AATIA & CAIS GROUND SUPPORT

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ABSTRACT

The Advanced Airborne Test Instrumentation System (AATIS) was developed by the Air Force to satisfy its flight-test mission needs through the 1990s. The Common Airborne Instrumentation System (CAIS) is a tri-service development aimed at providing a common airborne data acquisition system for all DoD flight-test programs into the next century. Both AATIS and CAIS include ground support equipment which performs the primary functions of documenting the instrumentation system, generating and loading the telemetry data formats, and performing instrumentation system diagnostics. The AATIS and CAIS ground systems will each support both the AATIS and the CAIS airborne systems. The AATIS ground system also supports the older ATIS airborne systems. The approach taken by the two ground support systems is similar but the scope of functionality is larger in the AATIS ground system because it needed to respond to the more extensive ground support requirements of the Air Force users. This paper provides a brief description of both ground systems and discusses the issues of commonality and interoperability.

KEY WORDS

Airborne Test Instrumentation; Telemetry Ground System

INTRODUCTION

An instrumentation ground support unit (GSU) can provide useful functionality for many different potential users, including instrumentation engineers and technicians, hangar and flightline personnel, flight-test engineers, and range personnel. In addition to providing the tools for creating the pulse code modulation (PCM) formats, downloading them to the airborne system, and checking out that system, the GSU can also provide for documenting and calibrating the on-board instrumentation system or parts thereof; troubleshooting any part of the instrumentation system or the GSU itself; viewing, analyzing, and presenting data; transferring data or entire databases to other GSUs or to the range systems; and training users in the use of the GSU's tools.

With so many different users and a multitude of functions to perform, the characteristics of these systems need to be carefully designed. The user interface is a critical part of the system and needs to be as intuitive and consistent as possible. In view of the rough-and-tumble and often hectic hangar and flightline environment, the system needs to be both robust in its implementation and speedy in the performance of its functions. Size is also an issue, as the system must perform in many environments from an engineer's lab or office to the flightline, at a remote site, or even on-board an airplane or a Naval aircraft carrier. Power requirements are often different in each of these environments. These are just a few of the issues that are being addressed, to give you the flavor of the system design task,

The Air Force has been striving to acquire *standard* airborne test instrumentation equipment since the late 1960s. The original Airborne Test Instrumentation System (ATIS) was delivered in 1973, along with an associated ATIS GSU. In late 1987, a development effort was begun to significantly upgrade the ATIS GSU and its software. At that time, the ATIS airborne units were undergoing an upgrade to the Advanced ATIS (AATIS) system. The new GSU, which supports both ATIS and AATIS airborne units, is called the Test Instrumentation Management System (TIMS). The TIMS is currently in the final phase of its development. Most of the original requirements have been implemented and are being used at Edwards AFB, California and Eglin AFB, Florida. Due to the funding-driven schedule, the development is expected to continue to the end of 1996.

In 1989, a tri-service program, with the Navy as the lead, was initiated to develop a standard airborne test instrumentation system for *all three services*. The system being developed by this program is the Common Airborne Instrumentation System (CAIS). The CAIS program will develop a ground support unit called the Portable Flightline Unit (PFU). The CAIS PFU is currently (May 1993) in the requirements analysis phase.

The CAIS PFU is required to support the flight test of the initial CAIS units in mid 1994, and the TIMS GSU will support these units by late 1994. While the PFU software will run on a PC, the TIMS software currently runs on a workstation, giving the user a larger hardware package but with more comprehensive and sophisticated functions. This paper will compare and contrast the major capabilities of the existing TIMS with the planned CAIS PFU. It will then briefly discuss the issues of commonality and interoperability between these two ground support systems. To avoid misunderstandings we will adhere to the following definitions:

commonality - A measure of the extent to which a system can be serviced and maintained by multiple programs, centers, and agencies. Also, the extent to which two

or more systems use the same or at least *interchangeable* hardware or software.

instrumentation system - The terms "instrumentation system" and "test instrumentation system" are used interchangeably. When we refer to the production instrumentation system we will use the word "production".

interoperability - A measure of a system's ability to exchange data or programs with another system or to *operate* with systems that were designed to operate with the other system.

measurand - The end item of interest to the flight test engineer, after first-generation processing or beyond.

sample - The data gathered from the data acquisition units, before processing, but would also be used for a multi-word sample that has merely been pieced together.

OVERALL DESCRIPTION

TIMS — Care has been taken to provide a system that is modular and expandable, to make future upgrades and enhancements easier. The hardware and software functionality can be hosted on a rack-mount server system (for lab use, or installation in a mobile flightline cart), a deskside workstation, or a "roll-around" portable unit (Figure 1). In addition, a laptop PC configuration can be used to load and verify the airborne units. While the PC configuration does not contain a database or perform decommutation and display, work is underway to host these functions on a portable PC by mid 1994. The computer platform, except for the PC, is a Data General AViiON® workstation or server.

Figure 1 — "Roll-around" TIMS unit - Approximately 5 feet high, the unit weighs about 200 pounds.

TIMS employs "open systems" concepts. The computer hardware is based on the Motorola 88000 chip set and utilizes the VME bus. All communications and data transfers are performed using RS-232, Ethernet (TCP/IP), modem, modified SDLC (IBM Synchronous Data Link Control protocol), 3.5 inch floppy disk, 9-track tape, or 1/4 inch cartridge tape. The interface to the airborne units is currently achieved using two VME interface cards, one for the old (non-SDLC) ATIS units and one for the SDLC units which include AATIS (Figure 2). A modified SDLC is required because that is how the interface was implemented in the airborne units. A card to interface to both these unit types plus the new CAIS units is currently in development. The system also interfaces to the front-end decom system—the Telemetry Data Processor (TDP)—and to various strip chart recorders. The TDP can be either an external rackmount unit or an internal VME card set, both manufactured by Acroamatics, Inc.

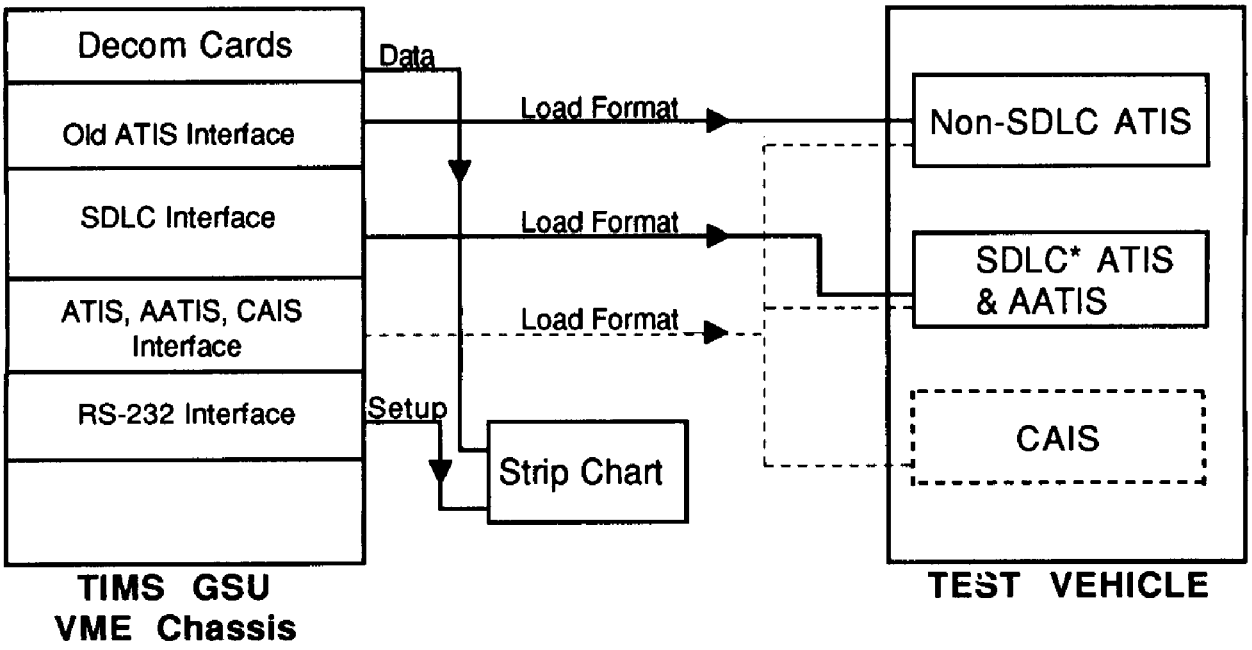

Figure 2— TIMS Block Diagram - some interfaces are not shown. * = modified. - - - = planned or in development.

The operating system is Data General Corporation's U nix® variant, DG/UX™, and the database is Unify Corporation's Unify® Relational Database Management System. The software, which is being developed by Data General, is written in C and Accell™, which is Unify's 4GL. The windowing system used is the X window™ system and several of the TIMS programs are Motif™ applications. The Unify data entry screens are text-based. The two user interfaces employed, the text-based data entry screens and menus and the Motif window applications, each present a consistent, well-integrated interface to the user.

PFU — The CAIS PFU is intended to be a small, portable, low-cost ground support unit. Its custom software will be hosted on a portable IBM-AT-compatible PC with four extra card slots and using the MS-DOS operating system. Physical specifications will be 16 inches wide, 11 inches high, 8 inches deep, and no more than 23 pounds in weight. The software will be developed by SCI Technology, Inc. Communications and data transfers will be performed using RS-232, modified SDLC, the CAIS bus, and 3.5 inch floppy disk. The software will be written in C and the user interface will be text-based. The PFU will use a database, specified as a commercial DBMS. The decommutation functions will be performed by a bit sync card and a decom card, both hosted on the PC bus. The interface to the CAIS airborne units will be performed by two additional printed circuit cards, one an off-the-shelf SDLC card (this card loads the units via the CAIS System Controller), the other a custom CAIS Bus Interface card (Figure 3). The initial PFU implementation will not load the AATIS units but later versions will, using the SDLC interface. Since none of these cards will be required to build the database or generate the formats, the user will be able to load the software onto any compatible PC for the purpose of performing this initial work. The floppy disk can then be used to transfer the formats to the PFU that will perform the preflight.

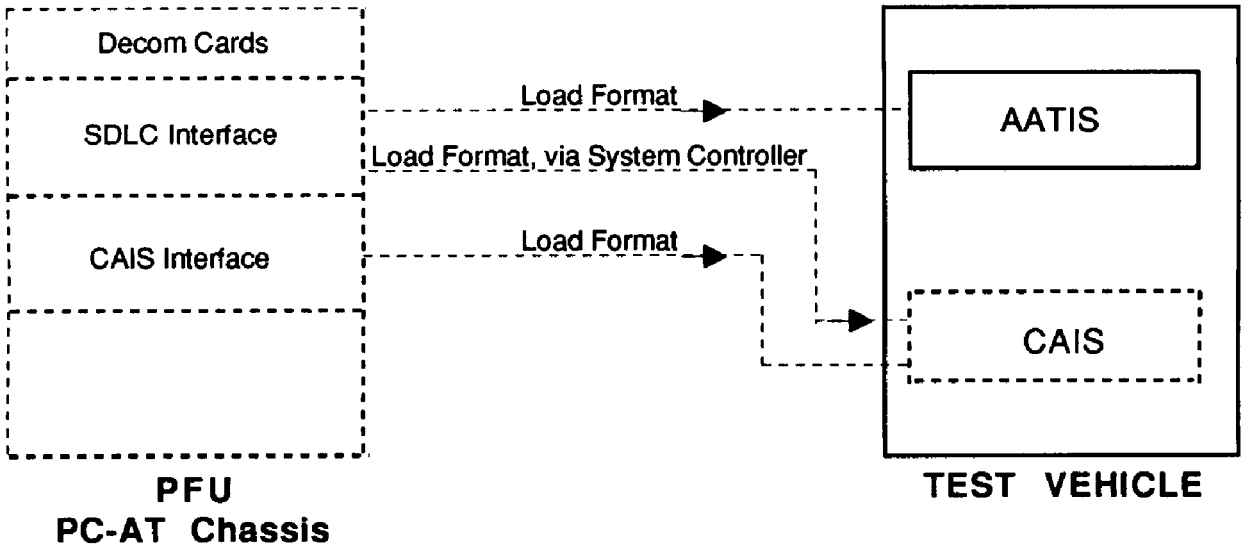

Figure 3 — PFU Block Diagram - some interfaces are not shown. - - - = planned or in development.

FUNCTIONALITY

Both the TIMS and the PFU provide a set of "tools" primarily for the instrumentation engineers and technicians to assist them in their daily tasks. The major functions are:

- Designing and documenting the test instrumentation system network and PCM formats,

- Loading the airborne and GSU programmable units and sending the format description to the Telemetry Control Center (TCC),
- Performing the preflight and/or postflight checkout of the instrumentation system, and
- System maintenance.

Design and Document the instrumentation System Network and Programs

TIMS — TIMS provides a database that is integrated with all of the application programs. The database is the repository for all information pertaining to the physical instrumentation system on the aircraft and the measurands that are to be instrumented, sampled, processed, and analyzed. The measurands are described by:

- Identifier (mnemonic),
- Description,
- Type (analog, digital, bus, etc),
- Engineering units (g, Hz, ft, etc),
- Engineering units coefficients (calculated by an integrated regression analysis program),
- Processing method (raw, polynomial, discrete translation, etc),
- Data limit values (for Data Limit Check),
- Etc.

The physical instrumentation system is described by:

- Data acquisition unit name,
- Data acquisition unit address on the ATIS, AATIS, or CAIS bus,
- Which measurands are connected to which channels of the data acquisition units,
- Description of the associated transducer and signal conditioner,
- The controller unit's configuration (bit rate, word size, etc),
- Connections between data acquisition units and control unit,
- Etc.

PCM formats are laid out using a spreadsheet-like Motif program. Using a mouse, the user drops the samples into cells in the spreadsheet, thereby describing the format of the PCM stream. The output of this program is a data file that is used to automatically generate the loadable images for the airborne controller unit(s) and the front-end decom unit. TIMS currently supports all the ATIS and AATIS units and future releases will support the CAIS units including the CAIS Airborne Processor. The data acquisition units that gather data from the production buses (currently 1553 and H009; CAIS will also support the F-16 Weapons Bus) are programmed by identifying, in the

database, what measurands are to be collected. This information is then used to automatically generate the loadable image. Non-PCM data (e.g., FM data) can be defined in the database and will be demodulated and processed by future versions of TIMS. Inventory control and automatic format generation will also be included in future versions.

TIMS can handle multiple formats for each of any number of controller units and can program the front-end for multiple PCM streams. The system has been tested with four simultaneous streams and can theoretically handle many more with additional decom hardware. The display program can also handle multiple display screens from any number of incoming streams.

User-defined data display screens are laid out by specifying, in the database, which measurands or samples need to be displayed and where each screen entity (text value, bar chart, or graph) is to be placed and what it will look like. This information is used by TIMS to generate the display screens and display the data during the decom operation. In the future, the user will be able to lay out these display screens using a "draw" type of interface.

PFU —The PFU database will contain the information pertaining to the physical instrumentation system on the aircraft and the measurands. The measurands, as a minimum, will be described by:

- Identifier (mnemonic),
- Description,
- Required sample rate and actual sample rate (based on the format),
- Data limit values (for Data Limit Check),
- Calibration date, and
- Calibration data pairs or coefficients (coefficients are a least-squares best-fit derivation from the calibration data pairs).

The physical instrumentation system will be described by (as a minimum):

- Data acquisition unit address on the AATIS or CAIS bus,
- Which measurands are connected to which channels of the data acquisition units,
- Description of the associated transducer,
- Calibration apparatus and method,
- Names of persons performing the calibration, and
- Notes regarding the instrumentation configuration.

The PCM formats will be developed by the user in two ways, an automated format layout program and a spreadsheet-like program similar to the one in TIMS. The automated format layout program will acquire general format parameters from the database (e.g., desired sampling rates and bit rate, desired word length, mainframe length, and maximum subcom depth) and output a format that can be manually modified in the spreadsheet program or sent directly to the format generator program for generation of the loadable image. The automated layout program will use an internal database of CAIS programming rules to ensure a proper format layout. Bus data acquisition units (1553, H009, and Weapons Bus) will be programmed in a similar manner to TIMS, that is, measurands to be sampled will be identified in the database and this information will be sent to the appropriate program generators. The PFU will also generate the programs for the CAIS Airborne Processor which is used to send processed data to displays in the cockpit o r inject it into the PCM stream.

The PFU data display screens will include text-only displays and the user will be able to select from two kinds of display. The large-character display allows the user to select up to three samples, specifying them by word number and minor frame number. This display, which will use large characters to display the data, will be legible from several feet away. The second kind of display, the full-page display, allows the user to view a whole page of samples, 10 samples across and a minimum of 10 lines down, or one frame of data, whichever is less. The user will be able to scroll through this display one line at a time.

Load the Airborne and GSU Programmable Units

TIMS —TIMS automatically loads and verifies all of the ATIS and AATIS airborne units, either singly or as a subsystem. TIMS will also be able to load and verify the CAIS units when they are available. TIMS also loads and performs software configuration of the front-end decom processor and the strip chart recorders. The user can automatically produce a file containing the format description which can then be sent to the Ridley Mission Control Center at Edwards AFB for mission computer set-up. This file is specific to the Edwards MCC, but the capability of producing an IRIG TMATS-compatible file will also be developed.

PFU —The PFU will automatically load and verify all of the AATIS and CAIS airborne units, either singly or as a subsystem. It will also load and perform software configuration of the front-end decom boards and produce an IRIG TMATS file that can be used to set up the compatible telemetry control systems.

Perform the Preflight Checkout

TIMS —The user now invokes the "near-real-time" decommutation, processing, and display programs. As noted above, data can be displayed as text values, bar charts, or graphs. The textual data displays can be shown in decimal, hex, octal, or binary. Besides displaying data, in multiple displays, from multiple PCM streams (the source can be any device outputting PCM data), the system can also simultaneously store the host-processed data into a disk file for later viewing or printing, or it can store the raw or preprocessed data to a disk file for later playback. The playback program gives the user complete control over the data stream, as though it were coming from a tape drive with a very sophisticated user interface. The user can specify, in great detail, the segment to be played back, the speed of playback, and the frequency of playback (one time or repeatedly). The user can also "mark" time-slices of data to be stored in another disk file for later examination or transfer to a PC plotting program. Most of these data-display and -storage operations can be performed concurrently.

Data limit checking can be performed on any one or more raw samples specified by the user. TIMS can use previously-entered limit values from the database, store new limit values from the incoming PCM stream, store new limit values entered by the user during the limit check, or calculate new limit values based on an average of the incoming sampled data. In each case where new limit values are stored in the database, these values are used as the limit for all subsequent checks.

Other diagnostics, to be performed by future versions of TIMS, include a Configuration Match Test, in which TIMS will poll the CAIS units on the aircraft and receive back the identification and status of each unit (including the signal conditioning cards' type and location). An indication of any differences between the airborne system and the configuration files on the GSU will be presented to the user, including any units present on the aircraft but not appearing in the configuration file. TIMS will also perform internal testing of all the VME cards, and it will command the airborne system to perform a Built-in Test and alert the user of any anomalies. Other data input capabilities to be added include Heads-Up-Display data displayed on the GSU's CRT, and voice data processed by a VME card and played back during the decom operation.

PFU —The PFU will decommutate a single PCM stream and display the data in raw form. The user will be able to display the data in either of the two display screens previously described. For the full-page display, the user sequences through the measurands by using the keys on the keyboard. The data values will be displayed as decimal, hex, or binary, according to the user's choice, and the status of the bit sync and decommutator will also be displayed.

Data limit checking will provide the same input options as TIMS except for the capability to store current incoming values from the data stream. The PFU will also perform most of the "other diagnostics" described above, under TIMS functionality, including the Configuration Match Test, commanding the airborne system to perform the Built-in Test, and testing the SDLC, CAIS Bus Interface, and decom cards. There are no plans to provide video inputs to the PFU, but an external unit is planned to allow decommutation of the voice track from the PCM stream for playback while displaying data.

System Maintenance

TIMS and the PFU will both provide system maintenance functions including database copy, database backup, effective test copy, and data transfers between like or compatible systems. A method for transferring formats or databases between PFU and TIMS systems is still to be identified. The TIMS software also includes a computer-based TIMS tutorial.

PERFORMANCE

TIMS —TIMS systems are supporting the C-17 and B-l flight-test programs. The C-17 TIMS system was installed at Eglin AFB to support the climatic testing there. This system, in its preoperational configurations, was tested with two input streams of approximately 670,000 bits per second (bps) each. The input capacities of the Acroamatics TDP (rackmount unit) are 16 Mbps for NRZ coded data and 8 Mbps for Bi-phase coded data. The data is decommutated by the TDP, preprocessed to perform such functions as data scaling and format conversion, and selectively passed to the host via the VME General-Purpose Data Channel card (GPVME). The TDP can pass raw data at 1,000,000 samples per second (sps), and for a typical mix of data preprocessing, averages 500 Ksps. This is about one tenth the constant (not burst) throughput capacity of the GPVME. On the production C-17 support system, the throughput rate being used is 92.5 Ksps.

On the host, the data is handled by a distribution process called nrtserv (this is the near-real-time process), which has been tested with two streams of 2 Mbps each. The capabilities of nrtserv to record raw data to disk have been tested in the development lab at the rate of 1.2 million bytes per second (MBps), with a goal of 2 MBps or 500 Ksps.

Performance over the thin Ethernet network is 150 Ksps, regardless of the number of client terminals viewing data, i.e., all the incoming data is broadcast to the net and the clients pick up whatever they need, This figure is for a *remote* nrt session. For *local*

nrt sessions (wherein the clients are not on a network) the data can be distributed to the display client(s) at 500 Ksps. The C-17 TIMS system is configured with dual networks for better data display performance.

The B-l TIMS system was installed in March 1993. This system currently supports IRIG Chapter 8 decom from the AATIS Multiple 1553 Data Bus Monitor (MDBM) and in the near future it will be capable of accepting multiple PCM streams (from multiple IRIG Chapter 8 buses) and determining the correct time correlation between them. Note that the MDBM does not adhere 100% to the IRIG Chapter 8 standard.

PFU —The PFU's bit sync is specified to operate at bit rates up to 15 Mbps for NRZ-L coded data and up to 7.5 Mbps for all other PCM codes. The decom board is specified to operate at up to 15 Mbps. At least two word lengths will be supported, 12 and 16 bits per word.

COMMONALITY AND INTEROPERABILITY

Commonality and especially interoperability are vital issues to the government organizations. Commonality (same or similar equipment, including software) allows more efficient logistics and maintenance support. Organizational impacts include numbers of personnel and training required, cost of the spare parts inventory, government-furnished equipment required for follow-on projects, and shipment of equipment to remote test sites. Another issue is the similarity of user interfaces and reports. In these times of budget cuts and hiring freezes, it is an advantage to have similar systems, user interfaces, and computer products at organizations that must work together. It improves communications between the personnel and makes sharing of personnel and resources much more likely. The TIMS GSU and the CAIS PFU, as currently planned, will not use common hardware. However, some of the software that will be developed for the PFU may use some parts of the TIMS software as a starting point and the goal is to make the applications as similar as practical. This goal will be worked by a CAIS-TIMS Working Group which will be initiated this year.

Interoperability, or the lack thereof, affects many areas of operations. One of the advantages of the open systems standards chosen for use in the TIMS system is the relative ease with which several of the aircraft manufacturer' s computer systems were interfaced to TIMS for downloading of format data available on those systems. Another issue is the sharing of test ranges and facilities between organizations and between the three services. A test aircraft that is taken to a different test facility for specialized testing can be better supported if the equipment at the remote facility is interoperable with the on-board systems, including software. To this end, the CAIS-TIMS Working Group, mentioned above, will work to ensure the TIMS GSU

and CAIS PFU will be able to exchange format files on floppy disk. A secondary goal will be to exchange database files.

CONCLUSION

The military services are attempting to meet their needs for flight-test instrumentation with the AATIS and CAIS development projects. The ground support systems associated with these projects are intended to meet the total instrumentation requirements from the test measurand database through flight line operations to the user interface. The continued rapid growth in hardware capabilities has enabled the provision of large amounts of information and resources to the users. The challenge is to provide these resources in the way that is most suitable to the needs and capabilities of the users. Important considerations also include commonality of equipment and interoperability between systems. This paper has presented a brief overview of two test instrumentation ground support systems, the AATIS TIMS system and the planned CAIS PFU. While both systems are intended to support flightline operations and system setup, the TIMS system is aimed at satisfying a larger set of requirements specifically for the Air Force users. Version 2.0 of TIMS is currently in use at Edwards AFB and Eglin AFB while the CAIS PFU is in the requirements analysis stage of development. As the CAIS PFU development gets underway, the TIMS and CAIS PFU development teams will work together to make the two systems interoperable on the PCM format and database level.

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