RISK REDUCTION FLIGHT CON-OPS

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Figures

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Revision History

Revision	Description of Changes	Date	Revised By
1	Initial version	10/12/2022	LA

INTRODUCTION

This document describes the emitters and associated scenarios for their use pertaining to the Brass Hawk development program funded by the Naval Research Labs (NRL). The first risk reduction flight as well as engineering development activities will utilize these emitters. The basic concept of operations for these tests will be described in subsequent sections and then technical details and their implications will be described in later sections.

BASIC CONCEPT OF OPERATIONS

The purpose of this system of radio links is to provide Beyond Line of Sight (BLOS) range to an Unmanned Aerial System (UAS) using a High Altitude Platform (HAP) system as a data relay. To accomplish this, both a C band and an S band radio link will be employed. This is shown in Fig. 1.

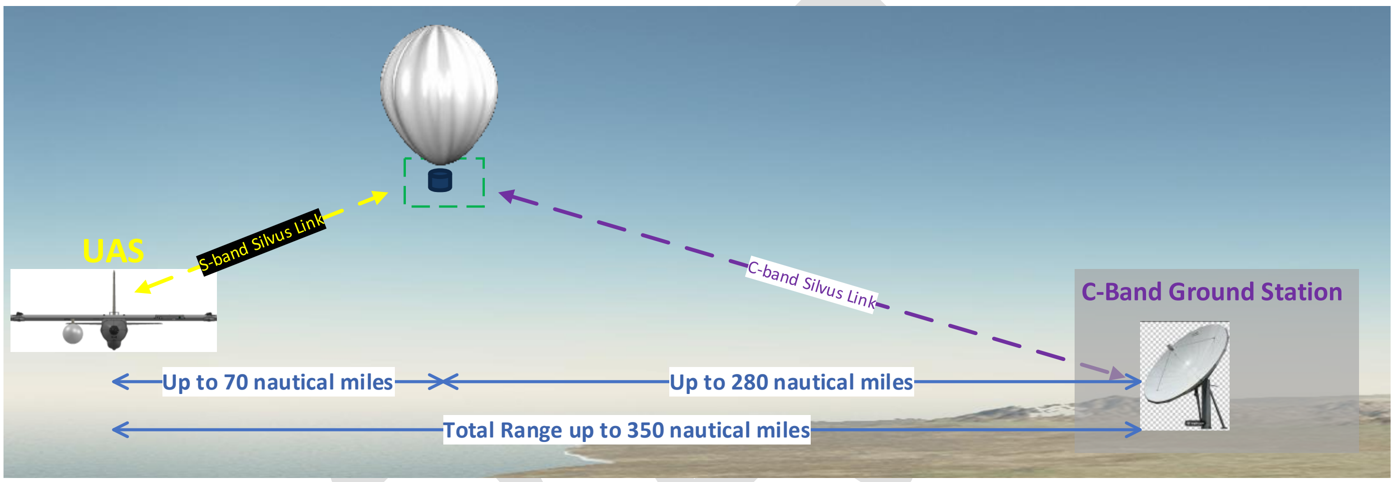


Figure 1: Basic description of the operations.

The C-band link to the ground station employs our standard C band LOS kit on the HAP and our standard C band ground station. These components are currently approved under an experimental license for our South Dakota location until October of 2024. Additionally, temporary (STA) approval for this will be required for our Stanley, New Mexico location. Since the details of the C band link are already known to the FCC and approved under an experimental license, this document does not go into additional detail describing the technical parameters for this link and instead will focus on the S band portion of the system.

The S-band link will be utilized for communications between the UAS and the HAP. The details of this link and its emitters will be described in subsequent sections of this document.

S BAND COMMS LINK

UAS COMMS CONFIGURATION

Fig. 2 shows a block diagram of the components used on the UAS side of the S band link. A structure like that shown in Fig. 2 will be mounted to the "top" of the UAS – so the antennas will have a view of the sky above them but will be shielded from direction of the ground below for typical flight attitudes of the UAS.

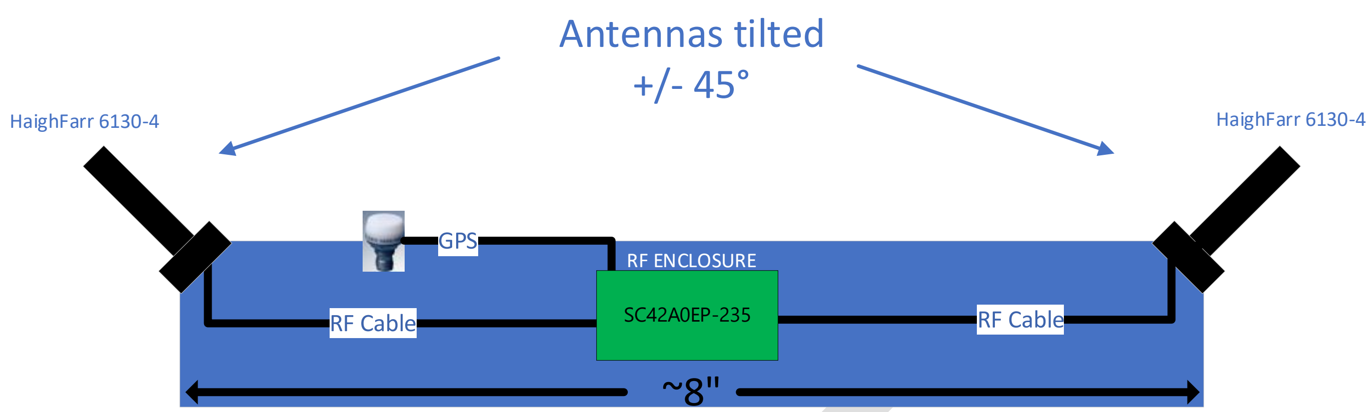


Figure 2: UAS S band comms configuration.

UAS RADIO:

The UAS will employ a 2 channel Silvus StreamCaster radio with the capability of transmitting up to 5 W per channel. The data sheet for this radio is included in the Appendix. No additional amplifiers will be included as part of this configuration.

UAS ANTENNA(S)

The antennas used on the UAS are rounded blade antennas manufactured by Haigh Farr, part # 6130-4. They provide a hemispherical coverage pattern that is omni-directional in the azimuth plane with a maximum gain of 5 dBi. These are linearly polarized and oriented orthogonally to each other to provide dual-polarization coverage: slant-left and slant-right. The elevation plane radiation pattern relative to the antenna orientation is shown in Fig. 3.

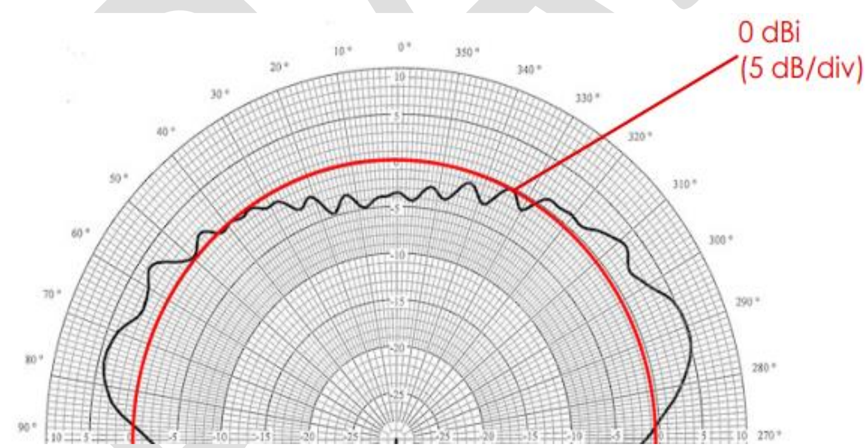


Figure 3: Haigh Farr 6130-4 elevation plane radiation pattern.

UAS COMMS PERFORMANCE

The maximum ERP for this transmitter configuration is 10.8 W but it must be noted that this is only in directions above the horizon of the UAS. Due to the hemispherical pattern shape of the blade antenna and shielding from the fuselage of the UAS only negligible radiation will be directed below the UAS toward the ground. Also, the altitude of the UAS will vary during the operation but will typically be 1000 feet or more above the ground providing additional isolation from this emitter and any receiver that might be located in its vicinity on the ground.

HAP COMMS CONFIGURATION

Fig. 4 shows a block diagram of the components used on the HAP side of the S band link along with a depiction of how the antenna is physically oriented underneath the balloon payload.

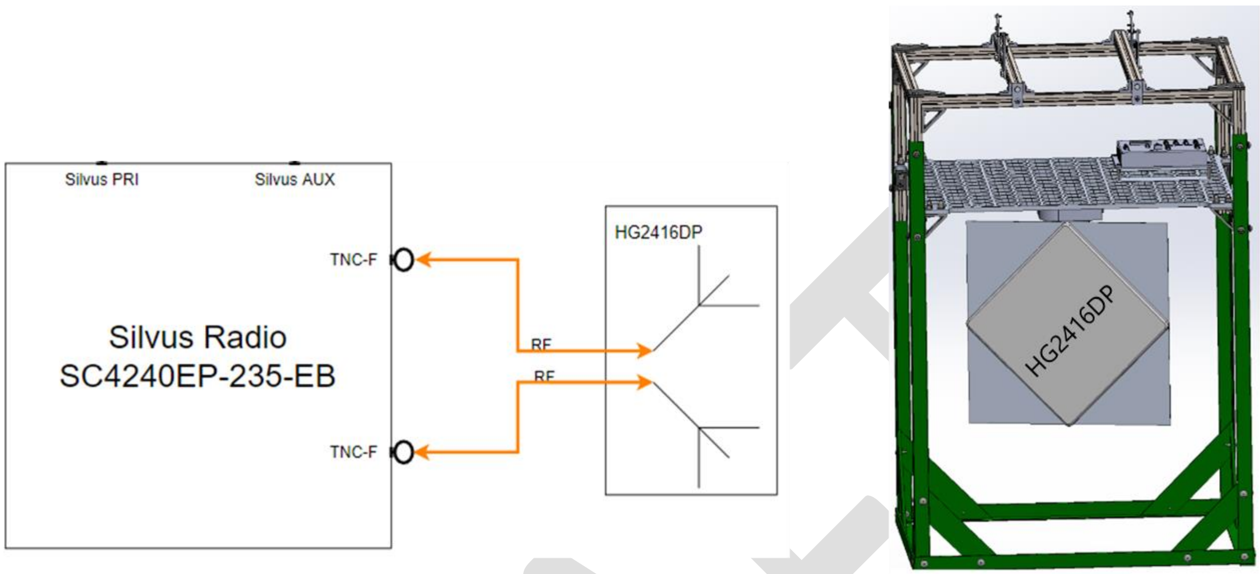


Figure 4: HAP S band comms configuration.

HAP RADIO:

The HAP will employ a 2 channel Silvus StreamCaster radio with the capability of transmitting up to 2 W per channel. The data sheet for this radio is included in the Appendix. No additional amplifiers will be included as part of this configuration.

HAP ANTENNA

The antenna used on the HAP is a directional, flat panel antenna sourced from L-COM – the part # isHG2416DP. The data sheet for this antenna is included in the appendix. Relevant RF specifications of this antenna are included in Table 1.

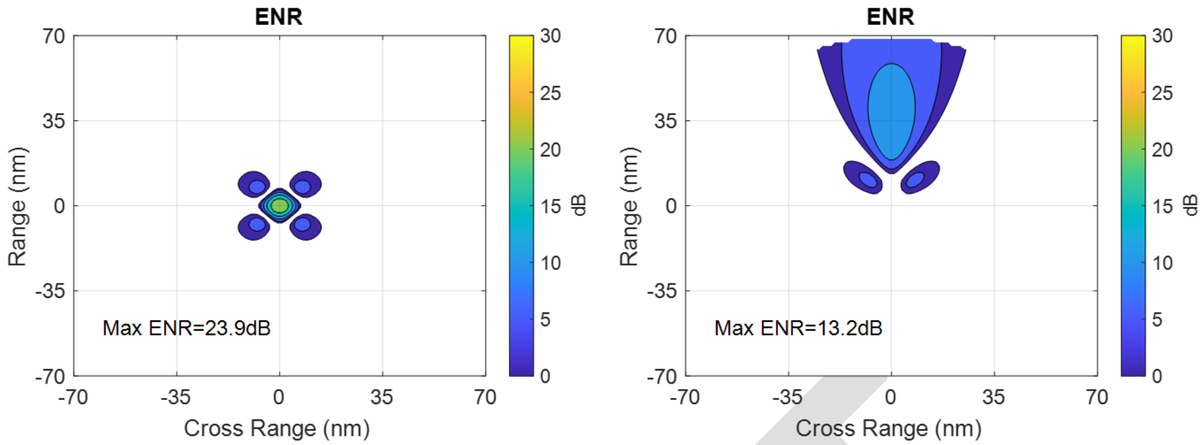
Table 1: Flat Panel Antenna RF Specifications

Gain	16 dBi
3 dB Beamwidth	34°/25° (H/V)

This antenna is dual-linearly polarized and will be oriented at a 45° tilt to provide slant-left and slant-right coverage. The antenna will be mechanically steered to point in the direction of the UAS.

HAP COMMS PERFORMANCE

The maximum ERP for this transmitter configuration is 54.6 W and this will be directed toward the UAS. The directive radiation pattern of this antenna will mitigate unwanted radiation in directions other than toward the UAS. This is illustrated by plots of Excess Noise Ratio (ENR) in Fig. 5. Here the ENR is the power received by an incidental S band receiver located on the ground compared to the thermal noise that would be present at such a receiver. For example, for an ENR<0 dB, the received power is actually less than the power of thermal noise at the receiver.



a.) Range to UAS=0 nautical miles

b.) Range to UAS=70 nautical miles

Figure 5: a.) ENR on the ground for the case where the UAS is directly underneath the HAP b.) ENR on the ground for the case where the UAS is 70 nautical miles away from the HAP

For the case of Fig. 5 a.) the UAS is located directly beneath the HAP so the antenna is pointed straight down. In this case, the spot beam of the antenna is readily apparent and only small portions of the ground underneath the antenna are illuminated with significant energy. The white space on the plot represents areas where the ENR is actually less than 0 dB and therefore the HAP-based transmitter would pose no threat to a receiver in those areas.

For the case of Fig. 5 b.) the UAS is located 70 nautical miles away from the HAP. Now, when examining the energy on the ground it appears less like a spot beam. That is because the antenna has been steered up to be pointed near the horizon – directing energy out toward the horizon. This results in a larger portion of the map being illuminated with energy exceeding ENR of 0 dB (i.e. energy is slightly above thermal noise). However, the max ENR levels are lower because of the additional propagation distance. In either case, since we are using an extremely conservative method of analysis (comparing to thermal noise levels) it should be concluded that this system would pose no significant threat to any ground based receivers in the vicinity.

S BAND CENTER FREQUENCY

Two center frequencies for S band operation (2.38 and 2.45 GHz) have been included in the application -though only 1 will be used at any given time. The ERP results discussed earlier will not vary significantly over this small frequency change.

APPENDIX

SILVUS STREAMCASTER DATA SHEET

StreamCaster-4200-SC4200-Enhanced-P

FLAT PANEL ANTENNA DATA SHEET

ds_HG2416DP (1).pdf