High Altitude Relay and Router

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Introduction: The Satellite and Wireless Networking Section of NRL's Transmission Technology Branch has been tasked with determining the feasibility of the use/development of communications relays held aloft by balloons at high altitude (~65,000 ft above mean sea level, or MSL). The objective of this High Altitude Relay and Router (HARR) program is to extend the range of line-of-sight (LOS) communication links, particularly those compromised by terrain. The HARR project objectives are to

- develop payloads capable of doing on-board routing of network traffic between multiple ground nodes within and out of line-of-sight, and
- develop payloads capable of extending tactical communications in the UHF band for both data and voice communications for point-to-point links.

NRL has developed two candidate relay platforms. The first operates in L-band using the 802.11b protocol, and incorporates a router in the sky that can direct traffic from ground site to ground site, either directly or via another balloon-based relay. Converter/amplifiers allow these routers and associated ground terminals to operate at ranges exceeding 100 miles.

The second payload simulates a UHF FLTSAT payload, providing 25-kHz "bent-pipe" relays that can operate at SATCOM channels or LOS channels, transponding the signal to avoid self-interference. Voice at 240 miles and data at 80 miles were demonstrated using legacy UHF military systems.

The payloads were integrated with a telemetry package developed by the Air Force Research Laboratory (AFRL) of Kirtland AFB, NM. Two sets of launch testing were conducted, the first in Roswell, NM, in November 2005, and the second outside of Lubbock, TX, in June 2006. At each location, testing took place over an approximate 100 mile range and took advantage of the prevailing seasonal winds at 65,000 ft. The launch of the entire package is shown in Fig. 1. The payload shown has a UHF package with dual antennas.

Payload 1: UHF Transponder: The UHF transponder was tested using standard military radio sets: the AN/PRC-117F, and the standard Navy UHF radio, the AN/WSC-3 transceiver. Testing in Roswell focused on voice communications, achieving links between PRC-117F radios at 245 miles. Data communication was also successful with both radio sets, but over a more limited range.

In the second phase of testing in Lubbock, the emphasis was more on data throughput and performance as a function of slant range to the relay. Data sets were collected for the 117F operating in IP mode at slant ranges up to 80 miles, for both directional and omni-directional antennas (as shown in Fig. 2), and for uni-directional data using satellite modems at slant ranges up to 40 miles.

A dual transponder design was also tested on one of the launches in Lubbock, with each channel sharing the same antennas. This was to validate the design for the future payload, which will accommodate up to four channels simultaneously. Both channels were occupied simultaneously with digital waveforms, resulting in good performance and no interference issues, regardless of mode of operation.

Data throughputs for the PRC-117F radios were 9600 bps maximum, due to limitations in the radio's IP

FIGURE 1
Launching of NRL payload by AFRL personnel in Roswell, NM, November 2005.

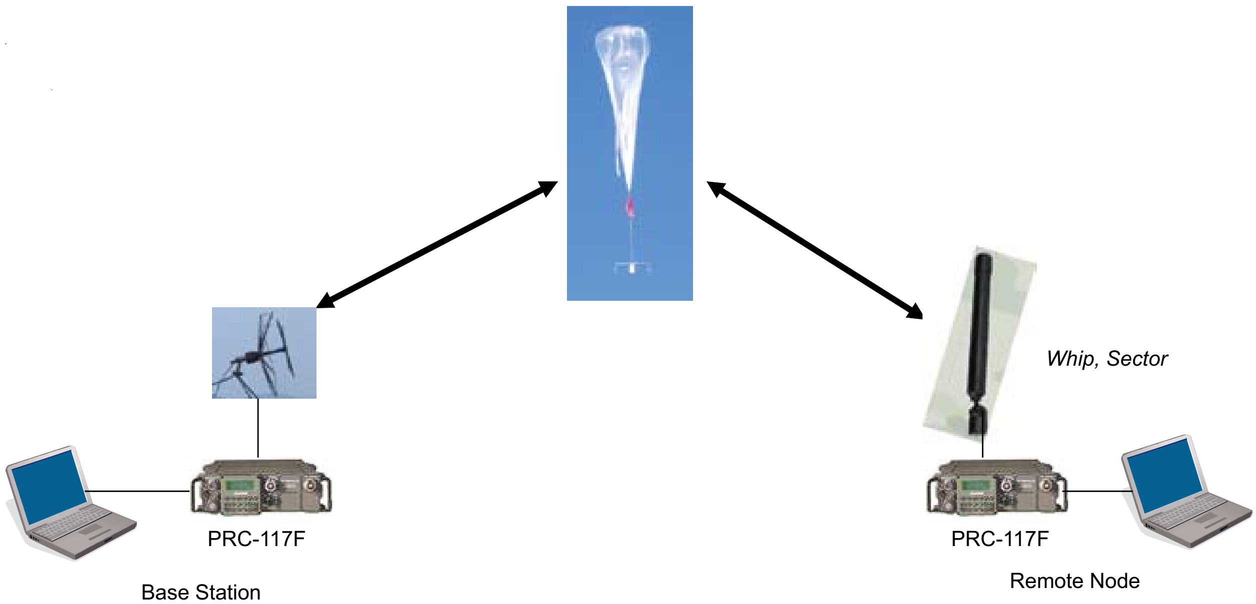

FIGURE 2
Test configuration, UHF high altitude transponder.

implementation, while 19.2 kbps were achieved using the WSC-3 radios in simplex mode.

Payload 2: 802.11b Transponder: The 802.11b payload was a Linux-based router in a hardened PC104 platform that was programmed by NRL to route information according to the destination, accommodating both unicast and multicast traffic. NRL commissioned Shireen, Inc., to build a set of amplifiers that would also do frequency translation of the standard 802.11b waveform to a frequency band near 1.8 GHz. These lightweight amplifiers were first successfully demonstrated in Roswell, and supported three very successful flight tests in Lubbock.

During the 802.11b testing, ground nodes were set no more than 30 miles apart. Data was taken during the entire duration of each flight, with a maximum slant range of 130 miles achieved. Data was collected in the form of UDP packets, utilizing NRL's Multi-Generation Tool Kit (MGEN).

Testing encompassed a number of scenarios: multicast and unicast traffic, uni-directional and bi-directional, all with two and three ground nodes in the network. An example of one test is illustrated in Fig. 3.

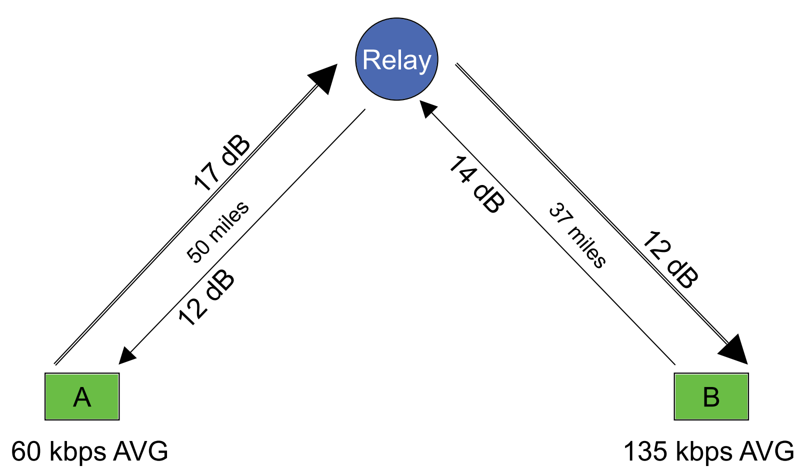

FIGURE 3
Example of 802.11b relay/router testing for two nodes conducting bi-directional multicast. The S/N ratios (expressed in dB) were collected at the receive point at each node in the link.

Scripts were generated to fill the path with as much data as possible, and the signal-to-noise ratio (S/N) was measured at each receive point to correlate networked performance with RF performance.

Conclusion: NRL has successfully demonstrated two communications payloads borne aloft by a high altitude balloon, one a UHF relay, the other a router in the sky operating with the 802.11b waveform. Each of these payloads can interface immediately or with minimal hardware investment with existing tactical communications in the fleet and Marine Corps ground units. The High Altitude Relay and Router can provide a line-of-sight extension of over 100 miles to existing tactical communications for periods in excess of ten hours as currently designed.

Future efforts will involve performance improvements, miniaturization of the payloads, and testing of multiple common applications.

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