



Hornsea Project Four

Air Defence and Offshore Wind: Working Together Towards Net Zero

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Coronavirus (COVID-19) (/coronavirus)

Latest updates and guidance

1. Home (<https://www.gov.uk/>)
 2. Defence and armed forces (<https://www.gov.uk/defence-and-armed-forces>)
 3. Air defence and offshore wind - working together towards Net Zero (<https://www.gov.uk/government/publications/air-defence-and-offshore-wind-working-together-towards-net-zero>)
- Department for Business, Energy & Industrial Strategy (<https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy>)
 - Ministry of Defence (<https://www.gov.uk/government/organisations/ministry-of-defence>)
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Policy paper

Air defence and offshore wind - working together towards Net Zero

Published 29 September 2021

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As the UK works to meet its net-zero targets, offshore wind will be an important part of our future energy mix. This strategy sets out how we are working together, across government and industry, to ensure that we continue to provide for our nation's security while enabling our critical renewable energy needs. In line with MOD's own net zero ambition, this collaboration directly supports the delivery of the Government's 10 point plan for a green industrial revolution and enabling the UK to become a world leader in clean energy.

Rt Hon Jeremy Quin MP, Minister for Defence Procurement

This strategic plan represents a key milestone for BEIS in ensuring the timely deployment of 40GW of offshore wind by 2030. It is moreover a testament to this government's ability to work collaboratively across boundaries in optimising our transition to net zero. I look forward to this programme's continued development with our partners in the Taskforce, and the resulting deployment of clean, cost-effective offshore wind energy this will produce.

Rt Hon Greg Hands MP, Minister for Energy, Clean Growth and Climate Change

Foreword

The critical move towards a Net Zero carbon economy is a huge and complex global challenge, in which the UK seeks to play a world leading role. Achieving the de-carbonised electricity generating capacity needed requires large-scale deployment of offshore wind that, if unmanaged, could have adverse impacts on the UK's air defence radars used to deliver the security of the UK and its airspace.

In 2019 the Offshore Wind Sector Deal acted as a catalyst to bring together the Ministry of Defence, Department for Business, Energy and Industrial Strategy, The Crown Estate and the Offshore Wind Industry Council. They formed a Joint Task Force, reporting to a Joint Programme Board, whose aim is to enable the co-existence of air defence and offshore wind.

This first iteration of our Strategy and Implementation Plan shows the great progress that can be achieved by working together, despite the disruption caused by the COVID-19 global pandemic, and serves as an exemplar for resolving other complex issues between multiple government, industry and other stakeholders. This document represents an important milestone by sharing the progress made thus far, together with setting out the direction of travel for further work.

The Task Force will continue working together, at pace, to make its aim of the effective coexistence of air defence and offshore wind a reality and together, we jointly commend it to you.

Air Vice Marshal Linc Taylor, Chief of Staff Capability (Air), Royal Air Force

Ms Fiona Mettam, Deputy Director Renewable Electricity, Department for Business Energy and Industrial Strategy

Mr Will Apps, Head of Energy Development, The Crown Estate

Mr Paul Cooley, Sector Deal Aviation Workstream Board Sponsor, Offshore Wind Industry Council

Executive summary

The UK Government intent is to deliver 40 gigawatts (GW) of offshore wind power by 2030 as a stepping stone towards its Net Zero target. Offshore wind will need to continue to grow to meet our energy demands, with the Climate Change Committee (CCC) indicating a central scenario of at least 75GW of generation by 2050. The achievement of these ambitions is reliant on the creation of numerous new offshore windfarms.

These offshore windfarm installations may adversely impact the quality of data obtained from the long-range Primary Surveillance Radars (PSR) which are the backbone of the UK's Air Defence (AD) detection capability.

Given that the primary task of the Ministry of Defence (MOD) is to defend UK territory, any such degradation of PSR capability will impact the production of the Recognised Air Picture (RAP) and thus could reduce both the range and time available in which to identify and act on a potential aggressor. This is unacceptable for the Nation's security.

This paper offers a roadmap through which future co-existence of these competing concerns are addressed, to assure stakeholders that a satisfactory radar picture can be achieved in the presence of windfarms. Doing so opens the doors to significant inward investment, to UK leadership and to the achievement of our Net Zero ambitions.

What follows are the results of an initiative set up through the Aviation and Radar Workstream of UK Government's Offshore Wind Sector Deal in March 2019. The Air Defence and Offshore Wind Windfarm Mitigation Task Force was formed as a collaboration between MOD, Department for Business, Energy and Industrial Strategy (BEIS), the Offshore Wind Industry Council (OWIC) and The Crown Estate (TCE) in August 2019.

Led at Board level by the RAF's Chief of Staff Capability on behalf of MOD, and supported at similar levels across BEIS, TCE and OWIC, the aim of the Task Force is to enable the co-existence of UK Air Defence and offshore wind. The specific intent is to support government objectives for Net Zero by identifying potential technical mitigations and supporting processes that will enable their delivery in time to support windfarm developments that will be part of the BEIS Contracts for Difference (CfD) Allocation Round Four (AR4) and beyond.

The Task Force is co-chaired by representatives from the RAF and OWIC with current work focussed on three workstreams: Evidence, Process Development and Risk Management. Through an Innovation Challenge funded by BEIS and delivered by MOD, the programme seeks to encourage the development of future technologies that might form part of a 'systems of systems' approach to long term co-existence.

An important breakthrough has already been made in identifying at least one or more technical mitigation that could potentially support windfarm developments in the medium term. Operational analysis along with an ongoing series of OWIC funded, MOD managed, concept demonstrations will inform decision making with the aim of helping us to develop a strategic approach to deploying a system of future-proofed mitigations which will enable future windfarms as well as those currently under development.

These technical advances are complemented by development of an agreed set of 15 high level joint principles which underpin the development of a procurement strategy supported by an MOD commercial strategy. This could facilitate the development of potential cost sharing arrangements that might support a national or regional strategic approach. Later work will develop template commercial agreements with the aim of streamlining the mitigation scheme negotiation process.

Initial risk management work has concentrated on development of a scenario-based approach to the key risks. This has allowed us to understand the impacts and available mitigation options for each stakeholder group and so minimise the possibility that the existing 2025-2030 procurement and development timeframe will be delayed.

Introduction

The Air Defence and Offshore Wind (AD&OW) Strategy & Implementation Plan (S&IP) sets the direction for collaboration between Government Departments and the Wind Industry in pursuit of identifying, assessing and deploying solutions that will enable the co-existence of AD&OW operations such that neither is unduly or excessively compromised.

Through identification of such solutions, and processes through which they will be deployed, the S&IP will support the achievement of its objective to enable the co-existence of AD&OW.

Mitigation of the adverse impacts of windfarms on current AD systems will be a stepping stone towards a longer term solution that will enable co-existence.

This plan contributes to the Government's ambition for the rapid increase of offshore wind developments out to 2030 and beyond.

In order to achieve the Strategy's aims, it will be necessary to:

- draw on timely evidence which enables a high degree of confidence that mitigation concepts and solutions can be resourced and deployed to meet 2030 targets and Net Zero timelines.
- implement processes that allow the MOD to make irrevocable decisions on the release of windfarm development planning consent conditions.
- confirm that such concepts and solutions are realistic in terms of:
 - performance: laws of Physics as well as against the MOD requirements
 - time: balancing the time available against the time necessary for deployment
 - cost: available funding and procurement processes
 - policy: laws, safety standards, security regulations, etc.
- outline how different concepts could be deployed in either a national, regional, clustered and/or project level such that solutions can be implemented according to short, medium and longer-term timelines

Defining 'Tolerable' and 'Acceptable' in the context of levels of windfarm mitigation for AD: 'Tolerable' refers to a minimum standard of performance that MOD is prepared to sustain until such time as a system that would deliver improved performance becomes available, consistent with the "As Low as Reasonably Practicable" (ALARP) principles for dealing with risk. 'Acceptable' refers to performance standards that MOD is prepared to sustain indefinitely, subject to there being no future changes in the requirement.

Defining 'Interim' and 'Enduring' in the context of timescales of solutions and their applicability: Tolerable mitigation is considered as an Interim solution, with the Acceptable mitigation regarded as the Enduring solution.

The S&IP will be a living document, updated through a regular review process to incorporate new evidence and adapt to policy developments over time. The Strategy identifies three key milestones for its implementation, recognising the sea-bed licensing processes run by TCE and Crown Estate Scotland (CES), national planning processes and the CfD process regulated by BEIS:

- 2020 - 2025: Implementation of next rounds of Offshore Wind developments to meet 40GW by 2030. The immediate imperative is that a strategy is agreed to set the conditions for bidding in CfD AR4 [\[footnote 1\]](#) such that windfarm developers and the MOD can each have confidence that mitigation plans will meet the relevant consent conditions in order to initiate construction and thus enable turbine operation from no earlier than Q2 2025 with a central scenario of Q4 2025 [\[footnote 2\]](#). The Contracts for Difference (CfD) scheme is the Government's main mechanism for supporting low-carbon energy generation by incentivising developer investment. The fourth round of the CfD scheme – to open in late 2021 – will aim to double the capacity of renewable energy compared to the last round and expand the number of technologies supported, with offshore wind, onshore wind, solar, tidal and floating offshore wind projects all eligible to bid.
- 2025 - 2030: Completion of projects to deliver 40GW of offshore wind energy through delivery of new windfarm installations and continuous improvement of mitigation knowledge to meet AD requirements in a windfarm-rich operating environment to accommodate TCE leasing rounds (Round 4), CES ScotWind leasing rounds and BEIS CfD ARs (eg AR5 & AR6).
- 2030 - 2050: Upscaling from 40GW of UK offshore wind footprint to deliver Net Zero and implementation of the UK's next-generation AD surveillance capability.

Context

In 2020, the UK's Prime Minister unveiled plans to power every home in the UK using energy generated by offshore wind and set a target to deliver 40GW of offshore wind power (plus 1 GW of Floating Offshore Wind (FOW) by 2030, starting with a CfD AR opening in late 2021).^[footnote 3]

In parallel, the government has increased the UK's Nationally Determined Contribution (NDC) under the Paris Climate Agreement, aiming to reduce economy-wide greenhouse gas emissions by at least 68% by 2030, compared to 1990 levels.^[footnote 4]

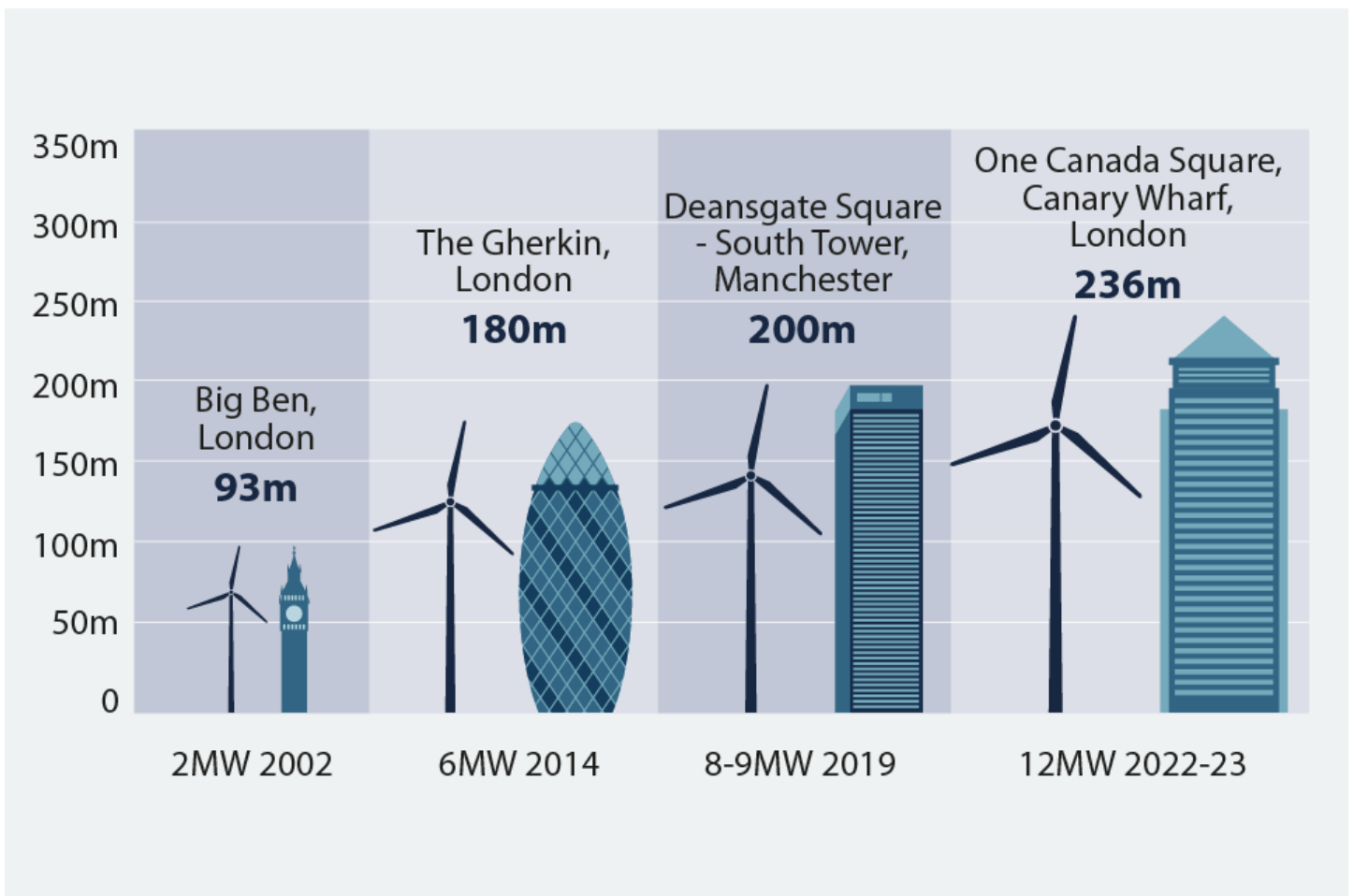
To oversee the expansion of renewable power in the UK, the government's Energy white paper: Powering our net zero future^[footnote 5] commits to, and has, established a Ministerial Delivery Group to bring together the relevant government departments and provide the cross-government coordination and collaboration necessary to achieve its ambition for renewable electricity. This includes tackling issues such as the impact of wind turbines on radar systems^[footnote 6].

The government, through MOD, is committed to defending UK territory. Long-range ground-based PSRs remain the backbone of the UK AD surveillance capability, but windfarms may create adverse impacts on the RAP, which require mitigation. To enable the government's renewable energy targets to be achieved, there is a need for a unified approach between the Government (MOD and BEIS), Wind Industry stakeholders of the OWIC (including windfarm developers and operators) and TCE to find Acceptable solutions to mitigate the effects of offshore windfarms on AD operations.

AD capability includes the ability to detect, identify and track in order to deter or engage air threats. Whilst the AD system is acknowledged to be a mosaic of capabilities, the S&IP focusses on the impact on PSR performance and potential routes to mitigation.

To bracket thinking, the S&IP considers short, medium and long term milestones^[footnote 7] acknowledging the necessary timelines for commercial investment decisions and allowing for emerging technologies to be included either as part of a sequential progress or inserted if they offer significant and enduring benefits earlier in the roadmap.

The intent of the S&IP is to support achievement of the Government's ambition for the rapid increase in offshore wind developments out to 2030 and beyond whilst maintaining an effective AD system to protect the UK. The ultimate goal is to describe the Ways and Means by which the co-existence of AD&OW operations can be enabled, such that neither is unduly or excessively compromised. The following sections articulate the framework within which the S&IP will mature to deliver against the overall aim.



Comparison of offshore wind turbine size over time. From 2002 (2MW, 93m) to 2022-23 (12MW, 236m).



Map showing offshore windfarm projects around the UK.

Assumptions, Principles and Constraints

General constraints

In order to make progress with development of the S&IP, it has been necessary to make documented assumptions. These will be regularly reviewed through future iterations of the S&IP document.

It will not be possible to eliminate the effects of future offshore wind developments on current deployed AD radar. Although significant, it should be stressed that the radar data source is one component of an overall integrated AD system. Developers looking to build their windfarms in line with expected CfD AR4 timelines (i.e. commence turbine operation from Q4 2025), should assume that:

- The evidence gathered to date indicates that Interim mitigation is most likely to derive from full-service AD radars deployed either as one-for-one replacements for legacy equipment, or in addition to extant equipment (in-fill), focussed primarily on the wind farm-affected airspace. In the longer term, other concepts may emerge as better prospects to take forward^[footnote 8].
- Preferred mitigation solutions are likely to be those which are MOD owned and located on the Defence Estate having followed MOD procurement processes. Other options would be considered on their merits.
- Where it is believed to be impossible or impractical to improve upon the performance of a solution that is delivering only Tolerable mitigation, that solution may need to endure for so long as a mitigation is required by MOD. In this situation it is recognised that a Tolerable mitigation could only be agreed where there is a commitment by all parties to continue to work actively and in good faith to find an enduring Acceptable mitigation.
- Subject to presentation of technical evidence and/or an ongoing assessment of the threat environment and operational risks, there may also be the opportunity for the MOD to re-evaluate a solution meeting a Tolerable standard of performance to assess whether it now meets a newly-defined Acceptable standard of performance.

Offshore Wind Industry Council (OWIC) principles and constraints

For the UK Offshore Wind Sector to have confidence to lease, develop, bid or take Final Investment Decision (FID) for offshore windfarms to deliver the Government's renewable energy policy targets, the sector requires certainty of construction, operations and generation of offshore wind projects.

Windfarm developers look for certainty of operation at acceptable cost and risk profile before entering CfD processes, investment decisions and committing to build a windfarm.

This certainty may be achieved by offshore wind developers entering agreements with the MOD covering relevant mitigation solutions (including interim mitigations where appropriate) and having a known and proportionate responsibility split on risk and cost assignment.

These agreements could be bilateral at project level or multilateral between more projects and MOD, depending on the mitigation measure and plan for implementation.

MOD principles and constraints

The provision of air surveillance using ground-based long-range AD PSRs supports Defence Task 1 (DT-1).^[footnote 9] This is of critical importance to the UK and expected to remain so for the foreseeable future. The MOD will not subject its AD network to effects that would unduly impact its ability to meet DT-1. MOD therefore requires certainty of mitigation for the adverse effects that any prospective windfarm may have on this essential capability.

AD surveillance and control capability comprises a combination of technology, organisation and procedures. Therefore, mitigation may be achieved through individual or combined changes to technical or procedural approaches and organisational factors. Where potential procedural or organisational mitigations are considered inadequate by MOD, technical mitigations will be required.

The present AD capability aims to protect UK airspace and to meet its obligations to NATO.

Through the AD&OW Programme Board (PB), the MOD will regard the OWIC-funded work, managed by MOD to identify and demonstrate candidate systems for their potential to mitigate adverse windfarm effects, as a valid part of a potential future solution procurement, subject to a successful outcome. MOD and Offshore wind developers may therefore build on this prior work within any resulting Radar Mitigation Scheme Agreements (RMSAs).

It has been customary for MOD to enter RMSAs where the uncertainty/risk associated with a mitigation project is accepted by the MOD in exchange for financial guarantee, provided that the mitigation plan itself assures the MOD that at least Tolerable mitigation would be in place from the time at which the windfarm development first impacts on the AD picture^[footnote 10], and that Acceptable mitigation would be a reasonable prospect within a timeframe agreed by MOD. Tolerable mitigation is considered as an Interim solution, with the Acceptable mitigation regarded as the Enduring solution. The principal aim is delivery of an Enduring, Acceptable, solution.

Assessment and determination of acceptability of windfarm mitigation will be an MOD responsibility through the procurement process, cognisant of other stakeholder requirements (e.g. BEIS, National Grid, Ofgem) and the need to secure mutual (MOD and wind industry) acceptance of mitigation measures. This may include Interim and Enduring solutions at a national, regional or project level.

Approach taken

The AD&OW Windfarm Mitigation Task Force (TF) was formed in August 2019, co-chaired by MOD and the OWIC representatives and supported by focussed activity across MOD, BEIS and Industry with TCE joining in April 2020. The TF meets each month in full, with an intermediate update meeting to review progress and a number of working sub-groups established to progress specific areas of work. Four focussed lines of activity were initially established to develop a body of evidence to support the development of the S&IP:

- Paper-based Studies. To investigate what technical mitigation solutions might exist. An executive summary is at Annex A:
 - An offshore wind industry contracted Thales report on mitigation concepts and scenarios.
 - MOD Paper-based Feasibility Study by Defence Equipment & Support (DE&S)^[footnote 11] on mature mitigation solutions.
 - MOD-contracted BAE Systems Windfarm Mitigation Study on low-Technical Readiness study.
- Concept Demonstrations. To demonstrate the practical performance of selected mature technical mitigations identified by the MOD in its paper-based feasibility study focussed on those that might support offshore windfarm developments in the 2025-2030 timeframe.
- Innovation. A BEIS funded, MOD delivered, Innovation Challenge to encourage development of novel solutions for the future. Managed by the Defence and Security Accelerator (DASA) with Defence Science and Technology Laboratory (Dstl).
- Operational Analysis. To help MOD understand the operational effect that adverse impacts of windfarms have on the AD system, and so inform the development of the detailed requirements against which solutions will be procured.

The TF's work evolved in early 2021 into three broad workstreams delivered through collaboration between the four stakeholder groups (MOD, BEIS, TCE & OWIC). These workstreams are:

- Evidence: comprising the Innovation Challenge, Concept Demonstrations, Operational Analysis, User and Systems Requirements and initial consideration of Integration aspects.
- Process Development: through which mitigation solutions would be chosen and delivered; specifically, a Procurement and a Commercial Strategy.
- Risk and Mitigation: a Joint Programme Risk Register along with the identification of impacts and mitigations for each stakeholder group: BEIS, MOD, TCE, OWIC. In this way the TF works together to identify potential technical mitigations and supporting processes to enable mitigation of windfarm impacts on AD in the 2025-2030 timeframe.

The focus is on supporting those offshore windfarms which are likely to be deployed soonest, i.e. those bidding into CfD AR4/AR5 and has encouraged the development of future technologies that could support long term co-existence.

The following section provides an update on each of these three workstreams with further detail in the appropriate annex, noting that the level of detail shared may have been limited by security classification, commercial and/or Intellectual Property Rights considerations.

The Programme Plan to April 2022 can be found at Annex B and an extended Programme Plan out to Q4 2025 is at Annex C.

Evidence

The S&IP draws on evidence provided through the paper-based studies, innovation challenge and concept demonstrations supported by operational analysis, user and systems requirements development and initial work to consider integration. Through this work stakeholders, including government and wind industry, can identify the Ways and Means to initially mitigate the effects of offshore wind turbines on AD operations and eventually enable their long-term co-existence. Delivered by the TF on behalf of the AD&OW PB, these have made good progress:

Innovation Challenge

- Phase One of the joint Innovation Challenge was completed in Mar 2021 with six projects from five suppliers successfully delivering their reports. A demonstration event was held in Mar 21 during which the suppliers provided a high-level briefing to TF stakeholders followed by a more detailed brief to BEIS and MOD. A summary is at Annex D.
- Phase Two was launched on 22 Apr 2021 with 20 bids being received. The project is on track for contracts to start in Sep 2021 and completion in Mar 2023.

Concept Demonstrations (CD)

2020

Campaign One of the CD programme aimed to conduct four demonstrations from Remote Radar Head Staxton Wold and one at a company facility overseas to provide an understanding of certain performance attributes of those systems.

The five candidates had emerged from an earlier study as being those most worthy of further examination and the intent was to establish an 'art-of-the-possible' baseline to inform the development of a future set of requirements.

Unfortunately, CV-19 restrictions in 2020 disrupted the plans such that only two of the intended candidates were observed. A third candidate, from amongst the paper-based feasibility study, but outside the original five, was demonstrated on an opportunity basis.

All were demonstrated under contingent Plan B arrangements, none involving Staxton Wold.

All three demonstrations were conducted by the respective suppliers with relevant data then forwarded to 56 Squadron at the RAF Air and Space Warfare Centre (ASWC) for analysis, leading to the issue of individual observation reports. Whilst significantly fewer candidates were demonstrated by the end of 2020 than originally intended (which had bearing on the breadth of data collected), the trial objectives were largely achieved with encouraging results.

The TF was briefed, in May 21, on the observation reports for the three systems and together formed the view that there was now moderate evidence of potentially Tolerable mitigation solutions having been seen. This view, which was endorsed by the PB, is pivotal in establishing the joint opinion that technical mitigation may be achievable within CfD AR4 timelines.

2021

The focus for 2021 is to deliver the remainder of the Campaign One concept demonstrations delayed from the previous year in parallel with additional demonstrations that comprise Campaign Two. Further detail is at Annex E.

Operational Analysis (OA)

Phase One of the OA undertaken by Dstl developed a set of scenarios in which wind farms were relevant to help inform the User and Systems Requirements for future mitigations. Further detail is at Annex F.

Phase Two will build on this work including consideration of how the mitigation systems that had been demonstrated so far might be deployed in a strategic manner to enable CfD AR4 and AR5 developments whilst also facilitating likely future windfarm developments. Other work will consider windfarm layout, size and spacing on potential radar systems and so help us to understand the cumulative impact of potential future developments.

User and System Requirements

Undertaken by MOD, this work has developed a detailed User Requirements Document informed by the OA work above to an advanced level of maturity. Phase One of the Systems Requirement work has been completed, with Phase Two underway to develop the detailed Systems Requirements.

Integration

Initial work has identified the opportunities and constraints for integrating additional radar feeds into the UK AD system. Further work will be required to consider issues around offshore radar deployment or integration of any non-radar-based mitigation system. Deployment of supplementary land-based radar system(s) does not preclude other options. A Capability Integration Working Group (CIWG) will be stood up in autumn 21.

Process development

The process development workstream, formed in Feb 21, aims to establish new mechanisms and the contractual frameworks surrounding them, to procure solutions for those developers bidding into CfD AR4 and subsequent rounds.

This workstream will also be responsible for developing a Joint Procurement Strategy together with an associated Commercial Strategy. It will also facilitate discussions on potential cost-sharing arrangements and in due course, it will develop template commercial agreements with the intention to streamline the process for developing formal agreements between developers and MOD. Membership of this working group includes specialists from MOD governance organisations including the Air Investments and Approvals Committee and financial scrutineers. Support will be on call from OWIC member organisations.

Joint Procurement Strategy

The working group (WG) has approached this area in three phases: developing joint principles, developing the principles into a framework and then developing the framework into a formal document for endorsement by the Programme Board. The group has agreed 15 Joint Principles (at Annex G) that range from recognition of the importance of 'certainty of generation' and 'certainty of mitigation' through to the aspiration to develop a strategic approach to the delivery of the mitigation solution(s).

Another of the principles is that there be a roadmap that articulates the pathway from Tolerable performance to Acceptable performance and expectations for handling financial contributions to cover procurement activity and risk. The central assumption is that CfD AR4 windfarm developments will be operational in Q4 2025 and thus mitigations must be operational by then. This drives a very compressed procurement timeline with associated greater risk compared to one with more time available. It will be important for any change to the central assumption of Q4 2025 windfarm operational date to be shared as soon as possible as this could materially help to reduce risk in the procurement process. The next step is to develop the agreed principles into a more detailed framework to inform the Procurement Strategy itself.

Commercial strategy

The commercial strategy will be the formal document detailing the commercial aspects of how the procurement strategy will be delivered by DE&S. As such it must meet MOD and Civil Service Rule Book requirements for a process delivered by MOD. Whilst not a joint document, feedback from stakeholders may be used to inform the strategy.

Cost sharing arrangements

The TF seeks to facilitate discussion on how cost sharing could be used to enable a strategic approach to mitigation. Discussions are ongoing to explore opportunities or barriers and this work will continue with the results included in future versions of the S&IP. The aim is to agree a high-level approach by the end of Dec 21 if possible, to support a procurement process in 2022. It should be noted that cost sharing was successfully agreed when deploying previous mitigations.

Draft commercial agreements

The TF aims to develop draft commercial agreements based on the principles, framework and detailed strategies agreed through the TF's work. If successful, this would enable a streamlined process for negotiating formal, binding, agreements between MOD and developers to mitigate the impacts of their developments. The benefit of this approach would be that all parties would understand the process, and its likely outcome much earlier in the process, thereby reducing uncertainty of outcome, risk of protracted negotiations and ultimately realise cost efficiencies. The TF recognises that such draft agreements would not be binding on individual developers who could choose to negotiate bespoke agreements individually. This work is expected to start in Q4 2021.

Risk management

The TF formed a Risk Management Working Group to develop an agreed Joint Programme-level Risk Register and associated mitigation activity that is reviewed regularly. The group developed a scenario-based approach to managing key risks, with each stakeholder group considering the impacts and available mitigations from their own perspective. These inputs were collated into a common risk management approach.

Having seen the results of the three CDs completed at this stage (as described under the CD update in section 26 above), the TF considers that it has now seen 'moderate evidence of a tolerable mitigation' being available.

Next steps

The TF will continue its work through the three workstreams to build the body of evidence and associated detailed processes that will provide the Ways and Means to initially mitigate and in due course, enable the long term co-existence of AD and offshore wind.

Future iterations of this S&IP will identify the specific concepts and solutions that will mitigate the effects of offshore wind on MOD AD capabilities, and provide further detail on the financial, commercial and process changes required to implement these solutions within the required time periods.

As work progresses, further iterations of this strategy will be published such that the best information is available to stakeholders to support each milestone within the windfarm development and consenting processes.

Conclusion

The AD & OW TF seeks to enable the long-term co-existence of UK AD and offshore wind.

It recognises the importance of national defence, government policy objectives for Net Zero that are predicated on delivering 40GW of offshore wind by 2030 and that offshore wind developments must be deliverable and economically advantageous to attract investment.

By working together, the TF has overcome the challenges and disruption posed by CV-19 and has identified at least one or more 'off the shelf' radar system believed to have demonstrated the potential to provide at least Tolerable mitigation. Provided such a capability could also be procured and delivered against a schedule dictated by CfD AR4, then developers and MOD alike will have a degree of confidence in meeting the PB's most urgent aim.

The next challenge is to develop the detailed processes including procurement, cost sharing and draft commercial agreements through which such a mitigation would be acquired and ultimately deployed. Good progress has been made in agreeing joint principles from which the detailed processes will be based. The drive for deployment in Q4 2025 places significant pressure on the procurement process and such a compressed timeline will inevitably increase residual risk. The TF is actively managing that risk. It is investigating ways in which cost sharing might be facilitated and also how the supply chain might be primed to respond rapidly.

Whilst the programme must deliver at pace to achieve stakeholder objectives, good governance practice is essential to drive the right procurement decisions and ensure value for money.

Annex A

Summary of paper-based studies

Three paper-based studies were conducted throughout 2020 to aid the identification of mitigation solutions across the full spectrum of technology maturity. The studies covered a broad range of academic and market material, providing a foundation for practical activity during concept demonstrations, along with recommendations for future work. Since the referenced reports contain commercially sensitive information this summary seeks to highlight the key themes and recommendations for future work.

The three studies conducted were:

- "Windfarm Mitigation Request for Information Report, Air Defence Radar Market Survey", undertaken by Thales UK on behalf of Orsted, Scottish Power Renewables, Scottish and Southern Energy Renewables and Vattenfall Wind Power.
- "Report on a Paper-Based Feasibility Study to identify potential solutions for mitigating the adverse effects of wind turbines on air defence (AD) surveillance systems, undertaken by DE&S on behalf of MOD.
- "C14-Windfarm Mitigation Study", undertaken by BAE Systems on behalf of Air Capability through the Defence Science and Technology Laboratory.

The concepts covered in these reports included:

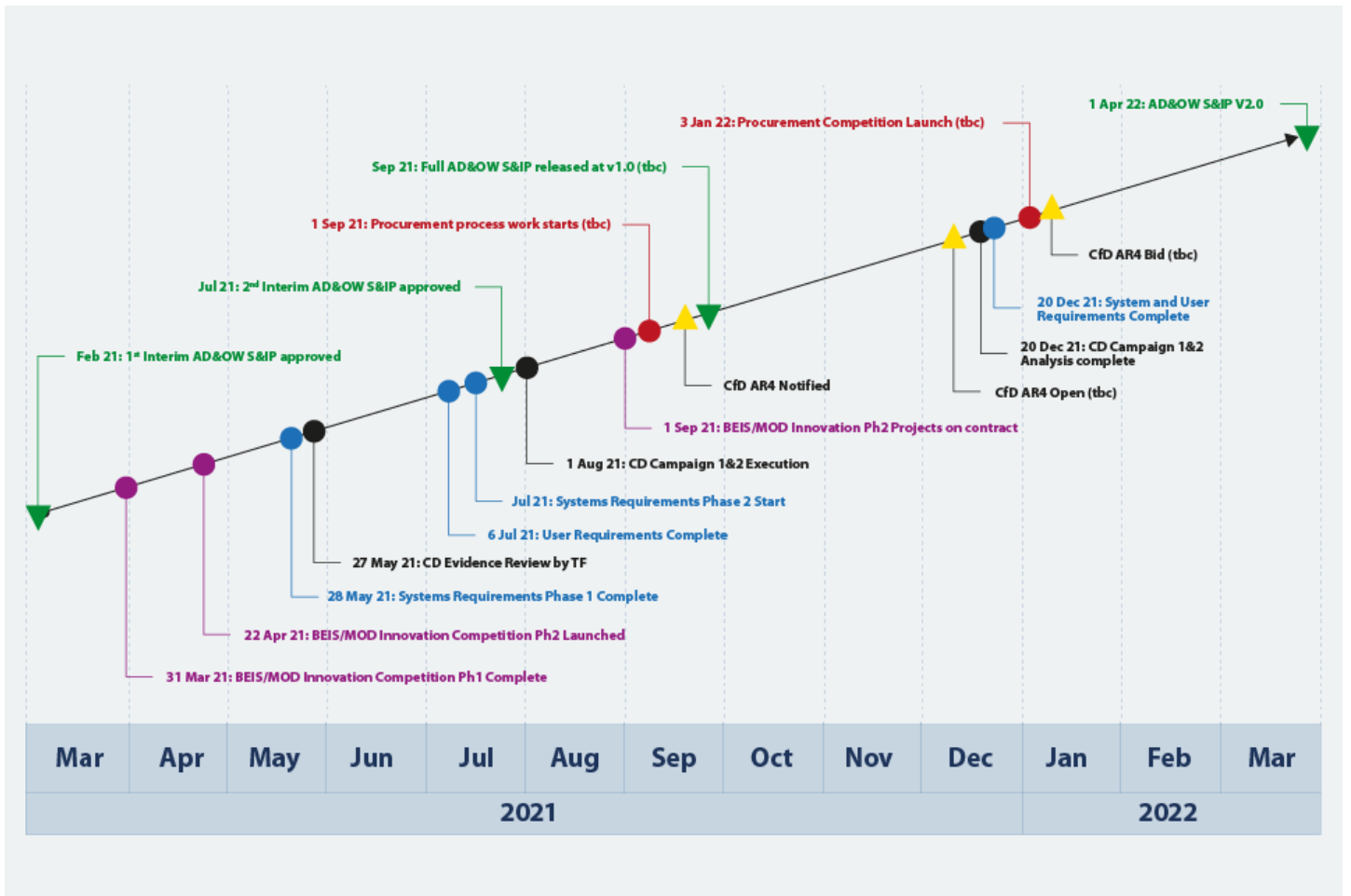
- Modifications to WTG shaping and radar reflectivity
- Use of gap / in-fill radars and staring arrays
- Offshore / onshore basing of radar systems
- Enhancing the transmitted radar waveform
- Radar processing techniques to reject windfarm clutter (e.g., machine learning and advanced signals processing)
- Solutions proposed through responses to the paper-based feasibility study, as listed at Annex D

The studies have shown that while there appear to be several potential windfarm mitigation solutions across the full range of Technical Readiness Levels (TRL), there appears to be no "magic bullet". However, many technologies appear to have potential against this problem-set, particularly when brought together in a 'system of- systems'. It was suggested that the viability of potential solutions be considered in combination with one-another and in different deployment scenarios (e.g., onshore / offshore).

To assess the viability of the proposed concepts, it was recommended that test and evaluation be conducted in representative environments. To facilitate consistent assessment of concepts, core requirements should be agreed and prioritised; this would also enable solution providers to target technology developments to meet the operational needs of likely deployment scenarios. To enable rapid assessment of mitigation proposals, development of synthetic modelling tools was advocated.

Annex B

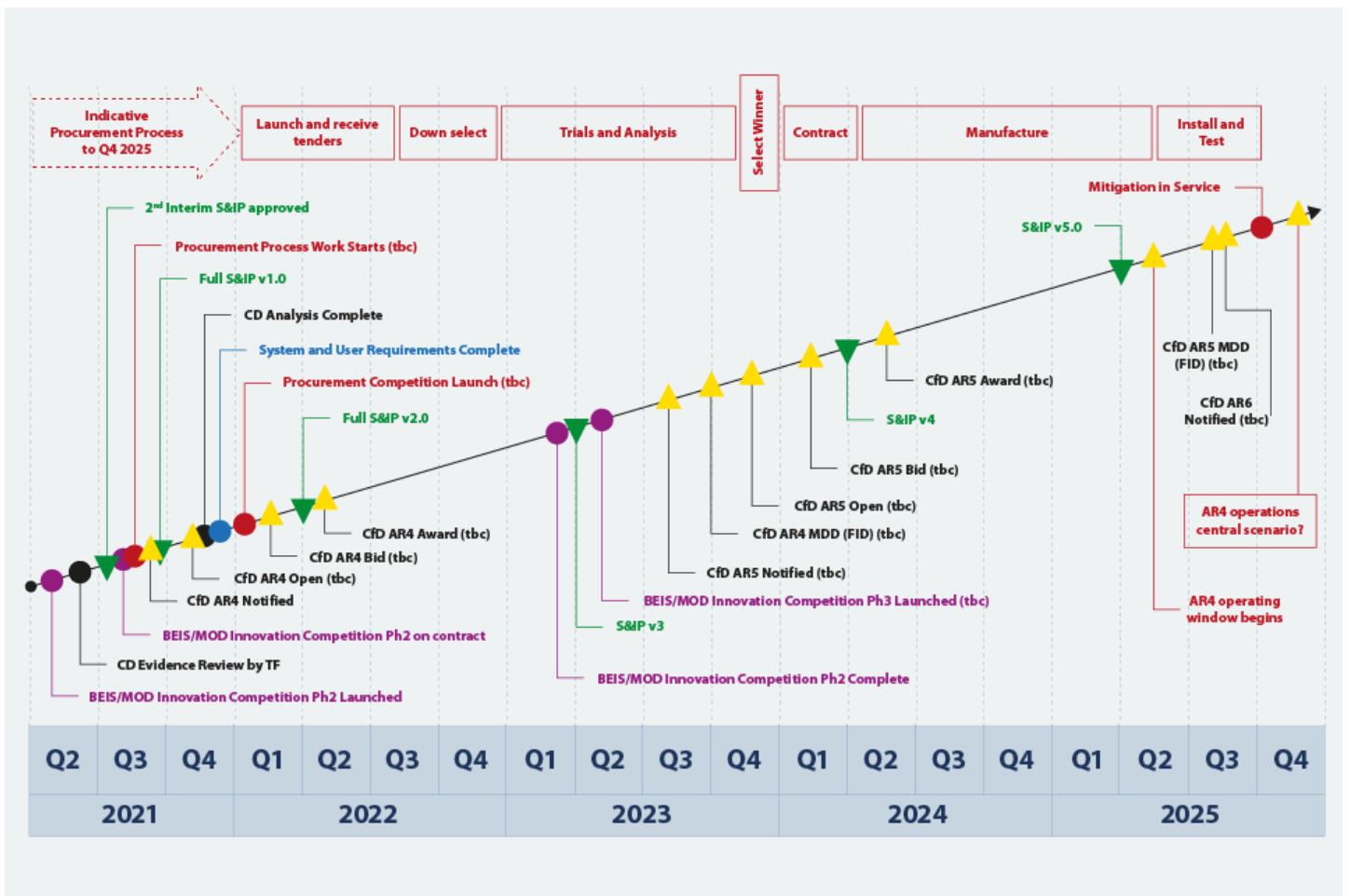
Task Force Timeline to April 2022



Task Force Timeline Graph. March 2021 to April 2022.

Annex C

Task Force Timeline to 2025



Task Force Timeline Graph. Q2 2021 to Q5 2025.

Annex D

Innovation Challenge - Windfarm Mitigation For UK Air Defence

Phase One

In support of the Air Defence and Offshore Wind Strategy and Implementation Plan, the BEIS and DASA^[footnote 12] launched a competition on March 2020. Proposals were sought to develop technology in four challenge areas:

- Alternatives to radar.
- Technologies applied to the wind turbine or installation.
- Technologies applied to the radar, its transmission, or its return.
- Technological mitigations not covered by Challenges 1, 2, or 3.

Fourteen proposals were submitted covering all four challenge areas and after assessment six were chosen for funding. The original budget for the competition was £2 million. Further funding was provided to allow support of a sixth proposal, resulting in a total budget of £2.1 million.

The Defence and Security Accelerator (DASA) aims to find and fund exploitable innovation to support UK defence and security quickly and effectively, and support UK prosperity. The accelerator runs a number of customer-led calls throughout the year to find new ideas to solve Defence and security problems.

Organisation	Proposal Title			
Thales	Multistatic RADAR for Windfarm Mitigation			
QinetiQ	Coded metamaterials and RADAR processing for mitigating the Radio Frequency effects of offshore wind turbines on surveillance RADARs			
QinetiQ	L-band RADAR Absorbing Materials for stealth wind turbines			
Plextek Ltd	Removal of Wind Farm Induced Artefacts on Primary RADAR using Deep Learning techniques			

Organisation	Proposal Title			
Saab	Windfarm RADAR mitigation through AI and advanced Doppler filtering			
TWI	Manufacturing methods for metasurfaces			

All contracts completed on time and all deliverables were received.

All suppliers from Phase One have submitted into Phase Two. The proposals were fairly judged alongside other proposals during the assessment process so further funding maybe possible but not guaranteed.

Phase Two

For Phase Two of the BEIS/DASA competition proposals were sought to address one overriding challenge; maintaining the effective surveillance of airspace despite the presence of larger windfarms. Four main subject areas were described:

- Reduction of clutter or the impact of clutter.
- Ensuring efficient detection and tracking time.
- Technologies to mitigate against larger turbine blades and wider turbine spacing development.
- Alternate methods of surveillance.

Twenty proposals were submitted covering all four challenge areas. Several proposals addressed more than one challenge area.

The budget for the competition is £3.6 million and it is expected to fund six proposals.

Annex E

Concept Demonstrations

The aim of the Concept Demonstrations is to assess currently available technical systems with potential relevance to air defence radar mitigation as part of the evidence gathering. This will enable the MOD to assess the ability of such technical systems to mitigate the risks to the UK's Air Security and Defence caused by future offshore wind farm developments.

A paper-based feasibility study was carried out to investigate the availability of "mature" technology as potential mitigation solutions. A Dynamic Pre-Qualification Questionnaire (DPQQ) was issued which sought responses from manufacturers relating to potential solutions at or above Technology Readiness Level Six. Seventeen submissions from 13 different companies were received. These were then evaluated by Suitably Qualified and Experience Personnel (SQEP) drawn from the MOD. The solutions claimed a range of techniques to mitigate the effects:

- Discrimination by Doppler identification /resolution.
- Discrimination by spatial resolution.
- Suppression of known wind farm plots by mapping (i.e., an "a priori" technique).
- Sophisticated trackers and/or non-radar-based sensor systems, which retain hold on genuine airborne plots, and are resilient to tracker seduction.
- Localised sensitisation/de-sensitisation techniques for the radar.
- RADAR absorbency properties of the wind turbine.

The impact of the COVID-19 pandemic was such that it was not possible to deliver demonstrations from three of the five Campaign One candidates. Two demonstrations were delivered in November 20 at sites of the suppliers' choosing with input from the TF in designing flight profiles and specifying data to be gathered. Results of these demonstrations were evaluated by 56 Sqn in early 2021 although less than 30% of the data that would have met original trial objectives was available.

Input to Strategy Based on:

- 3 x 3-D Tactical AD Radar
- 1 x Passive Radar
- 1 x Deployable AD Radar
- 1 x Electro-Optical Tracker
- 1 x 2-D Gap Infill
- 1 x 3-D Gap Infill

(Summary of Solution Types Contributing Evidence to the Strategy and Implementation Plan.)

Annex F

Operational Analysis - The Impact Of Offshore Windfarms On Air Defence Radar

Phase One

The Dstl was tasked with collating information on trials data, policy understanding, threat data and visualisation techniques to provide a holistic understanding of any current performance issues caused by wind farms to Air Defence Radar and how they will manifest themselves with the expected expansion of offshore wind farms.

Initial background research was undertaken to understand the impact caused by offshore wind farms (here on known as wind farms) on radar. This involved:

- Undertaking a literature review of previous reports from Dstl, Industry and Academia to locate the problem;
- Mapping out locations and sizes of the wind farms;
- Understanding the operational status of wind farms.

Phase Two

Phase Two work will address two areas:

- **Strategic Approach:** Analysis of potential mitigation deployment scenarios for those systems that form part of the Task Force's Concept Demonstration plan taking into account known and likely future windfarm developments. This will inform the development of a strategic approach to deploying windfarm mitigations and support the facilitation of discussions on any potential cost sharing arrangements.
- **Cumulative Impact:** This will consider issues around windfarm layout, size, distribution and location of windfarms to enable a better understanding of the cumulative impact of large numbers of windfarm developments in the future. This work will complement any work in this area undertaken by other stakeholders such as the Civil Aviation Authority (CAA) on behalf of the Department for Transport (DfT). This work is planned for later in 2021 to inform a future iteration of the Full S&IP.

Annex G

Joint Process Development Principles

The following high-level principles, endorsed by the Joint Programme Board, and agreed between stakeholders comprising the Joint Air Defence and Offshore Wind Windfarm Mitigation Task Force, inform the processes within the Strategy & Implementation Plan. Other principles, yet to be agreed, are expected to be added in due course.

General

The joint processes will recognise the importance of 'Certainty of Generation' for offshore wind stakeholders and 'Certainty of Mitigation' for MOD. In practice, this means identifying at what stages increasing levels of confidence in available mitigation solutions translates into decreasing risk both for stakeholders and for MOD through a process roadmap.

Strategic Approach

The Task Force will aim to develop a strategic approach to deploying mitigations, potentially on a regional basis with recognised deployment phases matched to BEIS CfD Allocation Rounds and seabed leasing of geographic areas, that will enable the maximum capacity of offshore wind to be mitigated in the most efficient manner.

In developing a strategic approach, the associated high-level assumptions for mitigation costs that would include all direct and supporting costs will be shared with relevant stakeholders recognising that all costs would be reconciled.

When developing a strategic approach to mitigation solutions for offshore wind, it will also consider, and enable where possible, onshore wind developments and/or ATC radar mitigation.

The Task Force will seek to develop cost sharing arrangements to enable relevant stakeholders to share the costs of mitigations across the planned and potential future developments that would benefit from the mitigation solutions deployed.

Procurement Strategy

The Strategy will provide a roadmap describing the pathway and anticipated timeline for procurement, deployment and acceptance testing of mitigation solutions together with milestones and decision points for the recommendation of discharge of planning conditions/Development Consent Order Requirements to consenting authorities and the release of funds to enable procurement activity and purchase to proceed.

Mitigations to support CfD AR4 offshore wind developments will need to be operational by Q2 2025.

The procurement process will therefore need to be adequately funded to start in Q1 2022.

Mitigations deployed will need to be able to support the full life of the mitigated windfarms and potentially become part of an enduring Acceptable co-existence solution.

Thresholds for meeting Tolerable and Acceptable performance standards will be developed through the Task Force's Operational Analysis and Requirements workstreams led by MOD. The detailed requirements will not be shared beyond potential supplier companies as part of a procurement competition due to security considerations.

The Procurement Strategy will aim to deliver a project delivering optimally against the performance criteria, cost and time. The Procurement Strategy will also note the requirements contained in the User Requirements Document to achieve Acceptable performance and MOD procurement regulations, including the most economically advantageous solution, social values, quality and timing.

In the event that only Tolerable mitigation performance will be available, or subsequently achieved, the Strategy will describe the pathway from Tolerable performance as an interim mitigation to Acceptable performance as an enduring mitigation. This will include milestones and decision points for releasing funds to identify and procure further mitigations required to achieve Acceptable performance and decision points for using, reducing and returning any money or bonds that are held against risk.

Developers will make financial contributions, in accordance with any cost sharing arrangements that are agreed, to provide Acceptable mitigation for their developments. If during the procurement competition there are 2 or more systems that would provide Acceptable performance in all respects, the one that represents best value for money (recognising better predicted performance represents a risk mitigation against subsequently only achieving Tolerable performance) would be selected. MOD may choose to select a more expensive mitigation if it would provide a significant benefit over and above the Acceptable threshold by making an MOD financial contribution.

When developing the Joint Procurement Strategy, the Task Force will aim, where possible, to take into account previous work such as concept demonstration activity.

The Joint Procurement Strategy will provide generic mitigation scheme principles and a template for individual agreements. The Task Force recognise that standard agreements will be a key enabler to progress agreements quickly to meet CfD timelines. Developers will be able to negotiate their own agreements whilst recognising the additional developer time and DE&S resource this process would require, and the potential knock-on impact, for DE&S availability to other developers.

If only potentially Tolerable mitigations are identified during the Task Force's CD programme, or subsequently through the procurement process, the Task Force will develop further work to identify future Acceptable mitigations.

Glossary

Abbreviation/Acronym - Meaning

AD - Air Defence

AD&OW - Air Defence and Offshore Wind

ALARP - As Low as Reasonably Practicable

AR - Allocation Round

ASWC - Air and Space Warfare Centre

ATC - Air Traffic Control

BEIS - Department for Business, Energy and Industrial Strategy

CAA - Civil Aviation Authority

CCC - Climate Change Committee

CD - Concept Demonstration

CES - Crown Estates Scotland

CfD - Contracts for Difference

CIWG- Capability Integration Working Group

DASA - Defence and Security Accelerator

DE&S - Defence Equipment & Support

DfT - Department for Transport

DPQQ- Dynamic Pre-Qualification Questionnaire

Dstl - Defence Science and Technology Laboratory

DT-1 - Defence Task One

FID - Final Investment Decision
FOW - Floating Offshore Wind
GW - Gigawatt
MOD - Ministry of Defence
OA - Operational Analysis
Ofgem - Office of Gas and Electricity Markets
OWIC - Offshore Wind Industry Council
PB - Programme Board
PSR - Primary Surveillance Radar
RAP - Recognised Air Picture
RMSA - Radar Mitigation Scheme Agreement
S&IP - Strategy & Implementation Plan
SD - Sector Deal
SQEP - Suitably Qualified and Experience Personnel
TCE - The Crown Estate
TF - Task Force
TRL - Technical Readiness Level
WG - Working Group

Disclaimer

This Strategy and Implementation Plan is provided to enable interested parties to understand the joint approach undertaken, significant progress and next steps in working towards the co-existence of Air Defence and Offshore Wind. The stakeholder groups working together in the area can not be responsible for any decisions taken by third parties whether or not based on the information provided in the document.

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1. [Green industrial revolution in sight as government sets out plans for more clean energy \(https://www.gov.uk/government/news/green-industrial-revolution-in-sight-as-government-sets-out-plans-for-more-clean-energy\)](https://www.gov.uk/government/news/green-industrial-revolution-in-sight-as-government-sets-out-plans-for-more-clean-energy)
 2. Indicative timelines for CfD AR4 are at Annex A and Annex B.
 3. [New plans to make UK world leader in green energy \(https://www.gov.uk/government/news/new-plans-to-make-uk-world-leader-in-green-energy\)](https://www.gov.uk/government/news/new-plans-to-make-uk-world-leader-in-green-energy)
 4. [UK sets ambitious new climate target ahead of UN Summit \(https://www.gov.uk/government/news/uk-sets-ambitious-new-climate-target-ahead-of-un-summit\)](https://www.gov.uk/government/news/uk-sets-ambitious-new-climate-target-ahead-of-un-summit)
 5. [Energy white paper: Powering our net zero future \(https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future\)](https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future)
 6. [Energy white paper: Powering our net zero future \(https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future\)](https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future)
 7. Short term to 2025; Medium term 2025 to 2030; Long term 2030 onwards, notionally up to 2050 in line with UK Government targets for achieving Net-Zero carbon emissions.
 8. Noting that all previously deployed solutions remain valid for those projects their solutions and legal/commercial agreements.
 9. Defence, security and resilience of the UK and its overseas territories
 10. Normally this can be taken as prior to first blade turning.
 11. DE&S are a bespoke trading entity, and arm's length body of the Ministry of Defence, responsible for managing a vast range of complex projects to buy and support all the equipment and services that the Royal Navy, British Army and Royal Air Force need to operate effectively. DE&S work closely with industry, including through partnering agreements and private finance initiatives.
 12. [Defence and Security Accelerator \(https://www.gov.uk/government/organisations/defence-and-security-accelerator\)](https://www.gov.uk/government/organisations/defence-and-security-accelerator)
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