

LPR Wake Vortex Radar Special Temporary Authority (STA) License Request

Purpose of Operation:

FAA frequency coordination is being requested prior to submitting an application for an experimental Special Temporary Authorization to the FCC. Raytheon is requesting permission to perform testing in the 9.5 GHz - 9.8 GHz radiolocation band in order to demonstrate the operation of a prototype low power radar system. This activity follows the successful demonstration of the system for use as an air traffic radar and weather radar. The testing is intended to evaluate the ability of the system to detect and track wake vortices generated by a lead aircraft in order to ensure safe separation between it and following aircraft near an airport.

This is the same radar that has been operated at Johnstown, PA under FAA 131212 and at Crane, TX under FAA 130087 for the development of wind turbine mitigation software. It was also operated under FCC call sign WG2XWA at McKinney, TX. The radar technical parameters have been modified somewhat to permit the detection of wake vortex hazards. The details can be found below.

File Number:	0663-EX-ST-2014
Class of Station:	FX
Stations Locations:	FIXED
Effective:	08/11/2014
Expiration:	02/11/2015

NOTE: This was coordinated with the FAA action Officer was Anuj K. Sinha phone # (718) 977-6609. Stated we did not need a coordination notes. "Sir Adams, FAA has no objection to the request of 9.51GHz to 9.8GHz Anuj Sinha Frequency Management Officer, Spectrum Engineer Federal Aviation Administration (FAA) ESA Spectrum Engineering Services, AJW-1C5 Office: 718 977 6609"

Test Summary:

The purpose of this testing is to acquire data for subsequent analysis and development of expert algorithms to detect, quantify and track wake vortex hazards to aviation. Testing is planned to begin this summer. The system will transmit pulsed Frequency Modulated (Chirp) waveforms. It is expected that the radar will be operated 24 hours a day, seven days per week for the duration of the testing. The radar will be controlled by a local operator during test conduct. The radar is a 1m x 1m and will be mounted on a trailer about 8 inches (0.2 meters) off the ground.

The Low Power Radar (LPR) is planned to be operated at multiple sites between 3/4 nautical mile and 3 nautical miles from the end of runways near Boston Logan (BOS) or Manchester-Boston Regional Airport (MHT). The system will be located 1/4 to 1 nautical mile to the side of the approach/departure path and scan in range height indicator (RHI) mode across the path.

Locations:

The radar is mounted on a trailer which will be repositioned to observe the wake vortices generated by aircraft on approach to different airport runways for the Boston Logan and

Manchester-Boston Regional Airports. The candidate sites are located within a 7km radius of these two airports. Latitude, longitude coordinates for the two airports are:

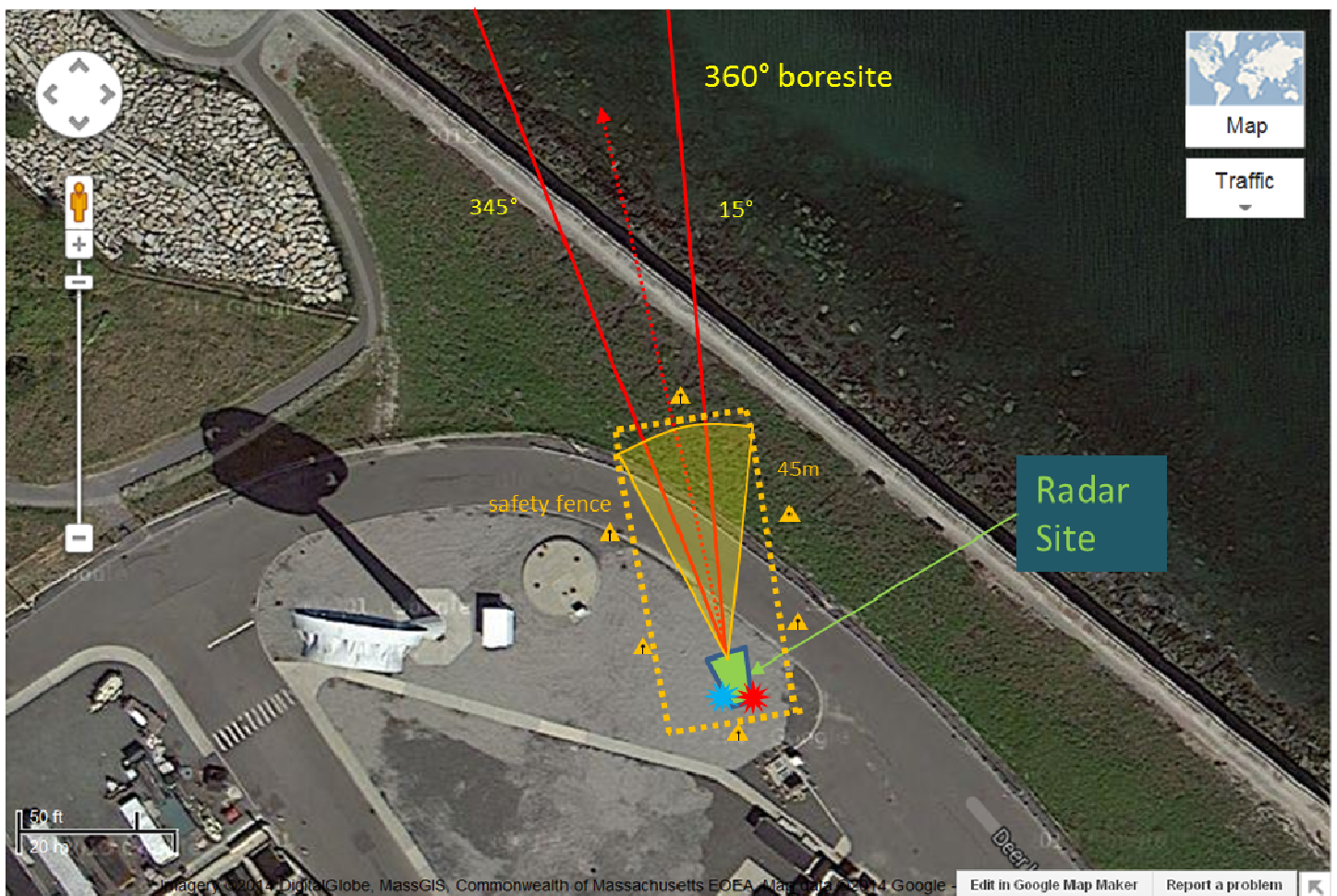
1. Boston Logan Airport: Latitude $42^{\circ} 21' 57.7008''$ Longitude $-71^{\circ} 1' 9.9978''$
Approximate site elevation: 7 meters
2. Manchester-Boston Regional Airport: Latitude $42^{\circ} 55' 56.9994''$ Longitude $-71^{\circ} 26' 8.1594''$
Approximate site elevation: 81 meters

Additional detail on potential locations is included later in this document.

RF Hazard Calculations and Site Safety Measures:

It is Raytheon's policy to ensure that our personnel, the general public and our customers are not exposed to RF levels which exceed applicable standards. For this testing, Raytheon has an RF Safety Control Plan which has been reviewed by Raytheon's RF safety group. The Plan defines the procedures and controls required to prevent personnel exposure to levels which exceed the Maximum Permissible Exposure (MPE) limits as defined by Part 1.1310 of the FCC Rules and the guidelines in FCC's OET Bulletin Number 65. A "Keep Out Zone" will be established around the radar using guidelines recommended in these documents. Also at initial system turn-on, an RF survey will be performed to verify the safety of personnel. All measured levels where personnel have access must be below the MPE limits before testing can proceed.

Initial calculations show that Limits for General Population/Uncontrolled Exposure will be reached at a 36.5 meter distance and Limits for Occupational/Controlled Exposure will be reached at 16.3 meters in the main beam, using equation (7) from FCC OET Bulletin 65 "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", dated August 1997. These calculations take



into account the highest duty factor of 28.125% and the RHI scan pattern utilized by the radar. Figure 1 shows the radar Keep Out Zone, including the radar radiation coverage. The shaded yellow area defines the Keep-Out Zones (KOZ). Beyond the regions of the KOZ, the power density levels are below MPE limits and people can move freely.

Figure 1: Radar Keep Out Zone

Raytheon Technical Point of Contact:

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Raytheon Spectrum Manager filing spectrum request:

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Spectrum Management/RF Safety
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Date Needed: June 9, 2014

RF output at the transmitter terminals: 115 Watts peak

Effective radiated power from the antenna:

The effective radiated power from the antenna, including antenna transmit gain and front-end losses, is 568 kW (peak).

Emission types:

6M50Q3N	- 12μsec FM-Pulsed with a 2.5 MHz FM chirp, centered at 9598.25 MHz (9597.00 MHz - 9599.50 MHz)
7M10Q3N	- 6μsec FM-Pulsed with a 2.5 MHz FM chirp, centered at 9598.25 MHz (9597.00 MHz - 9599.50 MHz)
7M10Q3N	- 6μsec FM-Pulsed with a 2.5 MHz FM chirp, centered at 9601.25 MHz (9600.00 MHz - 9602.50 MHz)
8M90Q3N	- 3μsec FM-Pulsed with a 3 MHz FM chirp, centered at 9601.50 MHz (9600.00 MHz – 9603.00 MHz)

The transmit waveform pulse sequence is programmable. Only single waveform type will be used: Non-Linear FM-Pulse (chirp). The FM-pulses are modulated with a programmable 2.5 MHz or 3 MHz chirp and programmable pulse width from 3μsec to 12μsec. The waveform types operate in the 9.5 GHz - 9.8 GHz band.

The maximum duty factor for the 12μsec pulse is 18.8% and the minimum for the 3μsec pulse is 4.7%. The highest duty factor of 28.125% occurs with a combination of a 6μs and 12μs pulse in a single pulse repetition interval. The maximum pulse repetition frequency is 15625 Hz for all waveform types.

Transmitter Waveform Modes										
Mode Emissions Designator	Center Frequency (GHz)	Azimuth Scan Coverage (degrees)	Elevation Scan Coverage (degrees)	Elevation Beam Width (degrees)	Elevation Beam Width (degrees)	Pulse Width (μsec)	Max Duty Factor %	Peak ERP (kW)	Max FM Chirp BW (MHz)	Necessary BW (MHz)
6M50Q3N	9.59825	+/- 15	0 to 15	1.87	2.16	12	4.8	568	2.5	6.5
7M10Q3N	9.59825	+/- 15	0 to 15	1.87	2.16	6	2.4	568	2.5	7.1
7M10Q3N	9.60125	+/- 15	0 to 15	1.87	2.16	6	2.4	568	2.5	7.1
8M90Q3N	9.60150	+/- 15	0 to 15	1.87	2.16	3	1.2	568	3	8.9

Necessary bandwidth: The necessary bandwidth was calculated using the equations in Annex J of the NTIA Manual.

FM-Pulsed Radar			
Pulse Width (μsec)	12	6	3
Rise Time (μsec)	0.128	0.128	0.128
Fall Time (μsec)	0.128	0.128	0.128
Chirp BW (MHz)	2.5	2.5	3
Necessary BW (MHz)	6.5	7.1	8.9
Designator	6M50Q3N	7M10Q3N	8M90Q3N

Candidate Radar Site Locations

Table 1 provides a list of potential radar sites to be used for LPR wave vortex testing in the areas surrounding Boston Logan and Manchester-Boston Regional airports. These sites are determined based on distances with respect to approach paths to the airport runways. References are provided to which runways' traffic is observed for each of these sites. Some sample figures of radar orientation are provided in Figure 2 - Figure 5.

Airport	Site	Runway #s	Figure	Direction from Runways
Logan	Deer Island	27 and 33L	2 and 3	East
Logan	Suffolk Downs, Deserted Parking Lot along Tomesello Way	22L and 22R	4	Northwest
Logan	16 St Pier, Deserted Lot Close to Pier, Charlestown	15R	5	West
Logan	O Street, Deserted Lot Close to Yacht Club	4L and 4R	none	Southwest
Manchester	Woodside Dr (Circle at End)	35	none	Southwest
Manchester	Construction Supply Company along Manmoth Rd, next to	35	none	Southeast
Manchester	Pine Grove Cemetery along Merrimack River	17	none	Northwest
Manchester	Radio Station or Driving Range on Daniel Webster Highway	24	none	Northeast
Manchester	Camp Allen Dr	24	none	Southwest

Table 1. Potential Radar Sites for Radar Wake Vortex Testing

5/12/2014



Figure 2: Radar on Deer Island to Observe Aircraft Approaching Boston Logan RWY 27

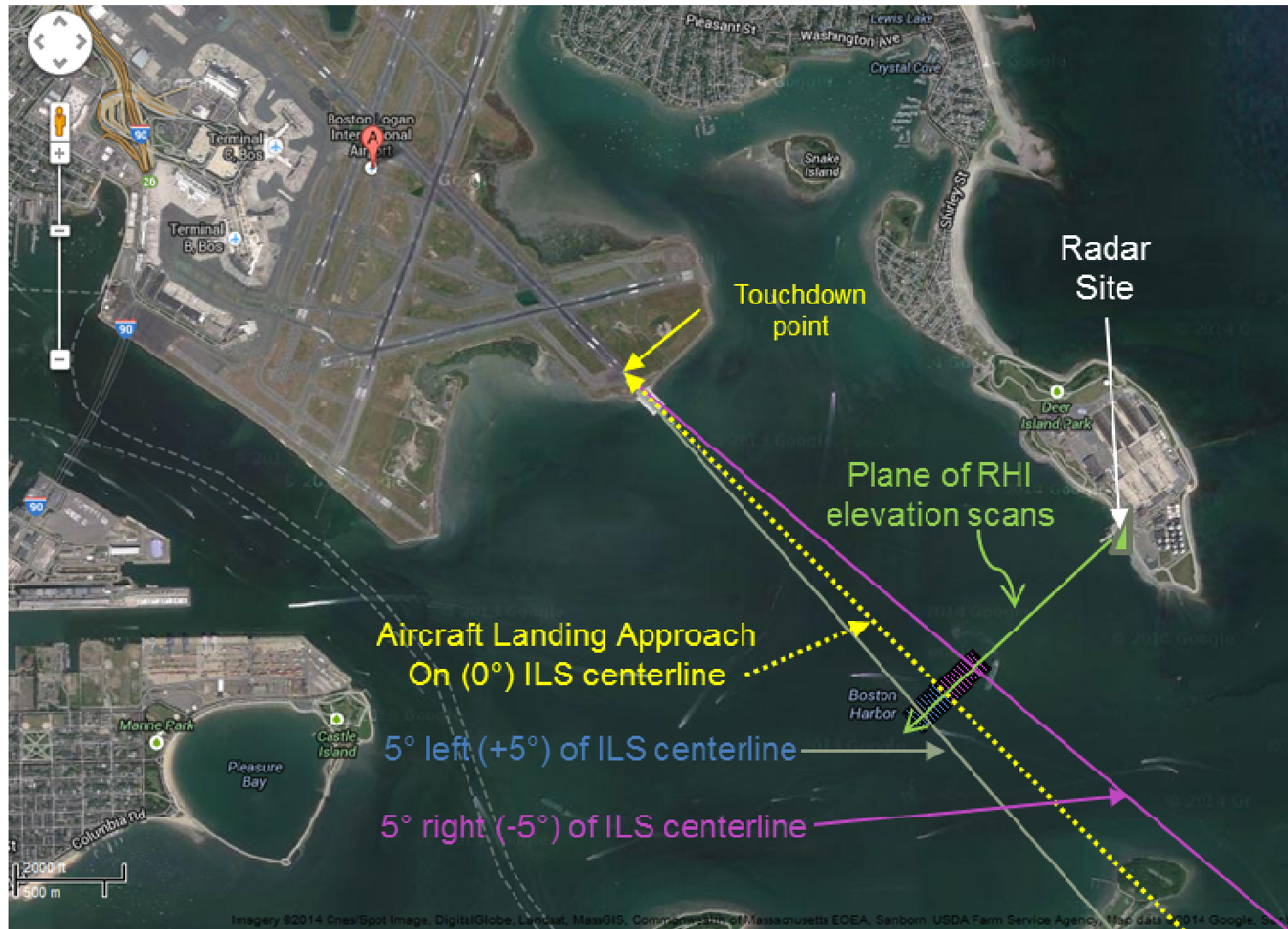


Figure 3: Radar on Deer Island to Observe Aircraft Approaching Boston Logan RWY 33L

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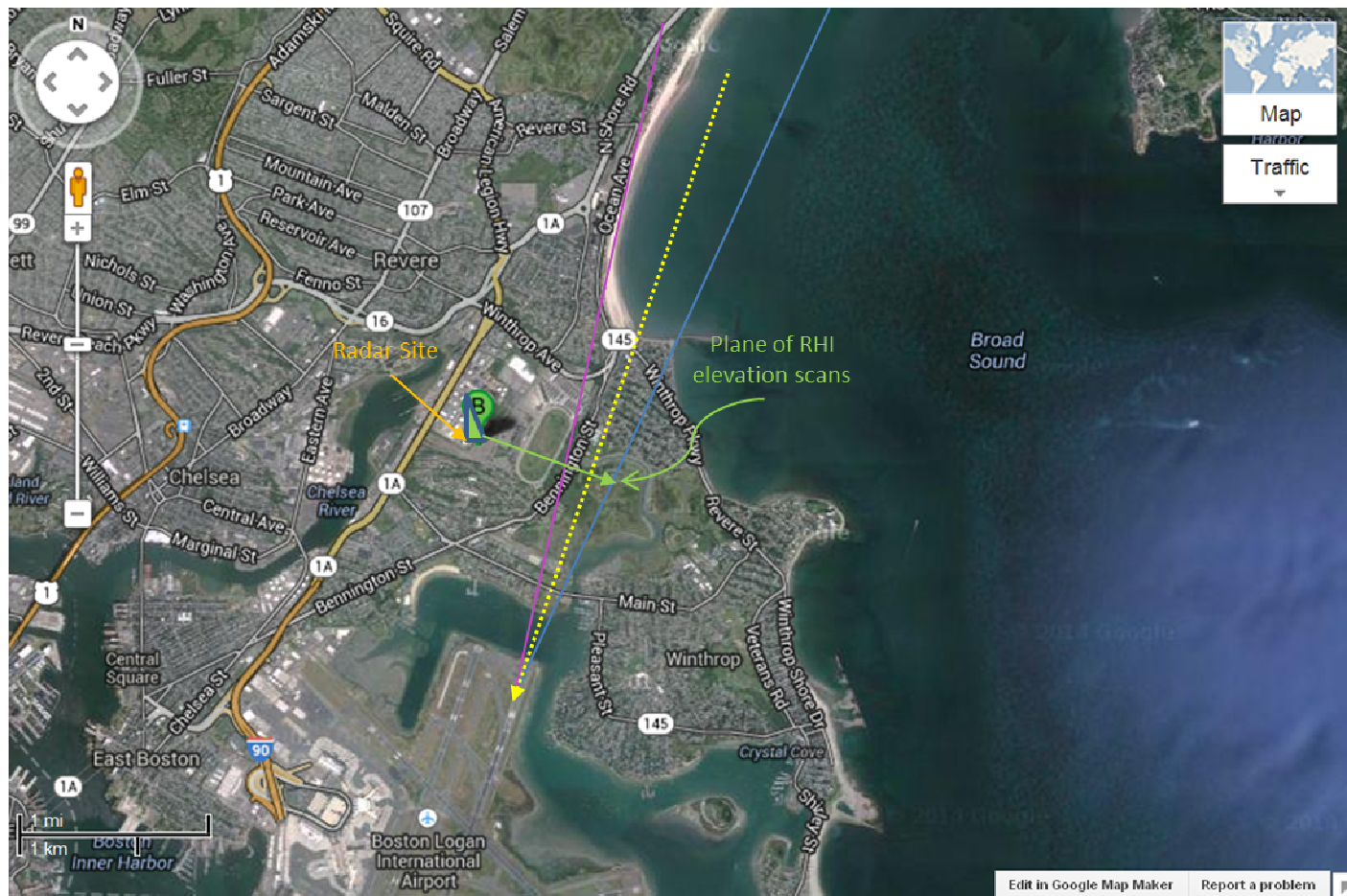


Figure 4: Radar near Suffolk Downs to Observe Aircraft Approaching Boston Logan RWY 22L and 22R

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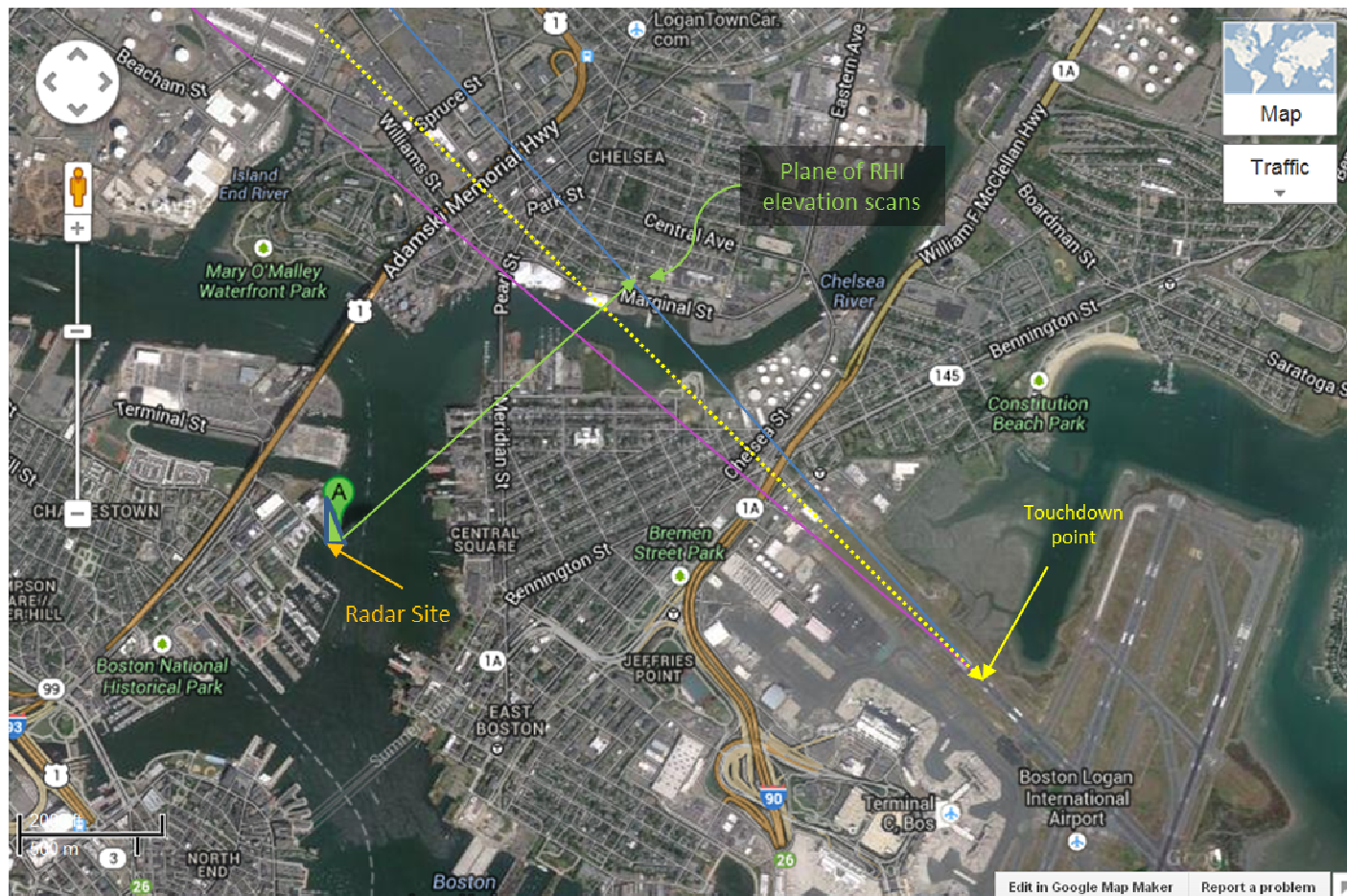


Figure 5: Radar near Charlestown 16th Street Pier to Observe Aircraft Approaching Boston Logan RWY 15R