ADVANCED RANGE TELEMETRY (ARTM)

Preparing for a new generation of Telemetry

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ABSTRACT

At open air test and training ranges, telemetry is beset by two opposing forces. One is the inexorable demand to deliver more information to users who must make decisions in ever shorter time frames. The other is the reduced availability of radio frequency spectrum, driven by its increased economic value to society as a whole. ARTM is planned to assure that test and training programs of the next several decades can meet their data quantity and quality objectives in the faces of these challenges. ARTM expects to improve the efficiency of spectrum usage by changing historical methods of acquiring telemetry data and transmitting it from systems under test to range customers. The program is initiating advances in coding, compression, data channel assignment, and modulation. Due to the strong interactions of these four dimensions, the effort is integrated in a single focused program. In that these are problems which are common throughout the test and training community, ARTM is a tri-service program embodying the DoD's Common Test and Training Range Architecture and Reliance principles in its management and organization. This paper will discuss the driving forces, the initial study areas, the organizational structure, and the program goals.

KEYWORDS

Telemetry, Data Compression, Coding, Spectrum Conservation

INTRODUCTION

There is a new initiative within the Department of Defense (DoD) that promises to make fundamental changes in the way that test and training programs requiring radio frequency telemetry are carried out. This program, Advanced Range Telemetry (ARTM), is at the beginning of a ten year program cycle. Because of its importance to the community, we are making an initial report and plan to continue to communicate our progress through the whole cycle. This paper discusses the causative factors behind ARTM, the program's organization and goals, and provides a peek into our present implementation initiatives.

The rate at which a typical test program produces telemetry data is increasing exponentially. A recent study determined that PCM bit rates have increased 100-fold over the past 25 years. This is a factor of ten increase each 12 years. This is a result of new sensors, higher speed platforms, and an increased user desire for real time information. There is increasing use of video sensors, generating wide bandwidth information. As test vehicles have become more automated, the amount and rate of digital computer data needed to fully characterize operational results has increased. The increased speed of test platforms, especially tactical aircraft has increased the rate at which data from conventional sensors must be sampled. Finally, the availability of real time data on the ground has been shown to save lives, money, and test time. Many programs that would have used on-board recording and post-flight analysis now insist upon radiated telemetry and real time analysis.

Acting to reduce the supply of spectrum available for these purposes is the newly discovered value of radio spectrum when used for commercial purposes such as personal communications and the distribution of music and video content. Pressed by commercial interests, the World Administrative Radio Conference of 1992 allocated primary usage of the 1452-1492 MHz Band to Digital Audio Broadcasting (DAB) in Canada and Mexico, and allocated primary usage of the 2310-2360 band to DAB in the United States. Primary usage of the 1525-1535 MHz was also allocated to Mobile Satellite Service. Although, telemetry may still use these bands as a secondary user, a recent FCC study concluded that the two uses are not compatible as the commercial services will cause unacceptable interference to telemetry users of those bands. Spurred on by Congressional mandate and the success of recent spectrum auctions, these bands previously available for telemetry have either been lost or will be as soon as commercial use actually begins.

WHAT IS ARTM?

The impact of the confluence of these two factors was realized at the Air Force Flight Test Center (AFFTC) during the fly-off testing and planning for the development testing of the Advanced Technology Fighter (ATF), now the F-22. This test program indicated early-on that increased bandwidth telemetry spectrum would be required in performance of the development test program. At the same time we learned of the loss of TM bands to commercial uses. We realized that in order to serve our customers we had to improve our usage of the remaining TM spectrum.

ARTM started at AFFTC as “TM 2000,” with a goal of providing a common 15 Mbps telemetry acquisition system that would be usable at all the open air test and training ranges. It was envisioned as a complement to the CAIS program for a common vehicle suite and an effort was made to obtain funding from the Central Test and Evaluation

Investment Program (CTEIP). As the program matured, it evolved from an Air Force Program with tri-service application to a fully tri-service program and was renamed.

The ARTM Joint Program Office (JPO) has an Air Force Program Manager with Army and Navy Deputies. It reports through a tri-service Executive Steering Group to the office of the Assistant Secretary of Defense for Acquisition and Technology (A&T). The JPO is the leader of an Integrated Product Team. Three Segment Implementation Teams; the Platform Segment Team, the Ground Segment Team, and the System Integration Team are responsible for the individual implementation projects. The JPO receives advisory inputs from a Tri-Service Technical Group and a Tri-Service Requirements Group. These two groups help the Program Managers to keep abreast of customer needs and the latest technology while they focus on coordinating the efforts of the three Segment Implementation Teams.

The ARTM technical goals are to push PCM telemetry to the limits of current technology leveraging, where possible, commercial off-the-shelf (COTS) and other existing technologies. Specific goals are to:

- Increase the efficiency of telemetry channels by a factor of four
- Reduce received bit error rates by a factor of ten
- Improve utilization of the telemetry spectrum by a factor of two
- Establish a mechanism to command and monitor onboard test instrumentation remotely.

Specific initiatives to reach these goals are discussed below.

In pursuing these objectives, the program office has developed a positive business strategy. At the head of the list we want to develop win-win solutions that satisfy the diverse needs of the customer community. These include accommodating both airframe and aircraft systems testers; looking at both test and training scenarios. Technically, we want to make our progress within constraints of limited cost and risk. We plan to do this through maximum use of open architecture, industry standards and where possible COTS implementations. Finally, we want to identify and select the alternatives that offer the highest payoff to the customer base and involve all of the open air ranges in participating in the program.

Schedule-wise we are on a ten year time frame before full operational deployment of the resulting system. At the present time we are exploring the concepts necessary to achieve our goals. We are presently funding studies of available techniques through SE/TA contractors and Small Business Innovative Research (SBIR) grants. Our status so far is discussed below. We hope to expand the present Phase I (exploratory) SBIR programs into Phase II (prototype development) programs if they yield useful results. Using the prototypes developed under SBIR funding and commercially available techniques, we expect to construct a prototype system to be tested and validated in the 1999-2000 time frame. Base upon the success of the prototype we will award production contracts with a goal of initial operational capability (IOC) for a production system in October of 2001. The deployment of production systems will then occur over the next four years.

PRESENT INITIATIVES

While we wait for full CTEIP funding (expected in FY '97), we are starting preliminary studies using funds from the SBIR program and a small amount of internal funding. These initiatives include studies in compression, improved modulation efficiency, and coding.

An SBIR effort entitled "Avionics Bus Data Compression," was advertised in SBIR 96.1. This research addresses the increasing numbers of digital devices in modern aircraft avionics and data acquisition systems which are interconnected with high speed busses. The data transferred on these busses are critical to the performance of the vehicle and must be monitored during any test program. However, most test-critical data are not generated continuously, but in bursts. The intent of this research is to determine methods that will reduce the radio frequency bandwidth required by this data and determine characteristics of the data that may be used for discrimination. The goal of this effort is to reduce avionics bus bandwidth requirements by a factor of two to four while maintaining data fidelity and time correlation. As a result of the SBIR procurement, four proposals were received of which two have been funded

A second effort, entitled "Optimal Utilization of Telemetry Spectrum," was also advertised in SBIR 96.1. This research focused upon more efficient assignment of the telemetry spectrum through development of a demand assignment multiple access scheduling capability. Such a method would replace the present practice of assigning large segments of the telemetry spectrum to a single user for the duration of a test program. This research would look at ways to reduce the frequency allocation required such as improved filtering and smaller inter-channel spacing. Other approaches would include tunable transmitters and a bi-directional data link to allow dynamic control of the spectrum allocation based upon the phase of the present test and the needs of other users.

The third initiative is in the area of forward error correction (FEC) coding. We have already sponsored an internal study to determine the present state of the art and the direction we should look to find our technology. Coding is important to the achievement of the ARTM objectives. While coding by itself leads to an increase in spectrum utilization, intelligently applied it produces the more robust link which is necessary for the transmission of compressed data. Overall, we expect both improved data quality and reduced spectrum utilization through the use of coding. The space exploration community, particularly NASA, is the leader in the application of coding to the telemetry problem. Because of their long experience, they have developed techniques which appear to provide a link quality in excess of our present needs. To fill their needs, they have also developed an infrastructure to produce the necessary components at a very high quality level. In order to use this available technology, we must learn more about the quantitative aspects of the open air test and training scenario, which differs from that of space exploration. In furtherance of this goal, we are proposing an additional SBIR task for inclusion in the FY ‘97 announcement.