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MASS USA

VINEYARD WIND

Draft Construction and Operations Plan

Volume III Appendices

Vineyard Wind Project

September 29, 2020

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Submitted to
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Appendices

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Swanson Environmental Associates
Wood Thilsted Partners Ltd
WSP

September 29, 2020

Appendix III-H.b

Vineyard Wind Project Historic Properties Visual Impact Assessment

VINEYARD WIND HISTORIC PROPERTIES VISUAL IMPACT ASSESSMENT



VINEYARD WIND OFFSHORE WIND FARM PROJECT

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VINEYARD WIND

TABLE OF CONTENTS

1.0	**INTRODUCTION**		**1-1**
	1.1	Purpose and Scope	1-1
	1.2	Project Description	1-1
2.0	**DEFINING THE AREA OF POTENTIAL EFFECT**		**2-1**
	2.1	Direct Physical Effects	2-1
	2.2	Direct Visual Effects	2-1
		2.2.1 Offshore APE (Direct Visual Effects)	2-2
		2.2.2 Onshore APE (Direct Visual Effects)	2-3
3.0	**MITIGATING FACTORS AFFECTING VISIBILTY**		**3-1**
	3.1	Earth's Curvature	3-1
	3.2	Meteorological Conditions and Color	3-1
	3.3	Distance and Visibility	3-4
4.0	**IMPACT ASSESSMENTS**		**4-1**
	4.1	Martha's Vineyard Property Identification and Assessment of Adverse Effect	4-1
		4.1.1 List of Martha's Vineyard Historic Properties Constituting the APE	4-1
		4.1.2 Application of the Criteria for Determining Adverse Effects to Martha's Vineyard Historic Properties	4-5
		4.1.3 Martha's Vineyard National Register Ineligible Properties Viewshed Assessments	4-16
	4.2	Nantucket, Tuckernuck, and Muskeget Islands Property Identification and Assessment of Adverse Effects	4-17
		4.2.1 List of Nantucket, Nantucket, Tuckernuck, and Muskeget Islands Properties Within the APE	4-17
		4.2.2 Application of the Criteria for Determining Adverse Effects to Nantucket, Tuckernuck, and Muskeget Islands Historic Properties	4-18
		4.2.3 Nantucket, Tuckernuck, and Muskeget Islands Ineligible Properties	4-20
	4.3	Nantucket Sound Property Identification and Assessment of Adverse Effects	4-20
		4.3.1 Nantucket Sound Historic Property Index	4-20
		4.3.2 Application of the Criteria for Determining Adverse Effects to Nantucket Sound	4-21
		4.3.3 Nantucket Sound Ineligible Properties	4-22
5.0	**CONCLUSIONS**		**5-1**
	5.1	Direct Physical Effects	5-1
	5.2	Direct Visual Effects	5-1
6.0	**REFERENCES**		**6-1**

List of Figures

Figure 1-1	Vineyard Wind Lease Area OCS-A 0501 - Nearest Onshore Areas	1-2
Figure 1-2	WTG Dimensions	1-4
Figure 2-1	Onshore Substation and Onshore Cable Routes Cape Cod APE	2-4
Figure 4-1	Martha's Vineyard Historic Properties	4-4

List of Tables

Table 3-1	Frequency of Reported Visibility Ranges from Martha's Vineyard and Nantucket Airports (Not Equivalent to Visibility of the Project from the Shoreline)	3-2
Table 3-2	Gay Head Lighthouse, Cape Poge Light, and Nantucket Island Historic District National Historic Landmark Visibility Estimates using Algorithm in BOEM 2017-037	3-3
Table 4-1	Martha's Vineyard Index of Historic Properties Constituting the APE	4-1
Table 4-2	Martha's Vineyard National Register Ineligible Properties Viewshed Assessments	4-16
Table 4-3	Nantucket, Tuckernuck and Muskeget Islands Historic Property Index	4-17
Table 4-4	Nantucket Sound Historic Property Index	4-21
Table 6-1	Guide to Location of Information Contained in the COP	6-1

List of Attachments

Attachment A Existing Conditions Photolocations

Attachment B Aircraft Detection Lighting System Technical Specifications and Design Information

1.0 INTRODUCTION

1.1 Purpose and Scope

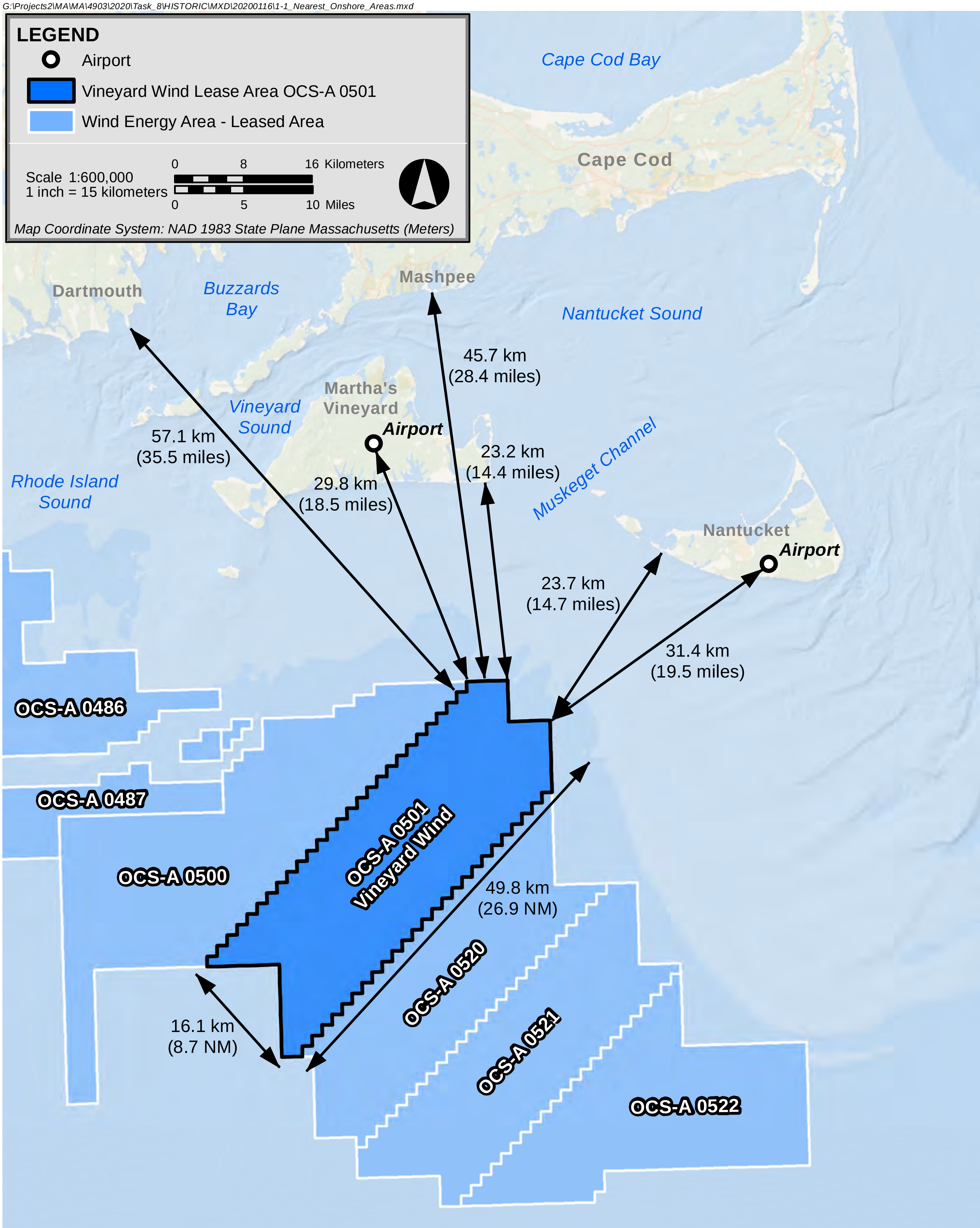
Vineyard Wind, LLC ("Vineyard Wind") is proposing an 800 megawatt ("MW") wind energy project within Bureau of Ocean Energy Management ("BOEM") Lease Area OCS-A 0501, consisting of offshore wind turbine generators ("WTGs", each placed on a foundation support structure), electrical service platforms ("ESPs"), an onshore substation, offshore and onshore cabling, and onshore operations & maintenance facilities (these facilities will hereafter be referred to as the "Project"). The following Historic Properties Visual Impact Assessment for the Project is intended to assist BOEM and the Massachusetts Historical Commission ("MHC"), in its role as the State Historic Preservation Office ("SHPO"), in their responsibilities in reviewing the Project under Section 106 of the National Historic Preservation Act and the National Environmental Policy Act. Further information regarding effects to archaeological properties within the Area of Potential Effect ("APE") are addressed in separately filed reports.

The Lease Area is a 16 x 50 kilometers ["km"] (8.6 nautical ["NM"] x 26.9 NM) area oriented northeast to southwest and located just over 23 km (14 miles ["mi"]) south/southwest of Nantucket and Martha's Vineyard (see Figure 1-1). The Project will be located in the northern portion of the over 675 square kilometer (166,886 acre) Lease Area; this northern area is referred to as the Wind Development Area ("WDA"). Power generated from the Project will be transmitted to Cape Cod via submarine offshore cables. Upon arriving at the shoreline of Cape Cod, the offshore cables will transition to underground onshore cables to connect with an onshore substation. An onshore substation will be constructed in order to accommodate the additional electrical load; a substation location in the Town of Barnstable is under consideration. The new onshore substation will be generally comparable in size and appearance to the existing Barnstable Switching Station located on an adjacent property.

Accordingly, the APE has been developed to assist BOEM and MHC in identifying historic resources listed, or eligible for listing, in the National Register of Historic Places in order to assess potential visual effects of the Project. As described in Section 2.0, the APE has been broken into direct physical (construction-related) effects and direct visual effects.

1.2 Project Description

The Project includes the construction of up to 100 WTGs and two ESPs within the WDA. The Project is designed to provide 800 MW of electricity and has defined a range of turbine sizes that may be used: from eight to ~14 MW. Up to 106 turbine locations are being permitted to allow for spare positions (in the event of environmental or engineering challenges). The WTGs will be laid out in a grid pattern along with one or two ESPs. The WTGs will be positioned approximately 1.4-1.8 km (0.76-1.0 NM) apart from each other.



Vineyard Wind Project

VINEYARD WIND

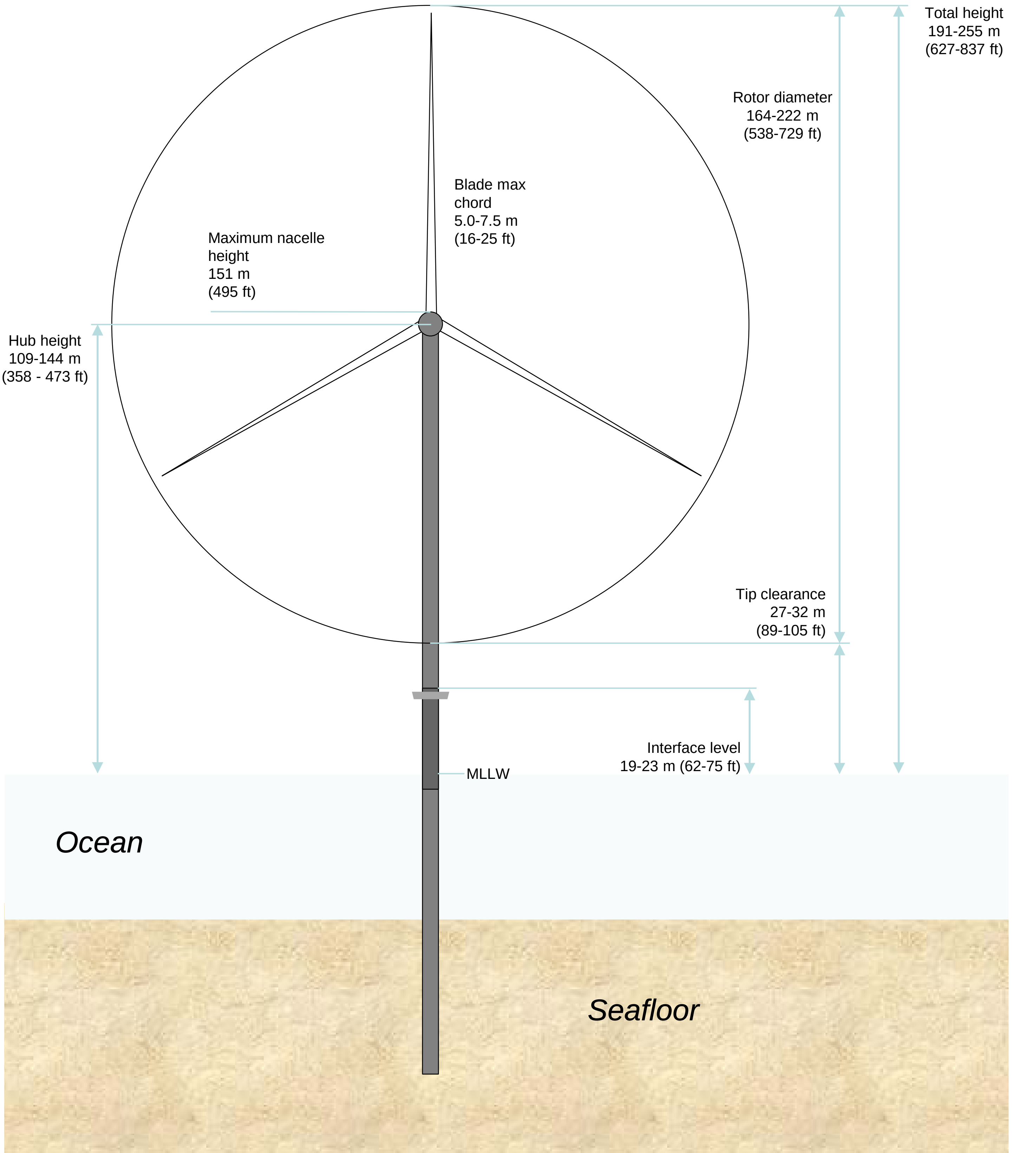
Figure 1-1

Vineyard Wind Lease Area OCS-A 0501 - Nearest Onshore Areas

The WTGs will be supported by foundations consisting of either steel monopiles embedded into the sea floor or jacket structures. The jacket foundations are cross-braced structures supported by three or four piles. Either foundation type (monopile or jacket) is designed to support the WTG. Scour protection (i.e., a layer of stone or rock) will be laid around each foundation. Inter-array cables will connect strings of six to 10 WTGs to the ESPs. Then, offshore export cables will transmit electricity from the ESPs to shore at the Landfall Site. Underground onshore cables, which are expected to utilize existing paved roadways and utility corridors, will connect the Landfall Site to the onshore substation in Barnstable. All offshore and onshore cables will be buried and will not be visible.

The maximum height of the WTGs considered for this Project will measure approximately 255 meters ("m") (837 feet ["ft"]) above Mean Lower Low Water ("MLLW") at the peak of the blade tip. As shown in Figure 1-2, the supporting foundation/transition piece, wind turbine tower, and nacelle extends a maximum of 151 m (495 ft) above MLLW to the "nacelle height." The rotor diameter formed by the three blades will be a maximum of 222 m (729 ft). The blades, which have a maximum width of 7.5 m (25 ft), will taper down from the base to the tip. In accordance with Federal Aviation Administration ("FAA") Advisory Circular ("AC") 70/7460-1L, Vineyard Wind will paint the WTGs no lighter than RAL 9010 Pure White and no darker than RAL 7035 Light Grey; however, we anticipate that the WTGs will be painted off-white/light grey to blend into the horizon. See Section 3.1.1 of Volume I of the COP for additional description of the WTGs. The specific dimensions of the WTGs used in photo simulations of the WTGs from select viewpoints are presented in Appendix III-H.a.

The Project's one or two ESPs will have a maximum width of 45 m (148 ft) and a maximum length of 70 m (230 ft). Additionally, the ESPs will have a maximum height of 66.5 m (218 ft) above water. The WTGs will be joined to the ESPs via submarine inter-array cables, and the ESPs will be joined to one another via submarine inter-link cables. See Section 3.1.4 of Volume I of the COP for additional description of the ESPs.



Vineyard Wind Project

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Figure 1-2
WTG Dimensions

2.0 DEFINING THE AREA OF POTENTIAL EFFECT

2.1 Direct Physical Effects

As stated in Section 1.0, direct physical effects are defined as construction-related impacts or areas of potential disturbance by the Project. These areas can be further defined as terrestrial and marine areas.

- Terrestrial areas of the Project include the proposed underground onshore cable routes (one route will ultimately be chosen) and the onshore substation site. Therefore, the APE for direct physical effects onshore is the cable routes and the onshore substation site (see Figure 2-1 for historic properties along potential onshore cable routes and the onshore substation site). Effects to potential terrestrial archaeological resources as a result of construction-related activities are addressed in separate reports located in Appendix III-G of COP Volume III and Appendices C and D of the COP Addendum.

- Marine areas of the Project include the portion of the WDA containing the WTGs, ESPs, scour protection, inter-array cables, and inter-link cables as well as the proposed Offshore Export Cable Corridor to the mainland. Therefore, the APE for direct physical effects offshore is the WTG and ESP locations (both in height and depth) as well as the seafloor to be affected by the offshore cables. Effects related to marine archaeological resources as a result of construction-related activities are addressed in a separate report located in Volume II-C of the COP.

Effects related to the visibility of built structures are addressed in the following section.

2.2 Direct Visual Effects

The APE is defined in 36 CFR § 800.16 as "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." The term "historic property" is further defined in 36 CFR § 800.16 as "any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria."

In its Finding of Adverse Effect for the Vineyard Wind Project Construction and Operations Plan (dated June 20, 2019), BOEM has further clarified that the APE for direct visual effects is "the viewshed from which renewable energy structures, whether located offshore or onshore, would be visible" (BOEM, 2019).

Using the regulatory definition of APE in 36 CFR § 800.16 and the further guidance from BOEM provided in its Finding of Adverse Effect, the APE is the location of those historic properties included in, or eligible for inclusion in, the National Register of Historic Places from which the Project would be visible (BOEM, 2019). The phrase “would be visible” is interpreted to mean the Project would, with some certainty, be visible under a reasonable range of meteorological conditions.

2.2.1 Offshore APE (Direct Visual Effects)

For the Project’s offshore components, the APE for direct visual effects includes those historic properties included in, or eligible for inclusion in, the National Register of Historic Places where the WTGs and ESPs would be visible. Since the maximum height of the ESPs (66.5 m [218 ft]) is much less than the maximum tip height of the WTGs (255 m [837 ft]), the APE for the WTGs encompasses the APE for the ESPs. The offshore export cables from the WDA to the mainland Landfall Site as well as the inter-array and inter-link cables within the WDA are underwater and will not have a visual impact.

<u>Delineating the APE involved a three-step process.</u>

Step 1: Identifying Areas with a Theoretical Line of Sight to the Project. The first step in determining the APE includes identifying the areas where there is a theoretical line of sight to the Project (this is referred to as the “Visual Impact Assessment [VIA] area of impact”). As described in Section 1.1 of the Addendum to the Visual Impact Assessment in Appendix III-H.a, the maximum theoretical distance that the WTG blades could potentially be visible is 61.8 km (38.4 mi). This is based upon a mathematical formula that calculates the maximum possible distance from which there is a line of sight to a WTG given a tip height of 255 m (837 ft) and the curvature of the earth. The areas of potential visibility within the 61.8 km (38.4 mi) radius were then generated using a Geographic Information System (GIS) viewshed calculation, which identifies the geographic area where a direct line of sight exists to the blade tip considering the curvature of the earth (with atmospheric refraction) and accounting for obstructions including topography, built structures, and vegetation. It is important to note that the VIA area of impact identifies where there is a theoretical line of sight to the Project and does not identify the degree to which the Project may be visible, if at all, or the number of WTGs that may be visible from any affected location. The VIA area of impact also does not consider the mitigating factors of atmospheric visibility, the limits of visual acuity, and ocean waves, or the reduction in apparent size of the WTG over increasing distance.

The VIA area of impact includes portions of the following locations: Martha’s Vineyard (and adjacent Nomans Land), Nantucket (and its adjacent outlying islands), Nantucket Sound, Cape Cod, the Elizabeth Islands, and the western shoreline of Buzzards Bay.

Step 2. Evaluating Areas with a Theoretical Line of Sight to Determine Where the Project Would be Visible. Once the area of theoretical visibility is determined, the second step in determining the APE includes utilizing the photo simulations and, where available, field observations to identify those areas within the VIA area of impact (i.e. those areas with a theoretical line of sight to the Project) where the Project "would be visible."

- Photo simulations from Cape Cod (simulations 19 and 20 included in the Addendum to the Visual Impact Assessment in Appendix III-H.a) and western shoreline of Buzzards Bay (simulation 21 included in the Addendum to the Visual Impact Assessment in Appendix III-H.a) demonstrate that the Project is not distinguishable from these extreme distances. Therefore, these locations (Cape Cod, the Elizabeth Islands, and the western shoreline of Buzzards Bay) are not included in the APE.

- Photo simulations and field observations from Martha's Vineyard (simulations 1-10 included in the Addendum to the Visual Impact Assessment in Appendix III-H.a and photographs in Attachment A of this report) indicate that the Project "would be visible" from portions of Martha's Vineyard (and adjacent Nomans Land).

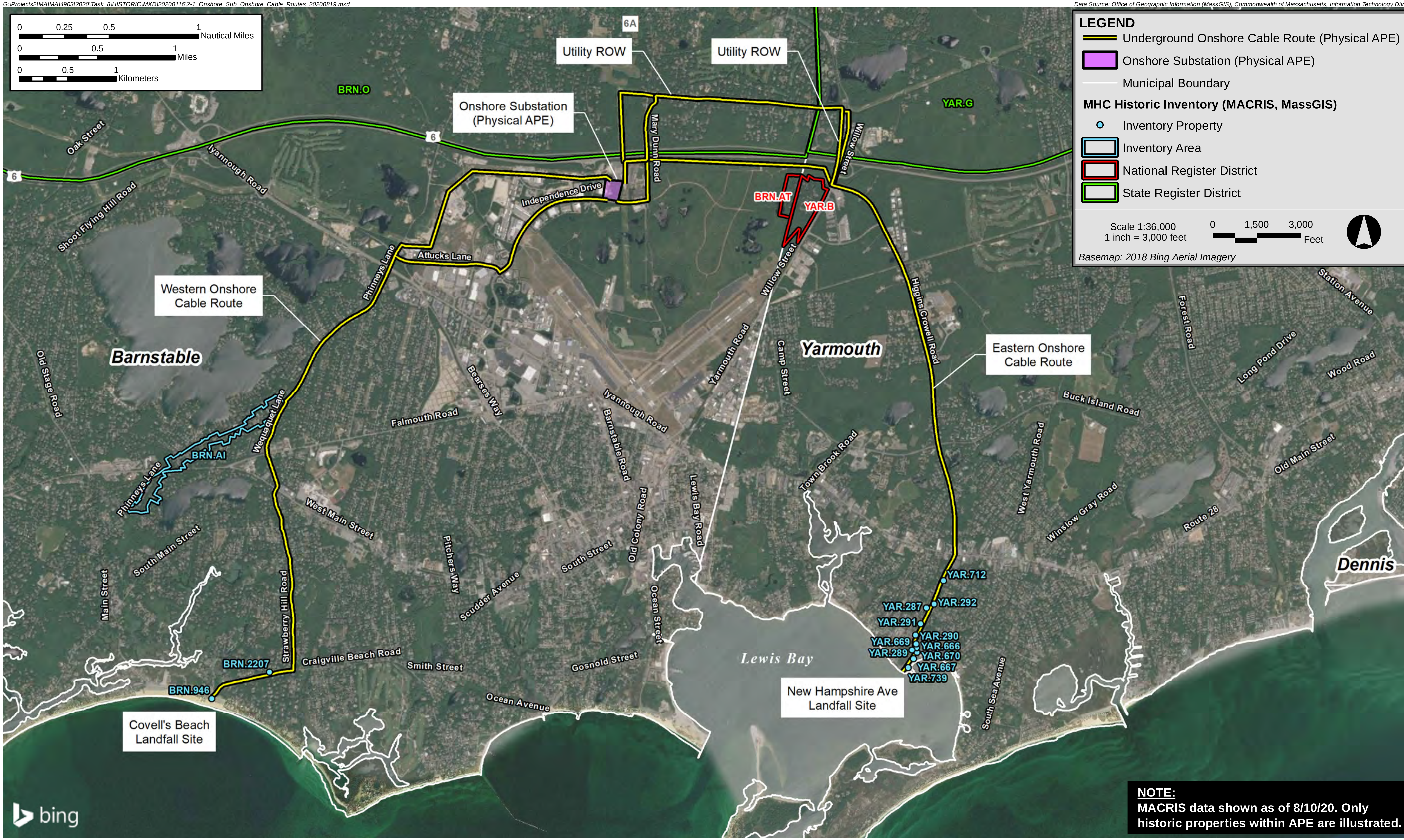
- Photo simulations and field observations from Nantucket (photo simulations 12-18 included in the Addendum to the Visual Impact Assessment in Appendix III-H.a and photographs in Attachment A of this report) indicate that the Project "would be visible" from portions of Nantucket (and its adjacent outlying islands).

- Photo simulations and field observations from Martha's Vineyard and Nantucket also indicate that the Project "would be visible" from a limited portion of Nantucket Sound.

Step 3. Identifying "Historic Properties" in Areas Where the Project Would be Visible. The third step in determining the APE involves assessing historic properties within those areas where the Project "would be visible." Any historic property included in, or eligible for inclusion in, the National Register of Historic Places, from which the Project would be visible, is included in the APE. This step is detailed in Section 4.0 of this report.

2.2.2 Onshore APE (Direct Visual Effects)

For onshore portions of the Project, the APE is related to the new onshore substation (Figure 2-1). The Project's underground onshore cables are proposed to be placed largely within existing roadways and utility corridors and will not be visible. Therefore, the onshore cables have no potential for visual impacts.



Vineyard Wind Project

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Figure 2-1

Onshore Substation and Onshore Cable Routes Cape Cod APE

3.0 MITIGATING FACTORS AFFECTING VISIBILTY

3.1 Earth's Curvature

As described further in Section 2.2 of the Addendum to Appendix III-H.a, the distance from the WDA to shore (over 23 km [14 mi]) results in the Earth's curvature creating a visual obstruction that prevents visibility of the WDA in its entirety from some locations. Elsewhere, the Earth's curvature creates a partial obstruction. There are no land-based vantage points from which a WTG or ESP can be viewed in its entirety.

3.2 Meteorological Conditions and Color

Visibility is dependent on numerous metrological factors, including the atmosphere itself, haze, fog, various forms and intensities of precipitation, and even more obscure events such as smoke or dust storms. Offshore, visibility is also reduced by wind and wave-induced sea spray and salts.

In addition, low-contrast paint will reduce the daytime visibility of the WTGs. As described in Section 1.2, Vineyard Wind anticipates painting the WTGs off-white/light grey to reduce contrast with the sea and sky and thus minimize daytime visibility of the WTGs. The conservative threshold for visibility in metrological analyses is "the greatest distance at which an observer can just see a black object viewed against the horizon sky" (see Appendix III-H.a, Appendix C, Section 3.3). The WTGs will not be black; instead, the off-white/light grey color will be highly compatible with the hue, saturation, and brightness of the background sky (see Appendix III-H.a, Section 6.2). This lack of contrast between the WTGs and the background means that the percentage of the time the structures might be visible is greatly reduced.

The lack of lighting during normal operation will nearly eliminate nighttime visibility of the WTGs, with meteorological conditions obscuring proposed lights, when activated. Vineyard Wind has voluntarily agreed to install an Aircraft Detection Lighting System ("ADLS") that will only activate the required FAA aviation obstruction lights at night when aircraft approach the WDA. As described in the ADLS report (see Appendix III-N), the proposed FAA aviation obstruction lights activate as an aircraft approaches the WDA and turn off when the aircraft is no longer in proximity to the WDA. More specifically, in accordance with FAA Advisory Circular 70/7460-1L, lights controlled by an ADLS must be activated and illuminated prior to an aircraft reaching 5.6 km (3 NM) from and 305 m (1,000 ft) above any wind turbine. Due the speed of the traveling aircraft and size of the WDA, the resulting appearance of the lights is limited to a few minutes as they turn on and then off quickly as demonstrated in the simulation video (see https://www.boem.gov/renewable-energy/state-activities/night-visual-simulation-video [Saratoga Associates, 2018]). Note that in the video both FAA aviation obstruction lights and the lights on an aircraft are simulated. As explained in Appendix III-N, based on historical use of the airspace, it is estimated that the aviation obstruction lights on both the nacelle and tower (if needed) will be activated for less than four hours per year (less than 0.1% of the total annual nighttime hours). Further discussion of the potential visibility of nighttime lighting is in Section 3.3. Further technical and design information for the ADLS is described in Attachment B.

Using historical weather data recorded at the Vineyard Haven Martha's Vineyard Airport and the Nantucket Memorial Airport, an average visibility from these locations was determined. The data examined was from an 11-year period (2006-2016) from the National Climatic Data Center. Recorded data included temperature, humidity, windspeed, and, visibility. Visibility measurements from meteorological stations at airports are typically recorded in intervals ranging from ¼ to 10 statute miles; visibilities greater than 10 statute miles are reported as 10 miles[1].

Table 3-1 provides the percentage of time that daytime and nighttime visibility is 16 km (10 mi) or greater, taking into account that ADLS reduces expected nighttime lighting to less than 0.1% of annual nighttime hours and that unlit objects will not be visible beyond 16 km (10 mi) at night.

Table 3-1 Frequency of Reported Visibility Ranges from Martha's Vineyard and Nantucket Airports (Not Equivalent to Visibility of the Project from the Shoreline)

Percentage of Time Airport Visibility is 16 km (10 miles) or Greater						
Location	Time	Winter	Spring	Summer	Fall	Annual
Martha's Vineyard Airport	Day	80%	82%	80%	84%	81%
	Night*	0%	0%	0%	0%	0%
	Total**	33%	48%	47%	35%	41%
Nantucket Airport	Day	71%	71%	69%	76%	72%
	Night*	0%	0%	0%	0%	0%
	Total**	30%	41%	40%	32%	36%

*Unlit objects will not be visible at >16 km (10 mi) at night. The use of ADLS reduces expected nighttime lighting to less than 4 hours/year, which is<0.1% of annual nighttime hours and is rounded to 0% in this table.
** Seasonal results adjusted to reflect daylight hours.

As shown in the table above, when taking into account the Project's use of ADLS, on average, visibility from Martha's Vineyard and Nantucket is 16 km (10 mi) or greater for 41% and 36% of the year, respectively. Given that the nearest shoreline vantage point is over 23 km (14 mi) away from the nearest turbine, it is reasonable to conclude that the Project will be obscured from coastal vantage points on Martha's Vineyard and Nantucket more frequently than 59% and 64% of the time, respectively. Furthermore, these on-land visibility measurements do not account for wind and wave-induced sea spray and salts that reduce visibility.

[1] Airports provide visibility data for the benefit of pilots, who are only interested in whether visibility is limited to less than ten miles.

Due to the historic significance of and recommended determination of adverse visual effect to the Gay Head Lighthouse on Martha's Vineyard and the Nantucket Island National Historic Landmark District, additional analysis of the effects of meteorological conditions on visibility was performed for these two historic properties. Further, due to the historic significance of Cape Poge Light, additional analysis of the effects of meteorological conditions on visibility was conducted for this property as well. As indicated above, one key limitation of the reported visibility data is that airports do not report visibility greater than 10 miles. To address this limitation, BOEM's OCS Study BOEM 2017-037, "Visualization Simulations for Offshore Massachusetts and Rhode Island Wind Energy Area Meteorological Report," presents a method to calculate visibility distances past 10 miles by performing a regression analysis of reported airport visibilities and relative humidity observations (Wood et al., 2014).

Table 3-2 below applies BOEM's methodology to calculate visibility specific to these three historic sites using Martha's Vineyard and Nantucket airport data (visibility and relative humidity), taking into account the Project's use of ADLS. For Martha's Vineyard, Table 3-2 shows the amount of time that visibility is greater than 38.7 km (24 mi), which is the distance from Gay Head Lighthouse to the closest Project structures, and 31.2 km (19.4 mi), which is the distance from Cape Poge Light to the closest Project structures. For Nantucket, Table 3-2 shows the amount of time visibility is greater than 23.7 km (14.7 mi), which is the distance from the closest Nantucket location (at Esther Island in the southwest corner of Nantucket) to the closest Project structures.

Table 3-2 Gay Head Lighthouse, Cape Poge Light, and Nantucket Island Historic District National Historic Landmark Visibility Estimates using Algorithm in BOEM 2017-037

Percentage of Time Visibility is 23.7 km (14.7 mi) or Greater for Nantucket, 31.2 km (19.4 mi) or Greater for Cape Poge Light, & 38.7 km (24 mi) or Greater for Gay Head Lighthouse Using BOEM Methodology						
Location	**Time**	**Winter**	**Spring**	**Summer**	**Fall**	**Annual**
Martha's Vineyard (Gay Head Lighthouse)	Day	46%	44%	28%	37%	39%
	Night*	0%	0%	0%	0%	0%
	Total**	19%	26%	16%	15%	19%
Martha's Vineyard (Cape Poge Light)	Day	59%	57%	44%	51%	52%
	Night*	0%	0%	0%	0%	0%
	Total**	25%	33%	25%	21%	26%
Nantucket (Closest Point on Nantucket Historic District National Historic Landmark)	Day	60%	52%	36%	54%	50%
	Night*	0%	0%	0%	0%	0%
	Total**	25%	30%	21%	23%	25%

*Unlit objects will not be visible at >16 km (10 mi) at night. The use of ADLS reduces expected nighttime lighting to less than 4 hours/year, which is<0.1% of annual nighttime hours and is rounded to 0% in this table.

** Seasonal results adjusted to reflect daylight hours.

Table 3-2 shows that, when taking into account the Project's use of ADLS, on average Project structures **might** be visible 19% of the time from Gay Head Lighthouse, **might** be visible 26% of the time from Cape Poge Light, and **might** be visible 25% of the time from the **closest** location on Nantucket. Again, because of sea spray, low-contrast paint color, and other factors, the actual amount of time structures would be visible is lower.

3.3 Distance and Visibility

On Martha's Vineyard and Nantucket, coastal vantage points for WTGs within the WDA range from 23-47 km (14-29 mi). From all land-based vantage points, the Project would appear in the far background distance zone (as defined in Section 4.1.1 of Appendix III-H.a) where elements lose detail and become less distinct, atmospheric perspective changes colors to blue-grays, and surface texture characteristics are lost. As an observer moves along the coast farther from the WDA, the smaller the WTGs will appear. Exclusive of the effect of earth curvature and meteorological visibility, viewing a WTG at a distance of 23.7 km (14.7 mi) is roughly equivalent to viewing an eight-inch pencil at a distance of about 30 m (100 ft). Similarly, viewing a blade with a maximum width of 7.5 m (25 ft) at that distance is roughly equivalent to the width of a coffee straw viewed at 30 m (100 ft).

As with daytime visibility, distance will minimize nighttime visibility of the WTGs. Only the nighttime lighting is expected to be visible under extremely limited circumstances. Three types of lights are proposed: US Coast Guard (USCG) navigation warning lights and FAA aviation obstruction lights. USCG navigation warning lights will be mounted near the top of the foundation on each WTG and ESP. This lighting is very low level and although the specific visibility of the lighting is yet to be determined, Vineyard Wind expects it will be 5 NM or less. The nearest coastal vantage point is approximately 23.7 km (14.7 mi).

FAA guidance provides that up to four aviation obstruction lights (L-810) be installed at the mid-point of the WTGs. The L-810 unit is a red low intensity omni-directional light emitting 25 candelas. This lighting is very low level compared to the nacelle mounted aviation obstruction lights which emit approximately 2,000 candelas. FAA aviation obstruction lights (2,000 candelas) will be mounted on top of the nacelle of each constructed WTG and the ESPs (if needed). These lights will be visible from coastal locations where daytime views of WTG nacelles occur, with the same mitigating factors as daytime visibility. Inland views, however, are typically screened by dunes, low hills, and existing vegetation. If the lights are visible from inland locations, views will include existing coastal light sources, including residential light sources, streetlights, and vehicle headlights. Existing light sources shall be an additional mitigating factor for nighttime visibility, as lights in the foreground would appear at a greater intensity to the observer than the lights over 23.7 km (14.7 mi) away. When visible, the FAA aviation obstruction lights will by very low on the horizon and will appear to shimmer and vary in intensity due to the slow flash rate, intermittent shadowing as rotating blades pass in front of the light source, and atmospheric variations.

4.0 IMPACT ASSESSMENTS

4.1 Martha's Vineyard Property Identification and Assessment of Adverse Effect

Historic maps, the State and National Registers of Historic Places, and the MHC's Inventory of Historic and Archaeological Assets of the Commonwealth (the "Inventory") were consulted to generate the list of historic resources evaluated (MACRIS, 2020; MACRIS Maps 3.0 Beta, 2020; National Park Service, 2020). As described in Section 2.2.1, any historic property within the VIA area of impact that is included in, or eligible for inclusion in, the National Register of Historic Places, from which the Project would be visible, is included in the APE.

The list documents those properties that define the APE and is organized by geographic location. Within each section for a specific geographic location, the first subsection provides an index of historic properties that are listed or eligible for listing on the National Register from which the Project would be visible (i.e. those properties that constitute the APE). The second subsection applies the criteria of adverse effect to historic properties within the APE. For informational purposes, the third section identifies those properties that were within the VIA area of impact but are ineligible for listing on the National Register and thus are not included in the APE. Photo simulations referenced in this document are included in the Addendum to Appendix III-H.a. Existing condition photographs for select locations on Martha's Vineyard and Nantucket are provided in Attachment A.

4.1.1 List of Martha's Vineyard Historic Properties Constituting the APE

The following is a list of properties that constitute the APE on Martha's Vineyard. All properties listed are shown on Figure 4-1.

No historic structures, buildings, or landscapes have been identified on Nomans Land.

Table 4-1 Martha's Vineyard Index of Historic Properties Constituting the APE

Property Name	MHC#	Address	Designation / Eligibility Recommendation	Photo Simulation (Yes/No)
Gay Head Lighthouse	GAY.900	15 Aquinnah Circle, Aquinnah	NRIND (Moved in 2015 150-feet, still listed). Significant under Criteria A and C as a historic maritime structure and aid to navigation.	Yes, Simulation #1
Gay Head – Aquinnah Shops Area	GAY.B	Aquinnah Circle, Aquinnah	INV Area / NRDIS eligible. Significant under Criteria A as a collection of mid-20th century roadside shops associated with the rise of the automobile era and increased tourism at Gay Head Cliffs. Buildings retain historic design integrity and character.	Yes, Simulation #2

Table 4-1 Martha's Vineyard Index of Historic Properties Constituting the APE (Continued)

Property Name	MHC#	Address	Designation / Eligibility Recommendation	Photo Simulation (Yes/No)
Edwin Vanderhoop Homestead	GAY.40	35 South Road, Aquinnah	NRIND. Significant under Criteria A and C as an example of Victorian Eclectic style and its association with the Vanderhoop family, a prominent local family.	Yes, Simulation #3
Elijah Smith House	CHL.39	9 Quista Lane, Chilmark	INV / NRDIS eligible. Significant under Criteria A & C as an 18th century Cape style farmhouse with connections to Revolutionary War raid. Building retains its historic design integrity and character.	No
Nathan Mayhew Gravestone	CHL.802	1 Quista Lane	INV / NRDIS eligible with CHL.39 as a district. Significant under Criteria A & C as an 18th century grave marker. Headstone has death's head motif. Contributes to 18th century setting of CHL.39.	No
Captain Ephraim Poole Farm	CHL.B	14 Menemsha Crossroad, Chilmark	INV Area / NR IND eligible. Significant under Criteria A & C as a 19th century farm complex with Greek Revival house, barns privy, corn crib, and stone walls.	No
Martha's Vineyard American Revolution Battlefield	CHL.E	Centered Along South Road in Chilmark	INV Area / NRDIS eligible. Significant under Criteria A & C as a collection of historic properties dating from the 18th century associated with the 1778 British raid, with later 19th and 20th century infill properties.	Yes, Simulation #6
Vincent Mayhew House	CHL.A	451 South Road, Chilmark	NRDIS	Yes, Simulation #6
Captain Samuel Hancock House	CHL.35	141 Quansoo Road, Chilmark	INV / MHC determined NRIND eligible.	No
Simon Mayhew House	CHL.5	34 Blacksmith Valley Rd	INV / NRIND eligible. Significant under Criterion A & C as an example of an early 18th century Cape and associated with the Mayhew family and development of Chilmark as an agricultural community.	No

Table 4-1 Martha's Vineyard Historic Property Index (Continued)

Property Name	MHC#	Address	Designation / Eligibility Recommendation	Photo Simulation (Yes/No)
Edgartown Village Historic District	EDG.A	Roughly bound by Katama Bay Main Street, Peases Point Way, Planting Field Way	NRDIS	Yes, Simulation #9
Edgartown Village Historic District	EDG.B	Roughly bound by Katama Bay Main Street, Peases Point Way, Planting Field Way	SR / NRDIS eligible. Significant under Criteria A & C as a collection of early 20th century residences and pattern of development in Edgartown. Contributes to a potential boundary expansion of EDG.A.	Yes, Simulation #9
Chappaquiddick Island	N/A	Roughly encompasses the Island of Chappaquiddick, Norton Point in Edgartown, and Katama Bay	BOEM determined eligible TCP	Yes, Simulation #9-10
Cape Poge Light	EDG.900	Northeastern tip of Chappaquiddick Island	NRIND	No, but simulation #6 is at a similar elevation as the observation deck of the lighthouse.

*Designation Legend

NRIND Individually listed on the National Register of Historic Places
NRDIS National Register of Historic Places Historic District
SR State Register of Historic Places
INV Individually included in the Inventory of Historic and Archaeological Assets of the Commonwealth
INV Area Area included in the Inventory of Historic and Archaeological Assets of the Commonwealth
TCP Traditional cultural property

G:\Projects2\MA\MA4903\2020\Task_8\HISTORIC\BOEHM_REV1\1_MV_20200908.mxd

Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

Vineyard Wind Project

VINEYARD WIND

Figure 4-1

Martha's Vineyard Listed or Eligible Historic Resources

4.1.2 *Application of the Criteria for Determining Adverse Effects to Martha's Vineyard Historic Properties*

Gay Head Lighthouse (GAY.900) 15 Aquinnah Circle, Aquinnah.

Gay Head Lighthouse, which is located on the southwesternmost portion of Martha's Vineyard, is listed on the National Register of Historic Places and is significant under Criteria A and C as a historic maritime structure and aid to navigation (National Park Service, 2020; DiStefano, 1980). Constructed in 1855-1856, the Gay Head Lighthouse was once one of the ten most important lights on the Atlantic Coast and originally contained one of the country's first Fresnel lenses. The 14 m (45 ft) tall brick and sandstone tower meets Criterion A for its association with the island's maritime history as an aid to navigation. The structure also meets Criterion C as an example of a 19th century maritime structure constructed of bricks utilizing the clay from the Gay Head Cliffs. Although the Gay Head Lighthouse was moved from its original location 150 feet east in 2015 and its setting and location are partially compromised, the structure retains integrity of design, material, workmanship, feeling, and association (DiStefano, 1980).

Recommended Determination – **Adverse Visual Effect**.[2] As a lighthouse, an ocean view toward the horizon is integral to its character and setting as well as historic function. The maritime setting of this resource, and its viewshed, would be adversely affected through the introduction of new elements. The construction of the WDA would inhibit the observer from experiencing the lighthouse in its historic setting when the WDA is visible.

Gay Head Lighthouse is located at the western end of Martha's Vineyard and is 38.7 km (24 mi) from the WDA at its closest point. As described in Section 3.2, based on BOEM's methodology in BOEM 2017-037 and taking into account the Project's use of ADLS, on average for all conditions, Project structures could be visible 19% of the time from the Gay Head Lighthouse (see Table 3-2). In addition to general weather conditions, other factors such as haze and sea spray may further reduce visibility.

Gay Head Lighthouse is located 150 feet from its original location and is surrounded by a modern stone wall and fence. Eligibility Criterion A would not be affected by the WDA, but Criterion C as it relates to the setting of Gay Head Lighthouse would be adversely affected. Although the structure has been moved from its original location (which has partially compromised its setting) and the WDA is only partially visible from Gay Head Lighthouse (depending on and meteorological conditions), the Project introduces visual elements that are out of character with the historic setting, feeling, and association of the property. Therefore, the Project has an adverse visual effect to the setting of Gay Head Lighthouse.

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2 Revised per BOEM's June 20, 2019 *Finding of Adverse Effect for the Vineyard Wind Project Construction and Operations Plan* (BOEM, 2019).

Edwin Vanderhoop Homestead (GAY.40) 35 South Road, Aquinnah

The Edwin Vanderhoop Homestead is individually listed on the National Register of Historic Places (National Park Service, 2020). The late 19th century Edwin Vanderhoop Homestead is a two-and-a-half story Victorian Eclectic style residence. The building's complex plan consists of a rectangular side-gable main block and several intersecting gable roof extensions. The house was constructed for Edwin Vanderhoop, son of William Adriann Vanderhoop, the first member of the family to settle in Gay Head. The Vanderhoop's would become important figures in the development of Gay Head. The building is significant under Criteria A and C as an excellent example of a Victorian Eclectic style house and its association with the Vanderhoop family, a prominent local family. The Edwin Vanderhoop Homestead retains integrity of location, design, setting, material, workmanship, feeling, and association (Parcon et al., 2006).

Recommended Determination - **No Adverse Effect**. The Homestead is oriented to take advantage of the ocean view and the seaside setting is integral to its setting. The maritime setting of this resource, and its viewshed, would be altered through the introduction of new elements; however, existing topography and vegetation partially screen the WDA from view. View from the Homestead toward the WDA is partially obstructed by topography and mature tree growth to the southeast. View of the WDA is possible to the south. View of the Homestead to the north and east will be unaffected. View of the Homestead to the south and the west (at an extreme angle) will be affected in ideal weather conditions.

The Homestead is located at the western end of Martha's Vineyard approximately 38.7 km (24 mi) to from the WDA at its closest point. On average, based on airport reported visibilities and accounting for the Project's use of ADLS, visibility from Martha's Vineyard is 16 km (10 mi) or greater 41% of the time in a given year due to weather conditions (see Table 3-1). This means that, at minimum, the WDA will not be visible 59% of the year. In addition to general weather conditions, other factors such as haze and sea spray may further reduce visibility.

Eligibility Criterion A would not be affected by the WDA. Criterion C as it relates to the setting of the Homestead would be affected; however, this effect would primarily be to the southern view and a portion of the western view. View of the Homestead to the north and east would remain unaffected. With only partial visibility of the WDA possible from the Homestead and variable visibility of the WDA depending upon weather conditions, no adverse effects to the setting of the Homestead are anticipated.

Gay Head – Aquinnah Shops Area (GAY.B) Aquinnah Circle, Aquinnah

The Aquinnah Shops Area is a cluster of eight commercial buildings overlooking the Atlantic Ocean. Constructed during the early- to mid-20th century, the buildings form a U-shaped cluster along the north and south sides of a walkway extending to the Clay Cliffs of Aquinnah Scenic Overlook. The Aquinnah Shops Area is significant under Criterion A as a collection of mid-20th century roadside shops associated with the rise of the automobile era and increased tourism at

Gay Head Cliffs. Despite some alterations to the buildings, the Gay Head-Aquinnah Shops Area retains integrity of location, setting, material, workmanship, feeling, and association (Harington et al., 1998).

Recommended Determination - **No Adverse Effect**. The Shops were built to take advantage of the ocean view and the seaside setting is integral to their setting. The maritime setting of this resource, and its viewshed, would be altered through the introduction of new elements; however, existing powerlines and other modern elements are already within the foreground of the viewshed as opposed to the WDA, which will only be partially visible, far off on the horizon. Additionally, existing topography and vegetation partially screen the WDA from view.

The Shops were constructed as a means of capitalizing on tourism in Gay Head, in particular the Gay Head Cliffs, which are located to the north, west, and south of the Shops. The Gay Head overlook, where tourists view the Cliffs, is located to the north of the Shops and views to the north and east of the Cliffs are the primary viewsheds of the Gay Head Cliffs. A view to the south over the Shops to the WDA is possible from the overlook, but is not a significant viewshed as the Shops themselves conflict with the purpose of the overlook, which is to view the natural scenic character of the Cliffs and no view of the Cliffs is possible from this angle. Eligibility Criterion A would not be affected by the WDA, but Criterion C as it relates to setting would be affected. The primary viewpoints of the Shops are west or north from Aquinnah Circle; view of the WDA is not possible with a northern view and the WDA is only partially visible at an extreme angle at the west. Although the setting will be affected, no adverse effects are anticipated as significant viewsheds will not be altered.

Elijah Smith House (CHL.39) 9 Quitsa Lane, Chilmark

The one-story Cape style residence was constructed in ca. 1770 by Elijah Smith. The side-gabled house has a three-bay wide symmetrical façade with a central door enhanced with a two light transom. Elijah Smith, a farmer and cordwainer, worked as the tax collector during the time of Grey's Raid of the Revolutionary War. The property remained in the Smith family until the early 20^{th} century (Arcuti & Otteson, 1998b). The Elijah Smith House is significant under Criterion A for its association with Gray's Raid of the Revolutionary War and Criterion C as an example of a 18^{th} century Cape style farmhouse. The building retains integrity of location, design, setting, material, workmanship, feeling, and association. The Elijah Smith House is considered eligible for listing on the National Register along with the Nathan Mayhew Gravestone (CHL.802).

Recommended Determination - No Adverse Effect. This property is oriented to the south as part of historically utilizing natural light. The setting of this resource, and its viewshed, would be altered through the introduction of new elements; however, existing modern buildings are already within the viewshed. Additionally, existing buildings and structures as well as topography and vegetation partially screen the WDA from view.

A comparison of historic aerials from 1936 to the present demonstrates dramatic changes to the setting of this property and surrounding area including dramatic shoreline erosion. Historic aerials show that mature vegetation historically existed between the Elijah Smith House and the waterline, obstructing view to the south toward the WDA. Additionally, in the late-20th century, new homes were constructed along Quista Lane between the property and the ocean further obstructing the viewshed to the WDA (NETROnline, 2020). Therefore, a water view is not historically associated with the setting of this property. Given the lack of historical association with a water view and partial obstruction of view toward the WDA, no adverse effects are anticipated to the setting of this property and National Register eligibility Criteria A and C will not be affected.

Nathan Mayhew Gravestone (CHL.802) 1 Quitsa Lane, Chilmark

The slate headstone and footstone of Nathan Mayhew was laid following Mayhew's death in 1760. Son of Captain Jeramiah and Deborah Smith Mayhew, Nathan was buried on the property of his uncle Elijah Smith (Elijah Smith House / CHL.39) (Arcuti et al., 1998). The gravestones are significant under Criterion A and Criterion C as 18th century grave markers and contribute to the 18th century setting of the Elijah Smith House as well as their association with the prominent Mayhew family. The markers retain integrity of location, design, setting, material, workmanship, feeling, and association.

Recommended Determination - **No Adverse Effect**. Due to the location and orientation of the gravestones as well as existing vegetation and buildings, visibility of the WDA (if possible) will be limited due to intervening buildings and vegetation. The gravestones are located at the rear of the Elijah Smith House, with the building between them and the WDA to the south. The Elijah Smith House therefore provides an obstruction to the southern view as do other buildings along Quitsa Lane and mature vegetation. Additionally, a water view is not associated with the gravestones and therefore not tied to their historic character and integrity. The WDA will have no adverse effect on the setting of the gravestones or National Register eligibility Criteria A and C.

Captain Ephraim Poole Farm (CHL.B) 14 Menemsha Crossroad, Chilmark

The 19th century farm complex includes several stone buildings, an uncommon building material in Chilmark. The one-and-a-half story stone Greek Revival Ephraim Pool House was constructed by local stonemason James Moshure. The complex represents one of the finest examples of stonework and stone buildings in Chilmark. The complex was constructed after a four-year period for Captain Ephraim Poole, a whaling captain. The farm showcases the wealth obtained by whaling captains in Chilmark at the time of its construction (Arcuti & Otteson, 1998a). The Captain Ephraim Poole Farm is significant under Criterion A for its association with the Chilmark and Martha's Vineyard whaling industry. The complex is significant under Criterion C as an example of a 19th century farm complex with Greek Revival house, barn privy, corn crib, and stone walls. The complex retains integrity of location, design, setting, material, workmanship, feeling, and association.

Recommended Determination - **No Adverse Effect**. Historically, this property would not have had a view toward the WDA as part of its setting. Additionally, the view toward the WDA is largely obstructed by vegetation and, therefore, the WDA will have no adverse effect on this National Register eligible resource.

Martha's Vineyard American Revolution Battlefield (CHL.E) Centered Along South Road in Chilmark

The Martha's Vineyard American Revolution Battlefield is significant under Criteria A and C as a collection of historic properties dating from the 18th century associated with the 1778 British raid and with later 19th and 20th century infill properties together forming a National Register eligible district (Burdick, 2001). The Martha's Vineyard American Revolution Battlefield incorporates the towns of Vineyard Haven, Tisbury, and Chilmark. The boundary begins at the intersection of North, South, and Vineyard Haven Roads and encompasses much of the southwestern British route. The raid represents the most significant event of the Revolution on Martha's Vineyard. The British seized all of the island's arms and destroyed the majority of the vessels, preventing island residents from serving as soldiers in the remainder of the war and greatly impacting the island's economy. The Battlefield is significant under Criterion A for its association with the 1778 British raid and Criterion C as a collection of 18th century residences with later 19th century and 20th century infill properties. Significant architectural styles represented include Cape, Georgian, and Greek Revival. Also included in the eligible district is the Able Hill Cemetery established in 1717. Despite some intrusions of later development, the eligible district retains integrity of location, design, setting, material, workmanship, feeling, and association.

Recommended Determination - No Adverse Effect. This eligible district is a three-mile-long area, connecting to other sections throughout Martha's Vineyard. From select locations within the area, the WDA is visible; however, the overall character of such a large area will not be adversely affected. The vast majority of the viewshed along South Road to the WDA is obstructed. Select locations where the WDA would be partially visible include existing conditions photolocation #12 (Allen Farm, 421 South Road, Chilmark), photolocation #11 (322 South Road, Chilmark), and the Vincent Mayhew House (CHL.A, 451 South Road, Chilmark). In each of these instances only a partial view of the WDA from State Road is possible through gaps in existing tree growth. Additionally, existing powerlines and other modern elements are already within the foreground of the viewshed as opposed to the WDA, which will be only be partially visible, far off on the horizon. Criterion A will not be affected by the Project. Criterion C as it relates to setting will be affected, but the WDA will not adversely affect the character of this National Register eligible district due to the isolated instances (only in ideal weather conditions) where the WDA will be partially visible. Only a portion of the overall area is illustrated on Figure 4-1 as the northern portion of the area will not have visibility of the WDA.

Vincent Mayhew House (CHL.A) 451 South Road, Chilmark

The Vincent Mayhew House contains a group of buildings from the early 20th century and one from the late 17th century collectively listed as a National Register district (Clouette, 2011). The one-and-a-half story Colonial Cape house was constructed in ca. 1690 for Nathan Skiff and has a rectangular footprint with a rear ell. The side gable house is five-bays by three bays wide and features asymmetrical façade with an off-centered door. Originally constructed as a half-house, it was enlarged by Nathan Skiff in ca. 1700. The house was sold in 1731 to Simon Mayhew and remained in the Mayhew family into the 19th century when it was sold to Herman Vincent, remaining in the Vincent family into the 20th century. The house was purchased by a group of artists and writers in 1919 to form a summer retreat community (Clouette, 2011). The house is significant under Criterion A as a reflection of Chilmark's agricultural history from the colonial period to the 20th century as well as its association as a vacation destination of the 20th century. The property is also significant under Criterion C as an example of an early Chilmark farmstead. The property retains integrity of location, design, setting, material, workmanship, feeling, and association.

Recommended Determination - **No Adverse Effect**. This property is oriented to the south as part of historically utilizing natural light. The setting of this resource, and its viewshed, would be altered through the introduction of new elements; however, existing mature tree growth largely screens the WDA from view. Directly south from the property across from 2 Rogers Lane is a modern residence constructed in approximately 1998, and mature tree growth is located to its south and west. To the east of 2 Rogers Lane is a large open field with views toward the WDA. From the southeast corner of the Vincent Mayhew House property, a partial view toward the WDA is possible to the southeast across the open field. A view southward from the house itself to the WDA is obstructed by vegetation. Photo simulation #6 provides a view from across South Road (but not directly in front of the Vincent Mayhew House) and is useful for reference, but does not take into account the viewshed directly from the property. Views of the property to the north, west, and east will not be affected and only a portion of the southeast view will be affected. Additionally, existing powerlines and other modern elements are already within the foreground of the viewshed as opposed to the WDA, which will be only be partially visible, far off on the horizon. Criterion A will not be affected and Criterion C as it relates to the WDA has the potential to impact the setting of this National Register listed resource. However, the effects are minimized by obstructing vegetation and the extreme angle necessary to view the WDA; therefore, no adverse effects are anticipated.

Captain Samuel Hancock House (CHL.35) 141 Quansoo Road, Chilmark

Historical research show a house at this location as early as the 1790s, under the ownership of James Hancock. The house continued in the Hancock-Mitchell family until the 1980s (Arcuti & Otteson, 1998d). The building is eligible under Criterion A for its association with local maritime history and Criterion C as a rare intact example of early timber frame architecture in Chilmark. The building retains integrity of location, design, setting, material, workmanship, feeling, and association. The Massachusetts Historical Commission has determined this property eligible for listing on the National Register (MACRIS, 2020).

Recommended Determination - **No Adverse Effect.** Due to the vegetation which largely obstructs the view toward the WDA, the Project will have no adverse effect on this National Register eligible resource.

Simon Mayhew House (CHL.5) 34 Blacksmith Valley Road, Chilmark

The Simon Mayhew House is an intact example of an early 18^{h} century Cape style farmhouse (Arcuti & Otteson, 1998c). The property also contains stone walls retaining an agricultural feel. The building is eligible under Criterion A for its association with early agricultural development of Chilmark and Criterion C as an intact example of early Cape style architecture in Chilmark. The building retains integrity of location, design, setting, material, workmanship, feeling, and association.

Recommended Determination - **No Adverse Effect.** Due to the vegetation which partially obstruct the view toward the WDA, the Project will have no adverse effect on this National Register eligible resource.

Edgartown Village Historic District (EDG.A) Roughly bound by Katama Bay Main Street, Peases Point Way, Planting Field Way

The Edgartown Village Historic District is listed on the National Register of Historic Places (National Park Service, 2020). The district comprises the historic town center of Edgartown along Edgartown Harbor. The district is historically associated with the early settlement of Martha's Vineyard, the development of whaling as the island's principal business during the 19th century, and the establishment of summer tourism as a major element in the local economy at the end of the 19th and the beginning of the 20th century. The district contains homes of individuals who were regionally prominent in the whaling trade such as Captain Valentine Pease (whom Herman Melville sailed with) and Dr. Daniel Fisher who operated a whale oil and candle factory. The Edgartown Village Historic District meets Criteria A, B, and C of the National Register of Historic Places, and possesses integrity of location, design, setting, materials, workmanship, feeling, and association from its several periods of development. The district is significant in particular for its association with the Colonial era as well as the Romantic and Victorian architectural periods, containing some of Martha's Vineyard's finest architectural examples of 18th, 19th, and early 20th century designs, which include buildings in Federal, Greek Revival, Italianate Queen Anne, and Colonial Revival styles (Fitch et al., 1983).

Recommended Determination - **No Adverse Effect**. The maritime setting of this resource and its viewshed will be altered through the introduction of new elements. Edgartown is a historic port community and the view toward the ocean via Katama Bay is integral to its character and setting. However, existing buildings and structures as well as topography and vegetation largely screen the WDA from view. The dense compact nature of the district with its multi-story buildings effectively screens the WDA from the majority of the district. Areas along the perimeter of the district at Edgartown Harbor would be able to view a small portion of the WDA in ideal weather conditions, but the vast majority of the WDA is also screened by Katama Point to the south with its buildings and mature tree growth. View of the district to the north, east, and west will not be affected by the Project. Only at select locations at the northern end of the district and along

Edgartown Harbor will it be possible to view the WDA and the district southward simultaneously. The presence of multistory buildings along the Harbor also screens view of the WDA unless at or in close proximity to the waterline facing south.

The center of the district on Edgartown Harbor is 27.9 km (17.34 mi) from the WDA at its closest point. On average, based on airport reported visibilities and accounting for the Project's use of ADLS, visibility from Martha's Vineyard is 16 km (10 mi) or greater 41% of the time in a given year (see Table 3-1). This means that, at minimum, the WDA will not be visible 59% of the year. In addition to general weather conditions, other factors such as haze and seas pray may further reduce visibility. With only partial visibility of the WDA possible from select locations within the district and variable visibility of the WDA depending upon weather conditions, no adverse effects to the setting of the Edgartown Village Historic District are anticipated.

Edgartown Village Historic District (EDG.B) Roughly bound by Katama Bay Main Street, Peases Point Way, Planting Field Way

Edgartown Village District is listed on the State Register of Historic Places and is considered eligible for listing on the National Register as a boundary increase to the Edgartown Village National Register Historic District (EDG.A) (MARCIS, 2020). The eligible district is predominantly characterized by the development of early 20th century residences associated with the rise of Martha's Vineyard and Edgartown as a summer residence and tourist destination. The district is significant under Criteria A and C as a collection of early 20th century residences and pattern of development in Edgartown including examples of Colonial Revival, Cape, and Ranch styles as well as some scattered 19th century buildings in Greek Revival and Queen Anne styles. Despite some intrusions in the form of modern buildings, the district retains integrity of location, design, setting, material, workmanship, feeling, and association.

Recommended Determination - **No Adverse Effect**. The maritime setting of this resource and its viewshed would be altered through the introduction of new elements. Edgartown is a historic port community and the view toward the ocean via Katama Bay is integral to its character and setting. However existing buildings and structures as well as topography and vegetation largely screen the WDA from view. The dense compact nature of the district with its multi-story buildings effectively screens the WDA from the majority of the district. Areas along the perimeter of the district at Edgartown Harbor would be able to view a small portion of the WDA in ideal weather conditions, but the vast majority of the WDA is also screened to the south by Katama Point's buildings and mature tree growth. View of the district to the north, east, and west will not be affected by the Project. Only at select locations at the northern end of the district and along Edgartown Harbor will it be possible to view the WDA and the district southward simultaneously. The presence of multistory buildings along the Harbor screens view of the WDA unless at or in close proximity to the waterline facing south.

The district on Edgartown Harbor is approximately 27.9 km (17.34 mi) from the WDA at its closest point. On average, based on airport reported visibilities and accounting for the Project's use of ADLS, visibility from Martha's Vineyard is 16 km (10 mi) or greater 41% of the time in a given year (see Table 3-1). This means that, at minimum, the WDA will not be visible 59% of the year. Other factors such as haze and sea spray may further reduce visibility. With only partial visibility of the WDA possible from select locations within the district and variable visibility of the WDA depending upon weather conditions, no adverse effects to the setting of the district are anticipated.

Chappaquiddick Island (No MHC Inventory Designation)

Chappaquiddick Island has been determined by BOEM to be potentially eligible for listing on the National Register as a traditional cultural property (BOEM, 2019). The designation does not contain specific boundaries, but would roughly encompass the Island of Chappaquiddick, Norton Point in Edgartown, and Katama Bay. According to BOEM (2019):

> *"The TCP would be significant under Criterion A for its association with and importance in maintaining the continuing cultural identity of the community."*

Within the bounds of the TCP are three historic properties: two are included in the Inventory (the Chappaquiddick Schoolhouse [EDG.506] and the Captain William Martin House [EDG.505]) and one, the Cape Poge Light (EDG.900), is listed in the National Register of Historic Places (MACRIS, 2020; National Register, 2020). The Chappaquiddick Schoolhouse (EDG.506) and the Captain William Martin House (EDG.506) are not included in the APE because they are outside areas of potential visibility identified in the GIS-based viewshed analysis. Therefore, these two historic properties are not illustrated on the Historic Resources Map (see Figure 4-1). Although a viewer at ground level at Cape Poge Light would not have a view of the WDA, components of the Project are theoretically visible from the observation deck. Thus, Cape Poge Light is included in the APE (see Figure 4-1).

Based upon a review of available historical information on the three properties, the Chappaquiddick Schoolhouse (EDG.506) and the Captain William Martin House (EDG.505) have historical associations with the Chappaquiddick TCP, as they existed contemporaneously with the Chappaquiddick Tribe (MACRIS, 2020). The Captain William Martin House (EDG.505) has a strong connection, as Captain William Martin married Sarah Brown a member of the Chappaquiddick Tribe (Fields, 2006). There are no known associations between Cape Poge Light (EDG.900) and the Chappaquiddick Tribe aside from the lighthouse being located on land that was once occupied by the Chappaquiddick Tribe (DiStefano & Salzam, 1980). In its June 20, 2019 Revised Finding of Adverse Effect, BOEM noted that in communications with the Chappaquiddick, the Chappaquiddick stated that the grounds around Cape Poge Light were used for hunting, but no cultural significance was ascribed to Cape Poge Light (EDG.900). This suggests that while Cape Poge Light (EDG.900) is a historic structure listed on the National Register within the bounds of the TCP, it is not historically associated with the Chappaquiddick TCP (BOEM, 2019). The current Cape Poge Light (EDG.900) is the third lighthouse constructed on Cape Poge. According to the National Register nomination, as of 1980, the Cape Poge Light had been moved or reconstructed at least six times. The nomination states that the current structure was moved in 1922 and indicates the USCG intended to relocate the light in 1986. Historic aerials confirm the current structure was moved again in the 1980s. Accordingly, the current lighthouse has been moved at least twice (in 1922 and again in the 1980s) since its original construction.

Recommended Determination – **Adverse Visual Effect**.[3] BOEM has concluded that there would be direct adverse visual effects to multiple traditional cultural places comprising the Chappaquiddick Island TCP, a newly identified property potentially eligible for the National Register, because "*The traditional viewshed will be altered by the introduction of man-made structures where no structures have previously existed*" (BOEM, 2019). Photo simulations from Martha's Vineyard, in particular Wasque Reservation (Simulation #10), demonstrate that the WDA will be visible from a portion of Chappaquiddick Island as well as Norton Point and Katama Bay when looking southward. Views to the north, east, and west from these locations will not be affected. Further, visibility of the WDA is limited to the areas along the coastline and within Katama Bay. Additionally, there will be no visual effect for undersea cables.

Cape Poge Light (EDG.900)

The existing Cape Poge Light, constructed in 1893, is the third lighthouse built on Cape Poge (DiStefano & Salzam, 1980). Overall, records indicate that, as of 1980, the Cape Poge Light (including the two previous versions of the lighthouse) had been moved or reconstructed at least six times. The present location is at least the third location for the current version of Cape Poge Light. The nomination states that the current structure was moved in 1922 and indicates the USCG intended to relocate the light in 1986. Historic aerials confirm the current structure was moved again in the 1980s. Accordingly, the current lighthouse has been moved at least twice (in 1922 and again in 1980s) since its original construction. The former lighthouse keeper's house was removed in the 1980s when the lighthouse was moved southwest and inland to its current and third location (NETROnline, 2020). The lighthouse is approximately 55 feet tall with a round tower and an observation deck[4] (DiStefano & Salzam, 1980). The lighthouse is listed on the National Register and meets Criteria A and C as an architectural example of a late 19th century aid to navigation and maritime structure as well as for its contribution to the 19th century maritime industry in Edgartown, including shipping and whaling.

Recommended Determination – **No Adverse Visual Effect**. At ground level, intervening vegetation and topography prevent view from the Cape Poge Light toward the WDA. However, the observation deck is high enough to see over the mature tree growth allowing for a view

3 Included per BOEM's June 20, 2019 *Finding of Adverse Effect for the Vineyard Wind Project Construction and Operations Plan* (BOEM, 2019).

4 Available documentation from the National Register nomination (DiStefano & Salzam, 1980) suggests that the height of the observation deck is approximately 33 feet.

southward toward the WDA. Based on the approximate elevation of the observation deck, the visibility of the WDA is anticipated to be similar to that shown in Simulation #6 for the Vincent Mayhew House, with a large foreground of vegetation and view to the WDA southward in the background.

The southerly view toward the WDA includes a large portion of Chappaquiddick Island, Cape Poge Bay, and Katama Bay in the foreground with the proposed WTGs partially visible on the horizon in the distant background. The intervening space of Chappaquiddick Island and the two bays include a number of modern visual elements including vessels, houses, recreational facilities, and other modern structures that detract from the historic setting of the lighthouse. Additionally, the historic setting of the lighthouse has already been compromised through its two movements, with its current location (third) dating to the 1980s. Cape Poge Light is over 500 feet from its previous (second) location and it is unknown where its historic location was; presumably, the historic location is now offshore due to coastal erosion.

The construction of the Project would alter the experience of the observer's southerly view from the observation deck of the lighthouse only when the WDA is visible. Cape Poge Light is 31.2 km (19.4 mi) from the closest WTG. Distance along with the large vegetated foreground will reduce the visibility of the WDA. As described in Section 3.2, based on BOEM's methodology in BOEM 2017-037 and taking into account the Project's use of ADLS, on average for all conditions, Project structures could be visible 26% of the time from Cape Poge Light (see Table 3-2). In addition to general weather conditions, other factors such as haze and sea spray will reduce visibility. It is also noted that access to the observation deck is very limited, as it is only accessible seasonally via private tour.

While the Project may alter the southerly view from the observation deck of the lighthouse (when the WDA is visible), the lighthouse did not likely serve as a historic aid to navigation for vessels traveling south of Chappaquiddick as evidenced by the lighthouse's location at the northeast end of Chappaquiddick. Thus, the southerly view toward the WDA (which is filled with a terrestrial landscape and two inland bays) is in the opposite direction the lighthouse was intended to serve and is not associated with the historic, maritime aid to navigation function of the lighthouse. The lighthouse's historic maritime views were to the north, east, and west, which will be unaffected by the Project. Views from ground level at any direction will be unaffected by the Project.

In summary, Eligibility Criterion A would not be affected by the WDA, but Criterion C as it relates to the setting of Cape Poge Light would be affected. The structure has been moved at least twice from its original location (which has compromised its setting) and the WDA is only partially visible and only at the southern view from the observation deck of Cape Poge Light (depending on meteorological conditions). While the Project introduces visual elements that are out of character with the setting, feeling, and association of the property; these visual elements will only affect the southern view, which is not a historic maritime view and already includes modern visual elements. The lighthouse's historic maritime views were to the north, east, and west, which will be unaffected by the Project. Therefore, the Project will have no adverse visual effect to the setting of Cape Poge Light.

4.1.3 Martha's Vineyard National Register Ineligible Properties Viewshed Assessments

Table 4-2 lists the National Register ineligible properties on Martha's Vineyard that are within the VIA area of impact but are not within the APE.

Table 4-2 Martha's Vineyard National Register Ineligible Properties Viewshed Assessments

Property Name	MHC#	Address	Designation / Eligibility Recommendation	Recommended Determination
Tom Cooper House	GAY.53 (Harington, et al. 1998c)	1-3 Sunset Ln	INV / not eligible	Not applicable, ineligible resource.
George Cooper House	GAY.54 (Harington, et al. 1998b)	5 Sunset Ln	INV / not eligible	Not applicable, ineligible resource.
Abiah Diamond House	GAY.7 (Harington, et al. 1998a)	7 East Pasture Rd	INV / not eligible	Not applicable, ineligible resource.
Dunroving Ranch Guest House	CHL.87 (MACRIS, 2020)	440 North Rd	INV / not eligible. Would be non-contributing to a NRDIS at 440 North Rd with Capt. Richard Flanders House, CHL.32.	Not applicable, ineligible resource.
Russell Hancock House	CHL.38 (Arcuti & Otteson, 1998f)	146 Quenames Road, Chilmark	INV / not eligible	Not applicable, ineligible resource.
Josiah Tilton House	CHL.23 (Arcuti & Otteson, 1998e)	291 Middle Rd	INV / not eligible.	Not applicable, ineligible resource.
Scrubby Neck Schoolhouse	WTI.170 (Bouck, 1985b)	330 Long Point Road	INV / not eligible	Not applicable, ineligible resource.
Daniel Manter House	WTI.164 (West Tisbury Historical Commission, 1986)	70 Pond View Farm Rd	INV / not eligible	Not applicable, ineligible resource.

Table 4-2 Martha's Vineyard National Register Ineligible Properties Viewshed Assessments (Continued)

Property Name	MHC#	Address	Designation / Eligibility Recommendation	Recommended Determination
Francis Foster House	WTI.73 (Bouck, 1985a)	97 State Rd	INV / not eligible	Not applicable, ineligible resource.
Simon Mayhew House	CHL.4 (Arcuti & Otteson, 1998g).	4 Austin Pasture	INV / not eligible	Not applicable, ineligible resource.
William Tilton House	CHL.49 (Arcuti & Otteson, 1998f)	377 South Rd	INV / not eligible	Not applicable, ineligible resource.

*Designation Legend
INV Individually included in the Inventory of Historic and Archaeological Assets of the Commonwealth
INV Area Area included in the Inventory of Historic and Archaeological Assets of the Commonwealth

4.2 Nantucket, Tuckernuck, and Muskeget Islands Property Identification and Assessment of Adverse Effects

4.2.1 List of Nantucket, Nantucket, Tuckernuck, and Muskeget Islands Properties Within the APE

The following is a list of properties evaluated for significance and effects on Nantucket, Tuckernuck, and Muskeget Islands.

Table 4-3 Nantucket, Tuckernuck and Muskeget Islands Historic Property Index

Property Name	MHC#	Address	Designation / Eligibility Recommendation	Photo Simulation (Yes/No)
Nantucket Historic District	NAN.D	Nantucket Island	NHL	Yes, Simulations #11-18
Nantucket Historic District	NAN.F	Tuckernuck Island	NHL	No
Nantucket Historic District	NAN.D	Muskeget Island	NHL	No

*Designation Legend
NHL National Historic Landmark

4.2.2 *Application of the Criteria for Determining Adverse Effects to Nantucket, Tuckernuck, and Muskeget Islands Historic Properties*

Nantucket Historic District (NAN.D)

The Nantucket Historic District (NAN.D) comprises the entire islands of Nantucket, Tuckernuck, and Muskeget and is a National Historic Landmark (National Park Service, 2020). The nomination for the island of Nantucket (NAN.D) notes its early development in the 17th and 18th centuries including the development of the downtown area and village of Siasconset with their collection of 17th and 18th century architecture (Chase-Harrell et al., 1975). However, significant historic development occurred during the early to mid-19th century as a result of fires and rebuilding in downtown as well as the rise of the whaling industry, which Nantucket became famous for. Nantucket retains a mixture of significant architectural styles from the 17th through the 20th centuries (Chase-Harrell et al., 1975). The district is significant under Criterion A for its association with the development of Nantucket and the whaling industry, Criterion C for excellent architectural examples including Georgian, Federal, Greek Revival, Italianate, Shingle, and Colonial Revival and Criterion D for the potential archaeological remains associated with Native American pre- and post-contact use as well as historical archaeology. Despite modern construction and intrusions in the district, it retains integrity of location, design, setting, material, workmanship, feeling, and association.

Recommended Determination - **Adverse Visual Effect.**[5] National Register Eligibility Criteria A and D would not be affected by the Project. Criterion C as it relates to the setting of the district would be affected. The maritime setting of this resource and its viewshed would be altered through the introduction of new elements.

Although the setting of the district will be altered, distance and weather will minimize the effect to partial visibility only in ideal weather conditions. The WDA at its closest point to Nantucket at Esther Island (southwest corner of Nantucket) is 23.7 km (14.7 mi) away. As described in Section 3.2, based on BOEM's methodology in BOEM 2017-037 and taking into account the Project's use of ADLS, on average for all conditions, Project structures could be visible 25% of the time from the closest location on Nantucket Island (see Table 3-2). In addition to general weather conditions, other factors such as haze and sea spray may further reduce visibility.

Nevertheless, as an island and a major whaling center, the character of Nantucket and its National Historic Landmark District are tied to the ocean view. While the WDA is only partially visible from Nantucket Historic District, and meteorological conditions will often obscure view of the WDA to

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[5] Revised per BOEM's June 20, 2019 *Finding of Adverse Effect for the Vineyard Wind Project Construction and Operations Plan* (BOEM, 2019).

only in ideal weather conditions, the Project introduces visual elements that are out of character with the historic setting, feeling, and association of the Property. Therefore, the Project has an adverse visual effect to the setting of Nantucket Historic District.

Tuckernuck Island

Tuckernuck Island (NAN.F) is part of the Nantucket National Landmark District and contains a small collection of 19th and 20th century buildings (National Park Service, 2020). Like Nantucket, it is largely known for its 19th century architecture and benefited from the rise of the whaling industry (Chase-Harrell et al., 1975). Tuckernuck's eligibility criteria are the same for the island of Nantucket (since they are part of the same district), but its architectural timespan is shorter starting with examples dating to the early 19th century.

Recommended Determination - **Adverse Visual Effect.**[6] National Register Eligibility Criterion A and D would not be affected by the proposed Project. Criterion C as it relates to the setting of the district would be affected. Located just off the western shore of Nantucket, Tuckernuck Island is expected to have the same visibility as areas along Nantucket's southern shoreline. Although distance and weather will minimize the effect to partial visibility only in ideal weather conditions, it is expected that the setting will be altered as a result of the WDA.

The WDA at its closest point to Tuckernuck Island is 22.1 km (13.7 mi) away, a similar distance as Nantucket, but slightly closer. On average, based on airport reported visibilities and accounting for the Project's use of ADLS, visibility from Nantucket is 16 km (10 mi) or greater for only 36% of the time in a given year (see Table 3-1). Assuming visibilities reported at Nantucket Memorial Airport are also representative of Tuckernuck Island, the WDA would not be visible from Tuckernuck Island due to weather conditions for at least 64% of the year. In addition to general weather conditions, other factors such as haze and sea spray may further reduce visibility. Lastly, the visibility of WTG rows further from Tuckernuck Island will also decrease due to closer rows obstructing the view of the rows to the rear. Nevertheless, the Project introduces visual elements that are out of character with the historic setting, feeling, and association of the property. Therefore, the Project has an adverse visual effect to the setting of Tuckernuck Island.

Muskeget Island

Muskeget Island (NAN.D) is a separate island but is also a part of the Nantucket National Landmark Historic District (National Park Service, 2020). The island is largely devoid of structures with only one building, a ca. 1910 former Coast Guard boathouse, which is used as a summer residence

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6 Revised per BOEM's June 20, 2019 *Finding of Adverse Effect for the Vineyard Wind Project Construction and Operations Plan* (BOEM, 2019).

(Chase-Harrell et al., 1975). Muskeget's eligibility criteria are the same for the island of Nantucket as they are part of the same district, but its architectural timespan is shorter starting with only one surviving building (the former Coast Guard boathouse).

Recommended Determination - **Adverse Visual Effect**.[7] National Register Eligibility Criterion A and D would not be affected by the Project. Criterion C as it relates to the setting of the district would be affected. Located off the western shore of Nantucket, Muskeget Island is expected to have the same visibility as areas along Nantucket's southern shoreline. It is expected that the setting will be altered as a result of the WDA; however, distance and weather will minimize the effect to partial visibility only in ideal weather conditions.

The WDA at its closest point to Muskeget Island is 23.5 km (14.6 mi) away, a similar distance as Nantucket, but slightly closer. On average, based on airport reported visibilities and accounting for the Project's use of ADLS, visibility from Nantucket is 16 km (10 mi) or greater for only 36% of the time in a given year (see Table 3-1). Assuming visibilities reported at Nantucket Memorial Airport are also representative of Muskeget Island, the WDA would not be visible from Muskeget Island due to weather conditions for at least 64% of the year. In addition to general weather conditions, other factors such as haze and sea spray may further reduce visibility. Lastly, the visibility of WTG rows further from Muskeget Island will also decrease due to closer rows obstructing the view of the rows to the rear.

While meteorological conditions will often obscure view of the WDA, the Project introduces visual elements that are out of character with the historic setting, feeling, and association of the property. Therefore, the Project has an adverse visual effect to the setting of Muskeget Island.

4.2.3 Nantucket, Tuckernuck, and Muskeget Islands Ineligible Properties

There are no ineligible properties on Nantucket, Tuckernuck Island, or Muskeget Island.

4.3 Nantucket Sound Property Identification and Assessment of Adverse Effects

4.3.1 Nantucket Sound Historic Property Index

The following is a list of properties evaluated for significance and effects in Nantucket Sound. A small portion of Nantucket Sound is within the visual APE for the WDA where there is a direct line of sight between the islands of Nantucket and Martha's Vineyard. As described in Section 2.2, the offshore export cables are underwater and will not have a visual impact.

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[7] Revised per BOEM's June 20, 2019 *Finding of Adverse Effect for the Vineyard Wind Project Construction and Operations Plan* (BOEM, 2019).

Table 4-4 Nantucket Sound Historic Property Index

Property Name	MHC#	Address	Designation / Eligibility Recommendation	Photo Simulation (Yes/No)
Nantucket Sound	Varies, and includes YAR.917, BRN.9072, DEN.930, FAL.973, HRW.918, EDG.907, and OAK.902	N/A	NRDOE	Yes, Simulations #18-20

*Designation Legend
NRDOE Determined eligible for inclusion in the National Register of Historic Places

4.3.2 Application of the Criteria for Determining Adverse Effects to Nantucket Sound

Nantucket Sound (Varies, shown on maps as YAR.917, BRN.9072, DEN.930, FAL.973, HRW.918, OAK.902, and EDG.907)

Nantucket Sound has been determined eligible for listing on the National Register as a traditional cultural property by the Keeper of the National Register (National Park Service, 2020). Roughly bound by Vineyard Sound, Cape Cod, Martha's Vineyard, and Nantucket, the boundary for the National Register eligible property of Nantucket Sound as it relates to other waterways has not been fully defined. The Keeper in her review of eligibility criteria determined that (National Park Service, 2009):

"Nantucket Sound is eligible for listing in the National Register as a traditional cultural property and as an historic and archeological property associated with and that has yielded and has the potential to yield important information about the Native American exploration and settlement of Cape Cod and the Islands. Although the exact boundary is not precisely defined, this determination answers the question for the area that prompted the request for this determination, the Sound itself. The Sound is eligible as an integral, contributing feature of a larger district, whose boundaries have not been precisely defined, under:

- *Criterion A for its associations with the ancient and historic period Native American exploration and settlement of Cape Cod and the Islands, and with the central events of the Wampanoags' stories of Maushop and Squant/Squannit;*
- *Criterion B for its association with Maushop and Squant/Squannit;*
- *Criterion C as a significant and distinguishable entity integral to Wampanoags' folklife traditions, practices, cosmology, religion, material culture, foodways, mentoring, and narratives; and,*

- *Criterion D for the important cultural, historical, and scientific information it has yielded and/or may be likely to yield through archeology, history, and ethnography about access to resources, patterns of settlement, mobility, and land use prior to and after 6,000 years ago as a result of the inundation of the Sound. It is also important for the significant information it provides and can provide about the cultural practices and traditions of the Native Americans of Cape Cod and the Islands in relationship with other peoples since ancient times."*

Recommended Determination - **No Adverse Effect**. Photo simulations from Nantucket and Cape Cod demonstrate that the WDA will only be visible at the southern end of the Sound. Views of Nantucket Sound to the north, east, and west from within the Sound will not be affected. For the majority of Nantucket Sound, the WDA will not be visible. Additionally, there will be no visual effect for undersea cables. For the southern view, visibility of the WDA will be intermittent depending upon weather conditions and the WDA would only be visible slightly above the horizon line.

National Register Eligibility Criteria A, B, and D would not be affected by potential visibility of the WDA. National Register Criterion C (which is typically for aspects of design related to the built environment) for this Historic Property references historic use and practices within Nantucket Sound, which will not be affected by the WDA. In particular, the area of most importance between the islands of Martha's Vineyard, Nantucket, and Cape Cod will have minimal visibility of the WDA as the islands themselves obstruct its view.

4.3.3 Nantucket Sound Ineligible Properties

As described in Section 4.3.2 above, Nantucket Sound been determined eligible for listing on the National Register as a traditional cultural property.

5.0 CONCLUSIONS

5.1 Direct Physical Effects

As described above, direct physical effects are defined as construction-related impacts or areas of potential disturbance by the Project. These areas include proposed cable routes and a new onshore substation in Barnstable. While the construction disturbance itself will be visible, it will be a temporary condition. Effects related to potential terrestrial archaeological impacts are addressed in Appendix III-G of COP Volume III and Appendices C and D of the COP Addendum. Effects related to potential marine archaeological impacts are addressed in Volume II-C of the COP.

5.2 Direct Visual Effects

As defined in BOEM's Finding of Adverse Effect for the Vineyard Wind Project Construction and Operations Plan (dated June 20, 2019), the APE for direct visual effects is "the viewshed from which renewable energy structures, whether located offshore or onshore, would be visible" (and includes those historic properties included in, or eligible for inclusion in, the National Register of Historic Places) (BOEM, 2019).

Based upon the location of the onshore substation site and nearby historic resources, only one property (BRN.O / Old King's Highway Regional Historic District) is near the onshore substation site (MACRIS, 2020). The district is located across Route 6, a secondary highway, and through existing mature tree growth. Furthermore, the Project's onshore substation will be generally comparable in size and appearance to the existing Barnstable Switching Station located on an adjacent property. Thus, no adverse visual effects are anticipated as a result of constructing the onshore substation.

For offshore portions of the Project, delineating the APE involves a three-step process. The first step in determining the APE includes identifying the areas where there is a theoretical line of sight to the Project. This is based upon a mathematical formula that calculates the maximum possible distance from which there is a line of sight to a WTG given a tip height of 255 m (837 ft) and the curvature of the earth. The areas of potential visibility within the 61.8 km (38.4 mi) radius were then generated using a GIS viewshed calculation, which identifies the geographic area where a direct line of sight exists to the blade tip considering the curvature of the earth (with atmospheric refraction) and accounting for obstructions including topography, built structures, and vegetation. The second step in determining the APE includes utilizing the photo simulations and, where available, field observations to identify those areas within the VIA area of impact (i.e. those areas with a theoretical line of sight to the Project) where the Project "would be visible." The third step in determining the APE involves assessing historic properties within those areas where the Project "would be visible" to determine which properties are included in, or eligible for inclusion in, the National Register of Historic Places. Such properties constitute the APE.

The following summarizes the assessment of adverse effects for the geographical areas within the APE:

Martha's Vineyard: The Project has been determined to have an adverse visual effect for the Gay Head Lighthouse on Martha's Vineyard. The maritime setting of this resource, and its viewshed, would be adversely affected through the introduction of new elements. Additionally, BOEM, for the purposes of its Section 106 review, is recognizing areas on and around Chappaquiddick Island as a traditional cultural property important to the Chappaquiddick Tribe and determined that the Project would have an adverse visual effect on the Chappaquiddick Island traditional cultural property (BOEM, 2019). Other than the Gay Head Lighthouse and the Chappaquiddick Island traditional cultural property, no adverse effects on historic properties within the visual APE on Martha's Vineyard are anticipated. While historic properties may now have a potential view toward the WDA, in many cases the view is a modern condition and not tied to the historic setting of the property.

Nantucket Island, Muskeget Island, Esther Island, and Tuckernuck Island: These islands are collectively designated as part of the same National Historic Landmark designation (National Park Service, 2020). Despite limited visibility of the WDA due to weather conditions, the Project has been determined to have adverse visual effects to these islands.

Nantucket Sound: Nantucket Sound been determined eligible for listing on the National Register as a traditional cultural property (National Park Service, 2009). No adverse effects to Nantucket Sound are anticipated as only a limited section of Nantucket Sound has the potential to be affected.

For all properties, it is not typically the viewshed of the property that is being affected, but rather the viewshed from the property, which in many cases is not as significant. For those properties with potential changes to their viewsheds, a variety of mitigating circumstances are present. For example, the Edgartown Historic Districts (EDG.A and EDG.B), intervening tree growth and structures mitigate the view to the WDA, which is only achievable when viewing down Katama Bay through the existing harbor.

For properties with a largely unobstructed view of the ocean, such as those in Gay Head, including the Gay Head Lighthouse (GAY.900), the Edwin Vanderhoop Homestead (GAY.40) and the Gay Head – Aquinnah Shops Area (GAY.B), it is only a portion of the southerly viewshed from the properties that will be affected and only a portion of the WDA will be visible due to obstructing topography and vegetation.

Most importantly, distance and weather conditions render the WDA not visible during many times of the year (see Section 5 of the Addendum to Appendix III-H.a). Therefore, while some properties may be adversely affected by the Project, they will only be so during ideal weather conditions and on a temporary basis. Further information regarding the potential visibility of the Project can be found in the Visual Impact Assessment and Visual Impact Assessment Addendum in Appendix III-H.a.

6.0 REFERENCES

The following table lists where Project information contained in this Historic Resources Visual Impact Assessment can be found in the Construction and Operations Plan (COP). The references list is provided below the table.

Table 6-1 Guide to Location of Information Contained in the COP

Topic	Location in COP or COP Addendum
Description of wind turbine generators	Section 3.1.1 of COP Volume I
Description of electrical service platforms	Section 3.1.4 of COP Volume I
Description of the landfall site	Section 3.2.2 of COP Volume I
Description of the onshore export cables	Section 3.2.3 of COP Volume I
Description of the onshore substation	Section 3.2.4 of COP Volume I
Effects to potential terrestrial archaeological resources	Appendix III-G of COP Volume III
Effects to potential marine archaeological resources	Volume II-C
Vineyard Wind Project Visual Impact Assessment	Appendix III-H.a of COP Volume III (Note: The Addendum to the VIA is provided as Appendix D of Appendix III-H.a)
Frequency of Activation of an Aircraft Detection Lighting System (ADLS) Report	Appendix III-N of COP Volume III

Arcuti, T., & Otteson, H. (1998a). Captain Ephraim Poole Place Form A – Area.

Arcuti, T., & Otteson, H. (1998b). Elijah Smith House Form B – Building.

Arcuti, T., & Otteson, H. (1998c). Flaghole Form B – Building.

Arcuti, T., & Otteson, H. (1998d). Hancock/Mitchell House Form B – Building.

Arcuti, T., & Otteson, H. (1998e). Josiah Tilton House Form B – Building.

Arcuti, T., & Otteson, H. (1998f). Russell Hancock House Form B – Building.

Arcuti, T., & Otteson, H. (1998g). Simon Mayhew House Form B – Building.

Arcuti, T., & Otteson, H. (1998h). William Tilton House Form B – Building.

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Bouck, J. (1985b). Scrubby Neck Schoolhouse Form B – Building.

Burdick, W. (2001). Martha's Vineyard Battlefield Form A – Area.

Chase-Harrell, P., & Pfeiffer, B. (1975). Nantucket Historic Landmark Nomination.

Clouette B. (2011). Skiff-Mayhew-Vincent House National Register Nomination.

DiStefano, V. (1980). Gay Head Light National Register Nomination.

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Fitch, V.A., Pfeiffer, B., & DiStefano, V. (1983). Edgartown Village Historic District National Register Nomination.

Fields, J. (2006). Captain William Martin House Form B – Building.

Harington, M.K., & Adams V. H. (1998). Aquinnah Shops Form A – Area.

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Harington, M.K., Paulus, E.L., & Adams, V.H. (1998b). George Cooper House Form B – Building.

Harington, M.K., Paulus, E.L., & Adams, V.H. (1998c). Tom Cooper Homestead Form B – Building.

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ATTACHMENT A - EXISTING CONDITIONS PHOTOLOCATIONS

Martha's Vineyard Existing Conditions Photolocations

A total of 19 locations were selected for an existing conditions survey of Martha's Vineyard. These locations are in proximity to some historic or archaeological resources The 19 locations below provide a variety of locations from directly along the shoreline to upper terrain inland locations (see Figure A-1).

Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

Vineyard Wind Project

VINEYARD WIND

Figure A-1

Martha's Vineyard Existing Conditions Photolocation Map

Photolocation #1 / Wasque Reservation, Chappaquiddick

Located along Wasque Avenue, this area includes shoreline and open fields with low tree growth and a northern treeline with larger mature tree growth approximately 4.5-6 m (15-20 ft) in height. A lagoon is located north of a sandbar with dunes approximately 2.4-3 m (8-10 ft) in height. The topography slopes upward inland allowing for view to the WDA above the dunes. Existing vegetation eliminates the WDA view northward along Wasque Avenue toward Pocha Road, with views present along intersecting streets at their southern ends at Katama Bay.

View toward the WDA at the end of Wasque Avenue.

View at shoreline of lagoon toward the WDA over the dunes.

Photolocation #2 / Wasque Point, Chappaquiddick

Located within the Wasque Reservation, Wasque Point has a cliffside view (approximately 6 m [20 ft] high) over the beach below, largely to the east with a southern view through existing tree growth approximately 4.5-6 m (15-20 ft) in height. The view from the beach below to the south along the shoreline is unobstructed.

View toward the WDA along the eastern shoreline.

Photolocation #3 / Washqua Avenue, Chappaquiddick

Running from Wasque Avenue and terminating downhill at Katama Bay, this area contains a mix of one to two-story residential buildings dating from the 20th century as well as open lawns and mature tree growth with shrubbery at Katama Bay. At the high/inland end of the street, the elevation is roughly 12.1 m (40 ft) above sea level. A view toward the WDA is possible at the end of the street looking over the dunes at Katama Bay. Existing tree height along Washqua Avenue is 6-7.6 m (20-25 ft).

View south across Katama Bay toward the WDA; dunes block view of the horizon line.

Photolocation #4 / Jerimiah Way, Chappaquiddick

Running from Litchfield Road southward and terminating at Katama Bay, Jerimiah Way consists of a mix of mid- to late-20th century single-family residences set on large lots with mature tree growth 4.5-9.1 m (15-30 ft) in height. Tree growth lowers in height toward Katama Bay. Views from the roadway toward the WDA were largely obscured by existing tree growth and buildings. The roadway also sits behind a small rise blocking view of the horizon line. Visibility from private property across Katama Bay toward the WDA is possible.

View south toward the WDA is limited due to topographic changes and vegetation.

Photolocation #5 / Chappy Point, Gardner Beach, Chappaquiddick

Located in the vicinity of the Edgartown Historic District on Chappaquiddick Road at the ferry landing, Gardner Beach has low sporadic vegetation 1.5-2.4 m (5-8 ft) in height with a wide open view southward to Katama Bay. View toward the WDA is partially blocked by the shoreline in Edgartown (in particular, Katama Point).

View south across Katama Bay toward the WDA.

Photolocation #6 / Katama Point Public Launch, Edgartown

The public launch overlooks a section of Katama Bay toward the dunes to the south. From this location, significant vegetation is not present and the dunes provide the only obstruction of the horizon line. Nearby residences dating from the mid- to late-20th century may have views over the dunes that could provide visibility of the WDA from this location. Access to private property was unavailable.

View south across Katama Bay toward the WDA; dunes block view of the horizon line.

Photolocation #7 / South Beach / Katama Beach, Edgartown

South Beach / Katama Beach has significant dunes in this location 1.8-3 m (6-10 ft) in height. From an inland location behind the dunes, a view of the horizon line and WDA is possible. Inland of this location is Katama Farm and Katama Airpark, both of which are devoid of significant vegetation, allowing for potential visibility of the WDA further inland until the treeline and nearby residences (dating from the mid-late 20th century) create an obstruction.

View toward the WDA; gap in dunes permits view of the WDA.

Photolocation #8 / Wilson's Landing, Edgartown

Located on Edgartown Great Pond, Wilson's Landing is a public boat launch. Existing mature tree growth in the area is 7.6-10 m (25-35 ft) in height. The landing has a southerly view across the pond toward the dunes and the inlet. View toward the WDA and horizon line is possible. Once back from the shoreline, existing vegetation quickly obstructs the viewshed to the south.

View south toward the WDA; inlet provides view of horizon line.

Photolocation #9 / Long Point Wildlife Refuge, West Tisbury

Located roughly midway along Martha's Vineyard's southern coast is the Long Point Wildlife Refuge. The Refuge has mature tree growth 9.1-12.1 m (30-40 ft) in height that lowers in height from Scrubby Neck Farm Road at the north down to shrubbery and grassed areas and dunes at the shoreline. Dunes at this location are 1.8-2.4 m (6-8 ft) in height. View of the WDA from inland areas is partially obstructed by tree growth to the north of this position but views of the WDA are possible.

View south toward the WDA, visible at right.

Photolocation #10 / Tississa Point, West Tisbury

Located within the Sepiessa Point Reservation, Tississa Point has a southerly view across Tisbury Great Pond through an inlet toward the WDA. The surrounding area consists of low vegetation near the shoreline with open fields and mature tree growth (approximately 9.1 m [30 ft] in height) further northward. Dune height on either side of the inlet varies, providing view of the horizon on either side of the inlet. View toward the WDA is possible from this location, but is obstructed further northward from this position due to dense vegetation.

View south toward the WDA.

Photolocation #11 / 322 South Road, Chilmark

Throughout most of South Road in Chilmark, view of the ocean is obstructed by tree growth. In the vicinity of Able Hill Cemetery (CHL.803) and specifically through the property at 322 South Road, a view of the horizon line toward the WDA exists via a gap in existing tree growth. Elsewhere, tree growth is 7.62-9.1 m (25-30 ft) in height. Some of the private residences (largely dating from the mid- to late-20th century) on the southern side of South Road have a clear view toward the WDA due to the steep slope down to the shoreline and lack of vegetation. Access to private property was not available during the field survey.

View south toward the WDA.

Photolocation #12 / Allen Farm, 421 South Road, Chilmark

The Allen Farm (CHL.E) consists of an 18th century house and associated farm buildings. This area along South Road has some large open fields and some historic farm complexes. Via the open fields to the south, view toward the WDA and horizon line is possible through openings in the vegetation and over the cliffs at Lucy Vincent Beach (see Photolocation #13 below).

View south toward the WDA, visible at right.

Photolocation #13 / Lucy Vincent Beach, Chilmark

Lucy Vincent Beach has a combination of beach shoreline and cliffs roughly 10.6 m (35 ft) in height. At the shoreline, southerly views toward the WDA are unobstructed. Inland of the beach, the topography rises quickly and the immediate area has some open fields allowing for overlooking views toward the WDA. Where present, such as the road to the parking lot, existing tree growth is 7.6-10.6 m (25-35 ft) in height and, with the exception of the path to the beach, obstructs view of the horizon.

View south toward the WDA from Lucy Vincent Beach.

Photolocation #14 / Chilmark General Store, 7 State Road, Chilmark

Located in the town center of Chilmark, the area around the Chilmark General Store (CHL.E) is obstructed from viewing the WDA and ocean generally by dense vegetation. Mature tree growth in this area is 9.1-12.1 m (30-40 ft) in height.

View south toward the WDA; no ocean view from this location.

Photolocation #15 / Squibnocket Beach, Aquinnah

Squibnocket Beach has unobstructed views toward the WDA. The area around the beach has varying topography including rolling hills and a high point of Squibnocket Ridge. The area surrounding the beach also has predominantly low vegetation and sporadic mature tree growth allowing for views from surrounding properties as well.

View south toward the WDA.

Photolocation #16 / Zach's Cliffs / Moshup Trail, Aquinnah

This section of Moshup Trail has dense vegetation, but at the road, a partially obstructed oblique view to the southeast toward the WDA is possible. Most of the surrounding vegetation is 1.8-3 m (6-10 ft) in height. From the road, Zack's Bluffs largely obstruct the view toward the WDA, but from the bluffs themselves, views toward the WDA can be achieved.

View southeast toward the WDA, at back right.

Photolocation #17 / Gay Head Lighthouse, Aquinnah

Located on a prominent rise, the State and National Register-listed Gay Head Lighthouse's (GAY.900) southerly view is too far east to view the WDA due to its location at the western end of Martha's Vineyard. A southeast view is required to look toward the WDA and this view is partially obstructed by existing topography and vegetation. Only the southwestern portion of the WDA would potentially be viewable, which is at the furthest distance from the lighthouse. The area surrounding the lighthouse is a mixture of open fields and low vegetation (shrubbery) with sporadic tree growth 1.8-3 m (6-10 ft) in height. A view from within or atop the lighthouse was not obtainable during the field survey.

View southeast toward the WDA, at right.

Photolocation #18 / Gay Head Cliffs Overlook, Aquinnah

The Gay Head Cliffs Overlook is located just north of the Aquinnah Shops. From this vantage point, a better view toward the WDA can be achieved than from the Gay Head Lighthouse due to the increased elevation and ability to see across Aquinnah toward the WDA at the southeast; however, the landmass of Aquinnah creates an obstruction. Only a partial view toward the WDA is possible and, as with the lighthouse, only the southwestern portion of the WDA would the viewable.

View southeast toward the WDA, at right.

Photolocation #19 / Aquinnah Town Hall, 65 State Road, Aquinnah (GAY.A)

Located in an area of dense tree growth ranging from 4.5-12.1 m (15-40 ft) in height, the area in and around State and National Register-listed Aquinnah Town Hall has no view of the ocean or WDA due to obstructing dense vegetation and topography.

View southeast toward the WDA; viewshed obstructed.

Nantucket Existing Conditions Photolocations

A total of 14 locations were selected for an existing conditions survey of Nantucket. These locations are in proximity to some historic or archaeological resources. The 14 locations below provide a variety of locations from directly along the shoreline to upper terrain inland locations (see Figure A-2).

G:\Projects2\MA\MA\4903\2020\Task_8\HISTORIC\BOEHM_REV1\A-2_Nantucket_Photolocations.mxd

Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

Vineyard Wind Project

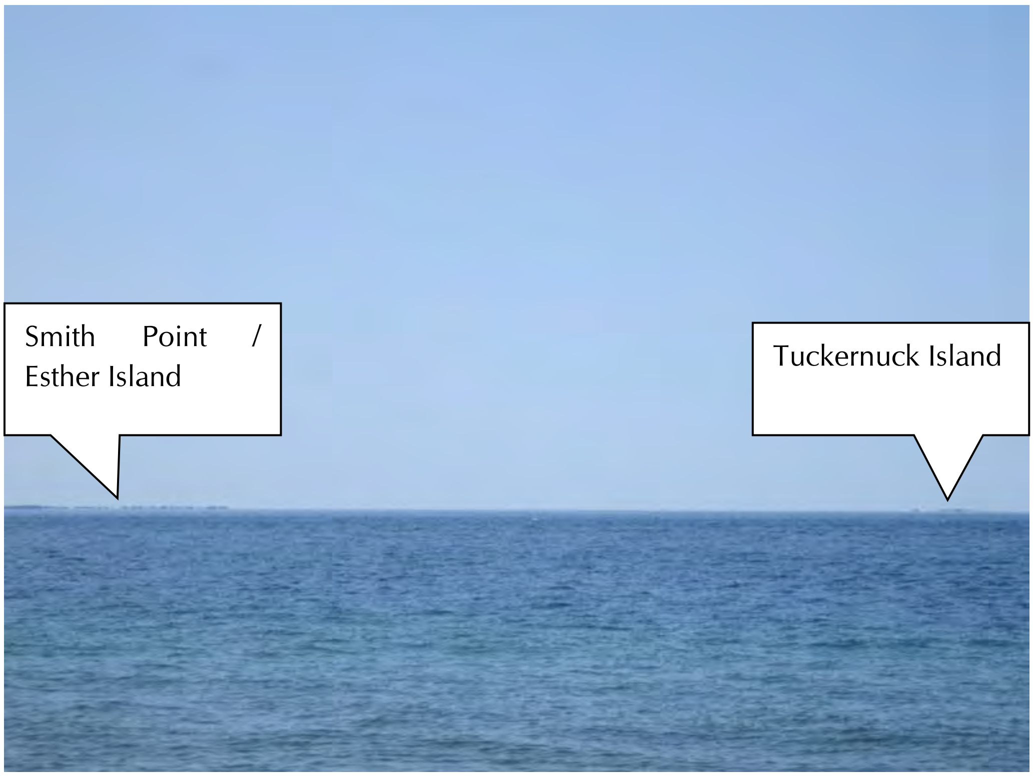
VINEYARD WIND

Figure A-2

Nantucket Existing Conditions Photolocation Map

Photolocation #1 / Great Point Lighthouse

Located at the northern end of the island is the Great Point Lighthouse, constructed in 1985 as a replacement for the original 19th-century lighthouse that was lost during a storm. Stones from the original lighthouse were salvaged and reused in the replacement built further inland. View toward the WDA is possible between Smith Point and Esther Island to the east and Tuckernuck Island to the west.



View southwest toward the WDA; Smith Point / Esther Island is at left and Tuckernuck Island at right.

Photolocation #2 / Siasconset Golf Club

Located at 260 Milestone Road (a main thoroughfare on the island), the Siasconset Golf Club is located on a small rise and occupies an area largely devoid of significant tree growth. The golf course can be observed as far away as the Sankaty Head Lighthouse to the northeast on Baxter Road, as much of the area in between has been cleared. Limited view toward the WDA can be obtained from this location due to vegetation and topography.

View southwest toward the WDA; view is partially obstructed by vegetation and topography.

Photolocation #3 / 54 Low Beach Road

Low Beach Road is located at the southeastern corner of the island. The road starts at the intersection of Morey Lane and Ocean Avenue and terminates at Tom Nevers Pond. Few houses are on the ocean side of the road, which looks down to the ocean past low scrub brush, dunes, and grassed areas. Buildings in the area largely consist of mid- to late-20th century single-family residences one to two and half stories in height. Due to the location, only an oblique view toward the WDA at the southwest is possible; however, most buildings are oriented south to southeast, to take in the full view of the water (if present).

View toward the WDA from 54 Low Beach Road; although largely obstructed, the WDA is viewable at background left.

Photolocation #4 / Low Beach

Low Beach is located at the southeastern corner of the island. Only an oblique view toward the WDA at the southwest is possible. The beach has short dunes 1.2-1.8 m (4-6 ft) in height and a mild grade down to the water.

View southwest across Low Beach toward the WDA.

Photolocation #5 / Tom Nevers Road

Tom Nevers Road is bordered by mid- to late-20th century two and a half story homes set on large lots. The road is also bordered by large hedges and trees planted to ensure privacy among the residences. Only an oblique view toward the WDA at the southwest is possible from this location.

View southwest toward WDA is partially obstructed, but a water view and the WDA are visible at background, right.

Photolocation #6 / Tom Nevers Field

Tom Nevers Field is located at the end of Tom Nevers Road. The field is set back from the shoreline by dunes and a small bluff roughly 3-3.6 m (10-12 ft) in height. The immediate area is largely devoid of trees and has low scrub brush and grassed areas. View southwest toward the WDA is possible from this location.

View southwest toward the WDA.

Photolocation #7 / Surfside Road

Surfside Road runs north to south at the southern end of the island in the village of Surfside. At its southern end, Surfside Road intersects with Western Avenue running east to west, which has early- to mid-20th century residences along its south side with a clear view of the ocean toward the WDA. Approximately 152.4 m (500 ft) of dunes, grassed areas, and scrub brush are between the residences and the beach. Residences on the northern side of Western Avenue have their water views partially obstructed by neighboring properties and vegetation, but views toward the WDA are possible.

View to the southwest toward the WDA from the intersection of Surfside Road and Western Avenue, WDA viewable at left.

Photolocation #8 / Miacomet Golf Club

Located at 12 West Miacomet Road, the Miacomet Golf Club has an open course with small knolls and sporadic mature tree growth approximately 7.6-9.1 m (25-30 ft) in height. Given the lack of significant vegetation, a view of the ocean and WDA is possible at this location.

View southwest toward WDA.

Photolocation 9 / Bartlett's Farm

Bartlett's Farm a 19th century farm complex, is located at 30 Bartlett Farm Road. As a farm, the fields provide a wide-open view of the surrounding area. View toward the WDA and WDA is possible through the fields. On nearby properties, existing treelines and residential development obstruct the view of the WDA, creating a narrow inland view corridor at this location.

View toward WDA, visible at background right.

Photolocation #10 / Heller's Way and Hummock Pond Road

Hellers Way runs roughly east to west between Hummock Pond Road and Walbang Avenue. At its southern end, Hummock Pond Road terminates at Cisco Beach with views toward the WDA. Cisco Beach has a small bluff approximately 3 m (10 ft) in height. Vegetation in the area consists of sporadic tree growth, approximately 7.6 m (25 ft) in height, along with shrubbery and grassed areas. Development in this area consists of two and half story 20th century single-family residences. The WDA view along the southern end of Hummock Pond Road diminishes quickly, with a narrow view corridor along Hummock Pond Road terminating after 243 Hummock Pond Road heading north. At the intersection of Hummock Pond Road and Hellers Way no ocean view is possible.

View southwest toward the WDA is obstructed by vegetation.

Photolocation #11 / Barrett Farm Road

Barrett Farm Road originates at its northern end at Madaket Road. The road is elevated, originating just south of Trots Hills and has a view overlooking Trots Swamp. There are few buildings along the road and the area has dense vegetation with mature trees approximately 7.6-10 m (25-35 ft) in height. Due to the elevation and a gap in vegetation, view of the WDA is possible at the northern end of the road and again at the southern end of the road where a small rise permits view over the dunes at the shoreline.

View southwest toward the WDA via gap in existing vegetation.

Photolocation #12 / Washington Street and Madaket Road

The village of Madaket largely consists of early- to mid-20th century residences one to two and a half stories in height. The village is centered along Madaket Road with short intersecting streets running off of it. The area has sporadic mature tree growth 7.6-10.6 m (25-35 ft) in height along with shrubbery and grassed areas. From H Street northward, a view toward the WDA along Madaket Road is obstructed. Madaket Beach at the terminus of Madaket Road has a clear view toward the WDA.

View southwest toward the WDA from the intersection of Madaket Road and Washington Avenue; WDA is visible at background left and center.

Photolocation #13 / Massachusetts Avenue Boat Launch

Adjacent to Madaket is Smith Point with a dense cluster of early- to mid-20th century single family residences, one to two and a half stories in height. This area also has a section of dense tree growth 10.6-12.1 m (35-40 ft) in height. The boat launch is located on Madaket Harbor and the view toward the WDA is possible.

View southwest toward the WDA.

Photolocation #14 / Eel Point

At the north end of Madaket Harbor is Eel Point and the Eel Point Marsh. Eel Point has large dunes 3.6-4.5 m (12-15 ft) in height along with grassed areas and scrub brush. From an elevated vantage point atop a dune, view toward the WDA is possible.

View southwest toward the WDA.

ATTACHMENT B - AIRCRAFT DETECTION LIGHTING SYSTEM INFORMATION

VINEYARD WIND

Aircraft Detection Lighting System Technical Specifications and Design Information

September 16, 2020

The Federal Aviation Administration (FAA) has approved Aircraft Detection Lighting Systems (ADLS) from multiple vendors. Vineyard Wind has worked closely with FAA-approved ADLS technology supplier Terma and provides the following information.

ADLS uses radar surveillance systems to track aircraft transiting in proximity to the Wind Development Area (WDA). Terma's proposed ADLS for the Project included two radars using an 18 ft high gain (HG) antenna mounted on the transition piece of two WTGs (see the schematic and technical drawing provided as Attachment 1). An example layout for the radars is provided as Attachment 2. If an aircraft is detected by the radar within a predetermined range from the WDA, the ADLS activates the WTG's FAA aviation obstruction lights. As described in Vineyard Wind's Construction and Operations Plan (COP) Volume I and the Historic Properties Visual Impact Assessment (Appendix III-H.b), per FAA guidance, the aviation obstruction lighting system will consist of two synchronized FAA "L-864" red flashing lights (2,000 candelas) mounted on top of the nacelle of each constructed WTG and the ESPs (if needed). If the WTGs' total tip height is 699 ft or higher, there will be up to four additional low intensity L-810 flashing red lights (25 candelas) at a point approximately midway between the top of the nacelle and sea level. If approved by BOEM and the FAA, the lights will flash 30 times per minute. Once the aircraft has departed the area, the lights are deactivated by the system. As previously noted, nighttime air traffic across the project area is extremely low and therefore the ADLS is expected to activate less than 4 hours a year.

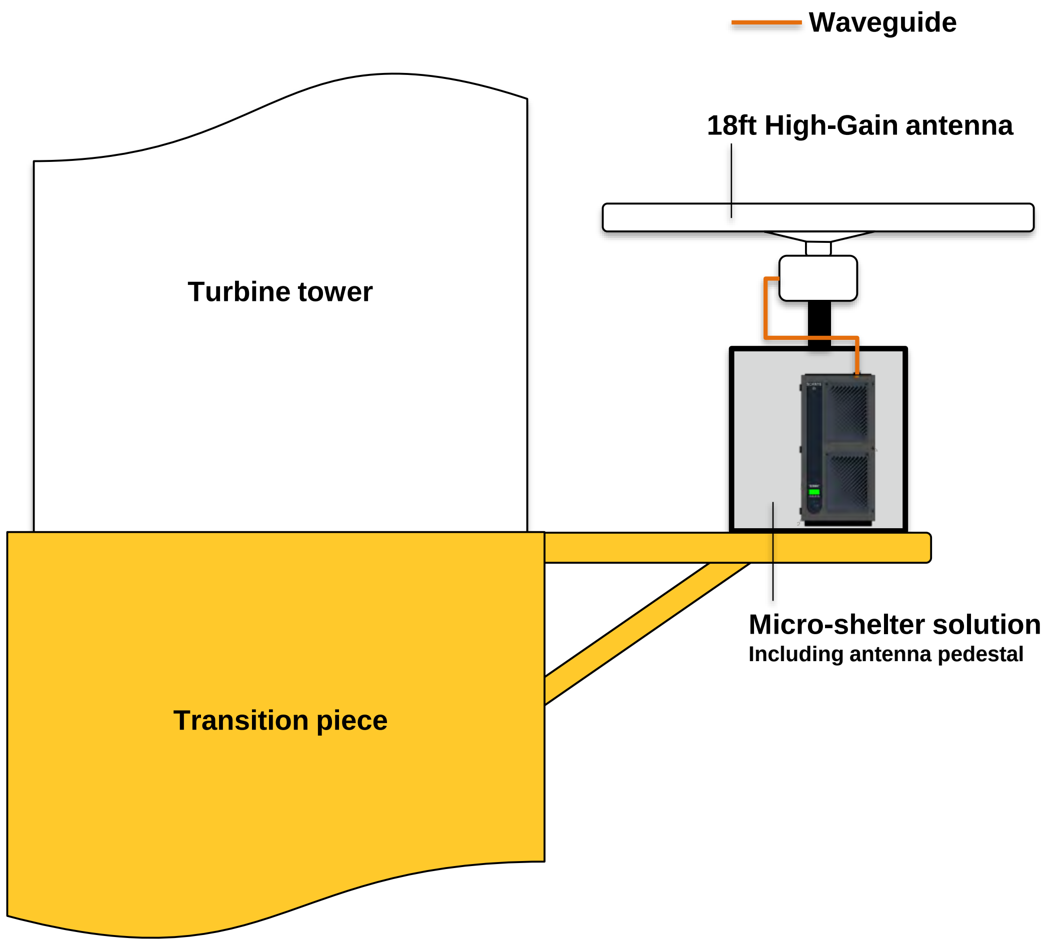
Failures of the ADLS are expected to occur very infrequently. Terma's performance specifications indicate that the system is expected to be operational 99.93% of the time or more and, on average, a repair is expected to take one hour. Per FAA guidance, if the ADLS fails, the ADLS would turn on the flashing aviation obstruction lights (either all lights or only the lights specifically affected by the component failure) until the system's functions are restored. Terma's fail-safe backup systems are further described in FAA's *Performance Assessment of the Terma Obstruction Light Control System as an Aircraft Detection Lighting System* (see Attachment 3, page 4).

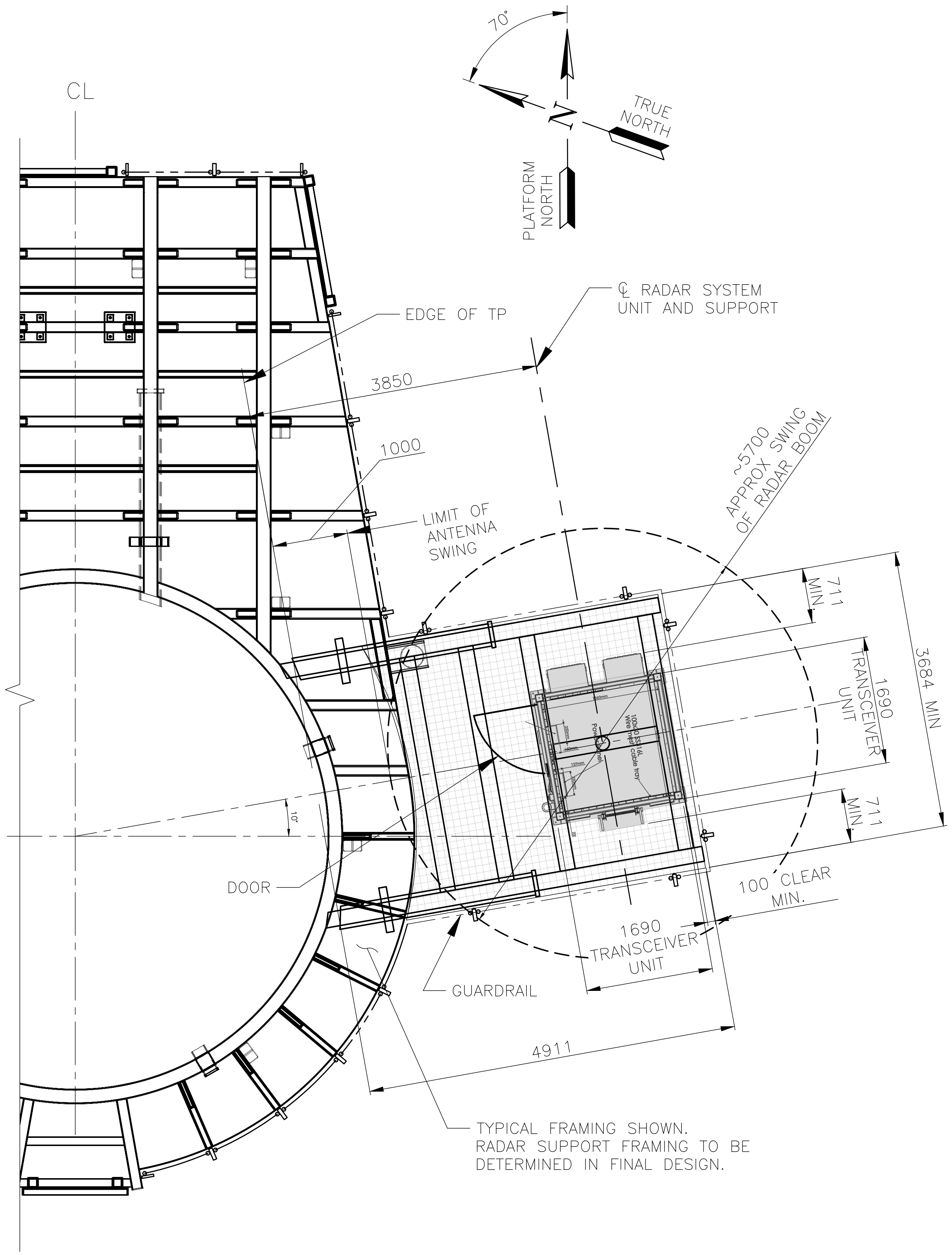
Vineyard Wind's technicians will monitor the status of the system 24 hours a day, seven days a week. If a failure occurs, Vineyard Wind's WTG technicians will perform the repairs during their daily trips to the WDA. Vineyard Wind will store most frequently used spares for the system so that they are readily available if a failure occurs. Overall, Vineyard Wind expects to be able to readily resolve any very limited system failures that may occur. Whether the lighted wind turbines will be visible during a failure will depend upon the number of lights affected by the failure, the location of the observer, and the visibility based on weather. Nevertheless, with a 99.93% operational rate, the overall contribution of any failure to the total hours the lights would be on is minimal.

Attachments

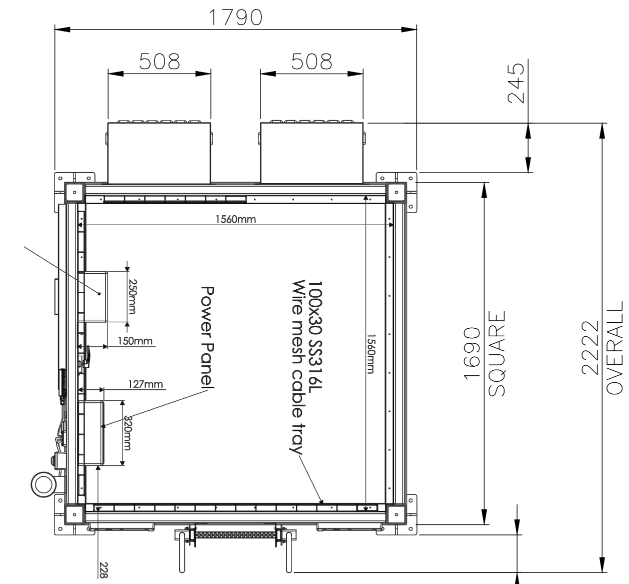
Attachment 1 Example ADLS Schematic and Technical Drawing
Attachment 2 Example ADLS Coverage Diagram
Attachment 3 FAA's (2016) *Performance Assessment of the Terma Obstruction Light Control System as an Aircraft Detection Lighting System*

ADLS Transceiver and Antenna

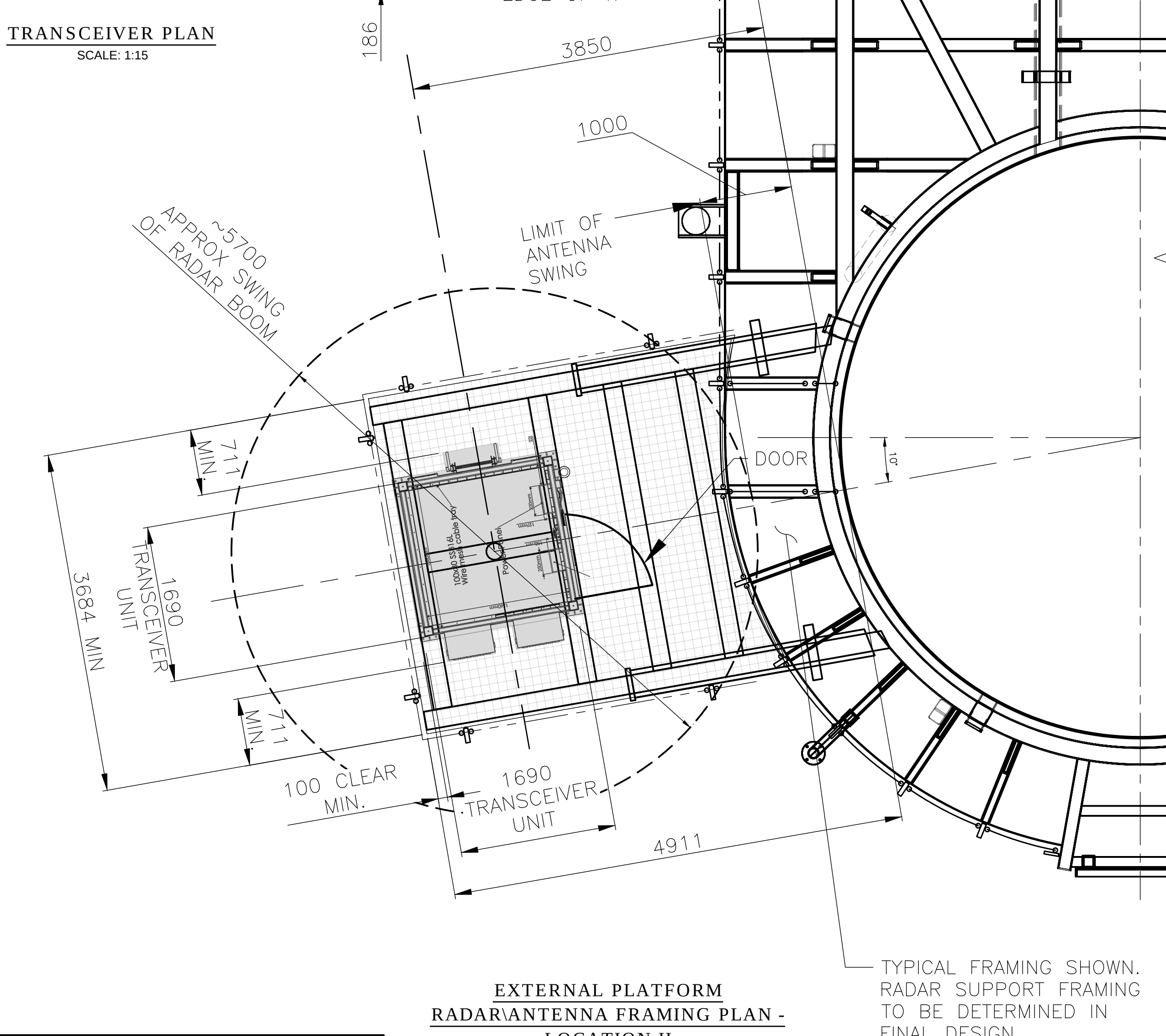




EXTERNAL PLATFORM
RADAR\ANTENNA FRAMING PLAN -
LOCATION I
SCALE: 1:30



TRANSCEIVER PLAN
SCALE: 1:15



EXTERNAL PLATFORM
RADAR\ANTENNA FRAMING PLAN -
LOCATION II
SCALE: 1:30

1 RADAR PER PLATFORM.
2 TOTAL FOR WIND FARM.

FOR DISCUSSION PURPOSES ONLY
NOT FOR CONSTRUCTION
APRIL 4, 2019

wsp

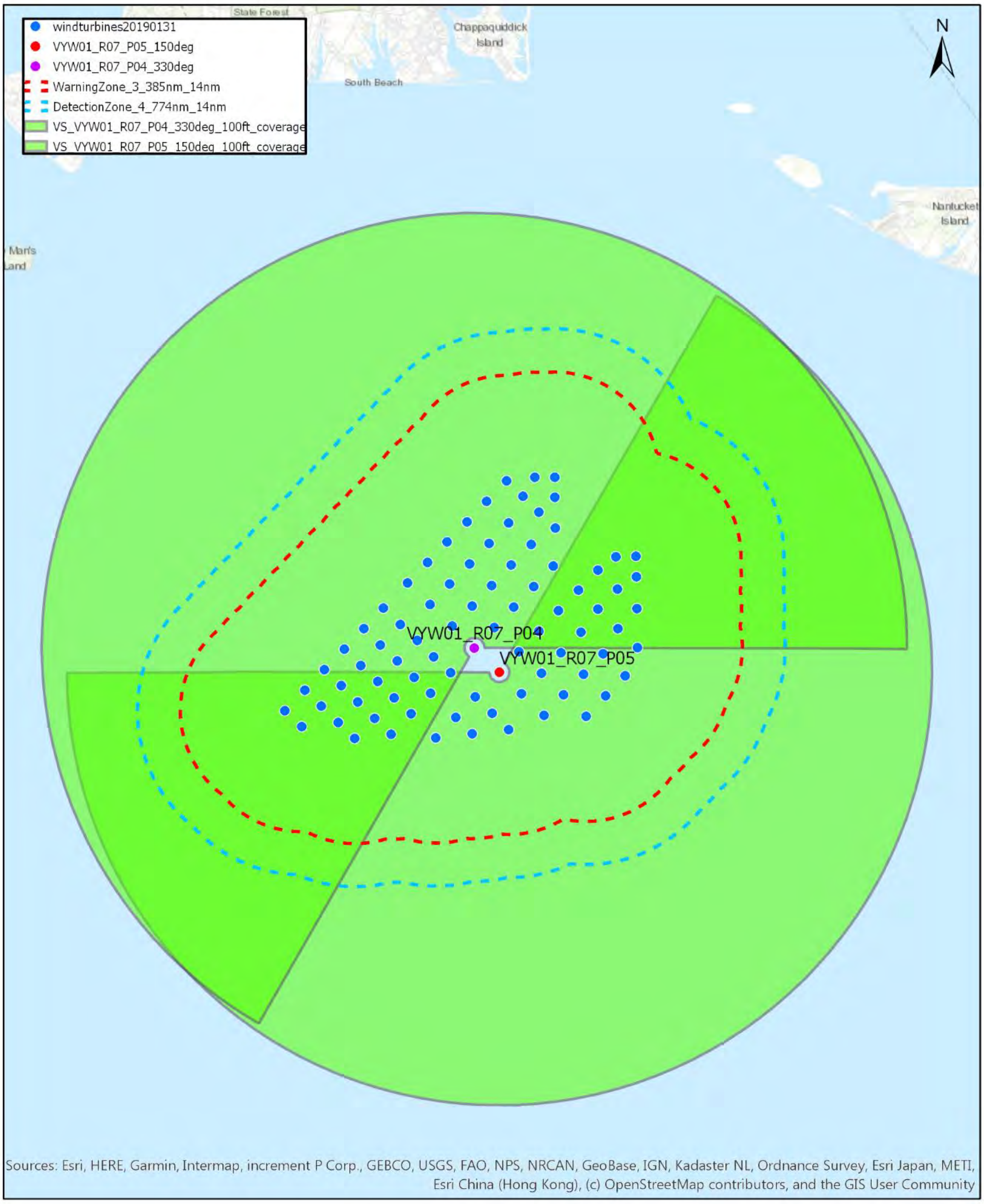


Figure 1 Sample ADLS Coverage for Vineyard Wind 1

ote technical note tech

Performance Assessment of the Terma Obstruction Light Control System as an Aircraft Detection Lighting System

June 2016

DOT/FAA/TC-TN16/41

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

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15. Supplementary Notes

Mike DiPilato, of CSRA International Inc., provided technical support during this performance assessment.

16. Abstract

Federal Aviation Administration (FAA) Airport Technology Research and Development Branch (ATR) personnel conducted a performance assessment of the Terma Obstruction Light Control (OLC) System. The purpose of this assessment was to determine if the Terma OLC system meets the aircraft detection lighting system requirements specified in FAA Advisory Circular (AC) 70/7460-1L, "Obstruction Marking and Lighting," Chapter 14 Aircraft Detection Lighting Systems.

FAA ATR personnel assessed the Terma OLC at the Tehachapi Wind Resource Area, located near Mojave, California. This performance assessment, consisting of demonstrations, flight testing, and data analysis was conducted on April 15, 2015. In the performance assessment, a series of flight patterns were flown against the Terma OLC system to demonstrate whether it could meet the FAA performance requirements specified in AC 70/7460-1L. The Terma OLC system performed according to the manufacturer's specifications and met the performance requirements identified in AC 70/7460-1L.

17. Key Words	18. Distribution Statement
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TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	vii
INTRODUCTION	1
Purpose	1
Background	1
Objectives	2
Related Documentation	2
AIRCRAFT DETECTION LIGHTING SYSTEM STANDARDS	3
TERMA OLC SYSTEM CHARACTERISTICS AND SPECIFICATIONS	5
Terma OLC System Operational Description	6
Terma OLC System Radar Description	6
Terma OLC System Perimeters	7
Terma OLC System Fail-Safe Design	7
TERMA OLC SYSTEM INSTALLATION DESCRIPTION AT THE TWRA	8
THE FAA ASSESSMENTS OF THE TERMA OLC SYSTEM AT THE TWRA	12
The FAA Flight Assessment	12
The FAA Component Failure Assessment	14
RESULTS	14
Basic Function Assessment	14
Detection Performance Assessment	16
Component Failure Assessment	28
CONCLUSIONS	28
REFERENCES	29
APPENDICES	

A—Advisory Circular 70/7460-1L, Obstruction Lighting and Marking, Chapter 14 - Aircraft Detection Lighting Systems

B—Terma Obstruction Light Control System Information

LIST OF FIGURES

Figure		Page
1	Required ADLS Detection Coverage	4
2	Terma OLC System Concept	5
3	Terma OLC System Radar Configuration	7
4	Wind Turbines at the TWRA	9
5	Google Earth Map Showing Ground Clutter Around TWRA Assessment Site	9
6	Terma SCANTER 5202 PSR Installed at TWRA	10
7	The OLC System Indicator Lamp Used in Assessment	10
8	Relative Position of Warning Zone to Terma OLC System Radar	11
9	Piper Tri-Pacer Used for Assessment	13
10	The GPS Flight Track Data From the Aircraft	13
11	Flight Assessment as Observed on Terma OLC System Monitor	15
12	Terma OLC System Cumulative Radar Tracks Overlaid on the FAA Aircraft's GPS Track	16
13	Flight Adjacent to North Edge of Warning Zone	18
14	Flight Directly Through the Warning Zone to the Northeast	19
15	Circling Flight Over the Warning Zone	20
16	Continuation of Circling Flight Over the Warning Zone, Then Exit to the East	21
17	Flight Over Radar Site, Then Directly to the Warning Zone	22
18	Flight to the Warning Zone With Aircraft Initially Hidden Behind a Mountain	23
19	Second Flight to Warning Zone With Aircraft Initially Hidden Behind a Mountain	24
20	Second Circling Flight Over the Warning Zone	25
21	Continuation of Second Circling Flight Over the Warning Zone	26
22	Descending Flight Into the Warning Zone	27

LIST OF TABLES

Table		Page
1	The GPS Coordinates of Terma OLC PSR and Warning Zone at TWRA	11

LIST OF ACRONYMS

AC	Advisory Circular
ADLS	Aircraft detection lighting system
AGL	Above ground level
ATR	Airport Technology Research and Development Branch
BITE	Built-in test equipment
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
GPS	Global positioning system
IP	Internet protocol
NM	Nautical mile
OLC	Obstruction light control
PSR	Primary surveillance radar
SCADA	Supervisory control and data acquisition
SM	Statute mile
TWRA	Tehachapi Wind Resource Area

EXECUTIVE SUMMARY

Federal Aviation Administration (FAA) Airport Technology Research and Development Branch (ATR) personnel conducted a performance assessment of the Terma Obstruction Light Control (OLC) system. The purpose of this assessment was to determine if the Terma OLC system meets the aircraft detection lighting system (ADLS) requirements specified in FAA Advisory Circular (AC) 70/7460-1L, "Obstruction Marking and Lighting," Chapter 14 – Aircraft Lighting Detection Systems.

Aircraft detection lighting systems continuously monitor the airspace around an obstruction or group of obstructions for aircraft; and when the detection system detects an aircraft in its airspace, the system sends an electronic signal to the lighting control unit, which turns on the lights. Once the aircraft clears the obstruction area and there is no longer a risk of collision, the detection system turns off the lights and the system returns to standby mode.

The United States has experienced a steady increase in the number of applications for construction of telecommunication towers and wind turbines. Any temporary or permanent structure, including telecommunication towers and wind turbines, that exceeds an overall height of 200 feet (61 meters) above ground level or exceeds any obstruction standard contained in Title 14 Code of Federal Regulations Part 77, "Safe, Efficient Use, and Preservation of the Navigable Airspace," should be marked and/or lighted with FAA-approved paint markings or lighting fixtures to ensure that they are visible to pilots at night. Due to the number of existing telecommunication towers and wind turbines, combined with expected future construction, the number of obstructions that have these required lighting fixtures has greatly increased. As a result, it has created a light pollution nuisance to residents living near these obstructions. Using an ADLS could have a positive impact on this problem, while still providing a sufficient level of safety for pilots operating at night in the vicinity of these obstructions.

FAA ATR personnel assessed the Terma OLC system at the Tehachapi Wind Resource Area, located near Mojave, California. This performance assessment, consisting of demonstrations, flight testing, and data analysis was conducted on April 15, 2015. In the performance assessment, a series of flight patterns were flown against the Terma OLC system to demonstrate whether it could meet the FAA performance requirements specified in AC 70/7460-1L. The Terma OLC system performed according to the manufacturer's specifications and met the performance requirements identified in AC 70/7460-1L.

INTRODUCTION

PURPOSE.

Federal Aviation Administration (FAA) Airport Technology Research and Development Branch (ATR) personnel conducted a performance assessment of an aircraft detection lighting system (ADLS) developed by Terma, referred to herein as Terma obstruction light control (OLC) system. The purpose of this assessment was to determine if the Terma OLC system meets the ADLS requirements specified in Chapter 14 of FAA Advisory Circular (AC) 70/7460-1L, "Obstruction Marking and Lighting." [1]

BACKGROUND.

In recent years, several companies have developed detection systems that monitor the airspace around an obstruction or group of obstructions to automatically turn the obstruction lighting on or off as needed. Such systems continuously monitor the airspace around their location; and when the detection system detects an aircraft in its airspace, the system sends an electronic signal to the lighting control unit, which turns on the lights. Once the aircraft clears the obstruction area and there is no longer a risk of collision, the ADLS turns the lights off and the system returns to standby mode. These detection systems are typically (1) mounted directly on the obstruction, (2) positioned on a dedicated tower close to the obstruction, or (3) mounted on a stand-alone structure located in the vicinity of the obstruction at an optimized vantage point to ensure that the sensor can cover the entire volume of airspace around the obstruction. In addition to controlling the obstruction lighting, some vendors have suggested using supplemental warning tools, such as an audible warning message or supplemental lighting that catches the pilot's attention, thereby providing an additional warning to the pilot that they are operating in close proximity to an obstruction.

The United States has experienced a steady increase in the number of applications for construction of telecommunication towers and wind turbines, partially because of government mandates to improve the nation's emergency communication network and to increase the amount of renewable energy generation. These telecommunication towers and wind turbines have begun to heavily occupy almost every corner of the country. Projections show that the accelerated rate of construction will continue well into the next decade. Any temporary or permanent structure, including these telecommunication towers and wind turbines, that exceeds an overall height of 200 ft (61 m) above ground level (AGL) or exceeds any obstruction standard contained in Title 14 Code of Federal Regulations (CFR) Part 77, "Safe, Efficient Use, and Preservation of the Navigable Airspace," [2] should be marked and/or lighted with FAA-approved paint markings or lighting fixtures to ensure that they are visible to pilots. Due to the number of existing telecommunication towers and wind turbines, combined with the expected construction of new structures, the number of obstructions that have FAA-required light fixtures has greatly increased. As a result, it has created a light pollution nuisance to residents living near these obstructions. Using an ADLS could have a positive impact on this problem, while still providing a sufficient level of safety for pilots operating at night in the vicinity of these obstructions.

From 2011 to 2015, ATR personnel have worked closely with several ADLS vendors to better understand the technologies, their capabilities, and the level of performance that would be necessary to safely integrate this concept into the National Airspace System. One major milestone achieved during the ADLS standards development was to enable the sensors to detect aircraft beyond the required 3 nautical miles (NM) from the obstruction, which would ensure that the lighting was on and the pilot was able to visually acquire the lights 3 NM away from the obstruction. The 3-NM visibility requirement is important because it ties directly to the inflight visibility requirements for a flight conducted under Visual Flight Rules. In 2013, ATR personnel first developed standards for ADLS that were based on technical reviews, discussions, and flight tests of ADLS in the United States and Canada. These ATR-developed standards have since been used by the FAA as the baseline to which new ADLSs, like the Terma OLC system, were tested against. The ATR-developed standards have since been integrated into AC 70/7460-1L as Chapter 14, titled "Aircraft Detection Lighting Systems," which was published in December 2015 [1].

OBJECTIVES.

The overall objective of this assessment was to conduct a performance assessment of the Terma OLC system according to the requirements and standards for ADLSs in Chapter 14 of AC 70/7460-1L. This technical note describes the performance assessment of the Terma OLC system conducted at the Tehachapi Wind Resource Area (TWRA), located near Mojave, California.

RELATED DOCUMENTATION.

The guidelines that have been in place for obstruction marking and lighting have remained mostly unchanged for the last 10 to 20 years and have proved to be sufficient for warning pilots of the presence of an obstruction. The recent update of AC 70/7460-1L does, however, include new material that is designed to improve safety, and at the same time, attempts to reduce the impact of obstruction lighting on nearby communities and wildlife. The introduction of ADLS suggests that the traditional obstruction lights remain the same in intensity, flash rate, and performance, but that the lights can be controlled by an automatic radar-activated monitoring system.

The following FAA documents provide a significant amount of information and guidance pertaining to the lighting of obstructions:

- AC 150/5345-43, "Specification for Obstruction Lighting Equipment."

  This document specifies the lighting equipment and fixtures that should be used for lighting obstructions. The color of the light, flash rate, intensity, and various electrical and performance requirements are all addressed in this document.

  Obstruction lights are given "L" type designations, which are described in this AC. The performance characteristics for the particular lights mentioned in this assessment are as follows:

- L-864—Red flashing obstruction light, 2000 peak Candela, a minimum 750 Candela, with a 3-degree vertical beam spread, flashing at a rate between 20 and 40 flashes per minute. This light is required on wind turbines.

- FAA Technical Note DOT/FAA/TC-TN12/9, "Evaluation of New Obstruction Lighting Techniques to Reduce Avian Fatalities," James W. Patterson, Jr., May 2012.

  This document describes research conducted by FAA ATR personnel in which researchers evaluated a proposal to omit or flash the normally steady-burning red obstruction lights as a way to mitigate their impact on birds, due to their unique color and flash pattern.

AIRCRAFT DETECTION LIGHTING SYSTEM STANDARDS

Based on the result of research efforts conducted by FAA ATR personnel, Chapter 14 of AC 70/7460-1L is the first fully comprehensive set of standards for ADLSs that has been published worldwide. Earlier research efforts in Canada and the United States led to the development of a few sets of very ambiguous descriptions of the technology, but it did not provide any specific guidance on the required range, coverage area, detection target size, or operational requirements for the technology. The following are the key ADLS operational requirements introduced in Chapter 14 of AC 70/7460-1L [1], which is included in its entirety in appendix A.

1. The system should be designed with sufficient sensors to provide complete detection coverage for aircraft that enter a three-dimensional volume of airspace, or coverage area, around the obstruction(s) (see figure 1), as follows:

   a. Horizontal detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the perimeter of the volume, which is a minimum of 3 NM (5.5 km) away from the obstruction or the perimeter of a group of obstructions.

   b. Vertical detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the volume, which extends from the ground up to 1000 ft (304 m) above the highest part of the obstruction or group of obstructions, for all areas within the 3-NM (5.5-km) perimeter defined above.

2. The ADLS should activate the obstruction lighting system in sufficient time to allow the lights to illuminate and synchronize to flash simultaneously prior to an aircraft penetrating the volume defined above. The lights should remain on for a specific time period, as follows:

   a. For ADLSs capable of continuously monitoring aircraft while they are within the 3-NM/1000-ft (5.5-km/304-m) volume, the obstruction lights should stay on until the aircraft exits the volume. In the event detection of the aircraft is lost while being continuously monitored within the 3-NM/1000-ft (5.5-km/304-m) volume, the ADLS should initiate a 30-minute timer and keep the obstruction lights on until the timer expires. This should provide the untracked aircraft sufficient time to exit the area and give the ADLS time to reset.

b. For ADLSs without the capability of monitoring aircraft targets in the 3-nm/1000 ft (5.5-km/304-m) volume, the obstruction lights should stay on for a preset amount of time, calculated as follows:

i. For single obstructions: 7 minutes.

ii. For groups of obstructions: (the widest dimension in nautical miles + 6) x 90 seconds equals the number of seconds the light(s) should remain on.

3. In the event of an ADLS component or system failure, the ADLS should automatically turn on all the obstruction lighting and operate in accordance with AC 70/7460-1L as if it was not controlled by an ADLS. The obstruction lighting must remain in this state until the ADLS and its components are restored.

4. In the event that an ADLS component failure occurs and an individual obstruction light cannot be controlled by the ADLS, but the rest of the ADLS is functional, that particular obstruction light should automatically turn on and operate in accordance with AC 70/7460-1L as if it was not controlled by an ADLS, and the remaining obstruction lights can continue to be controlled by the ADLS. The obstruction lighting will remain in this state until the ADLS and its components are restored.

5. The ADLS's communication and operational statuses shall be checked at least once every 24 hours to ensure both are operational.

6. Each ADLS installation should maintain a log of activity data for a period of no less than the previous 15 days. This data should include, but not be limited to, the date, time, duration of all system activations/deactivations, track of aircraft activity, maintenance issues, system errors, communication and operational issues, lighting outages/issues, etc.

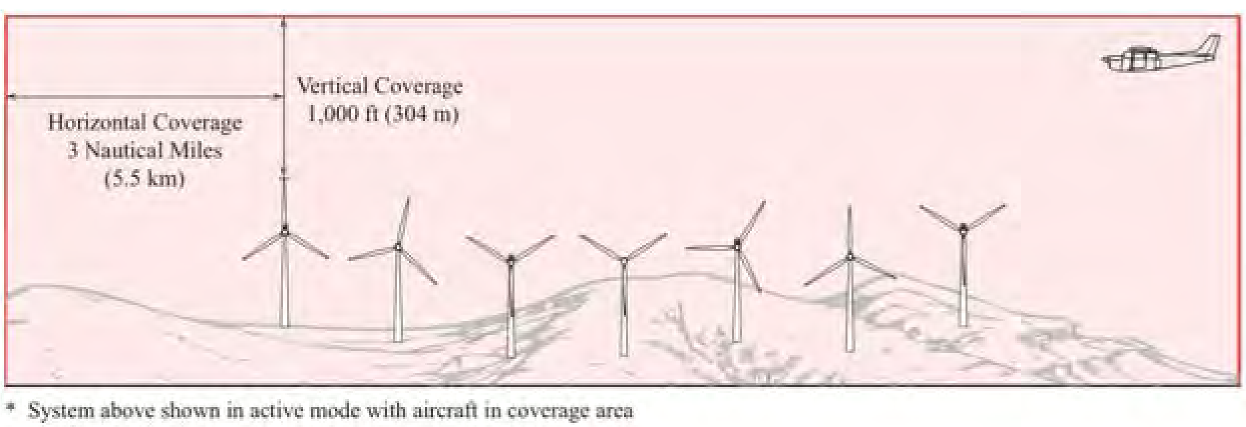


Figure 1. Required ADLS Detection Coverage [1]

In 2014, FAA ATR personnel completed an ADLS assessment, with the objective of validating the ADLS standards in AC 70/7460-1L. This assessment is described in FAA Technical Note DOT/FAA/TC-TN15/54, "Performance Assessment of the Laufer Wind Aircraft Detection System as an Aircraft Detection Lighting System." This technical note concluded the following:

> …the performance requirements provided in AC 70/7460-1L for ADLSs remain valid and provide for a technology that offers a satisfactory level of safety for the flying public, while at the same time, reduces the impact of obstruction lights on nearby communities and migratory bird populations. [3]

Chapter 14 of AC 70/7460-1L also contains language that allows for ADLSs to have an optional voice/audio feature that transmits a low-power, audible warning message over an aviation frequency licensed by the Federal Communications Commission (FCC) in the MULTICOM/UNICOM frequency band to provide pilots additional information on the obstruction they are approaching. The Terma OLC system does not offer this option, so these requirements do not apply to this assessment.

TERMA OLC SYSTEM CHARACTERISTICS AND SPECIFICATIONS

The Terma OLC system uses a SCANTER 5202 primary surveillance radar (PSR) to detect aircraft within range of a wind farm or obstruction area and follows the general description provided in AC 70/7460-1L. For instance, when there are no aircraft in the vicinity of the wind turbine farm or obstruction, the warning lights remain off. When aircraft are detected in the vicinity, the lights are activated (turned on). When all aircraft have safely left the vicinity, the lights are deactivated (turned off). The Terma OLC system allows wind turbine farm warning lights to remain safely off at night when aircraft are not in the area.

As shown in figure 2, Terma's OLC system concept consists of one or more SCANTER 5202 PSR system, including an antenna and a global positioning system (GPS) synchronized light control connected via a supervisory control and data acquisition (SCADA) internet protocol (IP) network [4].

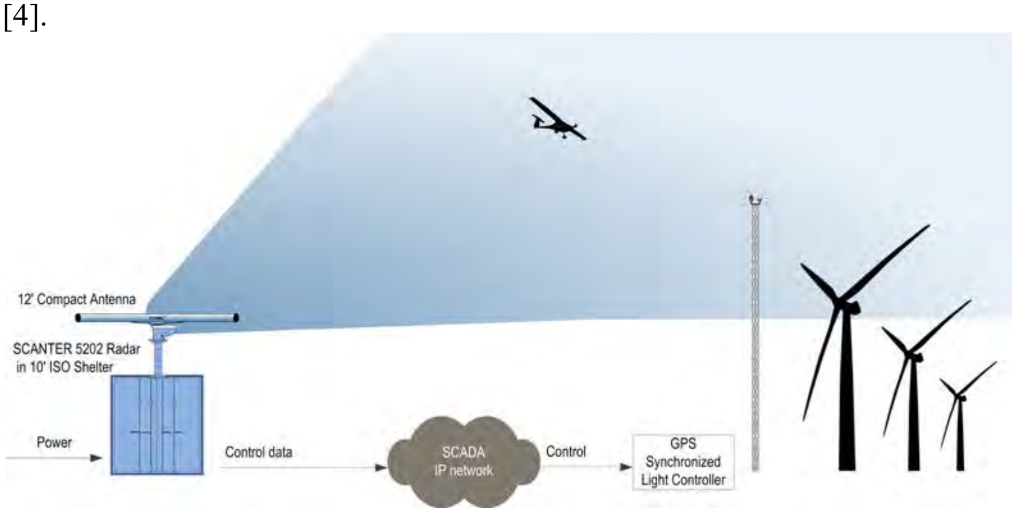


Figure 2. Terma OLC System Concept [4]

TERMA OLC SYSTEM OPERATIONAL DESCRIPTION.

The Terma OLC system operates as follows:

1. Prior to reaching the light activation perimeter of the warning zone (3-NM/1000-ft (5.5-km/304-m) volume), aircraft are detected and tracked by the SCANTER 5202 PSR(s).

2. The PSR sends a signal through the SCADA IP network to the GPS Synchronized OLC system when the aircraft reaches the light activation perimeter of the warning zone.

3. The OLC system turns on the obstruction light(s).

4. The PSR tracks the aircraft until it exits the warning zone light activation perimeter (3-NM/1000-ft (5.5-km/304-m) volume).

5. The OLC system determines when to turn the lights off after verifying that no aircraft are within the warning zone.

TERMA OLC SYSTEM RADAR DESCRIPTION.

Terma's SCANTER 5202 PSR, illustrated in figure 3, is a solid-state X-band radar. SCANTER 5000 series PSRs are in use throughout the world in a variety of applications, including airport surface movement surveillance [4]. These PSRs utilize a combination of technologies, such as solid-state power amplifiers; multiple transmission frequencies (i.e., frequency diversity); pulse-compression; coherent integration; and signal processing, designed to detect and track very small cooperative and noncooperative targets in high-clutter environments, under a variety of weather conditions (e.g., heavy rain and fog), and within and around a wind farm despite the turbulence and clutter created by the wind turbines themselves. Using high spatial resolution, high dynamic range, and side lob suppression the system can filter out noise caused by the spinning turbine blades. Airborne targets are primarily tracked using Doppler-processed signals [4]. These are supplemented by normal radar signals to follow targets with minimal radial velocities, such as helicopters. Terma states that the system has a range of 18 km (approximately 11.18 statute miles (SM)), with a total coverage of up to 1000 km^2 [5]. Therefore, Terma has proposed their OLC system for use at larger wind farms and wind farms with varied layouts. Appendix B contains additional information provided by Terma regarding this system.

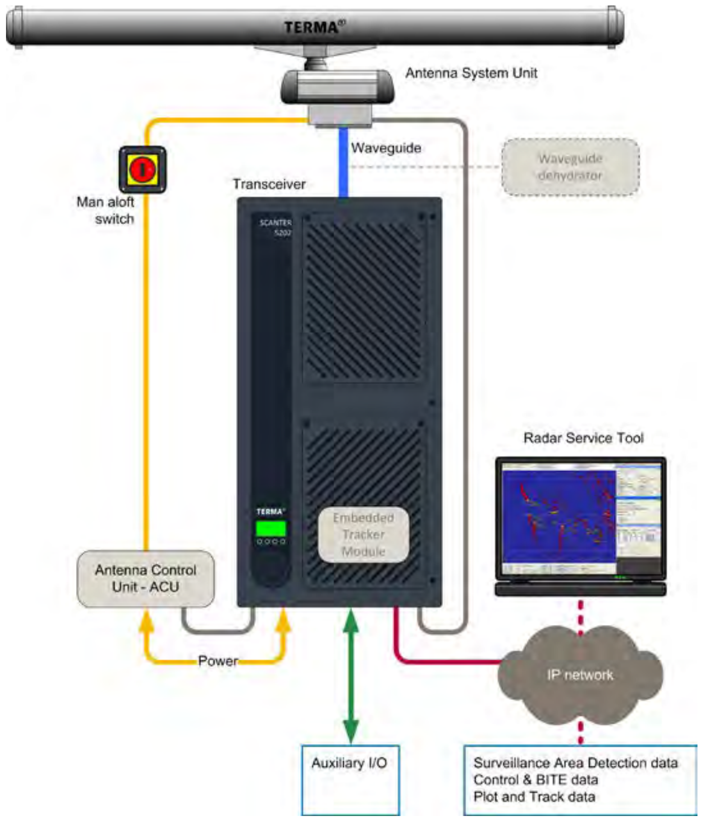


Figure 3. Terma OLC System Radar Configuration [4]

<u>TERMA OLC SYSTEM PERIMETERS</u>.

Terma's OLC system includes three zones to ensure adequate identification of obstructions and compliance with AC 70/7460-1L:

- Outer Detection Zone: Aircraft are detected and tracked by radar in this area, but the obstruction lights are not turned on until one of the aircraft enters the warning zone.

- Inner Warning Zone: Lights in the Obstruction Area are activated when aircraft enter this zone, and the lights remain lit while any aircraft is within this area. This zone will be located a minimum of 3 NM (5.5 km) away from the obstruction or the perimeter of a group of obstructions.

- Obstruction Area: This is a broadly defined area that includes lighted obstruction(s), such as a wind farm.

<u>TERMA OLC SYSTEM FAIL-SAFE DESIGN</u>.

The Terma OLC system includes multiple self-testing functions to provide fail-safe protection. When a failure occurs, the obstruction lights are turned on until the Terma OLC system and its components functions are restored [6]. Built-in test equipment (BITE) in the Terma OLC system provides continuous system status monitoring. The BITE monitors mains-on time, solid-state power amplifier status, forward power, noise figure, internal voltages and temperatures, turning unit status, and other parameters. Diagnostic tests are performed when the system starts up, including the following [6]:

- Module presence test
- Data link test
- Memory test of all circuits

The BITE also reports the following when monitoring the system during operation [6]:

- BITE errors/warnings
- Signal activity and processes
- Connectivity to OLC system
- Internal supply voltages
- Noise figure, internal voltages, and temperatures
- Forward power
- Reverse power
- Status from motor, gear, and optional inputs providing antenna status
- Temperatures
- Internal power supplies

The status of each BITE parameter is assessed automatically to ensure consistent operation. If any parameter is detected outside of normal operating specifications, error messages are automatically sent through the IP network interface and all obstruction lights are activated. Error records are stored automatically by the system in a log for future inspection [6].

TERMA OLC SYSTEM INSTALLATION DESCRIPTION AT THE TWRA

Terma installed its OLC system at the TWRA, located near Mojave, California. The TWRA is a large wind turbine farm on and around the Tehachapi Mountains containing a mix of turbines manufactured by different vendors. Examples of the wind turbines installed in the TWRA are shown in figure 4. This is a challenging radar coverage environment due to the mountainous terrain and ground clutter caused by the quantity of wind turbines. For example, figure 5 shows the locations of individual wind turbines in the vicinity of the assessment site, which are represented by colored points. The position of the radar is indicated by a red rectangle. It should be noted that for this assessment, the dimensions of the warning zone did not meet the requirement of extending at least 3 NM from the obstruction area as called for in AC 70/7460-1L. This was due to the assessment focusing on the system's ability to activate an indicator lamp when an aircraft was detected in a given area, rather than monitoring the activation of lighting on a specific obstruction or group of obstructions.

Figure 4. Wind Turbines at the TWRA

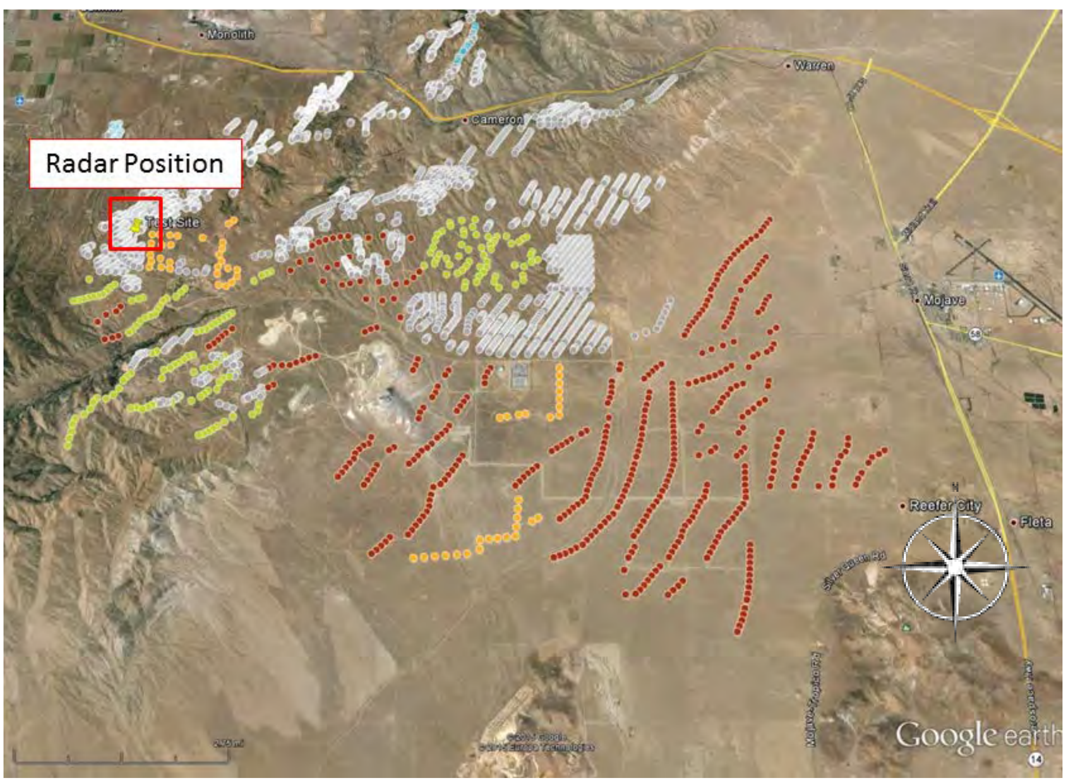


Figure 5. Google Earth Map Showing Ground Clutter Around TWRA Assessment Site
(The colored points indicate wind turbine locations.)

The Terma OLC system installation at TWRA utilized one SCANTER 5202 PSR. This radar was mounted on the top of a specially designed shipping container. The radar mounting configuration is shown in figure 6.

Figure 6. Terma SCANTER 5202 PSR Installed at TWRA

Because the Terma OLC system had not yet been connected to obstruction lighting in the wind farm, the OLC system was instead connected to the indicator lamp shown in figure 7. This indicator lamp provided a visual indication to ATR personnel observing the system that the OLC system could activate the light at the appropriate times when the aircraft entered and exited the warning zone airspace.

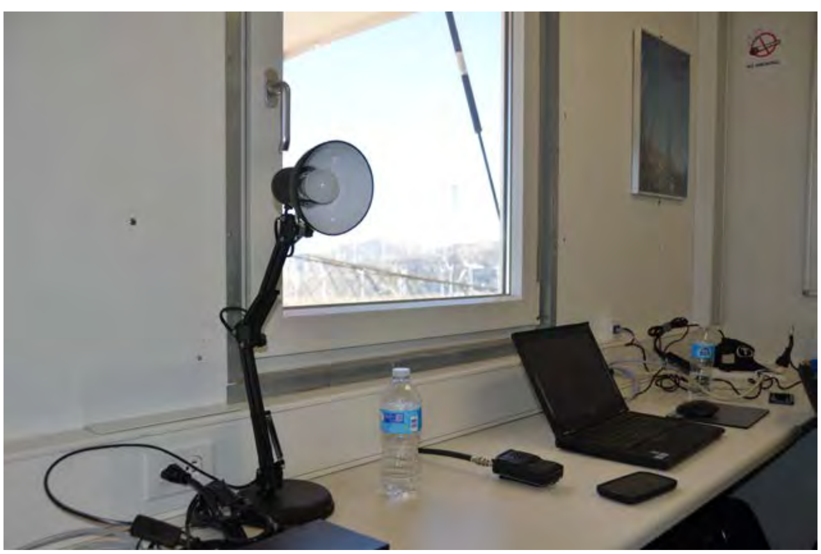


Figure 7. The OLC System Indicator Lamp Used in Assessment

The yellow polygon shown in figure 8 depicts the perimeter of the warning zone used for the assessment. This warning zone was 2 SM long and 1 SM wide, and the center of the zone was located approximately 4.5 NM southeast of the radar position. Although the size of this warning zone did not meet the 3-NM (5.5-km) perimeter requirement of AC 70/7460-1L, Terma's engineers indicated that the perimeter could be expanded as needed to fully encompass the required airspace volume. The reduced size of the warning zone allowed ATR personnel to conduct performance assessments with greater efficiency due to there being less distance to cover when flying through the zone. Table 1 provides the coordinates of Terma OLC system radar position and four corners of the warning zone used for the assessment.

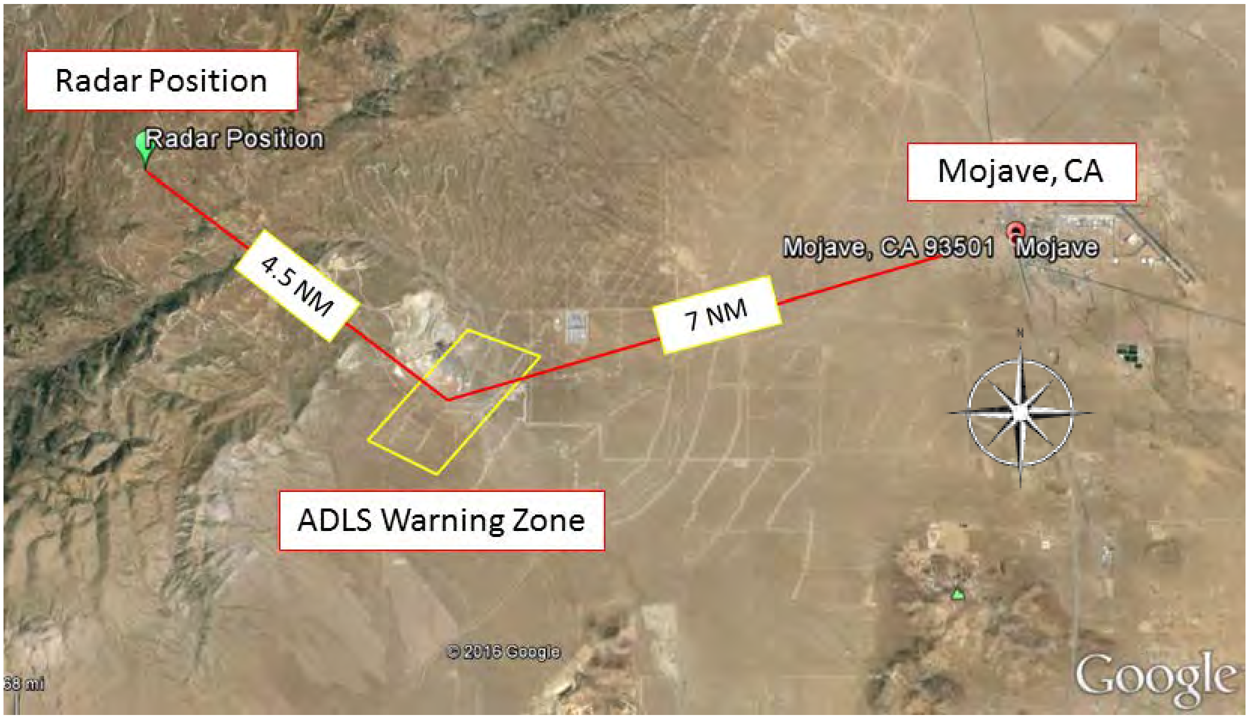


Figure 8. Relative Position of Warning Zone to Terma OLC System Radar

Table 1. The GPS Coordinates of Terma OLC PSR and Warning Zone at TWRA

Location	Latitude	Longitude
Terma OLC PSR SCANTER Radar	35°03'56.03"N	118° 23'02.96"W
Warning Zone – North Corner	35°02'05.39"N	118° 18'25.55"W
Warning Zone – East Corner	35°01'45.22"N	118° 17'23.33"W
Warning Zone – South Corner	35°00'21.07"N	118° 18'53.02"W
Warning Zone – West Corner	35°00'45.85"N	118° 19'53.01"W

THE FAA ASSESSMENTS OF THE TERMA OLC SYSTEM AT THE TWRA

THE FAA FLIGHT ASSESSMENT.

To properly assess the performance of the Terma OLC system, ATR personnel developed a series of flight patterns to assess the system's response to aircraft operating around the warning zone at various altitudes, flight paths, speed, etc. These flight patterns were based on similar ones conducted during a previous FAA ADLS assessment [3]. Each pattern was designed to assess a specific parameter of the ADLS to determine if the system meets the requirements in AC 70/7460-1L. Two flights were conducted, during which these six specific flight patterns were flown, in some cases multiple times. The six flight patterns are described below:

1. The aircraft flew through the center of the warning zone and exited the other side.

2. The aircraft flew inside the warning zone adjacent to its outer edge.

3. The aircraft flew over the radar site, and then flew directly to the warning zone after radar contact was lost.

4. The aircraft completed several tight circles inside the warning zone, and then exited the zone at a different heading from the entry heading.

5. The aircraft flew toward and over the warning zone at least 1500 ft AGL, and then steeply descended into the warning zone.

6. The aircraft flew toward the warning zone from a location where terrain masked the aircraft from initially being detected by the ADLS. The intent of this pattern was to identify how quickly the Terma ADLS could detect the aircraft without the benefit of early detection.

ATR personnel used the Piper PA-22 Tri-Pacer, shown in figure 9, to conduct the flight patterns. A notable characteristic of this aircraft is the outer skin of its wings and sections of fuselage is made of fabric rather than metal. The aircraft was owned and flown by a pilot with a commercial pilot certificate. All flights were operated out of the Mojave Air and Space Port, which was located approximately 20 SM southeast of the Terma OLC system installation. Figure 10 shows a Google Earth map image overlaid with the flight tracks (shown in blue) recorded by a GPS unit on board the aircraft.

Figure 9. Piper Tri-Pacer Used for Assessment

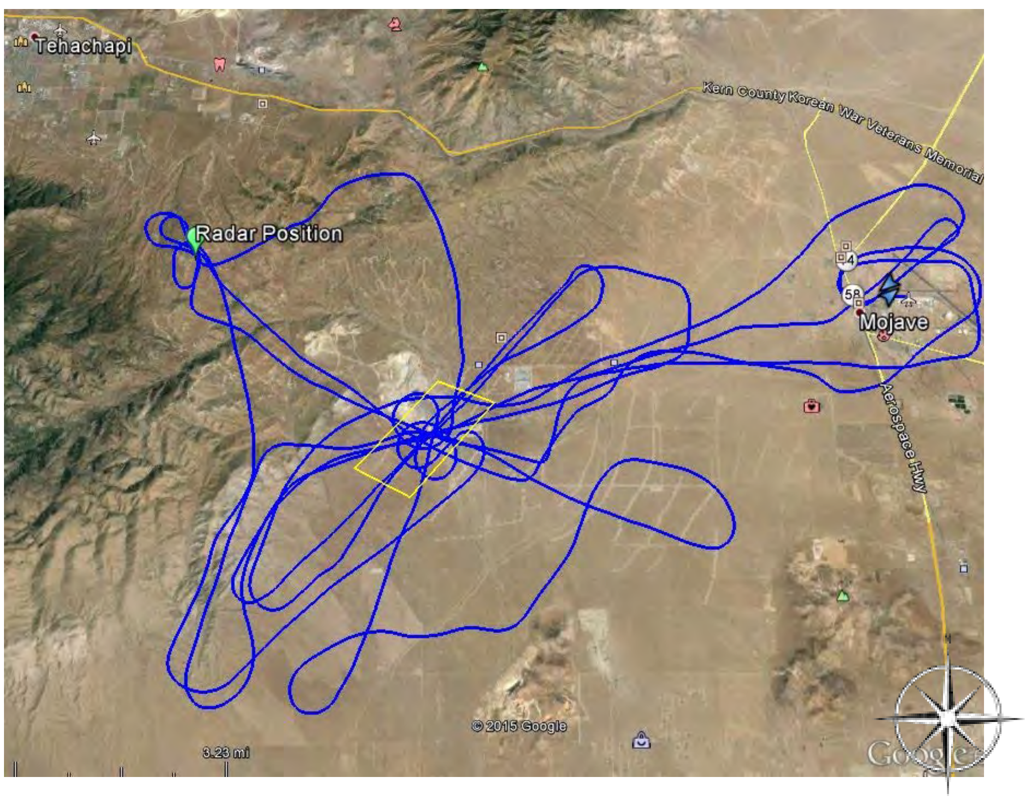


Figure 10. The GPS Flight Track Data From the Aircraft

THE FAA COMPONENT FAILURE ASSESSMENT.

ATR personnel were unable to directly assess the Terma OLC system's fail-safe mechanisms, which activate the obstruction lighting in the event of a component failure. However, Terma engineers did provide documentation of the fail-safe capabilities of the OLC system to ATR personnel. A comprehensive assessment of these features is planned to be conducted at a later date by ATR personnel once Terma's OLC system is connected to an obstruction lighting system and becomes fully operational.

RESULTS

The performance assessment of the Terma OLC system was based on the specifications and criteria provided in AC 70/7460-1L. AC 70/7460-1L lists specifications for basic functions, detection performance, and system output. The following sections document the performance of the Terma OLC system along with the data collected during the performance assessment and discuss how it relates to the AC 70/7460-1L performance specifications.

BASIC FUNCTION ASSESSMENT.

Prior to the assessment flight, the Terma OLC system was turned on, and ATR personnel verified that the system was up and running. ATR personnel verified that, without any aircraft present in the area, the system continuously scanned the area and kept the indicator lamp off. Before beginning the scheduled flight patterns, ATR personnel confirmed that the system was standing by and was not tracking any other aircraft in the area. With the system ready and the indicator lamp off, ATR personnel proceeded to evaluate the Terma OLC system's detection performance.

ATR personnel at the radar site monitored the Terma OLC system monitor and communicated with the ATR personnel on board the aircraft via a two-way radio. Figure 11 shows a screenshot of the flight track as it appeared on this monitor during the assessment. When the aircraft entered the warning zone, ATR personnel confirmed the indicator lamp connected to the OLC system was activated and stayed lit while the aircraft was in the zone. Conversely, when the aircraft exited the warning zone, ATR personnel confirmed the indicator lamp had deactivated.

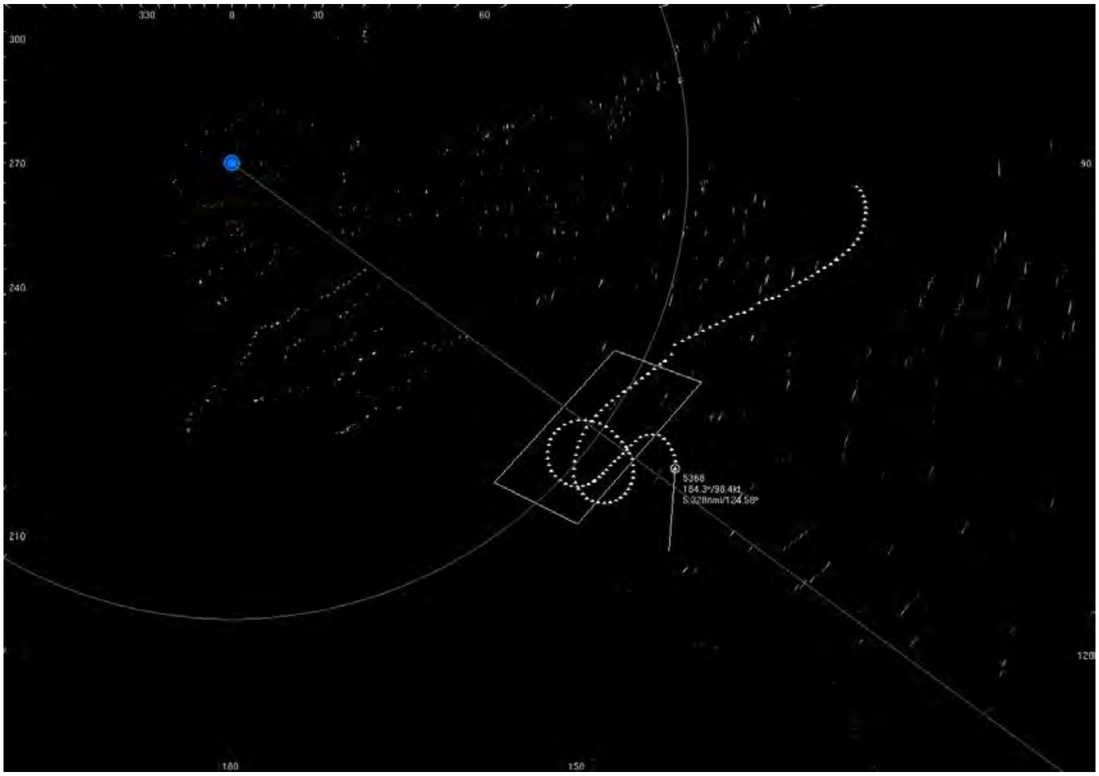


Figure 11. Flight Assessment as Observed on Terma OLC System Monitor

During the assessment flights, the Terma OLC system recorded radar tracks for all airborne targets operating within the vicinity of the system while the performance assessment was being conducted. These radar tracks were exported as Keyhole Markup Language files viewable in Google Earth. Figure 12 shows a record of the entire FAA assessment flight pattern. The dotted magenta lines represent the real-time tracks produced from the Terma SCANTER OLC PSR, and the solid blue lines represent the tracks recorded by the GPS on board the aircraft.

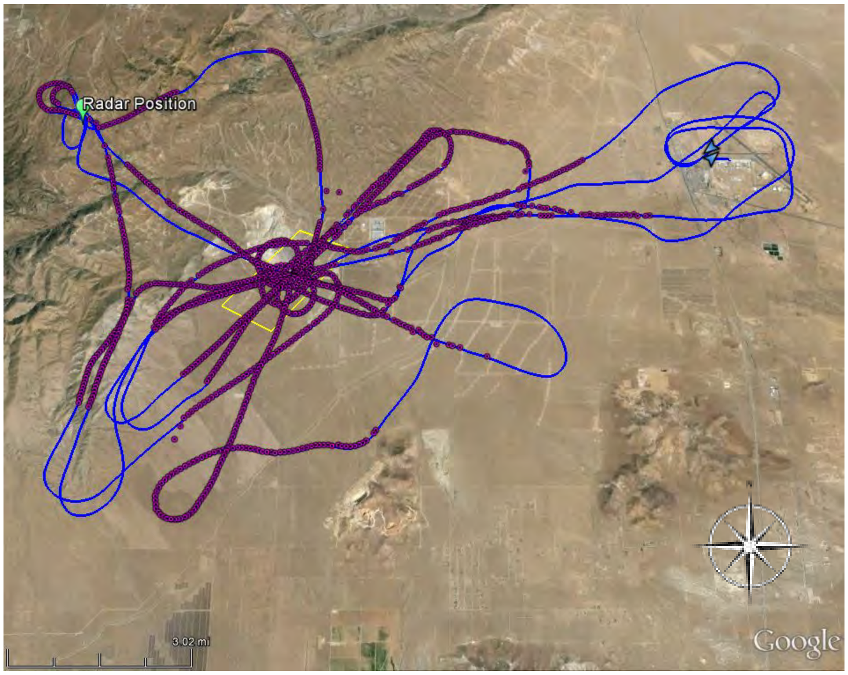


Figure 12. Terma OLC System Cumulative Radar Tracks Overlaid on the FAA Aircraft's GPS Track

DETECTION PERFORMANCE ASSESSMENT.

To demonstrate that the Terma OLC system was able to meet the detection performance requirements for an ADLS, ATR personnel developed and conducted a series of flight maneuvers designed to assess the system's detection capabilities. Descriptions of the maneuvers and the results of the Terma OLC system's detection capability are as follows:

- Flight Inside the Warning Zone Adjacent to its Outer Edge

  The Terma OLC system detected the aircraft 4.3 NM from the warning zone perimeter and activated the indicator lamp when the aircraft entered the warning zone. The indicator lamp deactivated as the aircraft exited the warning zone heading southwest. Figure 13 shows events 1-4 for this flight pattern.

- Flight Directly Through the Center of the Warning Zone and Exiting the Other Side

  The Terma OLC system detected the aircraft 1.2 NM outside the warning zone perimeter and activated the indicator lamp when the aircraft entered the zone, flying toward the northeast. Figure 14 shows events 5-8 for this flight pattern.

- Completion of Several Tight Circles Inside the Warning Zone, Then Exiting the Zone at a Different Heading From the Entry Heading

  The Terma OLC system maintained radar contact with the aircraft at a range of 2.75 NM from the warning zone and activated the indicator lamp as the aircraft entered the warning zone. The system tracked the aircraft even as it conducted a series of steep circling maneuvers within the warning zone. As the aircraft exited and re-entered the zone at random headings during these turns, the Terma OLC system recognized it as the same aircraft that had entered the perimeter and activated the indicator lamp as required. Figures 15 and 16 show events 9-15 for this flight pattern.

- Flight Over the Radar Site, Then Flying Directly Through the Warning Zone After Radar Contact is Lost

  The Terma OLC system lost contact with the aircraft as it flew directly over the radar site; however, this is typical of all radar systems, which are not designed to detect aircraft above the radar antenna. This gap is known as the cone of silence. Terma's OLC system was able to re-acquire the aircraft within 1.1 NM as it flew toward the warning zone perimeter, activating the indicator lamp when the aircraft entered the perimeter. The Terma OLC system then deactivated the indicator lamp as the aircraft left the zone heading southeast. Figure 17 shows events 16-19 for this flight pattern.

- Flights to the Warning Zone From a Location Where Terrain Masked the Aircraft From Initially Being Detected by the ADLS

  On two separate flights manuevers, the Terma OLC system successfully detected the aircraft as soon as it appeared from behind a mountain on the west of the warning zone. As soon as the Terma OLC system detected the aircraft (still outside the warning zone perimeter), the system continued to monitor the aircraft's track and activated the indicator lamp when the aircraft entered the warning zone perimeter. After the aircraft flew through the warning zone and exited the area, the Terma OLC system deactivated the indicator lamp, as required. Figures 18 and 19 show events 20-26 for these flight patterns.

- Circling Flight Over the Warning Zone (second flight)

  During a second flight, the Terma OLC system again detected and maintained contact with the aircraft as it circled inside the warning zone, activating and deactivating the indicator lamp as required when the aircraft exited and re-entered the zone. Figures 20 and 21 show events 27-32 for this flight pattern.

- Flight to and Over the Radar Site, Then Steeply Descending Into the Warning Zone

  Although contact with the aircraft was lost as it flew directly over the radar site and steeply descended behind mountains as it approached the warning zone, the Terma OLC system detected the aircraft with enough time to activate the indicator lamp as it entered the warning zone perimeter. After the aircraft completed the descent and exited the area, the Terma OLC system deactivated the indicator lamp as required. Figure 22 shows events 33-36 for this flight pattern.

Event 1:

- Aircraft approaches the warning zone from the northeast.
- Indicator lamp is off.

Event 2:

- Aircraft is detected and tracked by radar prior to reaching the warning zone.
- Indicator lamp is off.

Event 3:

- Aircraft penetrates the warning zone perimeter heading west.
- Indicator lamp is on.
- Aircraft is continuously monitored within the warning zone.

Event 4:

- Aircraft exits the warning zone to the west.
- Indicator lamp is off.

Figure 13. Flight Adjacent to North Edge of Warning Zone (events 1-4)

Event 5:

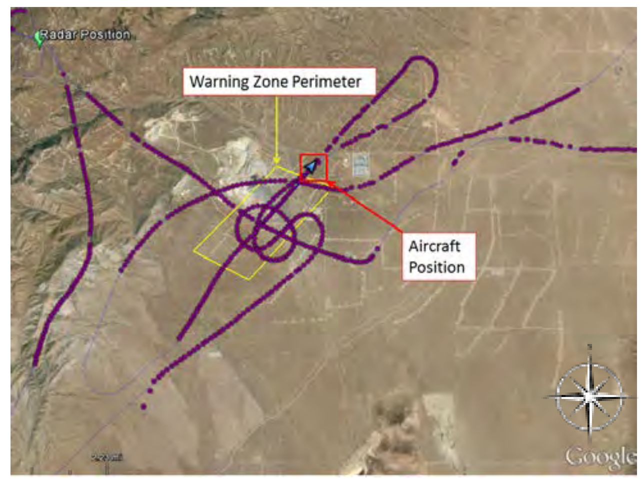
- Aircraft approaches the warning zone from the southwest.
- Indicator lamp is off.

Event 6:

- Aircraft is detected and tracked by radar prior to reaching the warning zone.
- Indicator lamp is off.

Event 7:

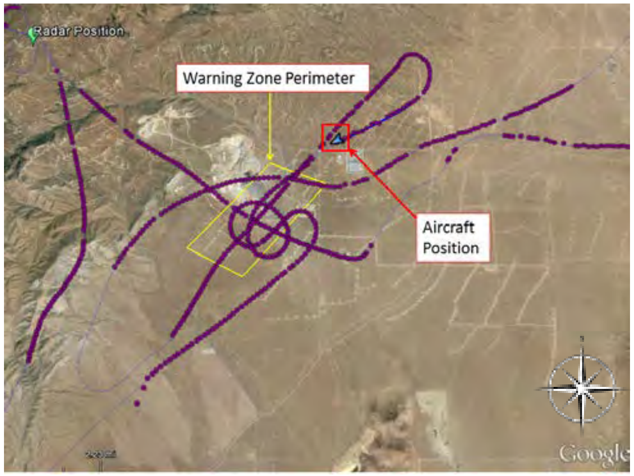
- Aircraft penetrates the warning zone perimeter heading northeast.
- Indicator lamp is on.
- Aircraft is continuously monitored within the warning zone.



Event 8:

- Aircraft exits the warning zone to the northeast.
- Indicator lamp is off.

Figure 14. Flight Directly Through the Warning Zone to the Northeast (events 5-8)



Event 9:

- Aircraft approaches the warning zone from the northeast.
- Indicator lamp is off.

Event 10:

- Aircraft is detected and is tracked by radar prior to reaching the warning zone.
- Indicator lamp is off.

Event 11:

- Aircraft penetrates the warning zone perimeter heading to the southwest.
- Indicator lamp is on.
- Aircraft is continuously monitored within the warning zone.

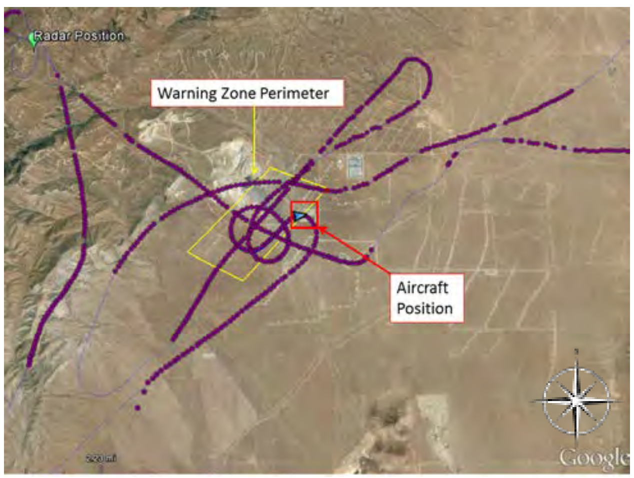
Event 12:

- Aircraft initiates a 540° left turn, exiting the warning zone to the southeast.
- Indicator lamp is off.

Figure 15. Circling Flight Over the Warning Zone (events 9-12)

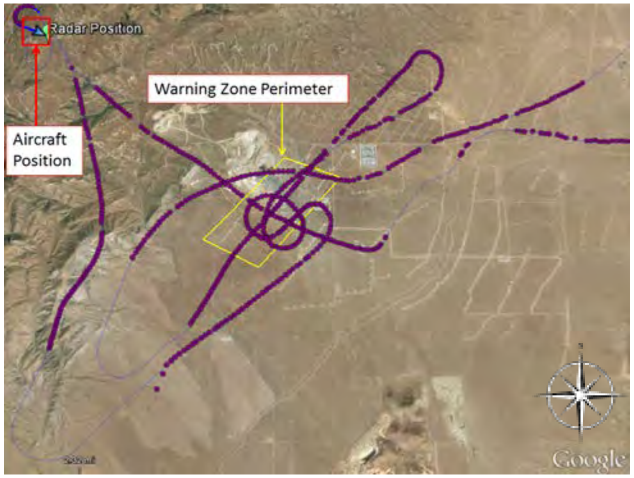
Event 13:
- Aircraft continues its left turn outside the warning zone.
- Indicator lamp is off.

Event 14:
- Aircraft penetrates the warning zone perimeter and continues its 540° left turn inside the warning zone.
- Indicator lamp is on.
- Aircraft is continuously monitored within the warning zone.



Event 15:
- Aircraft begins a right turn, exiting the warning zone to the east.
- Indicator lamp is off.

Figure 16. Continuation of Circling Flight Over the Warning Zone, Then Exit to the East (events 13-15)

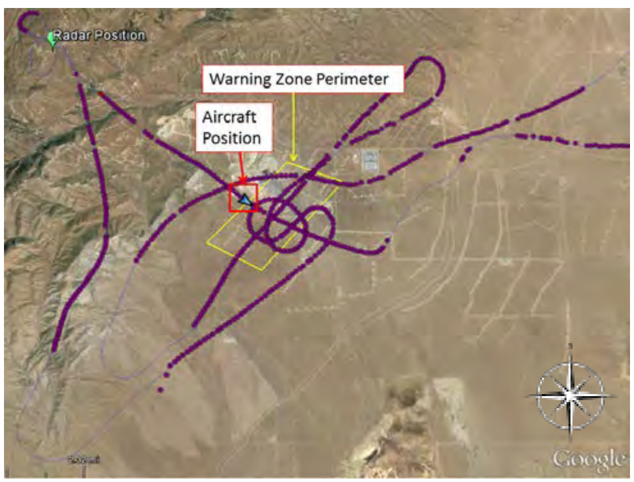


Event 16:

- Aircraft flies directly over the radar site, makes a 180° turn and begins to approach the warning zone from the northwest.
- Indicator lamp is off.

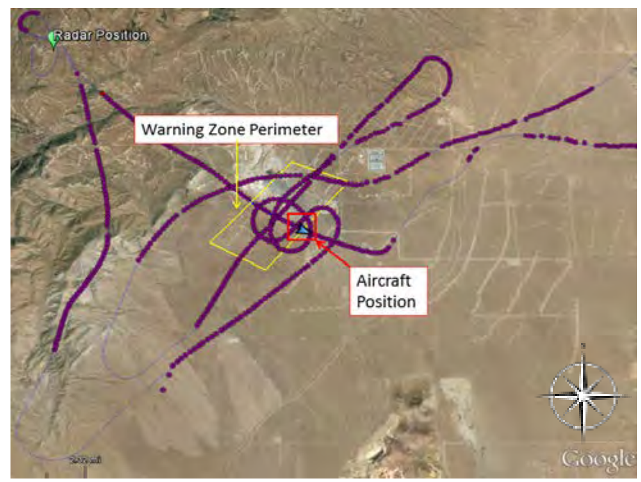
Event 17:

- Aircraft is reacquired and tracked by radar prior to reaching the warning zone.
- Indicator lamp is off.



Event 18:

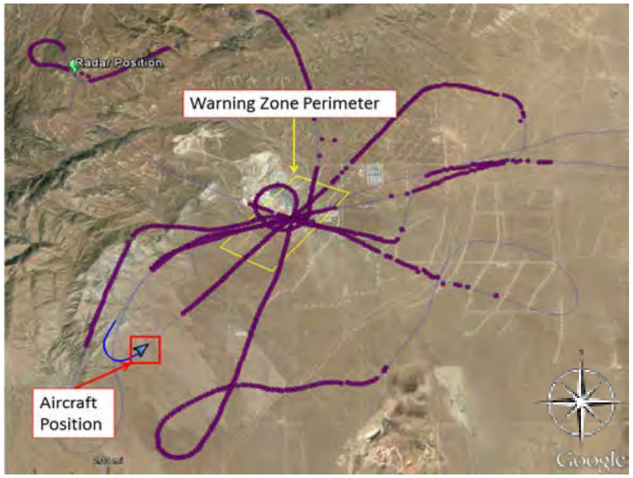
- Aircraft penetrates the warning zone perimeter heading southeast.
- Indicator lamp is on.
- Aircraft is continuously monitored within the warning zone.



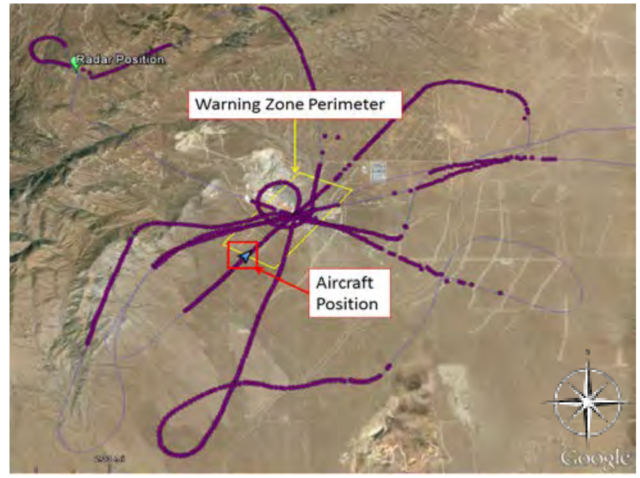
Event 19:

- Aircraft and exits the warning zone to the southeast.
- Indicator lamp is off.

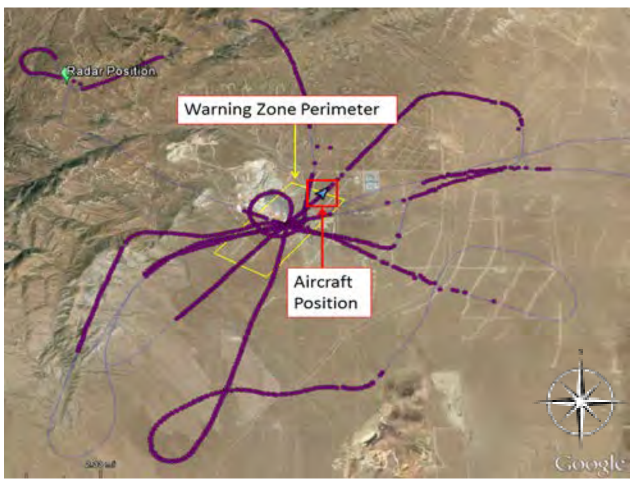
Figure 17. Flight Over Radar Site, Then Directly to the Warning Zone (events 16-19)



Event 20:
- Aircraft approaches the warning zone from the southwest then suddenly appears from behind the mountain.
- Indicator lamp is off.

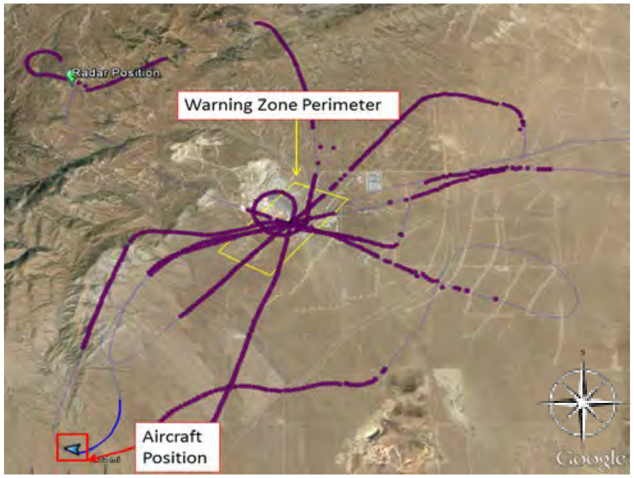


Event 21:
- Aircraft is detected and is tracked by radar shortly before entering the warning zone.
- Aircraft penetrates the warning zone perimeter heading northeast.
- Indicator lamp is on.



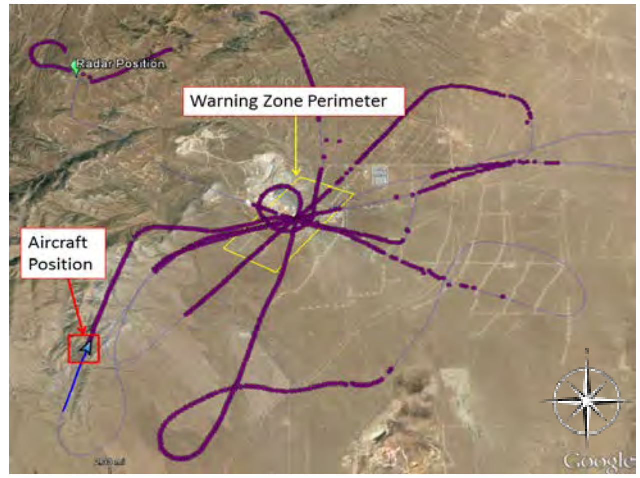
Event 22:
- Aircraft is continuously monitored within the warning zone.
- Aircraft exits the warning zone to the northeast.
- Indicator lamp is off.

Figure 18. Flight to the Warning Zone With Aircraft Initially Hidden Behind a Mountain (events 20-22)



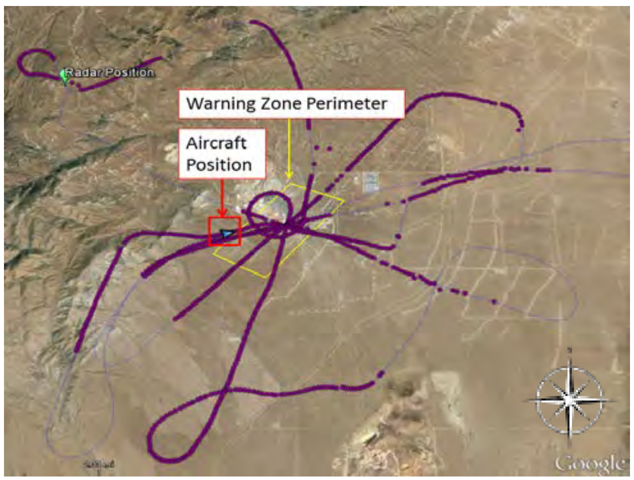
Event 23:

- Aircraft approaches the warning zone from the southwest then suddenly appears from behind the mountain.
- Indicator lamp is off.



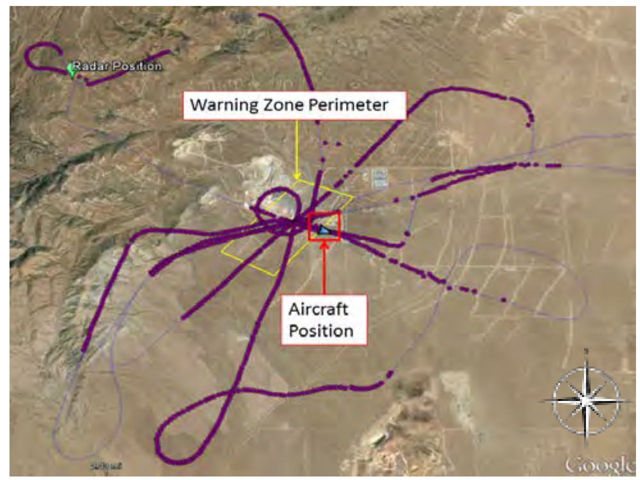
Event 24:

- Aircraft is detected and is tracked by radar.
- Indicator lamp is off.



Event 25:

- Aircraft penetrates the warning zone perimeter.
- Indicator lamp is on.
- Aircraft is continuously monitored within the warning zone.



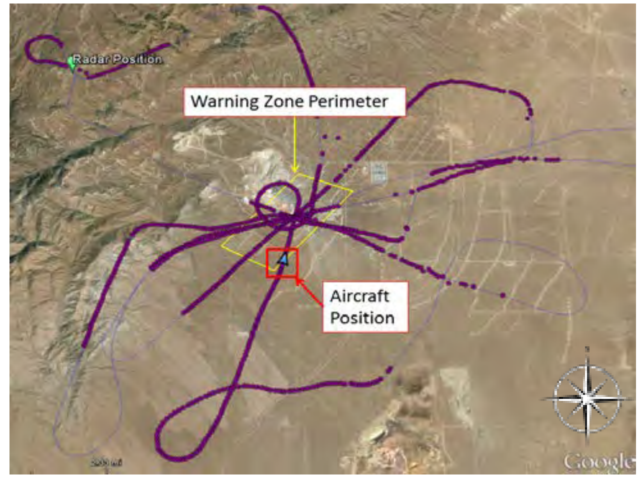
Event 26:

- Aircraft exits the warning zone to the southeast.
- Indicator lamp is off.

Figure 19. Second Flight to Warning Zone With Aircraft Initially Hidden Behind a Mountain (events 23-26)

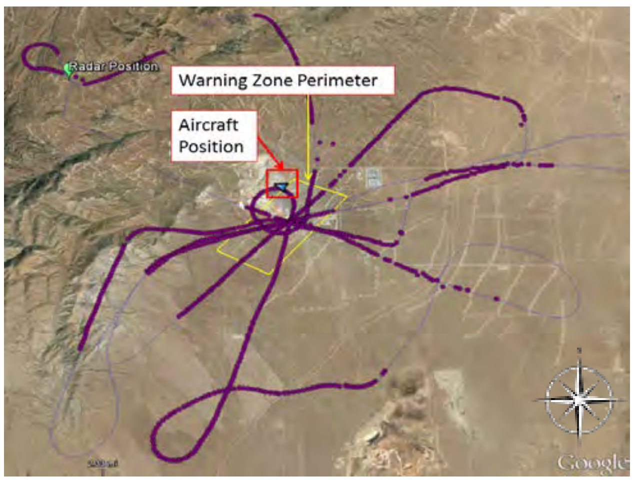
Event 27:

- Aircraft approaches the warning zone from the south.
- Aircraft is detected and is tracked by radar.
- Indicator lamp is off.



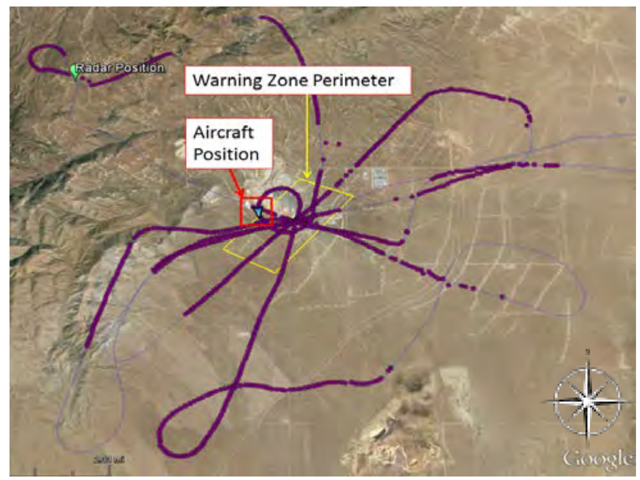
Event 28:

- Aircraft penetrates the warning zone perimeter heading north.
- Indicator lamp is on.
- Aircraft is continuously monitored within the warning zone.



Event 29:

- Aircraft exits the warning zone heading northwest.
- Aircraft begins a 270° left turn towards the warning zone, approaching from the northwest.
- Indicator lamp is off.



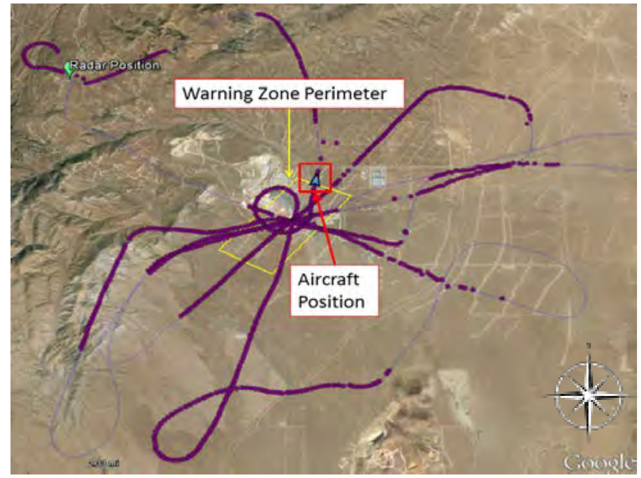
Event 30:

- Aircraft continues its turn and penetrates the warning zone perimeter heading southeast.
- Indicator lamp is on.

Figure 20. Second Circling Flight Over the Warning Zone (events 27-30)

Event 31:

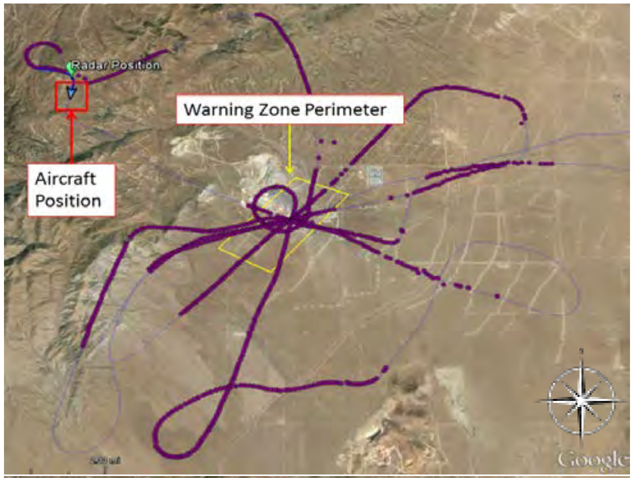
- Aircraft continues the 270° left turn inside the warning zone.
- Aircraft is continuously monitored within the warning zone.
- Indicator lamp is on.



Event 32:

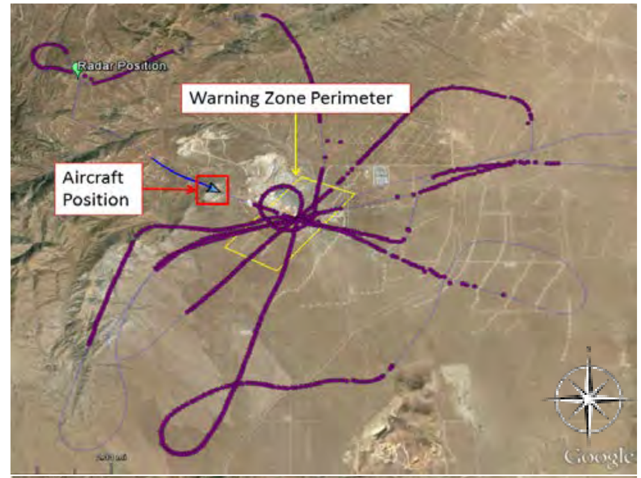
- Aircraft exits the warning zone to the north.
- Indicator lamp is off.

Figure 21. Continuation of Second Circling Flight Over the Warning Zone (events 31-32)



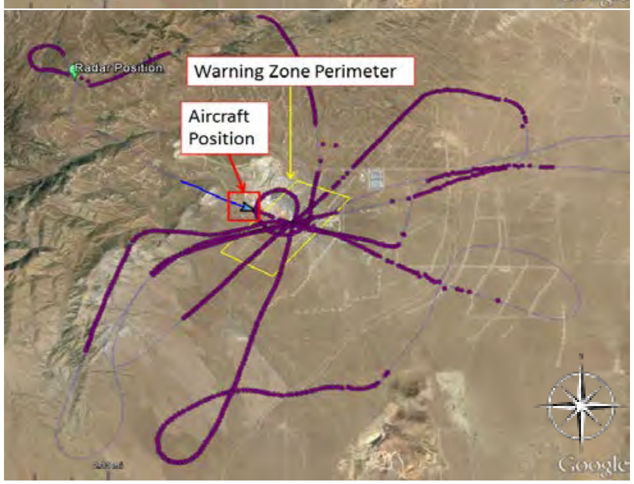
Event 33:

- Aircraft flies over the radar site.
- Radar contact is lost.
- Indicator lamp is off.



Event 34:

- Aircraft approaches warning zone from the northwest.
- Aircraft is not yet detected by radar.
- Indicator lamp is off.



Event 35:

- Aircraft is detected by radar prior to reaching warning zone.
- Aircraft descends into the zone from 1500 ft AGL heading southeast.
- Indicator lamp is on.

Event 36:

- Aircraft exits the warning zone to the southeast
- Indicator lamp is off.

Figure 22. Descending Flight Into the Warning Zone (events 33-36)

COMPONENT FAILURE ASSESSMENT.

To demonstrate that the Terma OLC system was able to meet the component failure requirements for an ADLS, ATR personnel conducted a series of activities designed to test the system's component failure responses. Descriptions of the activities and the results of the Terma OLC system's failure response are as follows:

- Individual Component and Obstruction Light Control Failure

  These functions were unable to be assessed due to the limited installation at the site. However, Terma engineers did provide the documentation of the fail-safe capabilities of the OLC system to ATR personnel.

- Communication and Status Monitoring

  ATR personnel verified that the Terma OLC system communication and operational status were checked at least once every 24 hours to ensure both are operational.

- Target Size

  ATR personnel confirmed that the Terma OLC system could detect an object with a cross-sectional area of 1 square meter or more within the detection area. This was accomplished by flying an aircraft straight toward the Terma OLC system radar unit, which resulted in the system detecting the narrow profile of the aircraft.

- Activity Log

  The Terma indicated that the data could be stored for an indefinite amount of time, depending on the user's requirement, which satisfies the 15-day requirement of AC 70/7460-1L.

- FCC Part 15 Compliance

  Based on the documentation provided to the ATR personnel by the Terma engineers, it was verified that the Terma OLC system components do not use FCC Part 15 devices [7].

- Audio/Voice Option

  The Terma OLC system does not currently offer a voice/audio option; therefore, this was not evaluated. As stated in AC 70/7460-1L, this is not a required ADLS component.

CONCLUSIONS

The Federal Aviation Administration (FAA) Airport Technology Research and Development Branch evaluated the Terma Obstruction Light Control (OLC) system at the Tehachapi Wind Resource Area, located near Mojave, California. A performance assessment, consisting of demonstrations, flight testing, and data analysis was conducted on April 15, 2015. In this performance assessment, a series of flight patterns were flown against the Terma OLC system to demonstrate that it could meet the FAA's performance requirements for aircraft detection lighting systems. The Terma OLC system performed according to the manufacturer's specifications and met the performance requirements identified specified in FAA Advisory Circular (AC) 70/7460-1L, "Obstruction Marking and Lighting."

REFERENCES

1. Federal Aviation Administration, "Obstruction Marking and Lighting," Advisory Circular (AC) 70/7460-1L, December 4, 2015.

2. U.S. Federal Register, Title 14 Code of Federal Regulations, Part 77, "Safe, Efficient Use, and Preservation of the Navigable Airspace," Government Printing Office, Washington DC.

3. Patterson, James, Jr., "Performance Assessment of the Laufer Wind Aircraft Detection System as an Aircraft Detection Lighting System," FAA technical note DOT/FAA/TC-TN15/54, September 2015.

4. Terma, "Coverage Report for OLC Demo, California," March 2015.

5. Terma, "SCANTER 5000 Radar Series Radar-Based Obstruction Light Control," 2015.

6. Terma, "SCANTER 5202 System Features: Built-in Test Equipment," 2015.

7. U.S. Federal Register, Title 47 Code of Federal Regulations, Part 15, "Radio Frequency Devices," Government Printing Office, Washington, DC.

APPENDIX A—ADVISORY CIRCULAR 70/7460-1L, CHAPTER 14, AIRCRAFT DETECTION LIGHTING SYSTEMS [1]

CHAPTER 14. AIRCRAFT DETECTION LIGHTING SYSTEMS

14.1 Purpose.

Aircraft Detection Lighting Systems (ADLS) are sensor-based systems designed to detect aircraft as they approach an obstruction or group of obstructions; these systems automatically activate the appropriate obstruction lights until they are no longer needed by the aircraft. This technology reduces the impact of nighttime lighting on nearby communities and migratory birds and extends the life expectancy of obstruction lights.

14.2 General Standards.

14.2.1 The system should be designed with sufficient sensors to provide complete detection coverage for aircraft that enter a three-dimensional volume of airspace, or coverage area, around the obstruction(s) (see Figure A-27 in Appendix A), as follows:

1. Horizontal detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the perimeter of the volume, which is a minimum of 3 NM (5.5 km) away from the obstruction or the perimeter of a group of obstructions.

2. Vertical detection coverage should provide for obstruction lighting to be activated and illuminated prior to aircraft penetrating the volume, which extends from the ground up to 1,000 feet (304 m) above the highest part of the obstruction or group of obstructions, for all areas within the 3 NM (5.5 km) perimeter defined in subparagraph 14.2.1 1 above.

3. In some circumstances, it may not be possible to meet the volume area defined above because the terrain may mask the detection signal from acquiring an aircraft target within the 3 NM (5.5 km) perimeter. In these cases, the sponsor should identify these areas in their application to the FAA for further evaluation.

4. In some situations, lighting not controlled by the ADLS may be required when the 3 NM (5.5 km) perimeter is not achievable to ensure pilots have sufficient warning before approaching the obstructions.

14.2.2 The ADLS should activate the obstruction lighting system in sufficient time to allow the lights to illuminate and synchronize to flash simultaneously prior to an aircraft penetrating the volume defined above. The lights should remain on for a specific time period, as follows:

---

[1] Federal Aviation Administration, "Obstruction Marking and Lighting," Advisory Circular (AC) 70/7460-1L, December 4, 2015.

1. For ADLSs capable of continuously monitoring aircraft while they are within the 3 NM/1,000 foot (5.5 km/304 m) volume, the obstruction lights should stay on until the aircraft exits the volume. In the event detection of the aircraft is lost while being continuously monitored within the 3 NM/1,000 foot (5.5 km/304 m) volume, the ADLS should initiate a 30-minute timer and keep the obstruction lights on until the timer expires. This should provide the untracked aircraft sufficient time to exit the area and give the ADLS time to reset.

2. For ADLSs without the capability of monitoring aircraft targets in the 3 nm/1,000 foot (5.5 km/304 m) volume, the obstruction lights should stay on for a preset amount of time, calculated as follows:

a. For single obstructions: 7 minutes.

b. For groups of obstructions: (the widest dimension in nautical miles + 6) x 90 seconds equals the number of seconds the light(s) should remain on.

14.2.3 Acceptance of ADLS applications will be on a case-by-case basis and may be modified, adjusted, or denied based on proximity of the obstruction or group of obstructions to airports, low-altitude flight routes, military training areas, or other areas of frequent flight activity. It may be appropriate to keep certain obstructions closest to these known activity areas illuminated during the nighttime hours, while the remainder of the group's obstruction lighting is controlled by the ADLS.

14.2.4 Project sponsors requesting ADLS use should include in their application maps or diagrams indicating the location of the proposed sensors, the range of each sensor, and a visual indication showing how each sensor's detection arc provides the full horizontal and vertical coverage, as required under paragraph 14.2.1. In the event that detection coverage is not 100 percent due to terrain masking, project sponsors should provide multiple maps or diagrams that indicate coverage at the affected altitudes. A sample diagram is shown in Figure A-27 in Appendix A.

14.2.5 Types of ADLS Component or System Failure Events.

1. In the event of an ADLS component or system failure, the ADLS should automatically turn on all the obstruction lighting and operate in accordance with this AC as if it was not controlled by an ADLS. The obstruction lighting must remain in this state until the ADLS and its components are restored.

2. In the event that an ADLS component failure occurs and an individual obstruction light cannot be controlled by the ADLS, but the rest of the ADLS is functional, that particular obstruction light should automatically turn on and operate in accordance with this AC as if it was not controlled by an ADLS, and the remaining obstruction lights can continue to be controlled by the ADLS. The obstruction lighting will remain in this state until the ADLS and its components are restored.

3. Complete light failure should be addressed in accordance with Chapter 2 paragraph 2.4.

14.2.6 The ADLS's communication and operational status shall be checked at least once every 24 hours to ensure both are operational.

14.2.7 The ADLS should be able to detect an aircraft with a cross-sectional area of 1 square meter or more within the volume, as required in subparagraphs 14.2.1 1 and 14.2.1 2.

14.2.8 Each ADLS installation should maintain a log of activity data for a period of no less than the previous 15 days. This data should include, but not be limited to, the date, time, duration of all system activations/deactivations, track of aircraft activity, maintenance issues, system errors, communication and operational issues, lighting outages/issues, etc.

14.2.9 Operational Frequencies.

1. Unlicensed devices (including FCC Part 15) devices cannot be used for this type of system.

2. Any frequency used for the operation of ADLS must be individually licensed through the FCC.

14.3 Voice/Audio Option.

14.3.1 ADLS may include an optional voice/audio feature that transmits a low-power, audible warning message to provide pilots additional information on the obstruction they are approaching.

14.3.2 The audible transmission should be in accordance with appropriate FAA and FCC regulations.

14.3.3 The audible transmission should be over an aviation frequency licensed by the FCC and authorized under the Code of Federal Regulations Title 47- Part 87.483 (excluding 121.5 MHz).

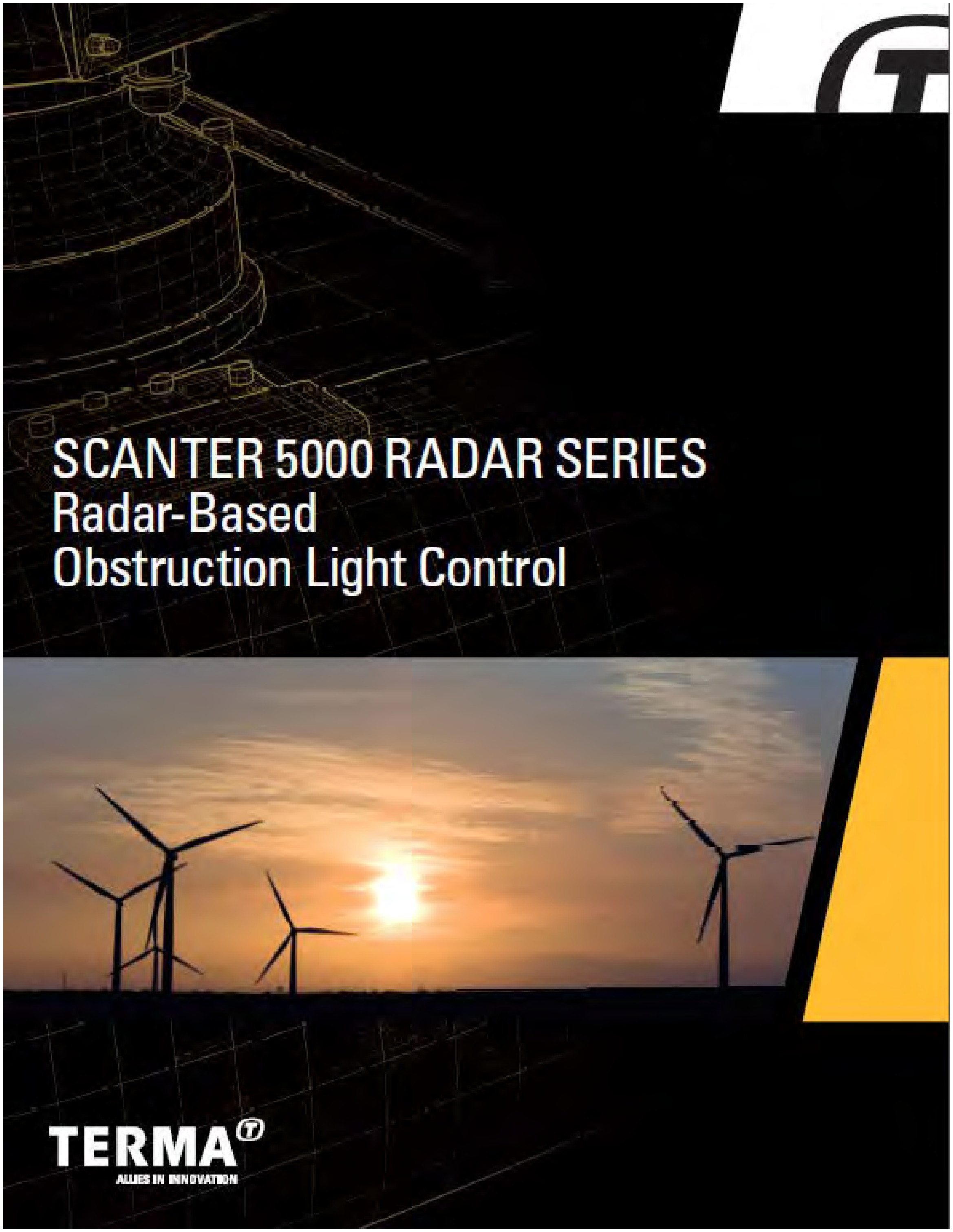
Note: Using air traffic control frequencies in the 117.975-MHz to 137-MHz frequency band is prohibited for this operation.

14.3.4 The audible message should consist of three quick tones, followed by a verbal message that describes the type of obstruction the system is protecting. Appropriate terms to be used include tower(s), wind turbine(s), or power line(s).

14.3.5 The audible message should be repeated three times or until the system determines the aircraft is no longer within the audible warning area defined in the following paragraph.

14.3.6 The audible message should be considered as a secondary, final warning and should be activated when an aircraft is within 1/2 NM (926 m) horizontally and 500 feet (152 m) vertically of the obstruction. The use of, or variation to, the audible warning zone may occur, depending on site-specific conditions or obstruction types.

APPENDIX B—TERMA OBSTRUCTION LIGHT CONTROL SYSTEM INFORMATION



Radar-Based Obstruction Light Control

The increasing size of wind turbines are creating safety and societal challenges for the wind industry, the authorities, and the surrounding municipalities when it comes to obstruction lighting and marking of wind turbines to comply with air traffic regulations. As wind turbines grow taller and enter the lower airspace, high intensity obstruction lights are needed. The high intensity lights required for higher wind turbines can appear very intrusive to wind farm neighbors and to an otherwise pristine night sky. The high intensity lights cause a growing number of delays and cancelations of wind farms due to complaints from neighbors and municipalities near planned wind farms. These problems can be overcome by turning the obstruction lights on only when necessary, i.e. when there is an aircraft in the vicinity of the wind farm. Terma's Obstruction Light Control (OLC) vastly improves the success rate of wind farm deployments, contributing to national climate objectives and at the same time greatly reducing light pollution caused by wind farms.

SOLUTION CAPABILITIES

Terma's radar-based OLC integrates seamlessly with existing infrastructure, aviation obstruction lights, obstruction lights monitoring, control equipment, and lighting from leading vendors.

Combined with Terma's professional services, our turn-key solution is the preferred choice for wind turbine generator manufacturers and wind farm developers.

APPROVALS

Terma has an extensive track record with approval authorities providing documentation, standard safety cases, and support. Terma's knowhow and domain leadership can be of great benefit in the approval process for planning and operational permits. Working with Terma is a long-term partnership from the approval process through to deployment or retrofit of the wind farm.

PRODUCT CHARACTERISTICS

Terma's SCANTER 5000 radar series is part of a larger family of Terma radar products, which have all benefitted from the introduction of fully digital signal processing and Solid State technology, providing extremely clear radar images with low probability of false alarms. The past 5 years of committed field testing governed by independent international aviation authorities has resulted in superior wind farm mitigation capabilities, enabling the radars to truly co-exist with wind turbines without the need for blanking out wind farm areas.

Terma's SCANTER 5000 radar series provides:

- True wind farm mitigation capabilities
- Solid State Power Amplifier (SSPA) ensuring high reliability and availability
- X-Band-based system
- Small target detection capability
- Detection of non-cooperative targets
- Open architecture – integrates via TCP/IP network protocol

SCALABILITY

Terma's radar sensor has a range of 18 km yielding in a total coverage of up to 1,000 km2, making the system ideal for larger wind farms and wind farms with a scattered layout. The exceptional range of the sensor also enables future developments and expansions of the wind farm.

PRODUCT SUSTAINMENT

The Terma SCANTER radar family has proven its performance, reliability, and sustainability in security applications all over the world. Based on Terma's vast knowhow and best-in-class hardware and software technology, the SCANTER 5000 series provides our clients with a proven platform ensuring high availability (High Mean-time Between Failure).

SERVICE & SUPPORT

At Terma, we know the importance of keeping the blades spinning. That is why we offer Global Support & Service Agreements for up to 25 years, supporting long time sustainability and obsolescence management of our SCANTER products throughout the life time of the wind farm.

A WORLD LEADER IN DETECTION TECHNOLOGIES

Terma has more than 60 years of experience in developing and manu-facturing radars, and more than +2,200 radar systems are installed worldwide. Terma provides radar sensors to Vessel Traffic Services (VTS), Coastal Surveillance Radar (CS), and Surface Movement Radar (SMR) segments. More than 85% of all major airports around the world and 65% of all coastal shores rely on Terma's sensor technology.

Terma's OLC is based on proven and reliable technology, ensuring continuous operation and low maintenance costs. Combined with our global service and maintenance capability, you obtain a high-performance system with very low risk.

KEY BENEFITS

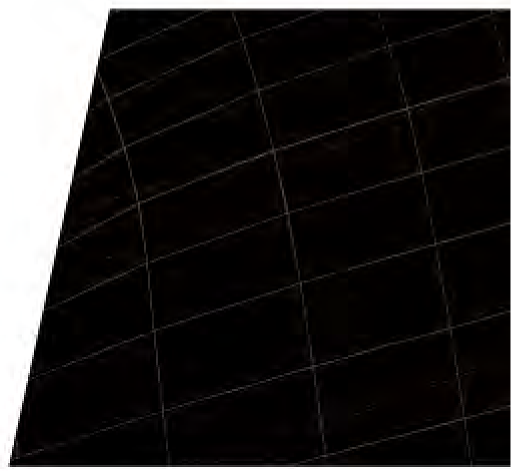
- **Wind Turbine Generator (WTG) manufacturer independent** – Terma's OLC integrates with existing infrastructure and lighting from leading WTG vendors.
- **Scalability / Deployment flexibility** – for larger wind farms that typically have a scattered layout, the Terma sensor capabilities and deployment offerings enable flexible solutions, bringing down the total cost.
- **Extensive track record with approval authorities (SME capabilities)** – each OLC installation typically requires a country-dependent, site-specific approval. Terma has an extensive track record with approval authorities, providing documentation, standard safety cases, and support.
- **Extended instrumented radar range ensures increased collision avoidance capabilities** – extended range provides more 'on time' for collision lighting, thus providing the pilot with an extended warning period beyond legal minimum requirement.

Operating in the aerospace, defense, and security sector, Terma supports customers and partners all over the world. With more than 1,100 committed employees globally, we develop and manufacture mission-critical products and solutions that meet exacting customer requirements.

At Terma, we believe in the premise that creating customer value is not just about strong engineering and manufacturing skills. It is also about being able to apply these skills in the context of our customers' specific needs. Only through close collaboration and dialog can we deliver a level of partnership and integration unmatched in the industry.

Our business activities, products, and systems include: command and control systems; radar systems; self-protection systems for ships and aircraft; space technology; and advanced aerostructures for the aircraft industry.

Headquartered in Aarhus, Denmark, Terma has subsidiaries and operations in The Netherlands, Germany, India, UAE, UK, Singapore as well as a wholly-owned U.S. subsidiary, Terma North America Inc. Terma North America Inc. is headquartered in Arlington, in the Wasington D.C. area, with other offices in Georgia, Texas, Alabama and Virginia.



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