# FCC 442

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## Introduction

Group 51 at MIT Lincoln Laboratory develops Cyber-Electromagnetic capabilities for the Department of Defense. In order to have a successful transition to the warfighter, we need to thoroughly test and evaluate our developed techniques and technologies including realistic operational environments such as over-the-air and flight-testing.

Bluebolt is one such capability that is investigating Link-11 communication system and requires over-the-air and flight-testing. Bluebolt, which is scheduled to be demonstrated at the NORTHERN EDGE 2017 military exercise in May 2017, will require advance testing starting in March 2017 to ensure a successful event. Given the importance of this technology and the tight timeline, MIT Lincoln Laboratory requests expedited approval for over the air testing and flight-testing of the Bluebolt system. The setup for this testing is described in this document.

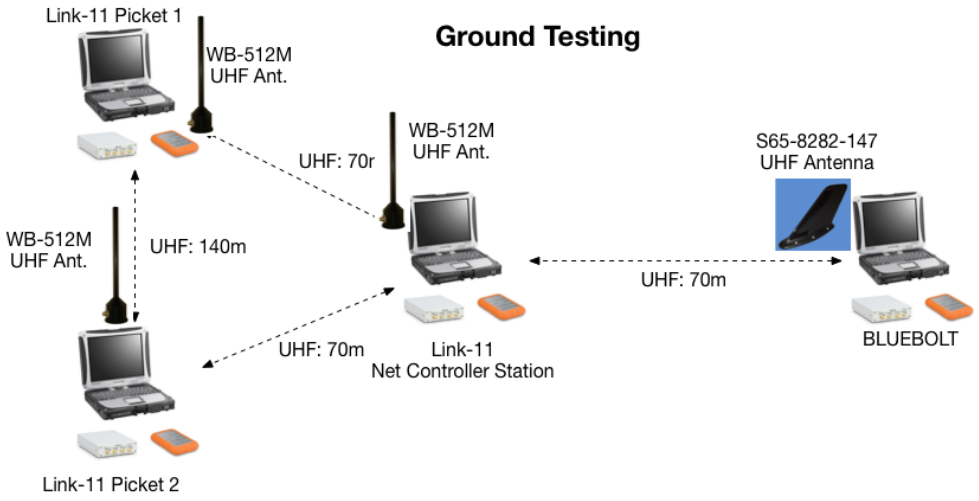
Lincoln Laboratory operates the Dassault Falcon 20D test bed aircraft under USAF contract (FA8721-05-C-0002). We plan to test in March 2017 the software-defined radio version of Link-11 (AKA: Bluebolt) as a risk reduction and prep for an upcoming military exercise, NORTHERN EDGE, in May 2017. To prepare for these events, Lincoln Laboratory plans to execute local ground and flight tests. The required use involves only one Lincoln-operated aircraft and three ground nodes. Ground tests will take place outside of Building 1718 on Hanscom AFB, MA. Flight tests will take place in the local area as well as at NAS Fallon, NV.

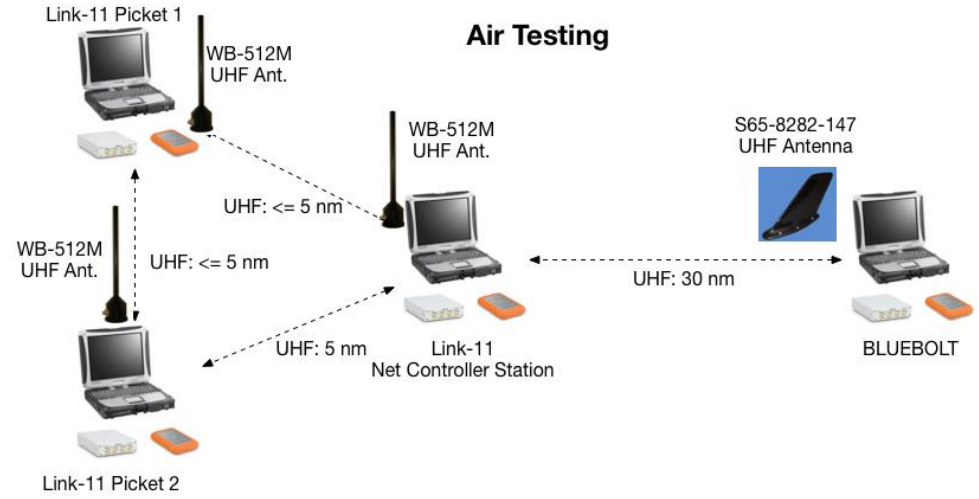
## System Description

The diagram below shows the desired system configuration for the BLUEBOLT tests. The Bluebolt tests (Link-11) will use three Ettus B210 software-defined radios on the ground and one installed in the N20NY Falcon-20 aircraft. For ground test, the Ground nodes will be placed at positions 1, 3, and 5 in the picture to the right. Ground node equipment consists of a laptop, an Ettus B210 software-defined radio, and a UHF225450VM omni-directional antenna. The aircraft node consists of a laptop, an Ettus B210 software defined radio, and a Vortex antenna. All transmit powers will be less than or equal to 41.76 dBm. The transmit power can be adjusted to meet FCC requirements for radiated power.


A Bluebolt network will establish a software defined Link-11 network between the ground nodes and the aircraft mounted node. The maximum duty cycle possible for a Link-11 network with 4 nodes is 55% at the maximum communication rate. The FAA forbids a communication rate of more than 50% with one terminal within a 100 Nautical Mile (NM) radius. Our testing will be with 4 terminals with a duty cycle of

55% for all.




## Radiated Power Calculations

An assessment of the electromagnetic safety for the Bluebolt system is provided. Specifically, the safe distances HERP (personnel), HERO (ordnance), and HERF (fuel) are calculated. As specified in NAVSEA OP 3565/NAVAIR 16-1-529 volume 1, the

PFD safe limits for operating frequencies of 225 MHz are 0.2 mW/cm$^2$(HERP) and 5,000 mW/cm$^2$(HERF).

In the Bluebolt test configuration, the N20NY Falcon 20 will use one transmit antenna blade – Sensor Systems Inc. model S65-8282-147 – installed on the bottom fore of the airplane. This antenna has essentially 180° coverage around the airplane. For the purposes of the hazard analysis, the maximum total power is assumed to be 15 Watts for radiating one antenna. This allows conservative or worst case safe distances to be calculated since losses in the cables will only add to the safety margin. The distance, *R*, as a function of power flux density (*PFD*) is given as

$$R = \sqrt{\frac{P_T G_T}{4\pi \cdot PFD}}$$

Taking unit conversions into account, the HERP safe operating distance is at least 77 cm, and the HERF safe operating distance is at least 0.5 cm. A one-meter safety buffer zone will be observed and will cover both of these cases.

According to NAVSEA OP 3565/NAVAIR 16-1-529 volume 2, the HERO safe distance in meters is given as

$$\frac{219\sqrt{P_T G_T}}{f}$$

For an operating frequency of 225 MHz, this minimum safety distance is 377 cm. We will maintain a minimum 4-meter separation from ordnance when the transmitter is active.

| **GENERAL PLATFORM AND Bluebolt TERMINAL INFORMATION:** | | | | | |
|---|---|---|---|---|---|
| Bluebolt Terminal Type | Platform and Platform TSDF | Bluebolt Output Power (Watts) | Bluebolt Antenna Nomenclatures (upper and lower if applicable) | Peak Antenna Gain (dBi) | RF Cable Loss, between Bluebolt terminal output and Bluebolt antenna input, excluding filters (dB) |

| | | | | | |
|---|---|---|---|---|---|
| Bluebolt | Falcon 20 (N20NY) | 15 Watts (41.76 dBm) | UHF/L-BAND S65-8282-147 transmit antenna (manufacturer Sensor Systems Inc.). Supports MIL-STD-810, DO-160E, MIL-E-4500, MIL-E-5272 | Around 0 dBi | Cable used throughout the aircraft is P/N 2801 (http://www.iw-microwave.com/html/280.htm). It has a loss ~ 5 dB/100 ft @ 1 GHz. The runs do not exceed 20 feet, giving a maximum loss of 1 dB. |
| Bluebolt NCS | Portable Ground | 10 Watts (40 dBm) | VHF/UHF Antenna WB-512M (Communication Solutions), MIL-STD-810E&F | Approx. 8dB | Cable from radio to antenna will be 6' and have an approx. loss of 1.2 dB |
| Bluebolt PU 1 | Portable Ground | 10 Watts (40 dBm) | VHF/UHF Antenna WB-512M (Communication Solutions), MIL-STD-810E&F | Approx. 8dB | Cable from radio to antenna will be 6' and have an approx. loss of 1.2 dB |
| Bluebolt PU 2 | Portable Ground | 10 Watts (40 dBm) | VHF/UHF Antenna WB-512M (Communication Solutions), MIL-STD-810E&F | Approx. 8dB | Cable from radio to antenna will be 6' and have an approx. loss of 1.2 dB |

## Bill of Materials

The components listed below are to be used in this transmitter test setup. Where appropriate datasheets are included.

- Lacie Rugged Mini 4TB
- E-10 GPS
- Ettus B210
- Dell Latitude 14 Rugged Extreme
- ZKL-1R5+
- UHF225450VM
- Vortex