MODERNIZING THE REMOTE TRACKING STATION

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ABSTRACT

Since the inception of the Air Force Satellite Control Network (AFSCN) in the late 1950s, capabilities of the network's Remote Tracking Stations (RTSs) were evolutionarily developed to meet satellite Tracking, Telemetry, and Commanding (TT&C) needs. The result, although fully satisfactory operationally, was an RTS network requiring manpower-intensive mission support. Additionally, reconfiguration of an RTS between satellite contacts consumed far more time than was operationally desirable as demands for RTS contact support continued to grow.

To improve network responsiveness and cost effectiveness, the Air Force undertook, in the mid-1980s, a major "block upgrade" under the Automated Remote Tracking Station (ARTS) Program. This paper traces historical RTS capabilities, identifies emerging mid-1980s RTS support requirements, and defines the operational and financial advantages accruing to the Air Force through ARTS implementation to meet those requirements. Possible future upgrades to further enhance AFSCN TT&C mission capability are also briefly discussed.

RTS CAPABILITIES CIRCA 1983

In 1983, the RTS network consisted of 12 tracking stations at 7 geographic locations, plus 2 vehicle checkout facilities. As shown in Figure 1, these were the Guam Tracking Station (GTS; comprised of two collocated stations or "sides"); Hawaii Tracking Station (HTS; 2 sides); Vandenberg Tracking Station, CA (VTS; 2 sides); New Hampshire Tracking Station (NHS; 2 sides); Thule Tracking Station, Greenland (TTS; 2 sides); Tracking and Command Station, England (TCS); Indian Ocean Station, Republic of Seychelles (IOS); Eastern Vehicle Checkout Facility (EVCF), Cape Canaveral, FL; and Western Vehicle Checkout Facility (WVCF), Vandenberg AFB, CA.

The fundamental requirement influencing development of the RTS network was that all stations had to be capable of supporting the TT&C needs of the complete family of DOD spacecraft. Because each new satellite program tended to levy at least some unique requirements on the AFSCN, the result was a multiplicity of different uplink/downlink configurations at the RTSs.

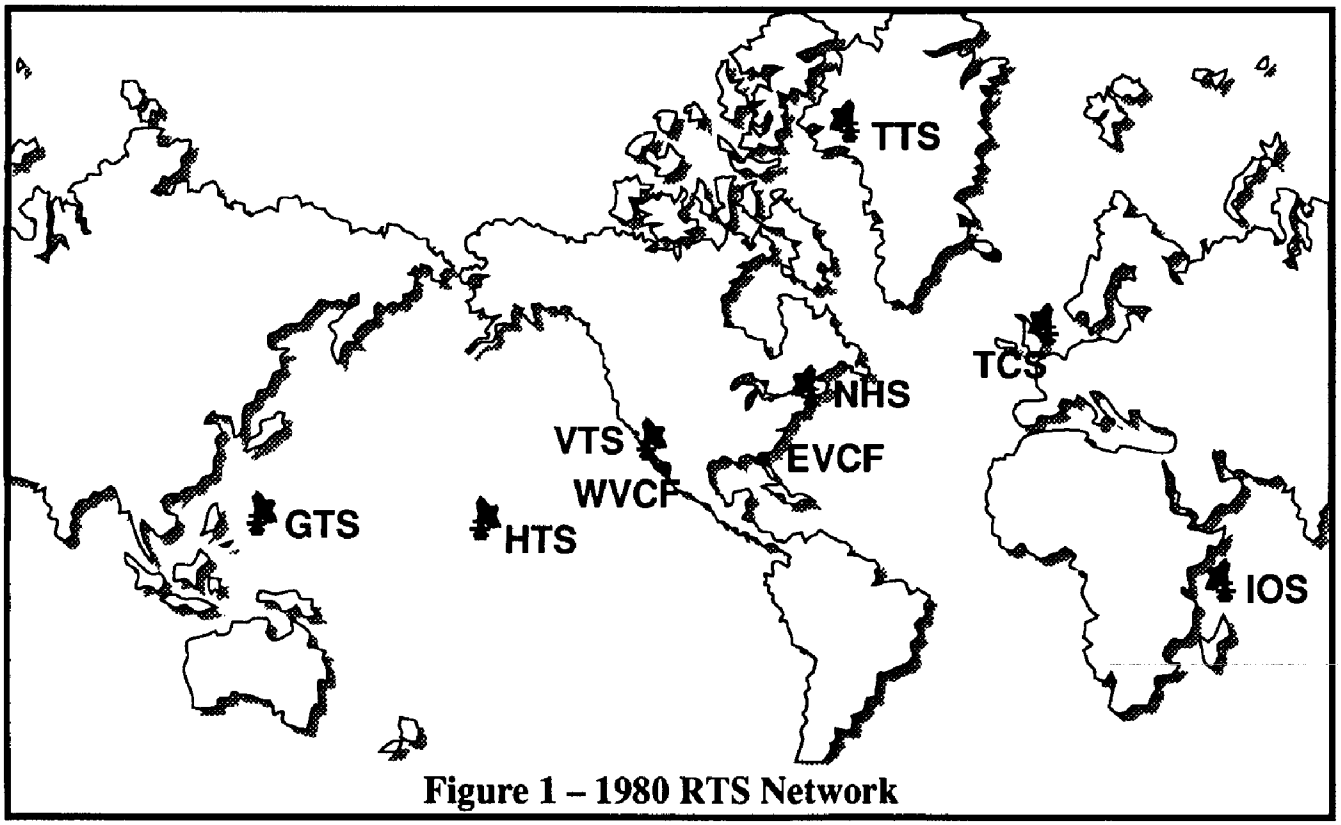

Figure 1 – 1980 RTS Network

Additionally, some satellite programs chose to incorporate program-unique capabilities at only some RTSs to complement dedicated program ground assets — for example, DMSP mission data support at HTS. Finally, modifications to support new programs had to be added without significant operational downtime, precluding "block changes" to the network. The resultant RTS technical configuration included a large number of manual patch and control panels, many of which had to be changed between each satellite contact. RTS operations were therefore manpower-intensive (nine technicians per RTS side). Average reconfiguration time between satellite contacts was approximately 20 minutes; given an average contact time of 15 minutes, each RTS side could support a theoretical maximum of 40 to 45 contacts per day. When adjusted for station downtime (e.g., for scheduled/unscheduled maintenance or modifications) and for some longer contact periods, actual network experience was 22 to 25 contacts per day per site side. The 12-RTS side AFSCN could thus be considered saturated at as many as 95,000 contacts per year, which was its actual support load in 1982.

KEY ARTS REQUIREMENTS OVERVIEW

A principal driver for major RTS modernization was the need for significantly increased AFSCN contact capacity. As shown in Figure 2, worst-case AFSCN contact saturation had been approached in 1982; despite a decrease in network loading in 1983, a conservative 5% projected annual increase in contacts implied significant support problems by 1987.

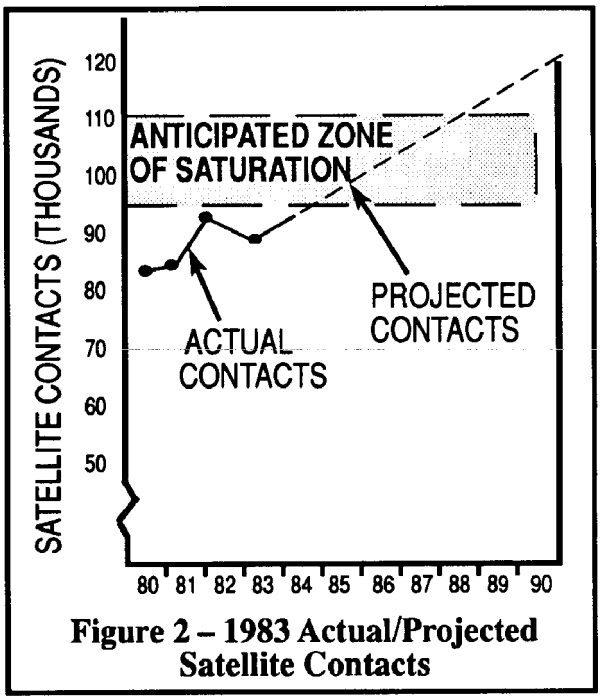

Figure 2 – 1983 Actual/Projected Satellite Contacts

While simple proliferation of existing-technology RTSs could provide temporary relief for capacity problems, using modem technology to reduce reconfiguration time offered a far more attractive long-term solution. A modernized station would also provide substantially improved reliability and reduced mean time to repair, further increasing overall network capacity.

A second objective of the modernization program was reduction of the number of personnel required to operate the RTS. The ARTS design objective was operation by 3 technicians (versus the 9 needed for the 1980 RTS); a life-cycle-cost goal was recovery of investment cost over a 15-year life cycle following ARTS activation throughout the network.

Implementation of site-unique special support capabilities (e.g., the ability to function as a Global Positioning System Ground Antenna) was a third category of key ARTS requirements. Such capabilities were to be added to specific sites as "enhancements," which did not invade (in a hardware or software sense) the core TT&C system of the station. A successful ARTS design would therefore allow further modular expansion to meet new special requirements at a site without causing the core TT&C configuration of that site to diverge from that of the remainder of the network. In addition, ARTS enhancements had to provide the appropriate hardware/software interfaces to ensure transparency of support to the user; for example, a GPS mission controller would perform exactly the same commanding functions in using an ARTS GPS enhancement as would be performed in using a dedicated GPS ground antenna.

ARTS IMPLEMENTATION

The ARTS Program was planned and implemented in two phases. Under the ARTS Acquisition I contract, awarded to Loral Space & Range Systems in mid-1984, the ARTS core design was completed and four systems were built. Three were complete new tracking stations, including a 10-meter antenna and radome, which were activated at the Colorado Tracking Station (CTS), pictured in Figure 3, near Colorado Springs; at TTS; and at TCS. These RTSs are now fully operational. The fourth system, termed the ARTS Development and Modification Facility, is used for continuing hardware/software development and training.

ARTS Acquisition II, the ARTS production contract, was awarded to Loral Space & Range Systems in August 1988. This contract, scheduled to be completed in 1993, provides 1 new 10-meter tracking station on the island of Diego Garcia (DGS); 10 ARTS cores to replace existing RTS equipment (one side of TTS and TCS are not currently scheduled for replacement); 2 additional ARTS cores, without antennas, to be used as ARTS EVCF and WVCF assets; and core retrofits to the 4 Acquisition I systems. To date, Acquisition II has completed installations at DGS, HTS-B, NHS-B, and VTS-B ahead of schedule. Figure 4 is the planned schedule for the remainder of Acquisition II.

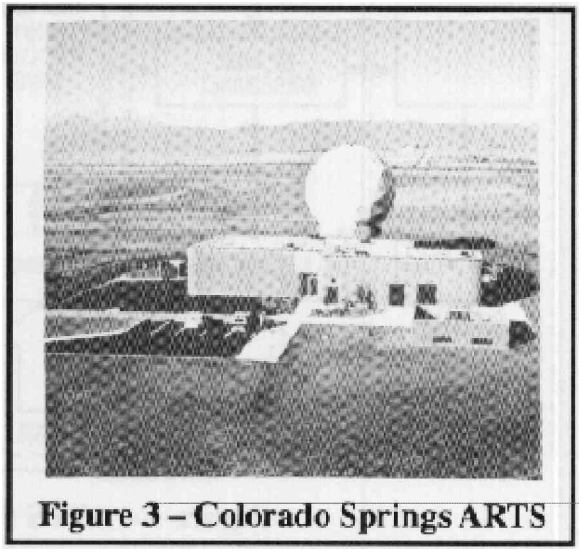

Figure 3 – Colorado Springs ARTS

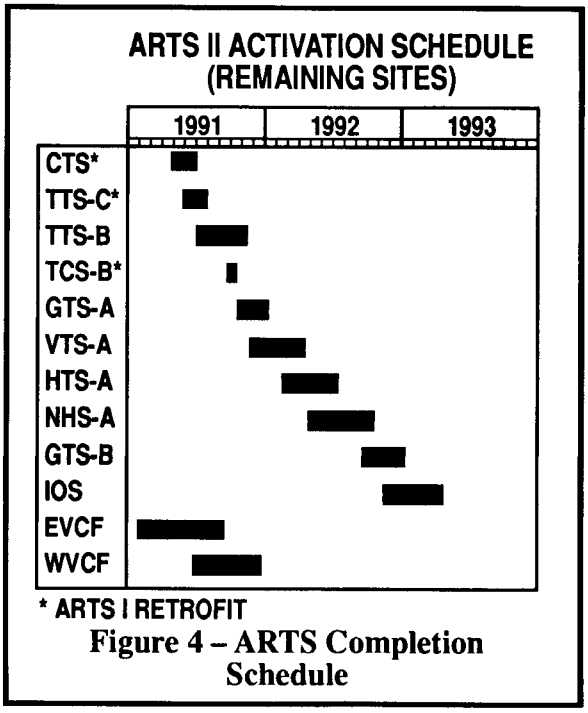

Figure 4 – ARTS Completion Schedule

Figure 5 is a simplified diagram of an ARTS, which includes an antenna, a core, site-specific enhancements, and communications. These are the basic subsystems of an ARTS as currently configured. The ARTS antennas are either new 33-foot antennas (Acquisition I or II) or upgraded existing 46-foot or 60-foot antennas (Acquisition II), depending upon the site.

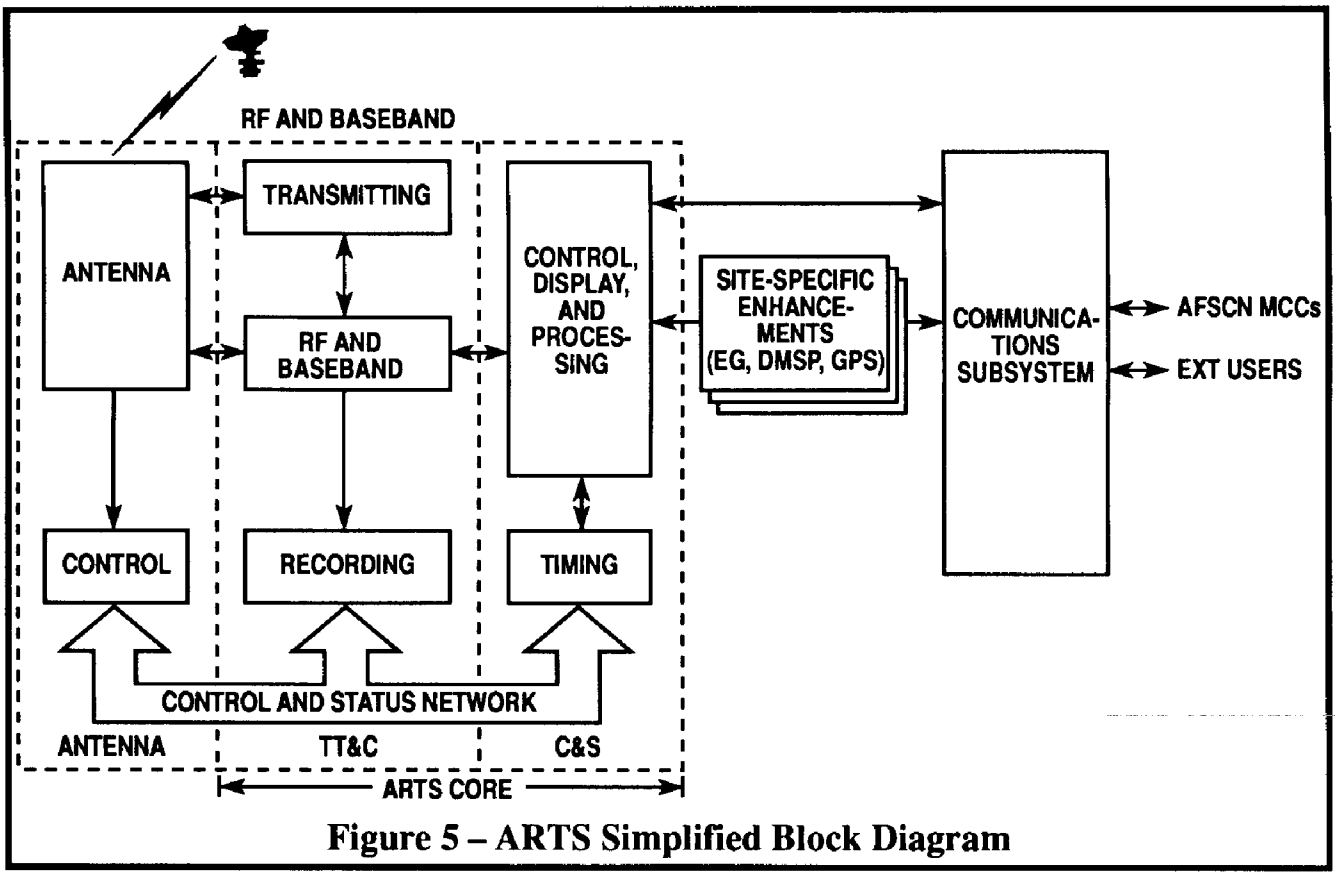

Figure 5 – ARTS Simplified Block Diagram

The ARTS core consists of a TF&C Subsystem and a Control and Status (C&S) subsystem. The TT&C Subsystem provides telemetry, tracking, and commanding capabilities that transmit and receive data to/from the space vehicle functionally identically to any pre-ARTS RTS site. The C&S Subsystem is a computer-based configuration, with approximately 270K lines of code, which automates the functions of equipment control; equipment status verification; and readiness, equipment performance, and calibration testing. Because the C&S computer stores a complete data base of preset satellite uplink/downlink equipment configurations for every spacecraft in the DOD inventory, actual reconfiguration of equipment between satellite contacts is achieved in under 10 seconds.

The basic system described above, developed as part of the Acquisition I effort, successfully met all system requirements. In addition, Acquisition II has added new capabilities that include core enhancements at all sites and 46-foot and 60-foot antenna upgrades, as well as certain site-specific enhancements to meet the unique needs of existing and new satellite programs not included as part of Acquisition 1. Core upgrades include the capability to process Quadrature Phase Shift Key downlink; Norad Element Data Set processing, and improved recording. Upgrades to the antennas include monoscan tracking for the 46-foot antennas, and new feeds and servo amplifiers for the 60-foot antennas. Site-specific enhancements include increased uplink power at 4 60-foot antenna

sites, ballistic missile downlink test support, simultaneous uplink, and payload test facility support.

In addition to the above subsystem configuration changes, the Acquisition II program is upgrading the EVCF and WVCF into Transportable Vehicle Checkout Facilities (TVCFs). Both the Eastern Test Range and the Western Test Range will now be supported by a transportable van-mounted ARTS for space vehicle checkout on the launch pad or at a vehicle manufacturer's facility for early compatibility checkout. A transportable 23-foot antenna and High-Power Amplifier are also being designed in a second van for use with the TVCF van to provide a full-up tracking station replacement when both are deployed at a remote site. This tracking station configuration can be used to reduce downtime for the remainder of the ARTS II activations when the first TVCF van and transportable antenna/HPA combination become available by the end of 1991. In addition, the TVCF could be deployed to maintain network capacity should a fixed-site ARTS be lost due to disaster.

ARTS OPERATIONAL BENEFITS

Table I contrasts ARTS performance with the performance of pre-ARTS stations. Turnaround time between satellite contacts, including both ARTS reconfiguration and complete automated station self-test to verify readiness, is consistently less than 5 minutes. In addition, its computer-assisted fault detection/fault isolation capability reduces ARTS Mean Time to Restore System (MTTRS) for the antenna and core from 3.79 hours to 26 minutes, the latter value established through actual tests at an Acquisition I site. ARTS reliability is also far greater than the precedent RTS. The basic Mean Time Between Failure (MTBF) requirement is 150 hours for an ARTS; actual mission reliability, determined on the basis of some early Acquisition I experience, is approximately 550 hours. The latter number compares with approximately 28 hours for an RTS. The net result is a modernized satellite tracking network that significantly increases the AFSCN's satellite contact capacity over the pre-ARTS tracking station network. Figure 6 compares minimum network capacity* with actual and projected loading demands through 1993. This data clearly indicates that ARTS implementation is providing a network reserve capacity well in excess of projected requirements.

Perhaps the most significant operational benefit of ARTS implementation has been the remarkable decrease in operator errors at ARTS sites. Such errors typically result in at least partial failure of the RTS satellite support mission. Operator error rates at pre-ARTS

*Including decrease in turnaround time, but not including further availability increase resulting from MTBF/MTTRS improvements.

tracking stations averaged approximately 1.3 per 1000 satellite contacts. Actual ARTS experience has been 0.22 errors per 1000 contacts, a sixfold improvement.

Table I – ARTS vs RTS Capabilities

ITEM	ARTS	PRESENT RTS
Number of Cabinets	18	86
Power Consumption (Peak)	120 KVA	182 KVA
(Average)	70 KVA	132 KVA
Operator Positions	2	9
MTBF (Mean Time Between Failures)	150 Hours	28 Hours
MTTRS (Mean Time to Restore System)	0.5 Hours	3.79 Hours
Turnaround Time	5 Minutes	15-20 Minutes
Automatic Acquisition	Yes	No
Interoperability	GPS	None
	DMSP	Downlink
Space Requirements	1000 Sq. Ft.	3500 Sq. Ft.

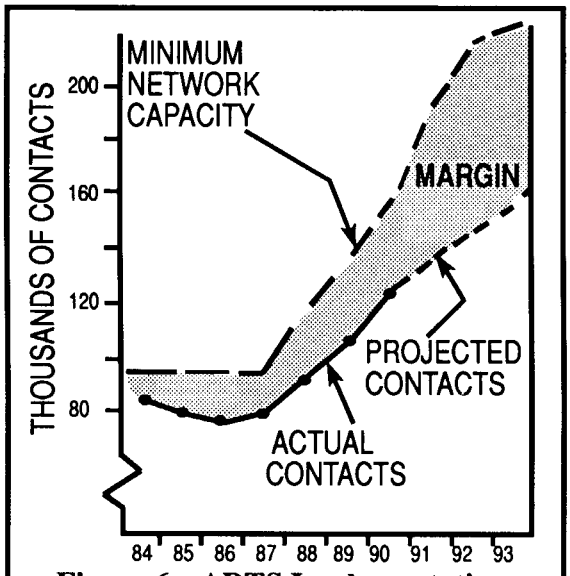

Figure 6 – ARTS Implementation Maintains Network Capacity Margins

ARTS FINANCIAL BENEFITS

As previously mentioned, the ARTS implementation objective was reduction of technician staffing from 9 per shift to 3. In fact, a single operator can execute all ARTS functions except for changing data recorder tapes. An operational staff of 2 is thus more than adequate (the second technician performs preventive maintenance actions as well). Additional savings result from the increased reliability of ARTS equipment. Figure 7 shows annual savings already realized and projected from ARTS implementation. Program

acquisition costs will be totally recouped through operational savings in approximately 10 years.

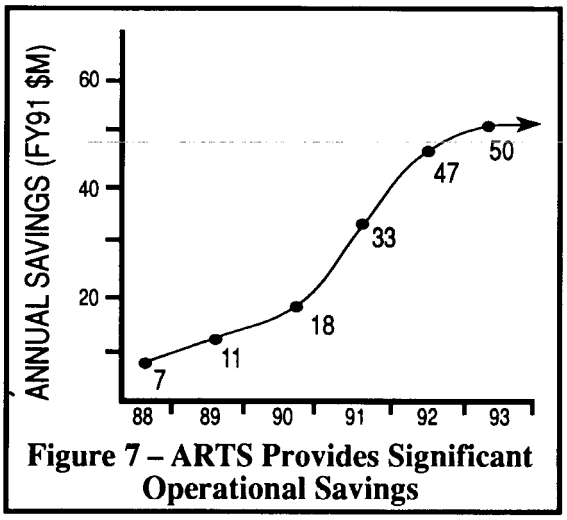

Figure 7 – ARTS Provides Significant Operational Savings

FUTURE ARTS ENHANCEMENTS

Given the breadth of support provided by the AFSCN, continued upgrades to the ARTS may be anticipated to meet new mission requirements and maintain RTS efficiency. Table II identifies potential enhancements. The table is purely illustrative — actual enhancements will undoubtedly be driven by evolving satellite needs.

Table II – Examples of Potential ARTS Enhancements

ENHANCEMENT	*BENEFIT*
• Extremely High Frequency Capability	• Antijam protection • Higher data rates
• Artificial Intelligence applications	• Improved response times • Improved fault isolation
• Addition of communications control to ARTS console	• Elimination of communications controller position
• Transfer of support data (eg, technical manuals) to 'soft media'	• Easier data retrieval • Reduced storage space

SUMMARY

The ARTS Program represents a quantum improvement in AFSCN RTS capabilities, with a concurrent significant decrease in operating costs. Based on operational evidence to date, this modernization effort is exceeding expectations. Furthermore, modular ARTS design allows ready accommodation of further station enhancements as mission needs dictate.