AN IMPLEMENTATION OF A COMPLETE XML SYSTEM FOR TELEMETRY SYSTEM CONFIGURATION

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ABSTRACT

Creating a generic, multi-vendor data exchange system for transmitting telemetry configurations between various systems is a daunting task. To date many different systems have been proposed including relational databases (RDBMS), TMATS, and several different XML schemas. Although many of these systems have been implemented, a complete, flexible solution has not been developed.

This paper describes an implementation that is currently in use for exporting and importing a complete telemetry system via XML. Using this system, an engineer can import an entire telemetry configuration, a partial telemetry configuration, or even just a single measurement (parameter). As a result, the gap between user database systems and the airborne instrumentation vendor's configuration software (IVCS) is seamlessly bridged. This provides many benefits including: the ability to rapidly change configurations, data entry error avoidance, version control, the protection of sensitive information, and configuration reusability. This system allows for the configuration of all aspects of the telemetry setup including data acquisition hardware, transmitters, ground stations, and recorders. In addition, the recorder settings and the definition of the data that are to be recorded are coupled and linked to the rest of the telemetry configuration, which facilitates future data recovery.

KEY WORDS

XML, Data Exchange, RDBMS, Telemetry Configuration Management

INTRODUCTION

As data acquisition systems become more complex to support newer aircraft and technologies, it becomes increasingly more difficult to create and manage large scale telemetry configurations. Alternative methods for telemetry system configuration and programming must therefore be pursued.

One way to simplify this process is to close the gap between user database systems and the airborne instrumentation vendor's configuration software (referred to as IVCS for the remainder of this paper). The system described in this paper is currently being used to bridge this gap. By facilitating the exchange of data using XML, much of the work typically involved with manually re-entering information from the user's measurement database to the IVCS is eliminated. As a

result, data entry errors are virtually eliminated and the user gains the ability to rapidly change telemetry configurations without incurring a huge setup burden. This paper discusses the XML import / export system and its benefits, and provides two examples of real world applications of the system.

SYSTEM DEFINITION

This system consists of a complete set of XML tag definitions for each of the vendor's data acquisition modules, XML tag definitions for the PCM format, and a graphical user interface that is part of the IVCS to import and export XML. Any XML file that is generated in accordance with the provided documentation can be imported into the IVCS. The XML files in this system have the high-level XML structure shown in Figure 1.

Figure 1. High-Level XML Structure.

```
<?xml version="1.0" ?>
- <TTC>
  - <PROJECT>
      <HARDWARE />
      <STREAMS />
      <PARAMETERS />
      <RECORDER_SETUP />
    </PROJECT>
  </TTC>
```

The "HARDWARE" section contains definitions for each data acquisition chassis and module along with its settings. The "STREAMS" section contains the definitions for all PCM outputs. The "PARAMETERS" section contains the definitions for each measurement along with their reference locations in the PCM format. The "RECORDER_SETUP" section contains definitions for recorder instructions.

Figure 2 provides an example of a 1553 parameter datasheet. Each datasheet contains the definitions for the card and parameter specific settings. Each tag contains a listing of its corresponding data type, input value range, and default values. Using these datasheets, an entire XML file representing a telemetry configuration can be created.

Figure 2. Sample Acquisition Module Datasheet.

PARAMETER CONFIGURATION			
REMOTE_TERMINAL			
-----	Enum	Remote Terminal 00	Remote Terminal 00 to Remote Terminal 31
Remote Terminal **NOTE:** Not applicable if "Residual Data or Extended Read" is specified for <MESSAGE_COMPONENT>			
TRANSMIT_RECEIVE			
-----	Enum	Receive	{Receive, Transmit}
Transmit / Receive **NOTE:** Not applicable if "Residual Data or Extended Read" is specified for <MESSAGE_COMPONENT>			
SUB_ADDRESS			
-----	Enum	Subaddress 00	Subaddress 00 to Subaddress 31
Sub Address **NOTE:** Not applicable if "Residual Data or Extended Read" is specified for <MESSAGE_COMPONENT>			
MESSAGE_COMPONENT			
-----	Enum	Data Word	{Data Word, First Command Word, Second Command Word, XMT Status, RCV Status, High Time Tag, Low Time Tag, Micro Time Tag, Residual Data or Extended Read, Discrete Word, Read Next Data Word}
Message Component.			
DATA_WORD			
-----	Enum	Data Word 00	Data Word 01 to Data Word 32
Data Word Number **NOTE:** Only applicable if "Data Word" is specified for <MESSAGE_COMPONENT>			

XML EXPORT

XML Export is a mechanism for extracting information from this data exchange system. The extracted information can then be used to create a new telemetry configuration or to augment existing configurations. Using the IVCS, a flight test engineer can generate an XML file representing the current telemetry configuration. These exports can then be used for archival purposes, report generation, and for future hardware configurations. Selected components of the configuration can be exported using the IVCS interface shown in Figure 3.
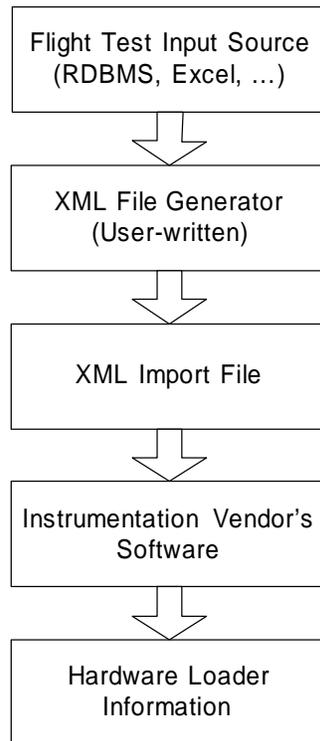
Figure 3. XML Export Screenshot.
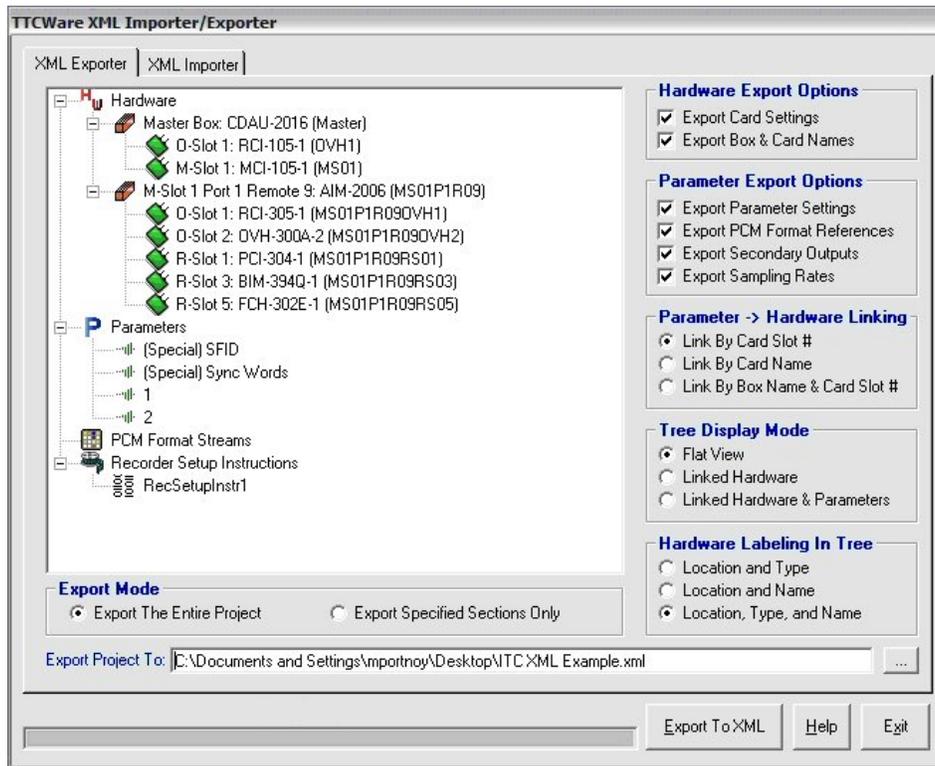

XML IMPORT

XML Import is a mechanism for mass data entry that allows a user to populate the IVCS automatically using an input XML file without requiring the user to manually enter data through a graphical user interface. Figure 4 illustrates the import process:

Figure 4. XML Import Flow Diagram.

To use XML Import, users must write a translator program to convert data from their RDBMS (or Excel spreadsheets) to an XML file in accordance with the provided XML schemas and documentation. These user-generated XML files are then loaded into the IVCS interface as shown in Figure 5.

Figure 5. XML Import Screenshot.
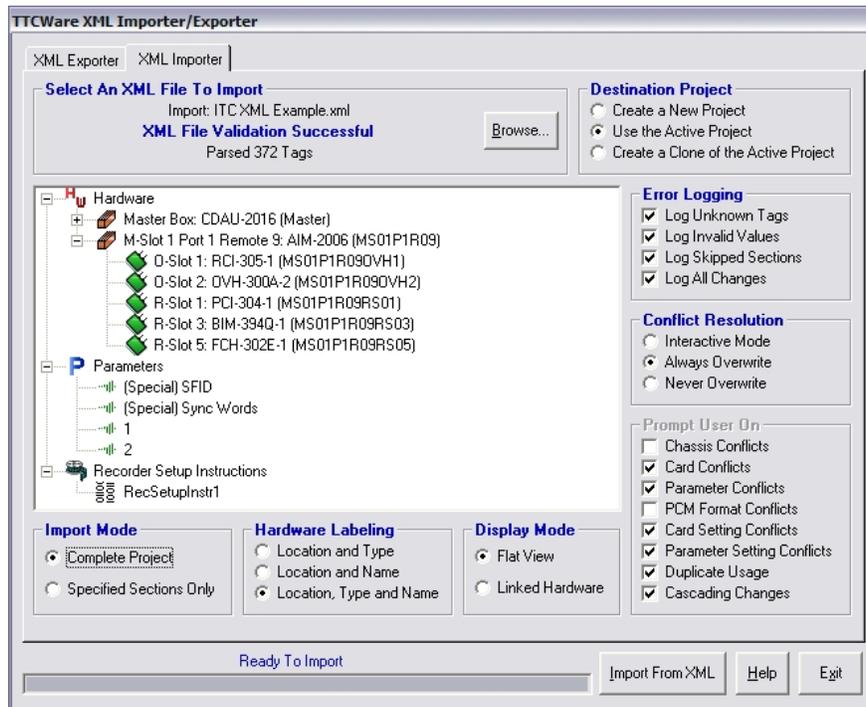
Once the file is loaded, the user can choose to create a new project, to augment the current project, or to create and modify a clone of the current project. The content of the import can be customized by specifying exactly which components are imported. During the import process, errors and other feedback are logged and can be viewed upon completion of the import.

BENEFITS

This system provides many benefits including:

- Availability of commercial off the shelf (COTS) XML applications for verification and validation
- Human readability of the data exchange files
- Database independence
- Unified airborne / ground station approach
- Data entry error avoidance
- Version control
- Protection of sensitive information
- Configuration reusability

By using XML and XML schemas, users of this system can make use of the many commercial off the shelf (COTS) XML applications to assist in XML generation, viewing, analysis, verification, and validation. This bypasses the often complex and expensive process of writing custom code to validate and process data exchange files. The use of commercial tools also ensures that these data exchange files will be easy to process in the future.

Since XML is a human readable markup language, one avoids the problem of decoding cryptic tags and attribute names that frequently occurs when working with other data exchange formats such as TMATS. Additionally, high level errors can be detected by a quick reading of the XML files. Finally, one can use XSLT to transform the data contained in the XML files into reports.

XML provides an abstraction layer between the user's database and the IVCS. This abstraction layer allows both the user and the vendor to alter their systems without affecting the overall data exchange process. This holds as long as the XML schema layer remains untouched.

Another feature of this system is that a single, unified architecture controls the configuration of all data acquisition hardware and ground stations. This simplifies configuration management and aids in future attempts to recover archived data and past flight test results.

The risk of human error due to manual data entry is virtually eliminated since this system automatically populates the instrumentation vendor's databases. A graphical user interface is only used to import and export the XML files; no data entry is done using the graphical user interface. By consolidating the number of possible input sources from several test engineers to a single translator program (described above in the XML Import section of this paper), the potential sources of error are reduced. Errors that are detected can then be fixed at the translator level and thus all subsequent XML files will be generated correctly.

The use of this system also facilitates good configuration practices such as version control. Since all configurations originate directly from the RDBMS and not from an engineer using a particular instance of the IVCS, configuration discrepancies are prevented. Whenever a change to the telemetry configuration is required, the change is made at the RDBMS level. Afterwards, a new XML input file is generated and then fed into the IVCS. Since the XML input file is generated by the user, the flow of information from the RDBMS to the IVCS can be very tightly controlled, which facilitates the protection of sensitive and classified data.

Since the user generates XML files programmatically, it is possible to easily reuse configurations. Subtle modifications can be made and the configuration can then be quickly regenerated and re-imported into the IVCS. These changes can be tracked at the RDBMS level for version control and easy maintenance.

PRACTICAL APPLICATIONS

This XML import / export system is being used in many programs, such as the Joint Strike Fighter (JSF / F-35) and the NAVY at Patuxent River. The JSF program is utilizing XML Import to completely generate their telemetry configurations from their RDBMS. In contrast, the NAVY is currently using this system only to import large quantities of 1553 parameters into telemetry configurations. These two examples illustrate dramatically different uses of this system (one for the entire system, the other for a specific type of measurement).

Application 1 (JSF)

This XML import / export system is uniquely suited to the needs of the JSF program due to their need to rapidly and dramatically change their instrumentation configurations. The JSF program intends to store their telemetry configuration in a proprietary RDBMS. Using conventional systems an engineer would be required to manually enter all of this information, which would take a tremendous amount of time to complete due to the size and complexity of the database. Furthermore, this manual data entry process would have to be repeated for each required

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configuration. Therefore, the JSF program is opting to use the system that is described in this paper. Using custom code that they are writing, the JSF data processing engineers generate an input XML file from their RDBMS. The task of writing this code, although time consuming, is a one time cost. In addition, the recorder setup information will also be defined in the XML form. This is in addition to being defined in the TMATS form per IRIG –106 chapter 10.

Application 2 (NAVY)

Using the 1553 Schema, Patuxent River has saved a tremendous amount of time by automating the import of thousands of 1553 parameters into their telemetry configurations. First, an input XML document is created in accordance with the provided 1553 Schema. Using XML Spy (a COTS XML processing suite), the input XML document is verified against the 1553 Schema. During the validation process, the input file is automatically checked for data type consistency and for input value range correctness. Following validation, the file is imported into the system configuration software using the import mechanism that was previously discussed. Due to the fact that the 1553 Schema is generic, the process of generating the following sample XML input file is very straightforward. Figure 6 provides an example that illustrates a single 1553 parameter XML import file.

Figure 6. Example 1553 XML Import File.

```xml
<?xml version="1.0" ?>
<TTC xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="1553Schema.xsd">
  <PROJECT Name="PAX Import Example" Description="Latest Hardware Setup with EUP-105-3" Source="D:\program
    Files\Teletronics\TTCWARE\521\TTC_USER.MDB" Revision="1" Exporter="TTCWare 3.04.7">
    <HARDWARE>
      <BOX Mode="Master" Type="EDAU-2016">
        <CARD Type="REI-105-1" Bus="O" Slot="1" />
        <CARD Type="MEI-105-1" Bus="M" Slot="1" />
        <CARD Type="EUP-105-3" Bus="M" Slot="4" />
        <CARD Type="BLS-148-1" Bus="M" Slot="9" />
        <CARD Type="BIM-553-4" Bus="M" Slot="14" />
      </BOX>
    </HARDWARE>
    <PARAMETERS>
      <PARAMETER ShortMnemonic="CMUX1234-01" LongMnemonic="CMUX1234-01" Source="Master" MasterSlot="5">
        <GROUP>None</GROUP>
        <NOTES>Automatically Generated 1553 Parameter added on 4-Feb-2005 16:09:23</NOTES>
        <SETTINGS>
          <REMOTE_TERMINAL>2</REMOTE_TERMINAL>
          <TRANSMIT_RECEIVE>Receive</TRANSMIT_RECEIVE>
          <SUB_ADDRESS>17</SUB_ADDRESS>
          <MESSAGE_COMPONENT>Data Word</MESSAGE_COMPONENT>
          <DATA_WORD>1</DATA_WORD>
        </SETTINGS>
        <REFERENCES>
          <REF Format="1" Word="2" Frame="1" WordIncrement="0" FrameIncrement="0" />
        </REFERENCES>
      </PARAMETER>
    </PARAMETERS>
  </PROJECT>
</TTC>
```

CONCLUSION

XML data exchange can be a powerful tool for simplifying the setup of telemetry configurations as demonstrated by the system described in this paper. To further improve the usability of this system, one could add the capability to bypass the remaining steps that must be performed manually using the IVCS. For example, a data acquisition system could then be programmed from the Internet using XML. Ultimately, approaches such as the one described above must be explored until a completely automated mechanism for telemetry system configuration is developed.

REFERENCES

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2. The latest TMATS Specification can be found on the RCC website: http://www.jcte.jcs.mil/rcc.
3. The homepage for XML Spy is: http://www.altova.com/products_ide.html

GLOSSARY OF TERMS

COTS   Commercial off the Shelf

IVCS   Instrumentation Vendor's Configuration Software – Software provided by the airborne instrumentation vendor for configuring the hardware, defining a PCM format, and programming the data acquisition system.

RDBMS   Relational Database Management System

XML   Extensible Markup Language

XSLT   Extensible Stylesheet Language Transformations