Telemetry of Aerial Radiological Measurements

Harvey W. Clark, Jr.

(Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521)

Summary

Telemetry has been added to National Nuclear Security Administration's (NNSA's) Aerial Measuring System (AMS) Incident Response aircraft to accelerate availability of aerial radiological mapping data. Rapid aerial radiological mapping is promptly performed by AMS Incident Response aircraft in the event of a major radiological dispersal. The AMS airplane flies the entire potentially affected area, plus a generous margin, to provide a quick look at the extent and severity of the event. The primary result of the AMS Incident Response over flight is a map of estimated exposure rate on the ground along the flight path. Formerly, it was necessary to wait for the airplane to land before the map could be seen. Now, while the flight is still in progress, data are relayed via satellite directly from the aircraft to an operations center, where they are displayed and disseminated. This permits more timely utilization of results by decision makers and redirection of the mission to optimize its value. The current telemetry capability can cover all of North America. Extension to a global capability is under consideration.

Background

The NNSA maintains a number of unique emergency response assets designed to address a radiological disaster. A key asset is the AMS[1], which is actually a variety of special radiological and non-radiological sensors for use on airborne platforms. The AMS Incident Response aircraft are designed and tasked to be NNSA's first airborne responders. The objective of the AMS Incident Response is to provide decision makers with a sweeping overview of the radiological impact as quickly as possible. The overview is used to assess protective actions based on modeling, renormalize transport/dispersion models, and plan ground-based monitoring. The AMS Incident Response can also provide radionuclide mix data to facilitate dose estimation and support modelers with meteorological conditions, particularly aloft, at locations far from fixed observations sites.

The value of this information is greater the more quickly it can be delivered. Therefore, two Beechcraft B-200 airplanes have been equipped and pre-positioned, one at Nellis Air Force Base (Las Vegas, Nevada) and the other at Andrews Air Force Base (Washington, D.C.). Aircraft and crews at both locations are flight-ready to meet a four-hour departure requirement. During plume phase the aircraft will fly around the perimeter of the plume repetitively tracing is shape as it migrates. After plume passage the deposition is mapped by flying a pattern of widely spaced lines, which crisscross the potentially affected area. In most cases, the entire area, including a generous margin, is surveyed in a single flight. The Airborne Radiological Computer System 2 (ARCS 2) is used for quick but simple exposure-rate mapping. The system displays the extrapolated ground-level exposure rate in real time as a color-coded flight path on a map. Upon landing the map can be printed and distributed almost immediately. Although the aircraft are equipped with a satellite voice/fax communications system, it is only appropriate for command and control. The maps and other data must be e-mailed to more distant consumers by indigenous ground-based communications resources.

The NNSA's Remote Sensing Laboratory (RSL) seeks to improve both the capability and value of the NNSA emergency response assets. One initiative is to utilize telemetry to accelerate delivery of results to decision makers and analysts. The AMS Emergency Response is the first NNSA airborne emergency response asset to incorporate data telemetry as part of its routine operational capability.

Operational Overview

The AMS Incident Response telemetry downlink workstation is located in the Operations - Home Team Support Room at RSL-Nellis in Las Vegas, Nevada. Its operator is the Home Team scientist on duty for the AMS Incident Response mission. The Home Team scientist is the functional equivalent of the scientist on board the aircraft and is the key communicator with the aircraft. As such, the Home Team scientist provides the aircrew with information such as site situation reports, model predictions and on scene contact information.

The AMS Incident Response telemetry permits the Home Team scientist to simultaneously access the mapping data from two aircraft in real time. The data links are established by the Home Team scientist and are entirely transparent to the aircrews. The data transferred are compressed versions of the actual second-by-second measurements. The ground-based viewing application is the same application running in the aircraft for acquisition and display. Therefore, the Home Team scientist can view, adjust and manipulate the data just as if onboard but still independently from actions in the aircraft. This permits fine-tuning of the data and enhancement of the mapping before delivery to users. Distribution of AMS Incident Response data products is controlled by NNSA, who identifies eligible recipients of the data and approves the data for release. Raw data are not distributed. Distribution is primarily by e-mail, but other arrangements are possible.

The ground operator's workstation has two data presentation options. Trivially, at any instant during the flight, the operator can simply complete a screen capture of the live map being plotted by the ARCS 2 application. It can then be e-mailed instantly to authorized recipients, regardless of their locations. Updates can be distributed frequently but no less than once every 15 minutes, because it becomes burdensome to do so. Screen captures are imbedded in a Microsoft® Word document with a caption describing the data.

The preferred option is to export the processed data to a Geographic Information System[2] (GIS) application for creation of presentation-quality graphics. This is routine and simple at the end of an ARCS 2 acquisition session, because the ARCS 2 application creates GIS ready shape files upon exit. If a flight were very long, then the ground-based ARCS 2 application could be closed briefly to create the shape files and restarted. However, it is possible to capture a copy of the partially processed data, while the acquisition is still in progress and import it into GIS. But this course of action is less convenient and slower. Examples of both a screen capture and GIS product are presented in Figures 1 and 2 respectively.

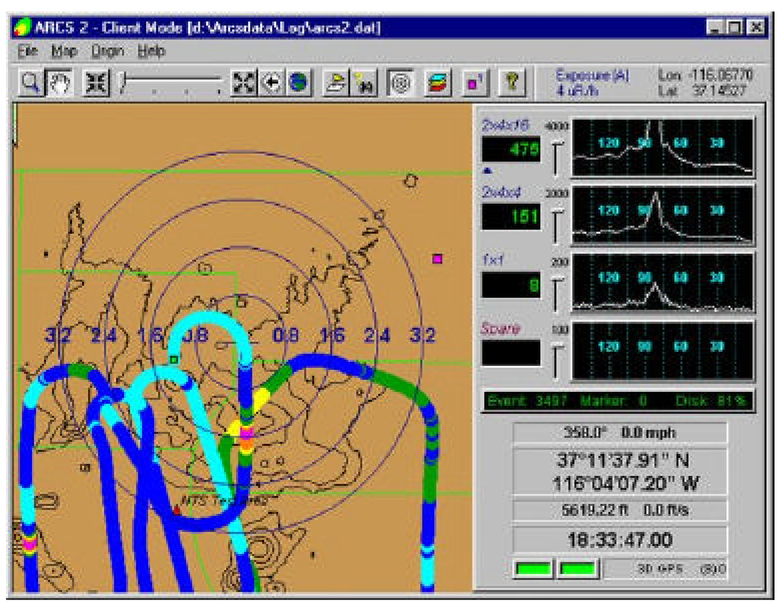
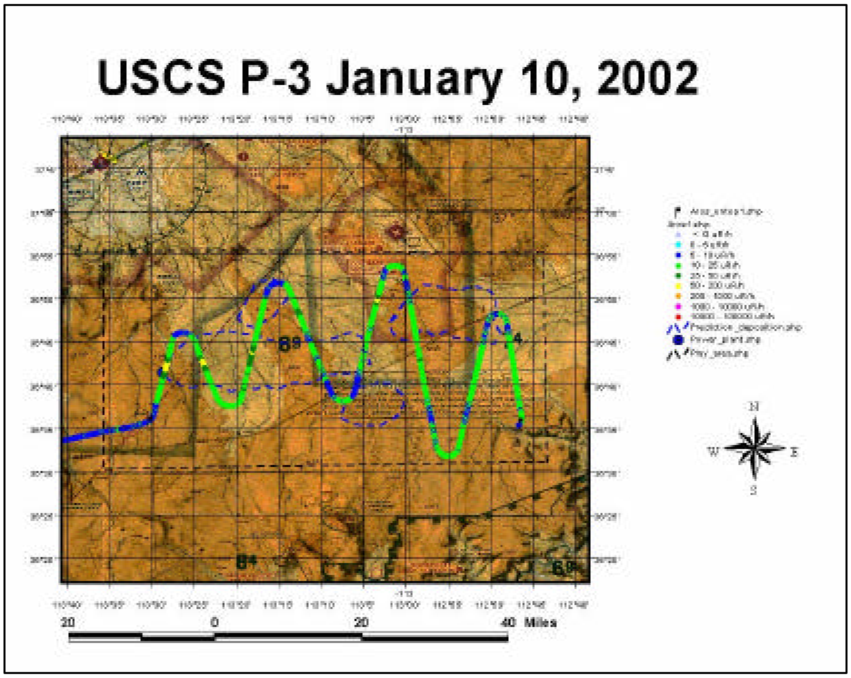


Fig. 1. Screen capture of the ARCS display.

Fig. 2. GIS rendition of flight data with model prediction.



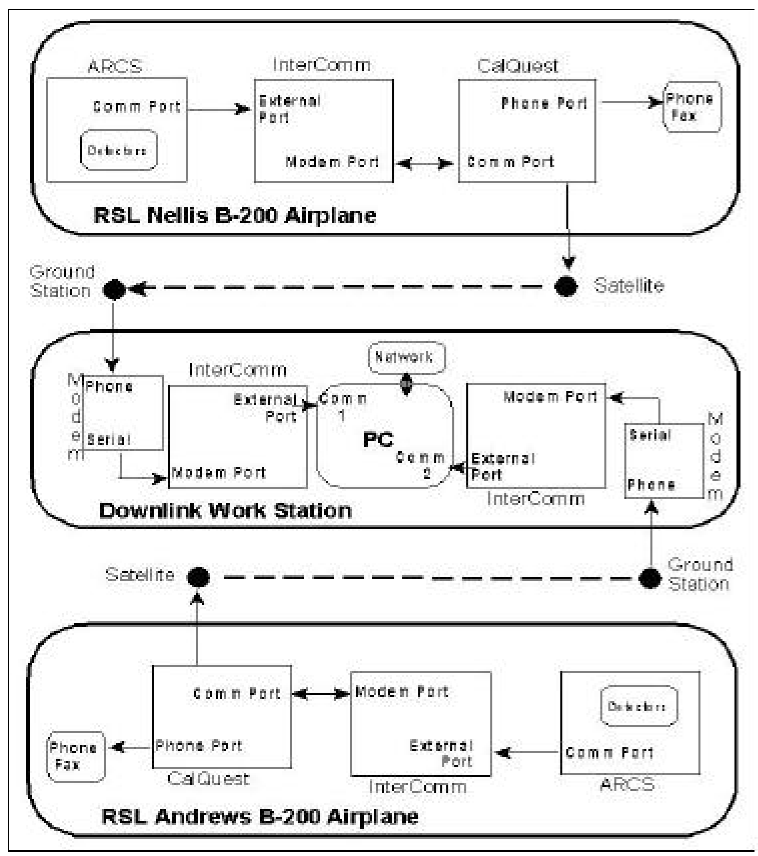
The GIS graphics are strongly preferred and promoted, even though they require more time to prepare. The reason is that GIS graphics offer many advantages over screen captures. First, the base map or photo can be tailored to reflect the boundaries for protective actions, such as evacuation, sheltering, or food embargo. Color-code break points for display of the AMS exposure rate data can be selected to correspond to Derived Response Levels (DRLs) for Protective Action Guidelines (PAGs). Model predictions can be plotted with the AMS data with matching break points for easy comparison. Informative legends and descriptions can be imbedded. But most importantly, data from multiple flights (or acquisition sessions) can be combined on a single figure. The maps produced by GIS are usually distributed as jpeg graphics.

If the telemetry link should fail in part or totally, no data are lost nor is delivery of results seriously compromised. The AMS Incident Response aircraft crew will plot and deliver the map upon landing, just as was done before advent of telemetry.

Implementation Details

Implementation of telemetry for the AMS Incident Response was required to meet several requirements: 1) maximize use of commercial, off-the-shelf components, 2) minimize development risk and implementation cost, 3) utilize existing systems where possible, and 4) minimize training requirements. Therefore, the approach merely modified ARCS to add a telemetry option, added a second channel to the existing satellite communicators on each aircraft, and set up a downlink workstation. Each is described below. The configuration of the AMS Incident response telemetry is summarized in Figure 3.

Fig. 3. Diagrammatic representation of the entire telemetry train for both AMS Incident Response aircraft including downlink workstation.



ARCS Enhancement

The ARCS consists of a customized personal computer (PC) environment with imbedded counters and global positioning system (GPS), plus its specialized application software. The enhancement to support telemetry required implementation of a host and client acquisition mode. The ARCS application gathers data from the counters and GPS with control inputs from the user via the keyboard and mouse. The application displays a map/photo with the exposure rate coded flight path, pseudo-strip charts for each of the detectors and post-GPS data and other status information. In host mode an abridged version of the GPS data, counter values and certain operator inputs are written to a communication port each second. In client mode the application skips the data acquisition and reads the data directly from a communication port. In both cases all other aspects of the application are the same. The data are exchanged as an ASCII string with typically only 64 bytes and a check sum. If damaged data are detected, they are discarded. The only change to the ARCS hardware was addition of another serial port.

The ARCS application will run on any Windows environment, but no data are collected, of course, if run in host mode without the customized ARCS hardware environment. In fact, doing so may generate random data or cause a system conflict.

Second Satellite Channel

From the beginning the AMS Incident Response aircraft have been equipped with a CalQuest[3] satellite communicator. The CalQuest provides a single, 4.8kbs channel to the publicly switched telephone network throughout North America. Each airplane has two telephone numbers, one for voice and the other for fax. However, voice and fax cannot be utilized simultaneously, because only one satellite channel is available. To conveniently accommodate telemetry, without compromise of the voice/fax capability, a second satellite receiver/transmitter was added, which uses the existing satellite antenna. The second channel is dedicated to data and has its own telephone number. The channel is set up to mimic the operation of a Hayes compatible modem with an RS-232 serial connector.

The key to making this data port transparent to the flight crew and relatively loss free is the use of an InterComm[4] data buffer at both the ends of the telemetry link. At the flip of the "Connect" switch, the ground-based InterComm unit calls its counterpart on the aircraft. After passwords are exchanged, the units begin exchanging data using a packet protocol, which can be soft encrypted. If the satellite link is broken, the units automatically redial and restore the link. During the communication interruption data are stored in an internal buffer, which can hold four minutes of data. Upon restoration of the link, the host buffer is immediately sent to catch up the ground-based client. If the interruption exceeds four minutes, the later data will not be sent to the ground-based client, but they are still recorded on board the aircraft. The link is terminated by the ground-based client until being switched out of "connect" mode.

Downlink Workstation

The downlink workstation is best understood by inspection of the diagram presented in Figure 3. Basically, it is just a Windows PC with the dual displays, two serial ports, and network access. Two telephone lines, each with a modem and InterComm data buffer, provide connectivity with the two aircraft via the publicly switched telephone network. The dual displays are used to expand the Windows desktop. The workstation does not interact with the modems. They are under the control of the InterComm data buffers. Network access provides e-mail services for distribution of products, access to other servers and the Internet. The NNSA's Emergency Communications Network, which ties all NNSA/DOE emergency operations centers to those of several other federal agencies, can also be accessed through another server. The workstation is equipped with the ARCS application, GIS and Microsoft® Office.

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DISTRIBUTION:

OSTI	(1) electronic copy
Technical Library	(1)
Public Reading Facility	(1)

[1] Aerial Measuring System – operated for the NNSA by Bechtel Nevada at the Nellis AFB and Andrews AFB facilities of the NNSA Remote Sensing Laboratory.

[2] GIS – Geographic Information System, specifically ESRI ArcView, ArcMap and ArcInfo.

[3] EMS Technologies, Ontario, Canada

[4] Matrix Communications, Calgary, Canada