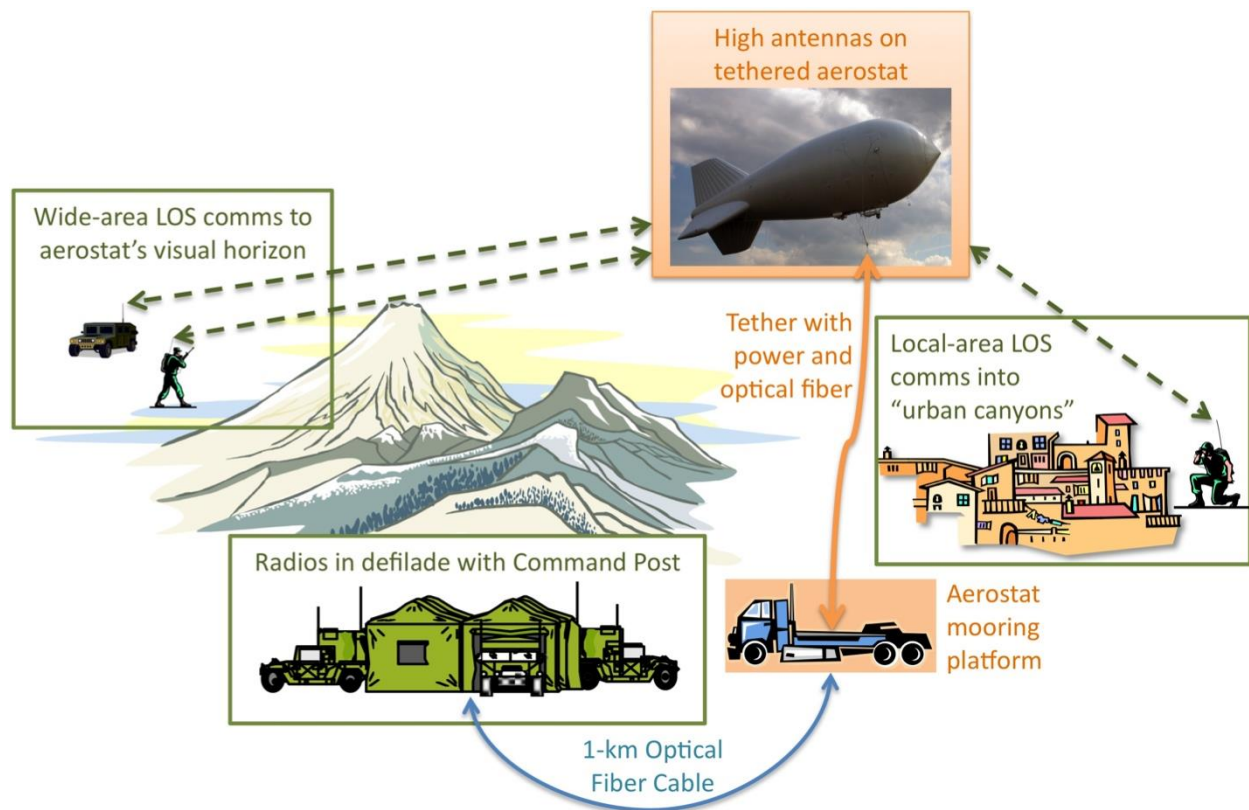


Communications Range Extension using “High Antennas for Radio Communications” (HARC)

Deploy inexpensive, persistent extended-range radio communications over long distances and high terrain using a balloon, tethered drone, aerostat, or tower.

HARC enables extended-range tactical, emergency, and disaster recovery communications.



June 2020

••• This White Paper is Approved for Public Release •••

1. FORAX-HARC Overview

The FORAX-HARC system enables persistent, inexpensive wide-area communications using balloons, aerostats or towers.

This White Paper explains how the FORAX-HARC* system enables any tethered balloon, tethered aerostat, or tall tower to provide extended-range radio communications over long distances and high terrain. The FORAX-HARC system enhances inexpensive, persistent:

- Tactical communications range extension
- Wide-area emergency communications
- Wide area disaster recovery communications.

Commanders can communicate out to the HARC antennas’ visual horizon — a range up to 130-km (80-mi) for an antenna 1000-m (3300-ft) above ground level — and talk over high terrain and down into valleys that are otherwise denied line-of-sight communications. Radio relay links can operate with the radios safely in the command post; only the antennas are on the high platform.



FORAX-HARC works with most modern radios used by military or civilian communicators. Multiple radios on the ground share one optical fiber that connects the radios in the command post to their antennas high overhead. The FORAX-HARC system has two major components:

- **A ground-based Radio Interface Unit (RIU)** is collocated with the radios in the command post.
- **A lightweight Antenna Interface Unit (AIU)** is installed on the airborne platform or tower top along with lightweight antennas, also supplied by Syntonic. An optical fiber runs from the RIU to the AIU, usually via the balloon’s or aerostat’s tether.

HARC systems have been deployed forward since 2009 and HARC systems are being deployed in quantity by the U.S. Army. Most radios and modern waveforms are supported, including:

- Voice and data using conventional or trunking public safety and P25 Land Mobile Radios
- Voice and data using ANW2, WNW, SRW, EPLRS, LOS or SINCGARS†
- Voice and data using 3GPP over cellular telephone radios.

* *Fiber Optic Remote Antenna eXtension (FORAX) — High Antennas for Radio Communications (HARC)*

† *Advanced Networking Wideband Waveform (ANW2); Wideband Networking Waveform (WNW); Soldier Radio Waveform (SRW); Enhanced Position Location Reporting System (EPLRS); Line of Sight (LOS); Single Channel Ground and Airborne Radio System (SINCGARS); 3rd Generation Partnership Project (3GPP)*

1.1. General FORAX Features and Benefits

HARC uses Syntonics’ proven FORAX™ RF-over-Fiber technology. FORAX systems are deployed around the world in mission-critical applications to enable users to position their radios without regard to the antenna location. For example:

- FORAX connects distant antennas to radios inside a Secure Compartmented Information Facility (SCIF), penetrating the SCIF perimeter with benign optical fibers.
- FORAX moves highly visible, emanating antennas — “aiming stakes” for an enemy — away from the command post (CP), reducing radiating emissions and enhancing the electronic covertness and survivability of the CP.

FORAX improves survivability because antennas can be positioned away from the CP. This decreases risk to personnel and costly equipment, decreases time for CP set-up, and lowers maintenance reaction time. FORAX can play a vital role in Operations Centers of all sizes and in other tactical and air traffic control programs. Initially developed for the U.S. Special Operations Command, FORAX features and benefits are highlighted in Figure 1-1.

Figure 1-1. FORAX Features and Benefits

Feature	Benefit
Long Connections	• Radio and its antenna can be located up to 10-km apart using single mode fiber; greater distances are possible.
Easy Routing	• RF signals are carried on lightweight, flexible, rugged, optical cables • Multiple radios can be carried on a single fiber optic cable • FORAX components are available in standard 19-in rack-mount configurations • Geographic diversity in RF signal routing becomes easy
All frequencies, all modulations	• FORAX™ products handle all modulations including HF SSB, VHF and UHF LOS, SINGARS, ANW2, SRW, WNW, UHF MILSATCOM, EPLRS
Radio security	• Controlled cryptographic items stay secure in the command post, convenient to the operator.
EMP/EMI Immunity	• Lightning, electromagnetic pulses, or RF interference cannot propagate over, or influence the signals on, optical fiber cables • Radio equipment is opto-isolated from antenna

1.2. FORAX-HARC Features and Benefits

Evolved from Syntonics’ proven FORAX™ RF-over-Fiber technology, FORAX-HARC creates an inexpensive, persistent communications range extension capability using tethered balloons, tethered aerostats, or tall towers. HARC dramatically improves radio coverage, radio network performance, and radio security:

- Prototype six-radio HARC systems have operating in Iraq and Afghanistan since 2010
- HARC was just recommended for fielding by NIE 12.1
- A large quantity of six-radio HARC systems are being deployed forward by the U.S. Army
- Lightweight 1- and 3-radio systems are available for balloons, small aerostats and tower tops.

Figure 1-2 summarizes the features, advantages and benefits of HARC.

Figure 1-2. Summary of HARC features, advantages and benefits

Feature	Advantage	Benefit
<ul style="list-style-type: none"> Lightweight FORAX-HARC payloads “piggyback” on balloons, aerostats or towers 	<ul style="list-style-type: none"> Minimizes operating costs Maximizes availability 	<ul style="list-style-type: none"> Implements large portions of a persistent “aerial layer” of network comms at lowest operational cost
<ul style="list-style-type: none"> Radios stay on the ground in the command post 	<ul style="list-style-type: none"> Maximizes radio security, convenience 	<ul style="list-style-type: none"> Minimizes risk of losing crypto assets Minimizes time to adjust/key/repair radios
<ul style="list-style-type: none"> Distant radios can connect directly to the radio on the ground at the command post 	<ul style="list-style-type: none"> Maximizes data rates by eliminating a network hop 	<ul style="list-style-type: none"> No high relay radio necessary above each command post
<ul style="list-style-type: none"> Provides Beyond Line-of-Sight (BLOS) communications to a command post 	<ul style="list-style-type: none"> Offloads tactical SATCOM requirements 	<ul style="list-style-type: none"> Adds BLOS range extension communication options Reduces tactical SATCOM congestion
<ul style="list-style-type: none"> HARC airborne weight is less than equivalent airborne radios HARC antennas mitigate co-site interference 	<ul style="list-style-type: none"> Minimizes payload weight while maximizing RF performance 	<ul style="list-style-type: none"> Enables radio relays from weight-constrained balloons, aerostats and tower tops

A large quantity of six-radio HARC systems, each handling four low VHF and two UHF radios, has been delivered to the U.S. Army. Figure 1-3 presents a notional system diagram of this HARC-4S2E system. Figure 1-4 shows the HARC-4S2E electronics (antennas not shown).

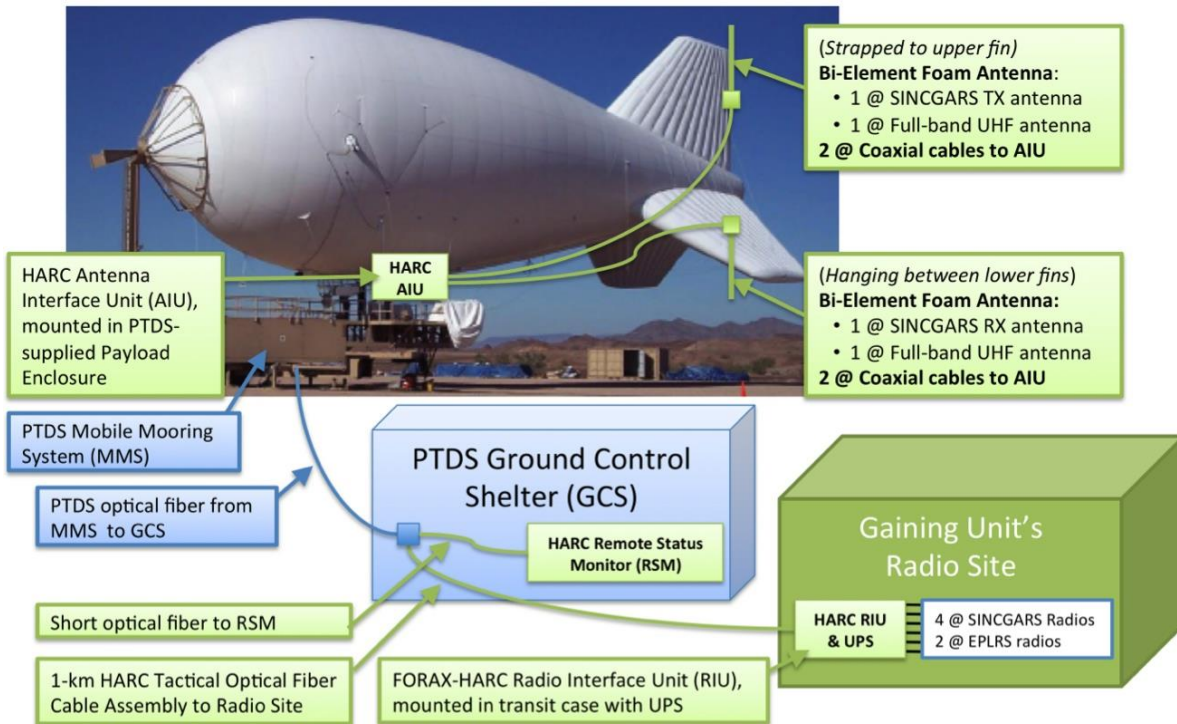


Figure 1-3. Notional system diagram of six-radio HARC system

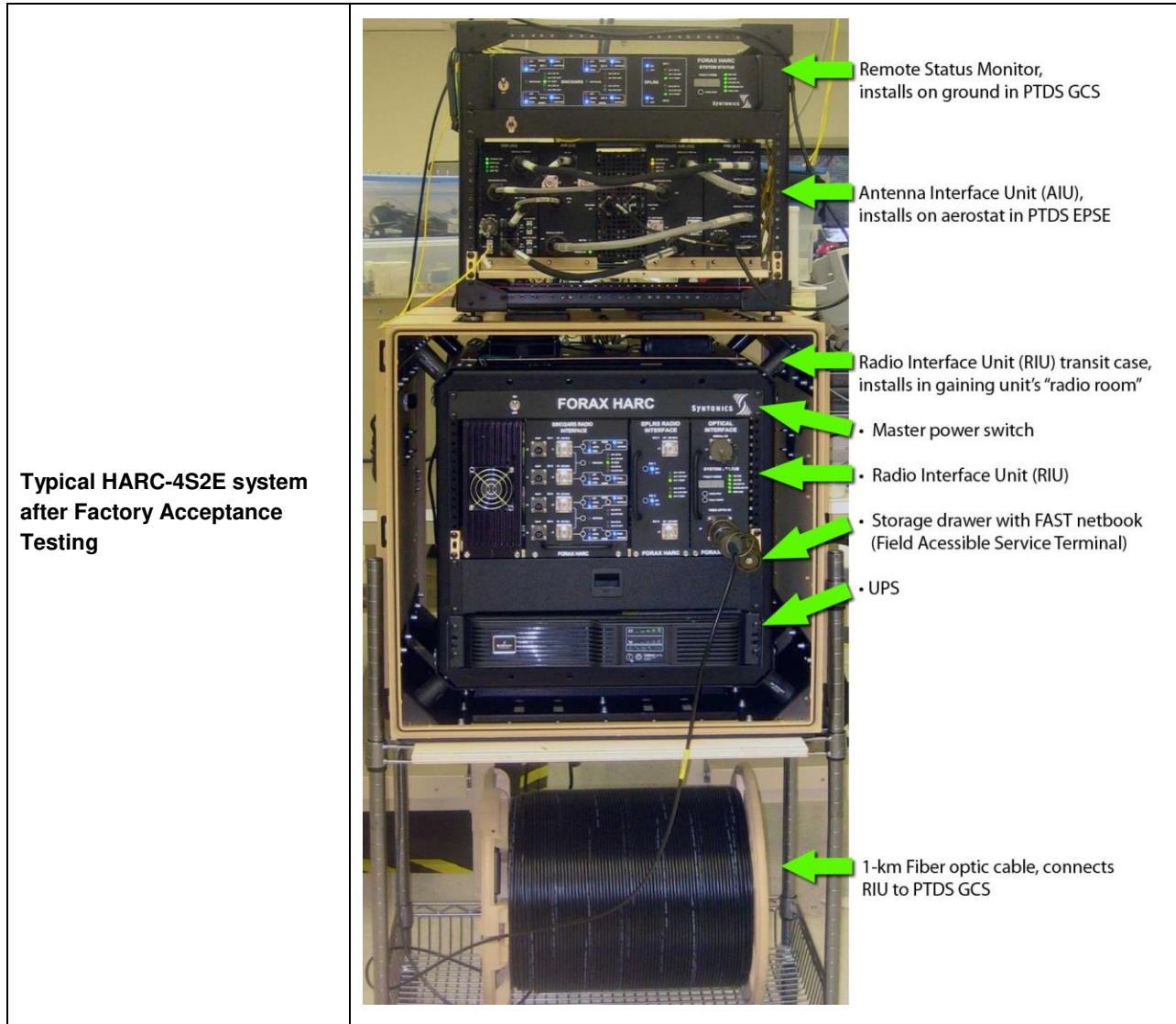
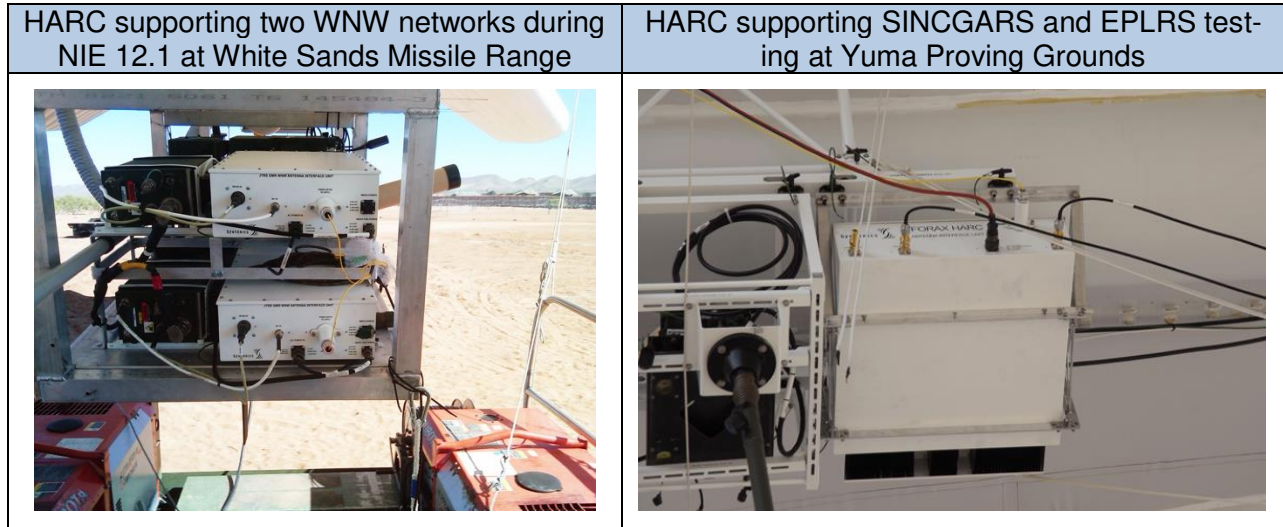


Figure 1-4. HARC-4S2E Electronics (antennas not shown)

Lightweight 1- and 3-radio HARC systems are available for balloons, small aerostats and tower tops. Figure 1-5 shows two of these lightweight systems installed on different aerostats during field tests. The HARC-WNW system was evaluated by NIE 12.1 and recommended for fielding. The HARC-2S1U system handles two low VHF (SINCGARS) radios and one UHF radio operating with waveforms including ANW2 and SRW.

Figure 1-5. HARC AIUs installed on aerostats



1.3. Conclusion

Any balloon, aerostat or tower can provide extended range radio comms over long distances and high terrain. Communication and relay links can operate with the radios safely in the command post; only the antennas are lofted on the high-flying platform.

With a lightweight FORAX-HARC payload, an aerostat can be used for tactical communications, emergency communications and disaster recovery, and military exercises. Using HARC, commanders can communicate out to the aerostat’s visual horizon and talk down into “urban canyons” and valleys that are otherwise denied line-of-sight ground communications.

2. Syntonics LLC

Syntonics develops innovative RF communications equipment that meets unique requirements.

Syntonics (www.SyntonicsCorp.com) is an engineering-driven technology company that designs, develops, and manufactures specialty RF communications equipment. Most Syntonics products trace their origins to a communication technology project originally sponsored by the U.S. Department of Defense.

Founded in 1999 and based in Columbia MD, Syntonics is a well-qualified supplier of radio communications accessories:

- Quality Management System registered to ISO 9001-2008.
- Cyber security conforming to NIST 800-171.
- Cost accounting system approved by the Defense Contracts Audit Agency (DCAA).
- Security clearances by the Defense Counterintelligence and Security Agency (DCSA).
- Traditional COMSEC account by the National Security Agency (NSA).

Since developing the first FORAX systems for a U.S. military sponsor, Syntonics has continued to develop the technology and expand the FORAX and FORAX-HARC product lines. FORAX now meets the tactical and operational needs of a wide range of military and “first responder” communicators. FORAX™ RF-over-fiber communication systems have been installed around the world in mission-critical 24x7 operations since 2005.



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