BRIDGING THE GAP: INTEGRATING THE RECCO R9 DETECTOR INTO SUAS FOR AERIAL AVALANCHE SEARCH

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ABSTRACT: The integration of the RECCO R9 detector onto a small Unmanned Aerial System (sUAS) offers a promising, force-multiplying tool to search and rescue teams. This technical presentation details the engineering challenges of the integration, primarily focusing on the mitigation of electromagnetic interference (EMI) from the sUAS powertrain and electronics to maintain an interference free environment for the R9's high receiver sensitivity. To ensure operational reliability, we developed a payload architecture which implements RF shielding so that the risk of distracting signal returns is mitigated. A key feature of this integration is the "dual-mode" feedback system: a new digital data bridge provides real-time signal visualization and GPS-tagging of detections, while the original analog audio feedback is preserved. This allows experienced rescuers to leverage their intuitive "search by ear" skills while benefiting from precise digital mapping of the debris field on the sUAS controller.

Operational analysis suggests that this sUAS-based platform occupies a unique niche between RECCO handheld detectors and helicopter-mounted systems. We will present data on search-speed efficiencies and signal resolution when operating at a variety of altitudes, particularly in terrain where secondary avalanche hazards limit ground access. By utilizing autonomous grid-pattern flight paths, the system ensures full coverage of an area, reducing human induced search pattern variation, and significantly decreases the time to cover avalanche debris, particularly crucial in emergencies where every minute counts. It is considered that this integration serves as a force multiplier, by providing high-resolution aerial search capabilities combined with the potential to be rapidly and remotely deployed by on-site responders, contributing to enhanced safety and efficacy of ground-based recovery teams.

KEYWORDS: sUAS, RECCO R9, Search and Rescue, Drone

1. INTRODUCTION

The survival probability of a buried avalanche victim drops as time goes on, making rapid search and rescue (SAR) response essential. Currently, search techniques utilize handheld RECCO detectors, and helicopter-mounted RECCO SAR units. While helicopter units cover vast areas rapidly, their deployment is constrained by high operational costs, delay in arrival time, and severe weather restrictions. Conversely, ground-based search teams face exposure to secondary avalanche hazards and reduced mobility in severe terrain and avalanche debris fields.

To bridge this operational gap, integrating the lightweight RECCO R9 detector onto a small Unmanned Aerial System (sUAS) (Figure 1) offers a rapidly deployable aerial search capability. Launched remotely by on-site responders, an sUAS-based detector can scan hazard zones without risking personnel. However, integrating high-sensitivity harmonic radar systems onto a drone platform presents significant technical challenges, primarily centered on the electromagnetic interference (EMI) generated by onboard electronics and other conductive components of the sUAS.

This presentation outlines the payload design, EMI mitigation techniques, signal architecture, and search methodologies developed to successfully operationalize the RECCO R9 on an sUAS platform.

Figure 1: RECCO R9 integrated onto a proprietary payload adapter mounted onto the underside of a drone.

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2. HARDWARE INTEGRATION AND EMI MITIGATION

2.1 Electromagnetic Interference (EMI) Mitigation

The RECCO system operates by transmitting a directional signal (~915 MHz or 868 MHz depending on region) and listening for the doubled harmonic frequency (~1.83 GHz or 1.73 GHz) reflected by passive transponders. Because the receiver is tuned to detect weak harmonic reflections, it is easily overwhelmed by ambient electromagnetic noise. Hardware like wires, connectors, and bolts can act as unintended antennas, while components like motors and circuit boards generate stray signals that flood the system with interference. To preserve the R9's native receiver sensitivity, a multi-layered RF shielding architecture was developed. In order to significantly attenuate the signal strength of the back lobes, a large metallic plate sits between the RECCO R9 and the drone. The shape and size of this plate was developed through expert knowledge, careful experimentation and meticulous testing and is integral to the noise-free performance of the system. On the top of the plate sits the communication interface, developed for audio processing and data transmission to the drone controller. The placement and shielding of this interface also required careful consideration and experimentation to prevent the excitement of the R9 receiver.

3. DUAL-MODE FEEDBACK ARCHITECTURE.

A core innovation of this system is the dual-mode feedback architecture, which maintains operational compatibility with established search protocols while introducing digital mapping capabilities.

3.1 Preserving Analog Audio

Experienced RECCO operators rely on their trained ears to determine the presence of a RECCO reflector. To maintain this intuitive skill set, the original analog audio output is captured via a high-quality analog-to-digital converter and streamed with ultra-low latency via a custom audio pipeline over the sUAS radio link directly to the GCS where the audio is played via integrated speakers or external Bluetooth audio devices.

3.2 Harmonic Return Mapping

In addition to being able to hear the RECCO search tone in its original form, the Drone Amplified Flight application (DA-Flight) provides additional visual feedback to the sUAS operator, with a live harmonic return mapping feature. With the careful combination of terrain data, precise tracking of the RECCO R9's position in space, careful characterization of the RECCO R9's radiation pattern, and some high-performance computing to process the analog signal, DA-Flight is able to paint a real-time heat-map, indicating the area covered by the system and highlighing areas of interest through color variation. (Figure 2).

Operators of all skill levels can leverage DA-Flight's harmonic return mapping feature as either the primary indicator of the presence of a reflector, or as a secondary indicator of search area coverage. The advantage of this system is that experienced RECCO users can continue to use their acquired skills (trained ears) to search, while inexperienced users can rely more on the mapping feature. The system supports efficient searching for both types of users, meaning rescuers have a more efficient RECCO search tool at their disposal.

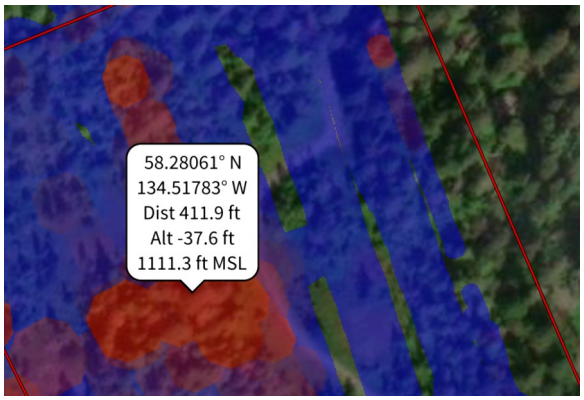

Figure 2: Heat-map generated by flying transects over a search area. Coordinates are easily extracted and can be communicated to rescuers.

4. SEARCH METHODOLOGY

In order to provide maximum flexibility to search and rescue professionals, the R9 sUAS integration is designed to facilitate manual, piloted searches as well as automated transect missions.

4.1 Piloted Searches

Situations in which search and rescue missions are taking place can be highly variable. A rescuer may desire to fly the sUAS along a known trail, or a rescuer may opt to use knowledge of lost person behavior to cover a particular stretch

of forest where a person is likely to end up. The RECCO sUAS integration provides rescuers the flexibility to pilot the sUAS by hand to target regions of interest and high probability of detection efficiently.

4.2 Automated Searches

For large search areas or situations were a more methodical transect search is desired, rescuers can utilize DA-Flight to send the drone on an automated transect mission, ensuring that the entire search area is completely covered. As the mission is being completed, a heatmap showing where the RECCO R9 indicates returns is generated, giving rescuers coordinates of interest to deploy ground-based rescue crews to complete the rescue. A second transect mission executed over the same area with the sUAS oriented 90 degrees offset from the first ensures that reflector orientation doesn't create a situation where a reflector is missed due to sub-optimal polarization. Automated flights can be taken over by the pilot at any time allowing for maximum flexibility and the ability to quickly determine locations to investigate further.

5. DISCUSSION

The operational niche filled by an sUAS-mounted RECCO R9 detector creates a potential search efficency increase for search teams. While handheld units require physical foot travel through hazardous, rough and potentially unstable snowpacks, and helicopter-mounted systems require favorable weather and time to deploy at considerable expense, we consider the sUAS platform acts as a rapid-response force multiplier.

5.1 Advantages

- Safety: Potentially reduces exposure of human rescuers to secondary avalanches and dangerous terrain.
- Speed: Provides the ability to begin the process of finding regions of interest while ground crews are still heading to the scene and offers the ability to cover complex terrain quickly from the air.
- Familiarity: It retains the same RECCO R9 tool SAR crews are used to, but with more efficient application from the air.

Having the trusted and familiar RECCO R9 detector mounted on a reliable, high-speed and stable sUAS platform, combined with our intuitive digital geospatial mapping system provides teams with an additional tool which can be used to reduce rescuers' risk exposure and increase effectiveness.

5.2 Future Work and Improvement

- Strategy: We are working with rescuers to develop more comprehensive strategic guidelines for making searches as fast and comprehensive as possible.
- Data visualization: Improved visualization of the projected heatmap and continued development of innovative ways to give rescuers situational awareness.
- Ease of use: Improvement of the mission planning interface to make it even easier to plan automated searches.

6. CONCLUSION

Integrating the RECCO R9 detector onto an sUAS platform can improve the speed, safety and efficiency of the RECCO search in an avalanche situation. By effectively mitigating onboard EMI, preserving raw analog audio, and integrating real-time digital detection mapping, this system provides high-resolution aerial search capabilities that enhance ground recovery efforts and may ultimately save more lives in time-sensitive emergencies.

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