GULF RANGE DRONE CONTROL UPGRADE SYSTEM MOBILE CONTROL SYSTEM

Steven M. Wagner, Captain, USAF
3200th Support Wing
Deputy for Communications—Computer Systems
Eglin Air Force Base, Florida

John H. Goodson
General Electric Government Services, Inc.
Range Projects Division
Eglin Air Force Base, Florida

ABSTRACT

The Gulf Range Drone Control Upgrade System (GRDCUS) Mobile Control System (GMCS) is an integral part of the test ranges located on the Gulf of Mexico. This paper begins with a brief overview of the current Gulf Range systems. These systems consist of five major components: ground stations, ground computer systems, data link/transponders, consoles, and software. The GMCS van contains many of these components to provide a stand-alone range capability for remote operations.

This paper describes the development and assembly of the GMCS van and focuses on the on-board computer systems, consoles, and data link technology. An overall system engineering approach was used during GMCS development and is highlighted through the use of rapid prototyping. This methodology and the lessons learned are presented in the paper.

Suggestions for future applications are considered.

Key words: GRDCUS, drone command and control, formation control, data link, multilateration real-time processing, weapon testing.

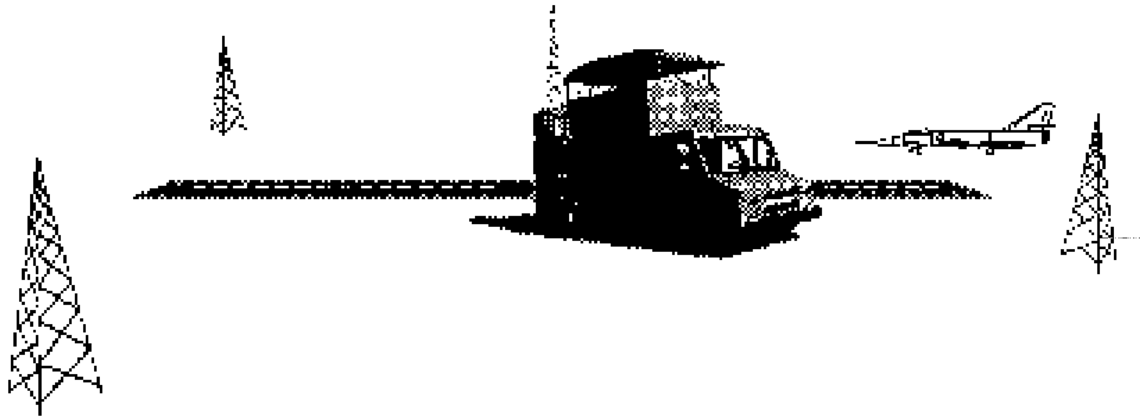

Figure 1. GRDCUS Mobile Control System (GMCS)

INTRODUCTION

The Gulf Range Drone Control Upgrade System (GRDCUS) is a major element of an overall Gulf Range Air-to-Air Upgrade Program. Other programs completing the upgrade are the Missile Endgame-Scoring System, the Airborne Platform/Telemetry Relay Program, the Range Control System Upgrade, and the Global Positioning System Program. (1)

The GRDCUS Mobile Control System (GMCS) is a part of the GRDCUS and utilizes many of the same technical disciplines with state-of-the-art computers. This paper will focus on a description of the GMCS van and its functional capabilities. Future applications are also discussed.

GRDCUS BACKGROUND

GRDCUS operates as a multifunction command and control, tracking, and data link system capable of supporting developmental and operational test and evaluation (DT&E and OT&E) air-to-air missions over the Gulf Range. The regions depicted in Figure 2 cover approximately 17,150 square miles of water. The main ground portions of the system are located at Tyndall Air Force Base (AFB), with a communication/ data link to the Central Control Facility (CCF) at Eglin AFB and ground stations located along the Gulf coast. (3)

The system will support simultaneous control of a mixture of subscale and full-scale drones flying independently or in close formation at altitudes from 50 to 50,000 feet. The system is capable of launching, controlling, maneuvering, and recovering up to four drones in a fully automatic mode through the use of ground stations. In addition to drone targets, the system is designed to acquire simultaneous time-space-position information (TSPI) on up to four shooter aircraft and four missiles, four support

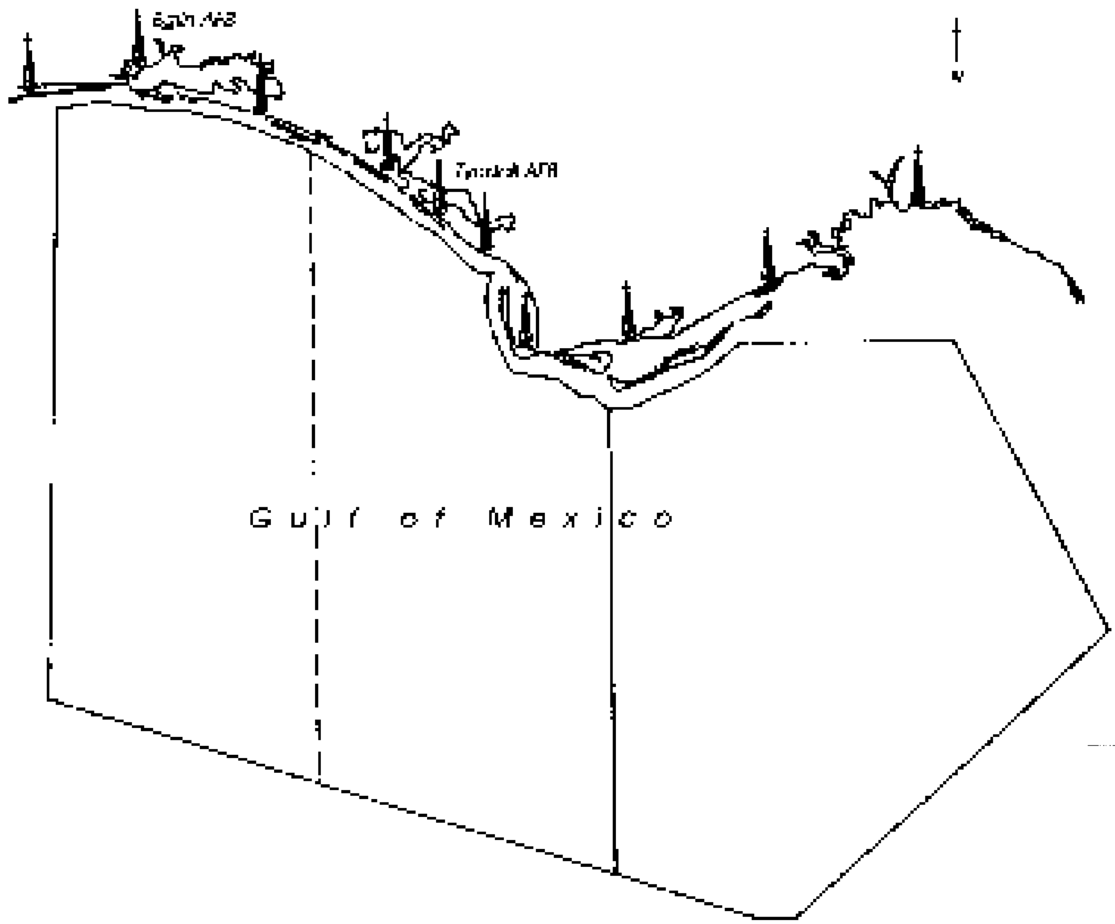

Figure 2. Gulf Range Area

aircraft (high fliers), plus one additional airborne platform. The high fliers and additional platform are used to relay control data when the drones are over-the-horizon (OTH) from the ground stations. (1)

The GRDCUS system software is derived from the White Sands Missile Range (WSMR) Drone Formation Control System (DFCS) software. DFCS and GRDCUS are functionally equivalent; differences lie in the ground computers and data link. WSMR uses an IBM computer suite for the ground system while GRDCUS is based on a VAX multiprocessing architecture. The DFCS data link tracks and controls drones by using a time-shared, single-frequency, high-duty-cycle radio link between a transponder in each drone and each of four interrogation substation sites (ground stations) as depicted in Figure 3. Signal propagation time from the ground station to each drone is measured ten times a second and is used to calculate slant ranges. Using these distances, plus the output of airborne altimeters, the space position of the drone is computed by the DFCS computer. (2) Details on the GRDCUS data link will be presented later in the paper.

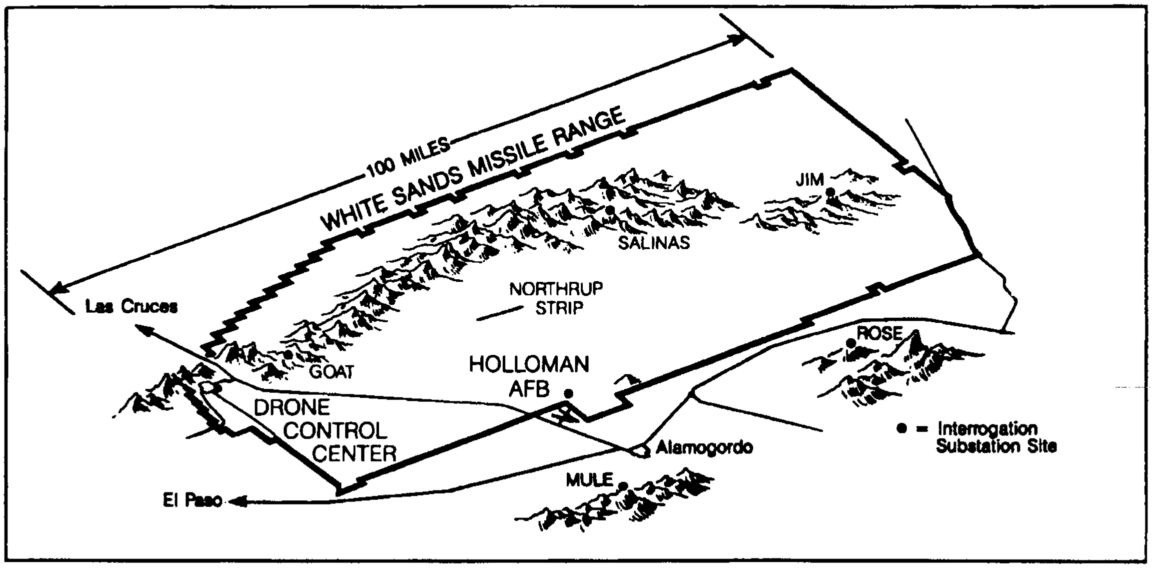

Figure 3. Drone Formation Control System at White Sands Missile Range

GRDCUS COMPONENTS

Similar to other drone control systems, GRDCUS can be broken into five basic subsystems:

1. Ground stations
2. Ground computer system
3. Data fink/transponders
4. Consoles
5. Software.

Listed below is a short description of each subsystem. Additional details are available in Reference 3, "Summary Description of the Gulf Range Drone Control Upgrade System."

Ground stations along the Florida coast and around Tyndall AFB drone runway were selected based on geometric requirements for tracking and controlling aircraft with GRDCUS. The surveyed coordinates of each site are stored in the GRDCUS data base and then used in the tracking process. Each ground station consists of a Data Link Subsystem (DLS) unit, a tower that varies in height from site-to-site, an alert monitor box, and microwave communications equipment.

Ground computer system , for the GRDCUS, is comprised of six VAX computers and associated peripherals (printers, terminals, drives, and disks). The underlying architecture is based on a multiprocessor, shared-memory configuration supporting parallel processing and interprocess communications. The software used for all applications resides in the VAX computers. Assisting the VAXes are four PDP 11/34s for data and information transfer only; no GRDCUS application processing is accomplished on these machines.

Data link/transponder is the heart of the GRDCUS because it provides for data link communication between the GRDCUS drone control subsystem software, ground and airborne stations, and other participating aircraft. It also permits the control system software to determine the locations of individual participants by having interrogation response times clocked and resolved using multilateration between different stations. The actual DLS hardware includes a radio frequency transmitter and receiver, time-of-arrival clock, drone interface unit, signal processor, and power supply.

Consoles fall into two categories: a master console which monitors the entire mission scenario, and a drone control console which monitors, commands, and controls one drone. The consoles, designed for operation by a single operator, are driven by CALCOMP display processors. Some of the display format options available to the operators are an area map, a drone pilot's display, time history, and navigation.

Software is best described in terms of the control subsystem software, which encompasses the GRDCUS computation and control functions. This software performs four types of processing: mission, simulation, console display and control, and support. All the GRDCUS software falls into one of these four processing categories. The software, written primarily in Fortran, relies heavily on data sharing, execution synchronization, and message-sending.

GRDCUS MOBILE CONTROL SYSTEM (GMCS) OVERVIEW

The GMCS is a completely self-contained system that provides the identical track, command, range, and telemetry capabilities of the GRDCUS fixed control facilities located at Tyndall AFB. GMCS must satisfy a requirement for a nonautomatic (manual) mobile control system for landing full-scale aerial targets (FSATs). Two systems are needed, one to be delivered to Tyndall AFB, Florida and the second to Holloman AFB, White Sands Missile Range, New Mexico. The GMCS will be installed in an 18-foot step van along with power generators, uninterruptible power supply, air conditioning system, data/signal generation systems, and communications necessary for autonomous operation. Operation of the GMCS mobile requires modification of the roof for the consoles and controllers. Two controllers are positioned on top of the van to facilitate visual sighting of the drone; one controls the drone pitch and power controls and the other controls lateral motion, brakes, and chute. A third person is required to monitor the systems from the lower section inside the van.

Along with the modifications to the van, a wide range of other items were addressed: a separate destruct system, antennas for communications with other range systems, and printers, disk drives, and a strip chart recorder that must be installed for system test and range operations.

GMCS VAN DEVELOPMENT

Many of the milestones, past and present, are identified in Figure 4. The first prototype computers, IBM RISC 6000 Models 320 and 520, were delivered in September 1990. Three critical areas were addressed: compatibility with existing GRDCUS consoles, demonstration of the graphics capability to support real-time processing, and compatibility with the GRDCUS data link system.

Initial testing was conducted to verify system compatibility with existing GRDCUS consoles and the Eglin AFB computer network. No problems were encountered; integration proceeded on schedule and was completed in October 1990.

90	Sep	First prototype computers arrive.
	Oct	Integration into existing network.
	Nov	Transition of GRDCUS software, successful demonstration of graphics.
	Dec	Completion of 3-D graphics test.
91	Jan	Second prototype arrives, hardware upgrade, sucsessful operation of GRDCUS software shell.
	Feb	Integration of token-ring network.
	Apr	Interface computers to data link.
	May	Live testing of data link with range.
	Jun	Console complete, start software integration.
	Jul	Software integration with data link. Receipt of vans.
	Aug	Software testing with console and data link.
	Sep	Interim capability, "desktop" GMCS fully integrated.
92	Jan	Install computer hardware into van.
	Mar	GMCS completely assembled in van ready for testing.
	Aug	Delivery of fully tested system .
	Oct	William Tell competition.

Figure 4. GMCS Milestones

GRDCUS requires a real-time graphics capability, and selecting the proper set of graphics cards required a great deal of preparation. A side-by-side test of two IBM systems was required to demonstrate the differences in graphics capability. Each system hosted the same software, was configured in the same manner, and executed the same test software. The only difference was the hardware graphics cards. The final test results revealed the need for upgrading our specification for graphics hardware and expanding the memory needed to execute the tests. The second prototype system was configured accordingly; it was also necessary to upgrade the first system for the expanded graphics capability. Figure 5 is representative of the type and number of display values used in pilot display format for the GMCS mobile.

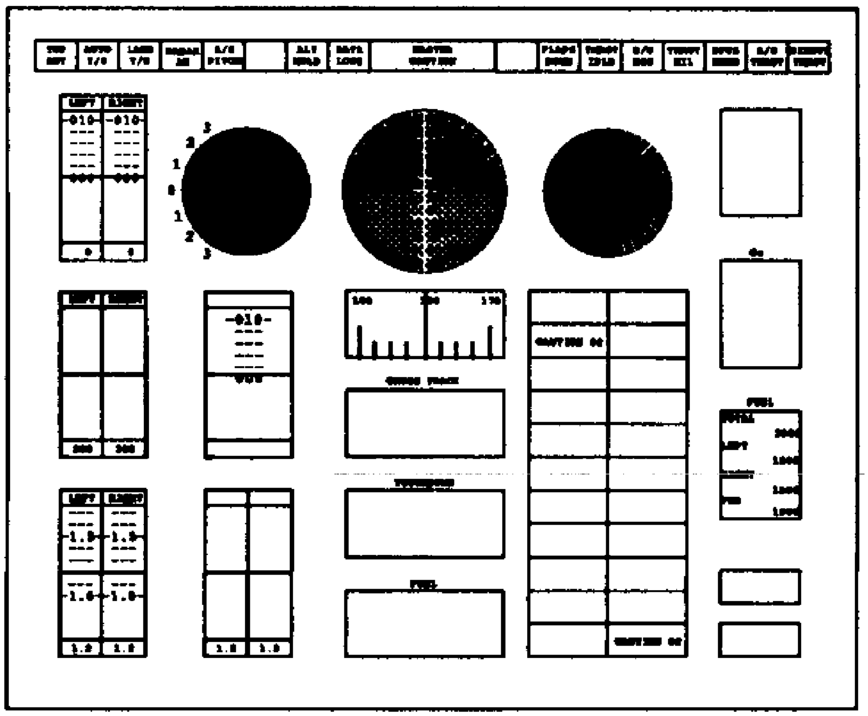

Figure 5. Test Display

January and February of 1991 were busy months for GMCS integration. All the prototype hardware was in place, testing was progressing well, and integration of the token ring was complete. The remaining critical link was interfacing to the GRDCUS data link subsystem. The fixed sites communicate with the drones using a DLS interface which in-turn communicates through ground stations along the Florida coast. Figure 6 depicts the ground stations and demonstrates a drone message being passed from the fixed site at Tyndall AFB to a drone by way of the high flier relay.

Initial designs for the DLS interface required an in-house hardware/firmware card connecting the IBM RISC system to the existing DLS interface. Fortunately, IBM identified a source, available on the open market, for the interface card. In a matter of

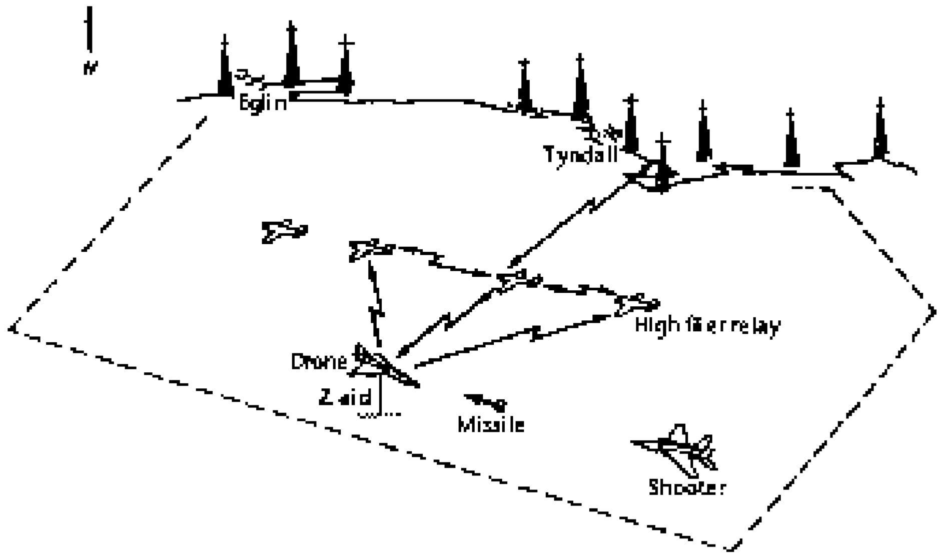

Figure 6. Drone Communication

weeks, rather than months. the prototype GMCS was able to perform a live test demonstrating the necessary range systems.

Following seven months of intensive design, prototyping, and testing, a final GMCS computer architecture was baselined. The system will require an IBM workstation for each controller console. A third IBM workstation will act as the master of the token ring and gateway for other systems such as disc logging, recording devices, and the data link subsystem. The block diagram in Figure 7 depicts the baseline system.

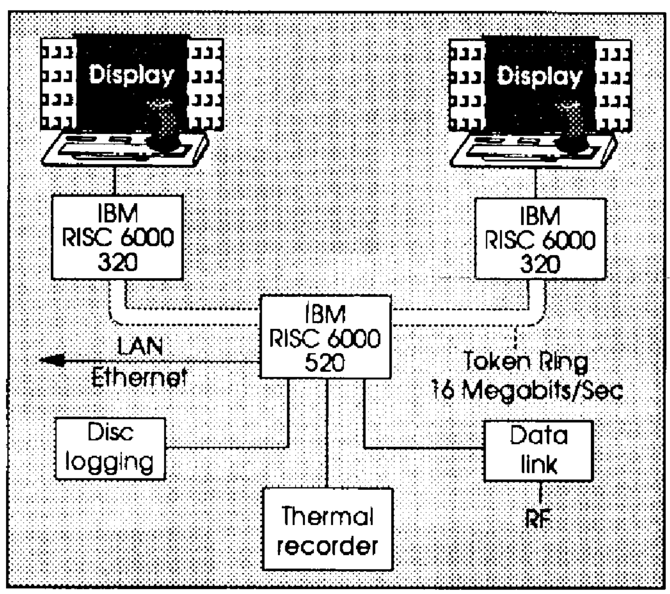

Figure 7. GMCS Baseline

GMCS LESSONS LEARNED

The GMCS van required a wide range of disciplines and talents. Manufacturing personnel were needed to fabricate the consoles and modify the vans. Technical people were needed to establish the design of the GMCS baseline, then assist in the testing. Finally, an unending stream of procurement actions plagued this program.

Manufacturing used a sound approach of developing the first consoles out of cardboard, whereby the first design changes were made with scissors. Once the design stabilized, a sheet metal prototype was manufactured. Using this evolutionary approach allowed for rapid changes and a cost effective method for accommodating changes.

The technical people used rapid prototyping to assist in establishing the baseline system. Keeping in mind all the design "ilities," almost all the system components are available off-the-shelf. This will help the supportability of the GMCS vans in the field and cut down on the up-front development costs.

The procurement personnel were supportive by offering alternative ways to procure materials. Focusing on off-the-shelf items and synopsizing higher priced items proved to be a sound approach for obtaining competitively priced items; competition drove the price down.

FUTURE APPLICATIONS

The future applications of the GMCS van fall into two categories: GMCS must match the automatic control and full range of capability of the GRDCUS system, and GMCS must look to the future, in support of other drones and support systems.

The current GMCS baseline is capable of hosting and executing the same GRDCUS software resident on the suite of six VAX computers. During system integration and test of the IBM RISC computers, the GRDCUS simulation was hosted on a workstation. All the GRDCUS drone features of takeoff, maneuvering, landing, and data collection were operational on the GMCS computer.

GMCS would be a viable option for the developer of the QF-4, the next Air Force drone. GMCS could provide the necessary ground control system for controlling the drone at a contractor facility. Another application involves the satellite based Global Positioning System (GPS). Positional data derived from GPS could be given to GMCS, thereby reducing/eliminating the dependency on multilateration and airborne tracking/relay aircraft.

CONCLUSIONS

The GRDCUS is an integral pan of testing weapons and weapons systems on the Gulf Range. The development of a GRDCUS-based mobile control system is underway. The GMCS van remains on schedule and will be delivered in the spring of 1992 to meet the needs of future test programs.

ACKNOWLEDGMENTS

Our thanks to TYBRIN Corporation, Fort Walton Beach, Florida for their support in preparing this paper for publication. In particular, Ms Lisa Wade for her editorial expertise and Ms Rebecca Hobbs for creating many of the figures and assembling the final product.

REFERENCES

I . Arbuckle, David L., Barton, Robert D., “Gulf Range Drone Control Upgrade System (GRDCUS),” AD-TR-88-8, 3246th Test Wing, Armament Division, Eglin Air Force Base, Florida, February, 1988.

2. Physical Science Laboratory, New Mexico State University, Las Cruces, New Mexico, “Data Systems Manual, Drone Formation Control System,” PD-00891-E, White Sands Missile Range, New Mexico, September, 1979.

3. SRI International, “Summary Description of the Gulf Range Drone Control Upgrade System (GRDCUS),” GRDCUS-TFG-4, 3246th Test Wing, Armament Division, Eglin Air Force Base, Florida, February, 1985.