SyTech | White Paper

Establishing Beyond-Visual-Line-of-Sight Radio Communications for Uncrewed Flight Operations

Challenges and resolutions for connecting the remote pilot to the air, ground, and beyond.

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The RADIUS nPoint Network: Beyond Line-of-Sight Communications for Unmanned Flight

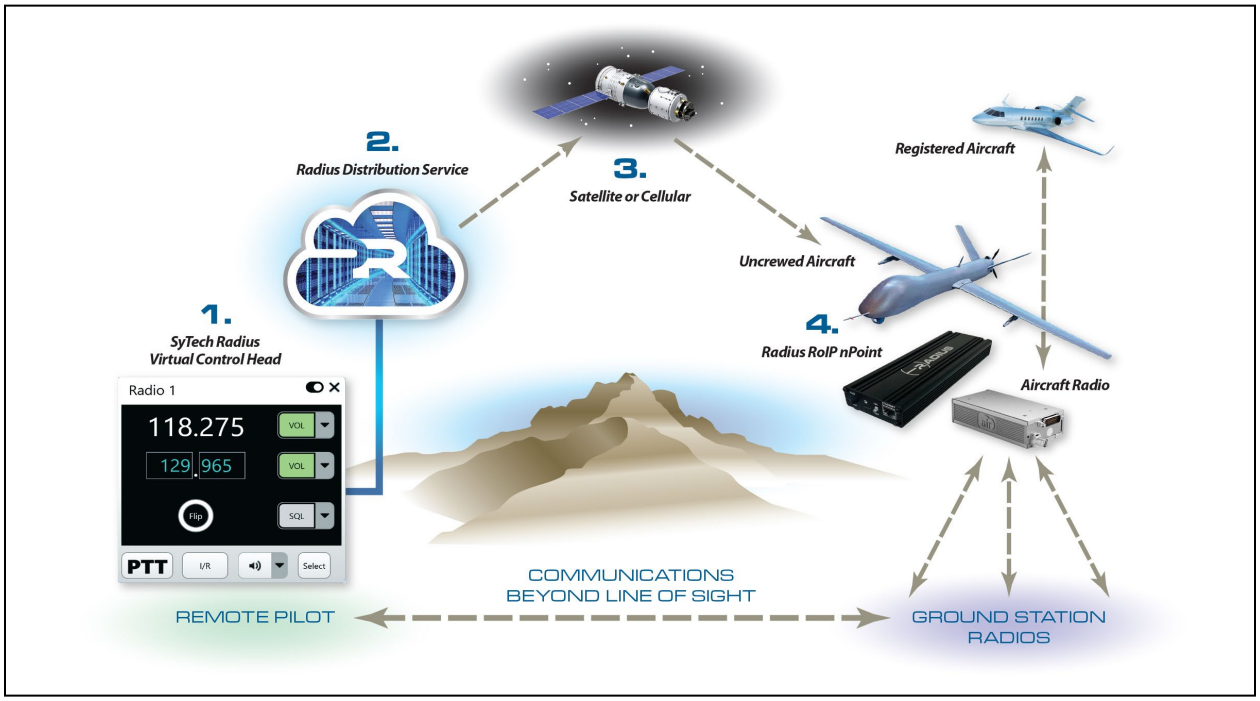
Leveraging SyTech RADIUS RoIP capabilities for Beyond-Line-of-Sight Radio Communications.

Unmanned aerial vehicles (UAVs) have revolutionized applications in defense, disaster response, agriculture, construction, maintenance, and photography. However, to meet Federal Aviation Administration (FAA) regulations, UAVs operating beyond visual line-of-sight must maintain radio communications with ground stations and registered aircraft while airborne. This can be a challenge, but beyond-visual-line-of-sight (BVLOS) radio communications offer a solution. In this white paper, we will explore how the SyTech RADIUS nPoint system is empowering unmanned aircraft to go beyond traditional limitations to expand the capabilities of unmanned aircraft.

Establishing BVLOS Radio Communications: Challenges and Resolutions

The SyTech Radius BVLOS Solution uses a combination of hardware and software to link the remote pilot to an uncrewed aircraft operating beyond line of sight. The diagram below illustrates the audio link from the remote pilot to the uncrewed aircraft, communicating with ground station radios and registered aircraft. To accomplish the link, the Radius BVLOS solution incorporates four key subsystems as shown in the diagram:

1. The Remote Pilot with Radius Virtual Control Head
2. The Radius Distribution Software
3. The IP Link
4. The Radius nPoint with VHF Radio



Establishing BVLOS communication for uncrewed aircraft involves multiple challenges. The process of linking a remote pilot to an unmanned aircraft operating beyond line of sight requires a solution that addresses the limitations while maximizing flexibility, ease of use for configuring the solution, and compliance with FAA regulations.

BVLOS Network Connectivity

There are two approaches to providing BVLOS network connectivity to uncrewed aircraft:

- Satellite communications: Advantages include reliability, vertical coverage, and generally accepted by authorities. Disadvantages include high usage cost, latency, and complexity of configuration.

- Cellular communications: Advantages include signal availability in populated areas, low usage cost, and easy configuration. Disadvantages include limited coverage in rural areas, susceptible to failure during emergencies, and generally not acceptable by authorities for long-term usage.

Although cellular communications can be a functional, low-cost alternative to satellite communications, this white paper will focus on satellite communications as the preferred approach to BVLOS.

Multiple challenges exist for establishing satellite communications for use with uncrewed aircraft. Although Starlink provides high-data, low-latency coverage, Starlink imposes an altitude governing system that limits operations for uncrewed aircraft (an existing solution exists for commercial aircraft). Furthermore, commercially available antennas may be too large for most UAS applications.

Conversely, Iridium Satellite Communications provides small, lightweight form factors that operate at all reasonable altitudes. Although latency differences are to be expected, with Starlink operating satellites as low as 340 km compared to Iridium's 780 km, Iridium's Certus line of satellite equipment is designed for UAS applications, meeting the required size, weight, and power requirements.

The proceeding challenge of implementing Iridium concerning BVLOS communications focuses on bandwidth, specifically when it comes to voice communications.

Latency and Buffering

The Federal Aviation Administration (FAA) has specific requirements regarding the latency of audio communications in aviation to ensure safety and effectiveness in air traffic control communications. The FAA recommends a best-practice end-to-end latency of 300 milliseconds for audio communications between aircraft and ground controllers.

The 300-millisecond recommendation for end-to-end audio is a lofty goal for BVLOS communications. SyTech has installed and supports BVLOS uncrewed aircraft with sub-second audio communications, such as the AiRanger uncrewed aircraft built by American Aerospace of Sterling, Virginia. As of the summer of 2023, American Aerospace has received a waiver from the FAA to proceed with BVLOS.

Multiple challenges exist to achieve 300-millisecond audio. These challenges include physical distance, the additional equipment required for BVLOS compared to traditional light-of-sight two-way radio, and audio buffering to overcome packet breakup.

For BVLOS audio to sound natural, the system must receive and reorder packets quickly. Moreover, the system must implement a codec to compress and decompress the audio to achieve minimal bandwidth usage. SyTech achieves sub-second audio by implementing multiple factors to overcome these limitations. For example, SyTech utilizes the OPUS codec to reduce bandwidth utilization to 9.6 kbps while buffering audio to achieve smooth, natural-sounding audio.

Size, Weight, and Power (SWaP)

Minimizing size, weight, and power (SWaP) in uncrewed aircraft is crucial for enhancing flight performance, operational efficiency, duration, cost efficiency, and versatility. To achieve BVLOS communications, an ultralight, low-power solution is required. For the VHF radio, SyTech implements the Air Avionics AC-1 radio. The AC-1 features dual watch, 8.33 kHz channel spacing at 6W transmit power. The radio without display, as shown, weighs 160 grams and measures 122 mm by 61.5 mm by 30.75 mm.

Air Avionics AC-1 VHF Radio

The SyTech Radius nPoint functions as an analog-to-IP network device. The currently available nPoint weighs 181 grams and measures 220 mm by 70 mm by 30 mm. SyTech plans to introduce a smaller, lighter nPoint directly compatible with the AC-1 in the third quarter of 2024.

The SyTech Radius nPoint and Air Avionics AC-1 VHF radio is the smallest, lightest radio/network device for BVLOS communications.

Remote Radio Control

A critical component to the success of BVLOS communications is the system's ability to access and control the onboard radio remotely. As uncrewed aircraft transits through different airspaces, changing radio frequencies to maintain communication with the appropriate air traffic control (ATC) centers or towers is crucial for safety and effective airspace management.

The Radius nPoint features a Linux-based ARM processor, which enables remote radio control with the SyTech Radius software. The Radius AC-1 Virtual Control Head allows dual channel receive with configurable channel promotion.

If ATC informs the remote pilot to change frequencies, the remote pilot can input a secondary frequency and, when ready, flip the frequency to become the primary frequency.

If the *physical* control head changes the radio frequency, the Radius virtual control head reflects the changes of the physical radio. The virtual control head allows for volume control of the primary and secondary channels, squelch level, instant recall, and enables a PTT trigger such as a keyboard hotkey.

Virtual Control Head for Air Avionics AC-1

Putting It All Together

System providers can overcome the unique challenges of the BVLOS by implementing the key features of the SyTech Radius BVLOS Solution. The following sections provide additional information on the technical aspects of the Radius BVLOS solution.

The Radius Distribution Service

The Radius Distribution Service (DS) functions as the radio-over-IP (RoIP) management software of the BVLOS solution. Built from the Linux kernel, the Radius operation system is designed to deliver secure, efficient RoIP and features the customizable capabilities critical to BVLOS. SyTech recommends that the Radius DS operate in the cloud to ensure optimal speeds and flexibility of configuration. The Radius Distribution Service is currently available on AWS and other cloud-based servers.

Radius nPoint

The Radius nPoint functions analog-to-digital radio interface gateway installed on the aircraft. The Radius nPoint physically connects to the airborne radio's auxiliary port, allowing for two-way transmit and receive capabilities. The nPoint runs on 5 volts DC, with a power draw of 300mA. Its small size and low power requirements make it ideal for use in UAVs.

Radius nPoint – Radio-to-IP Device

The nPoint receives radio audio and digitizes the reception. The nPoint utilizes an onboard Linux processor to compress the audio to 9.6 kbps. Audio is packaged as UDP, reducing bandwidth requirements over the satellite link. The audio is then transported through the aircraft modem, the satellite network, and to the Radius DS and Radius Virtual Control Head. SyTech's proprietary technology ensures clear, smooth audio at the operator locations in both transmitting and receiving from the remote pilot to the aircraft and from the ground station to the remote pilot.

The Radius nPoint offers the ability to communicate via RS-232 to the onboard radios, enabling remote radio control capabilities from the Radius Client. The resulting configuration allows the remote pilot to change frequencies as directed by ground control.

The Radius Client

The Radius Client functions as the graphical user interface for the Radius Network. The Radius Client offers easy-to-use features designed for radio-over-IP communications as well as advanced features for multi-operator dispatch and command and control.

The Radius Client features remote radio control for select radio models. The Radius Virtual Control Head (VCH) enables virtual radio control features such as channel and zone selection and other available radio functions.

The Radius Client provides a seamless communication experience for remote pilots, enabling them to operate UAVs from any location with an IP connection.

Conclusion

The SyTech RADIUS solution allows remote pilots to comply with FAA regulations while operating from any location with an IP connection. The BVLOS radio communications provided by the SyTech Radius solution enables clear, reliable communication between the ground station pilot and the airborne VHF radio.

Talk to SyTech today about your BVLOS requirements. You may reach us via email at Sales@SyTechCorp.com.