strike price of **£49.4/MWh in 2019, falling to £45/MWh in 2025 (2017 prices)** (£45.6/MWh and £41.6/MWh in 2012 prices) **£1.6 billion** net payback to the consumer over	A **UK content of 68%** for projects built in 2021, increasing to almost **70%** for projects built in 2027	**£12 billion** of gross value-added **60%** of the jobs will be created in Scotland, **23%** in England and **17%** in Wales

What is the problem?

Radars & WTGs

In short, primary radars think WTGs are aircraft – designed to detect moving targets – turbine blades move at equivalent speed to aircraft, having similar / greater radar cross sections as aircraft

Applies to all rotating radar

Limited time on target results in insufficient target data to characterise targets

Also, desensitisation and shadowing reducing aircraft detection

Military & Civil, AD & ATC

Current ATC PSR are 2-D so cannot distinguish elevation of target (WTG or aircraft?)
AD radar is 3D – less impact – but track seduction concerns remain at low altitudes

MoD blocking upwards of 10GW

2017 RenewableUK/AIFCL Aviation Survey indicates >10GW offshore wind with MoD AD concerns, >5GW offshore & 1.2GW onshore in Scotland with MoD ATC concerns

Why is this a problem?

MoD objections

Unacceptable impact on AD and ATC

Map of impacted areas

AD and key ATC MoD radar line of sight at 300m amsl shown

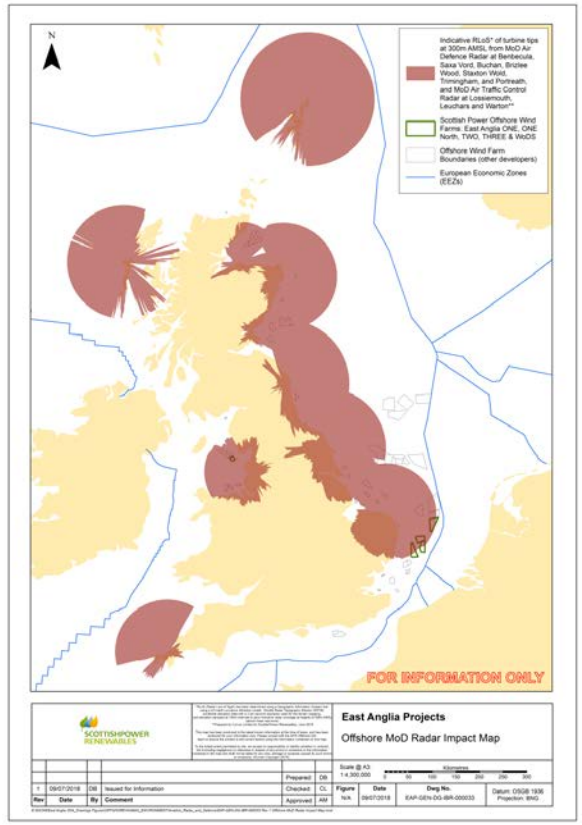
Ministerial statements in 2006/7

It is now 2018 – little progress to date

MoD still thinks WTGs are a “new” addition to the environment

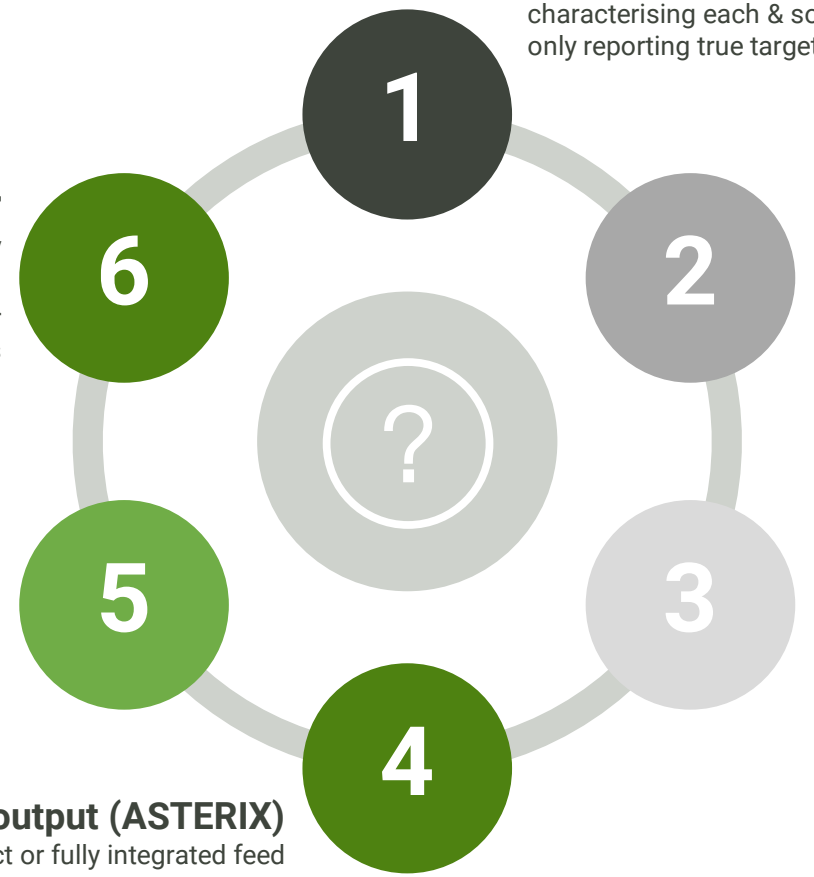
Cross Government co-ordination required

MoD approach to date fails to align with flagship Government policies of Clean Growth Strategy and Industrial Strategy



And the answer is …

Aveillant Theia Holographic Radar ™
A 3D staring radar that sees both aircraft and WTGs, characterising each & so discriminating between them (i.e. only reporting true targets) with no loss of performance



Electronic Warfare resilient
Due to system architecture

Proven technology
CAA Safety Cased & operational 5nm Theia for East Midlands Airport
20nm & 40nm Theia demonstrated at Muckleburgh & Deenethorpe respectively
Extended range Theia >50nm demonstration Q1 2019

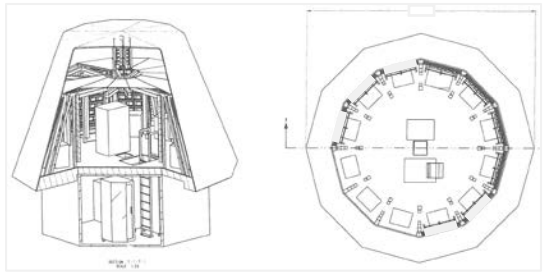
Industry standard output (ASTERIX)
either direct or fully integrated feed

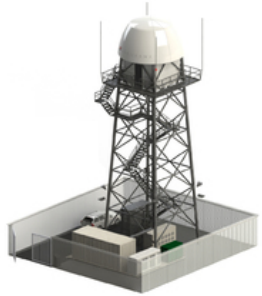
Aveillant, a Thales company
Based in Cambridge, UK
A sustainable solution, exportable globally

Solution can enhance future air defence capability
Interrogates whole field of view persistently, in contrast to existing scanning AD radar
Reporting interval of 1 second or less

Evolution of Aveillant Theia

From 5nm at East Midlands Airport

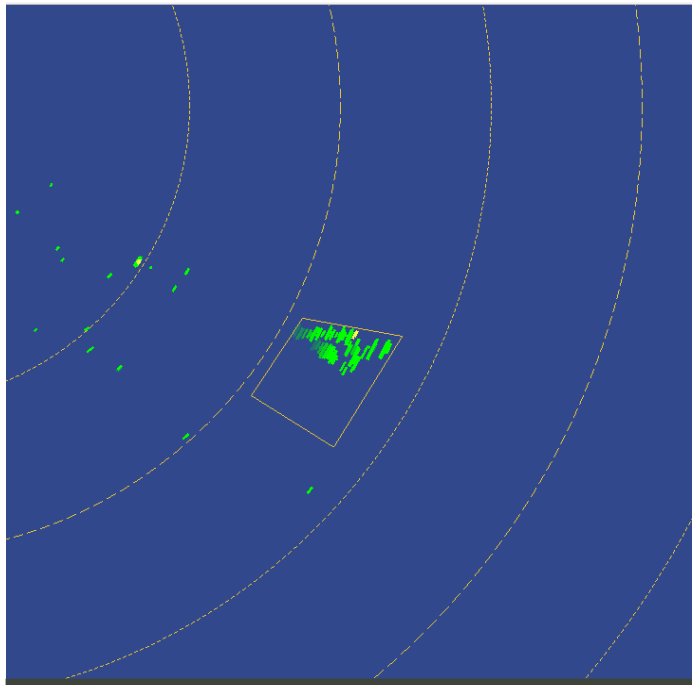




Theia progression extended range >50nm

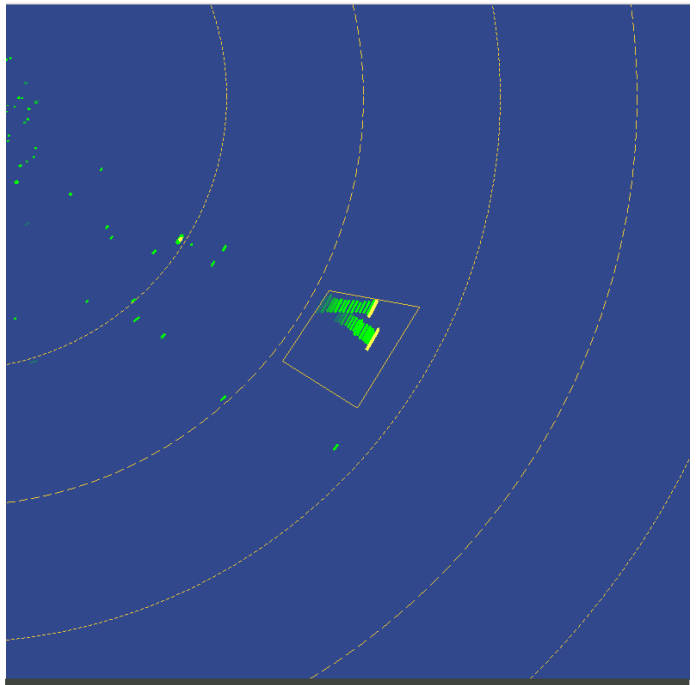
all using same basic components / technology

Aveillant Theia integrated with Prestwick PSR for Hare Hill Windfarm



Prestwick PSR

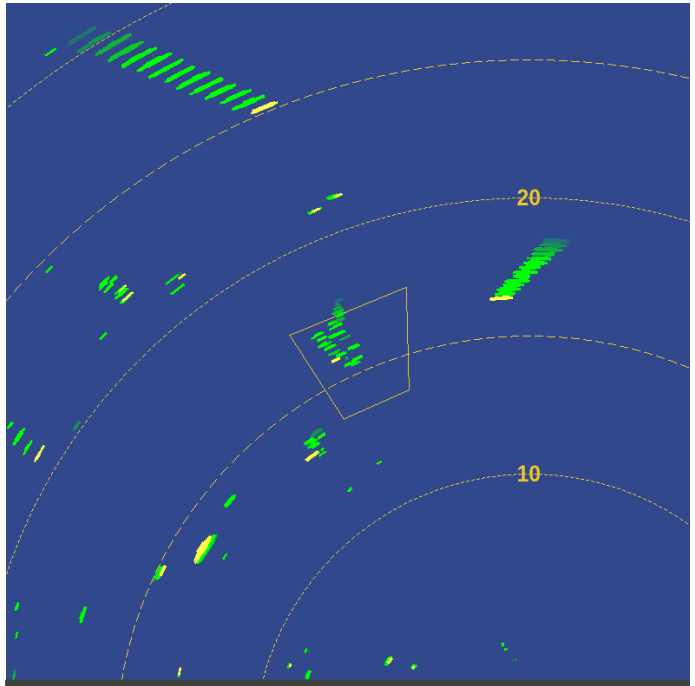
Aveillant **switched out**



Prestwick PSR

Aveillant **switched in**

Aveillant Theia integrated with Prestwick PSR for Windfarms near Knockendon



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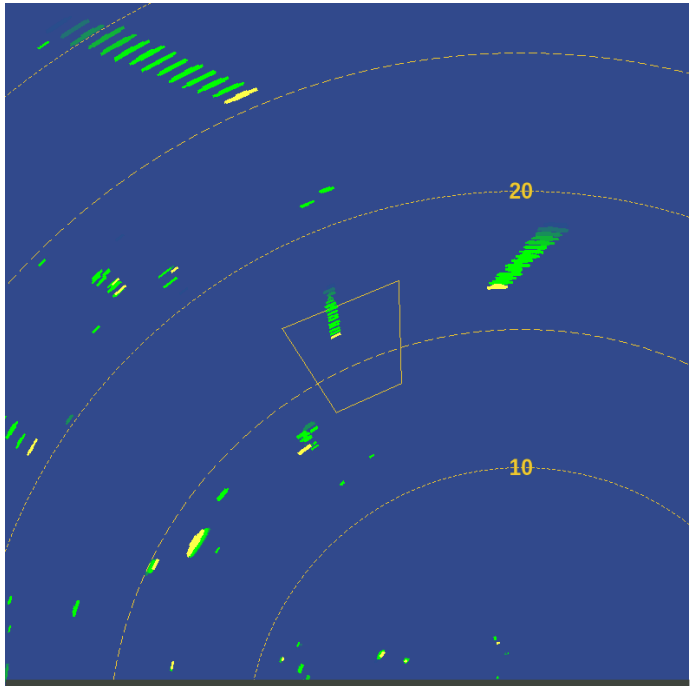

Prestwick PSR

Aveillant **switched in**

How do we move forward?

Phase 1
Extended Range Trial
SPR has taken lead - is happening now into Q2 2019

Phase 2
Product Qualification
In presence of offshore & onshore WTGs (2019 – 2020)
Delivers full evidence of product compliance (i.e. CAP670 & DEFSTAN requirements)

Phase 3
Implementation
It's just another radar project!

Anticipate that Theia will offer both AD & ATC solutions

Working towards MoD
assuming responsibility for ensuring its surveillance systems windfarm tolerant by 2030

Project Green Blade assists in delivering this plan

What is Project Green Blade?

Enabling radar friendly wind energy

- Offers a sector wide opportunity to meet government & industry objectives
- Aveillant Theia is the solution

- Technology, industry & government collaboration sought for Phase 2 (Product Qualification in presence of WTGs)
- MoD / RAF input & engagement critical to success of Project Green Blade & delivery of UK Government's Clean Growth & Industrial Strategies

SCOTTISHPOWER RENEWABLES

THALES

AVEILLANT
A Thales company

CYRRUS
Enabling Excellence in Aviation

Project Green Blade

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