Reducing the Cost of Ground System Development and Mission Operations Using Automated XML Technologies

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Overview

- The Problem
- Rationale
- Solution
- What is XML?
- Dictionary Management
- Report Generation
- Lessons Learned
- Future Work
- Conclusion

The Problem

- Spacecraft flight and ground system development must occur in parallel
  - The system must be able to adapt to design changes in the flight system as they occur

- Ground system development must occur before mission operations team is fully staffed
  - The ground system must be highly configurable to meet anticipated needs of mission operations personnel

Rationale

- We needed a well structured interface
  - allows for the possibility of automated ground system updates
  - enables mission operations personnel to reconfigure the system to meet their needs without possessing advanced programming skills

Solution

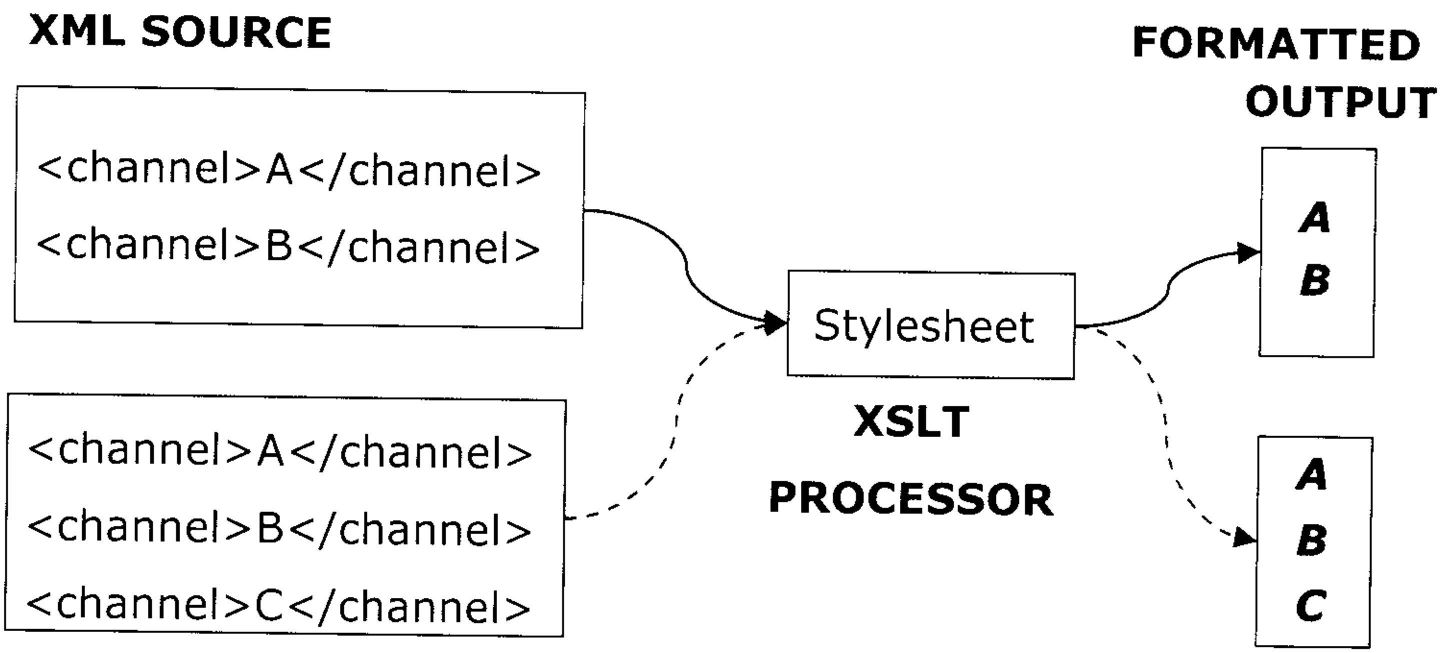
- Use XML to define the interfaces between the flight and ground system
  - Automate command and telemetry dictionary generation and deployment
- Use XML to configure ground tools used for mission operations
  - Automate report generation and deployment

What is XML?

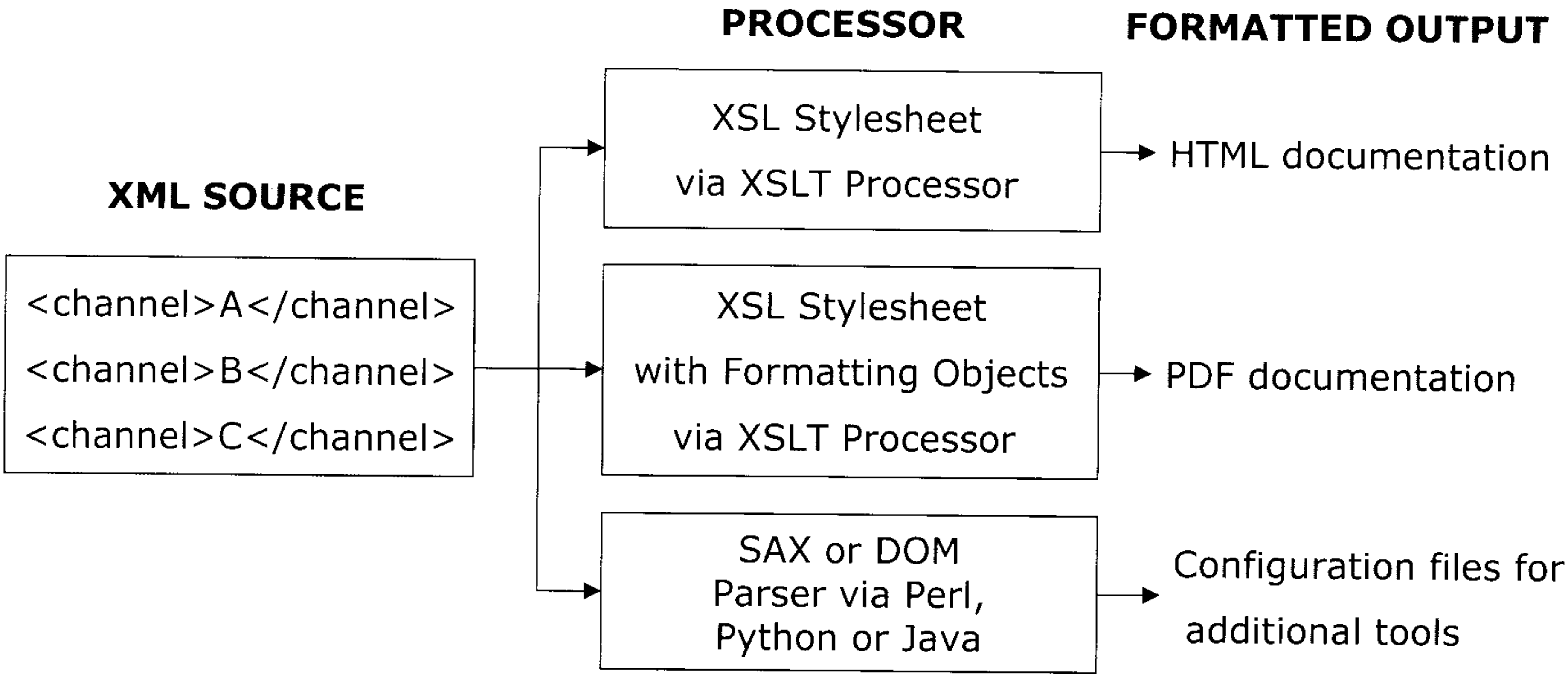
- Extensible Markup Language
- XML is a "meta-markup language"
  - Data is in human-readable text form
    - Can be edited with simple text editors and/or specialized tools
- As Java gives us "portable code", XML is intended to provide "portable data"

```
<?xml version="1.0">
<greeting>
    <message>
        Hello World!
    </message>
</greeting>
```

Flexible Input



Flexible Output



Dictionary Management

- The flight team provides XML versions of both the command and telemetry dictionaries
- Automation scripts (XSLT, Python) are used to generate and deploy
  - Configuration files
    - used by the ground system to process the telemetry and generate commands
  - Dictionary documentation
  - This entire process can be completed by a full time employee in ~4 hours from receipt of the XML from the flight team

```
<?xml version="1.0"?>
<channel_parameter_table>
  <header>
    <project>Example Project Documentation</project>
    <version ver_id="X" date="X" owner="X"/>
  </header>
  <channel_definitions>
    <channel id="A-AAAA" size="X" type="XXXXX"
             subsystem="XXX" source="XXX">
      <module>XXX</module>
      <fsw_name>XXX</fsw_name>
      <gds_title>XXX</gds_title>
      <ccl_parameter>XXX</ccl_parameter>
      <ccl_process>XXX</ccl_process>
      <time_type>XXX</time_type>
      <dn_conversion>XXX</dn_conversion>
      <dn_format/>
      <eu_format/>
      <eng_units>XXX</eng_units>
      <children>
        <child>XXX</child>
      </children>
      <sample_rate/>
      <range_type>XXX</range_type>
      <range>
        <min/>
        <max/>
      </range>
      <maturity>XXX</maturity>
      <description>XXX</description>
    </channel>
  </channel_definitions>
</channel_parameter_table>
```

C:\Documents and Settings\Colette Wilklow\Desktop\A-AAAA.html - Microsoft Internet Explorer

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A-AAAA **GDS Name: XXX** **Review:** **Maturity: XXX**

Subsystem: XXX **Size: X bit** **Type: XXXXX** **Source: XXX** **MPF ID:**

Description: XXX

FSW Name: XXX
FSW Module: XXX
Sample Rate:

Range Type: XXX
Range Min:
Range Max:
Time Type: XXX

States:

Derived Channel Information
Trigger Channel:
Derived Children: | XXX |
Parents:

CCL Process: XXX CCL Parameter: XXX
DN-EU Conv: XXX EU Units: XXX
DN Format: EU Format:

Test Selection Criteria

	Update	Criteria	Low	High
Real Time	XXX	XXX	XXX	XXX
Recorded	XXX	XXX	XXX	XXX

Cruise Selection Criteria

	Update	Criteria	Low	High
Real Time	XXX	XXX	XXX	XXX
Recorded	XXX	XXX	XXX	XXX

Fault Selection Criteria

	Update	Criteria	Low	High
Real Time	XXX	XXX	XXX	XXX
Recorded	XXX	XXX	XXX	XXX

Surface Selection Criteria

	Update	Criteria	Low	High
Real Time	XXX	XXX	XXX	XXX
Recorded	XXX	XXX	XXX	XXX

Done My Computer

Example Project Documentation

JPL

A-AAAA GDS Name: XXX Review: Maturity: XXX

Subsystem: XXX Size: X bit Type: XXXXX Source: XXX MPF ID:

Description: XXX

FSW Name: XXX
FSW Module: XXX
Sample Rate:

Range Type: XXX
Range Min:
Range Max:
Time Type: XXX

States:

Derived Channel Information
Trigger Channel:
Derived Children: | XXX |
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Fault Selection Criteria

	Update	Criteria	Low	High
Real Time	XXX	XXX	XXX	XXX
Recorded	XXX	XXX	XXX	XXX

Surface Selection Criteria

	Update	Criteria	Low	High
Real Time	XXX	XXX	XXX	XXX
Recorded	XXX	XXX	XXX	

Example Project Documentation (EPD)

Example - Mission System
Volume X Telemetry Dictionary
IS_1x

Author: E. X. Ample

Approved:

Grand Poobah, Project Manager

Big Kahuna, Deputy Project Manager

Big Kahuna, Deputy Project Manager

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October 24, 2002

JPL

Jet Propulsion Laboratory
California Institute of Technology

A-AAAA [illegible] XXX [illegible] [illegible] XXX
[illegible] XXX [illegible] [illegible] XXX [illegible] XXX [illegible]

[illegible] XXX

[illegible] XXX
[illegible] XXX
[illegible]

[illegible] Type XXX
[illegible]
[illegible]
[illegible] Type XXX

[illegible]

[illegible] Channel [illegible]
[illegible] Channel
[illegible] (XXX)
[illegible]

[illegible] XXX
[illegible] XXX
[illegible]

[illegible] XXX
[illegible] XXX
[illegible]

[illegible]

	[illegible]	[illegible]	Low	High
[illegible]	XXX	XXX	XXX	XXX
[illegible]	XXX	XXX	XXX	XXX

[illegible]

	[illegible]	[illegible]	Low	High
[illegible]	XXX	XXX	XXX	XXX
[illegible]	XXX	XXX	XXX	XXX

[illegible]

	[illegible]	[illegible]	Low	High
[illegible]	XXX	XXX	XXX	XXX
[illegible]	XXX	XXX	XXX	XXX

[illegible]

	[illegible]	[illegible]	Low	High
[illegible]	XXX	XXX	XXX	XXX
[illegible]	XXX	XXX	XXX	

Report Generation

- Motivation – to automatically process mission data and populate outputs that would otherwise be hand-generated by mission operations personnel
- MER Report Generation is a suite of XML definitions, Java and Python tools and XSL Transformations

Appetizers

End of Pass Summary Overview Reports

This report gives an overview of telemetry from the most recent Sol, including channelized telemetry, event reports and data product accounting. This report is intended provide a quick look at spacecraft data in support of the initial downlink assessment

Initial Conditions Reports

These reports are created to support the needs of spacecraft modeling tools to have the most up-to-date knowledge of Rover states. These reports are generated from telemetry and are then ingested in the various tools including those used for Planning & Scheduling, Rover Modeling and Power Modeling

Main Courses

End of Pass Detailed Reports

This report gives a detailed summary of telemetry from the most recent Sol, including channelized telemetry, event reports and data product accounting

Special of the Sol

End of Sol Reports

This report gives a detailed summary of telemetry from the most recent Sol, including channelized telemetry, event reports and data product accounting

Build Your Own Report

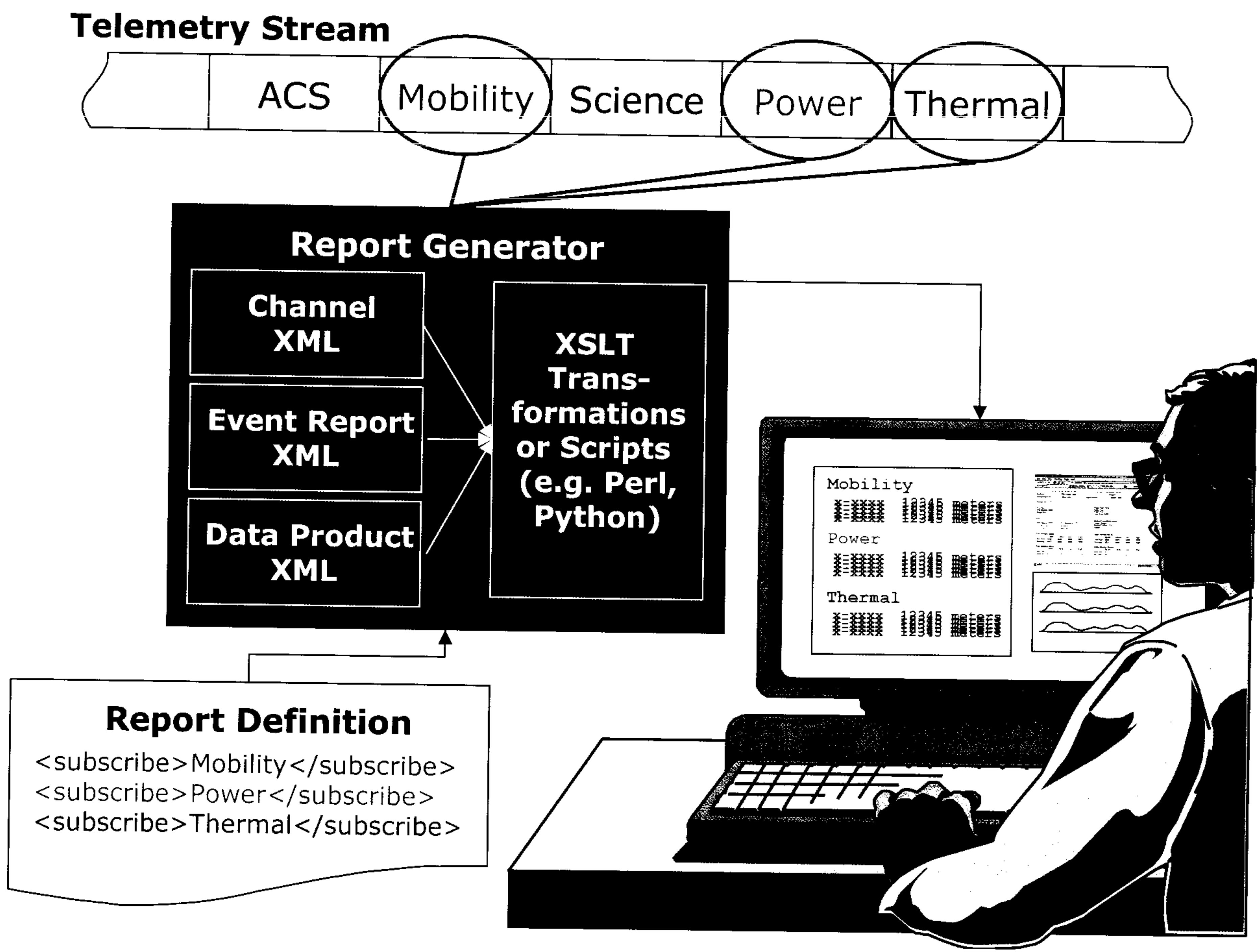
*Capabilities**

Subscribe to one or more of packet application identifier counts, event reports, latest telemetry channels, telemetry channels on change, all telemetry channels, new product availability and values to be plotted by an external plotting tool.

Output Formats

ASCII text, Encapsulated Comma-Separated Value (ECSV), Extensible Markup Language (XML), HyperText Markup Language (HTML), and Portable Document Format (PDF)

*New capabilities may be added upon request



Telemetry Stream
ACS
Mobility
Science
Power
Thermal
Report Generator
Channel XML
Event Report XML
Data Product XML
XSLT Trans-formations or Scripts (e.g. Perl, Python)
Report Definition
<subscribe>Mobility</subscribe>
<subscribe>Power</subscribe>
<subscribe>Thermal</subscribe>
Mobility
Power
Thermal

Lessons Learned

- It is worthwhile to spend time carefully defining the XML schema
  - The schema defines the rules for what is allowed in a given XML file
  - This will save time in later development!
    - Almost all code updates in the last year for the telemetry dictionary generation/deployment process were due to schema changes
- Use multiple XML files if data is orthogonal
  - Generally, XML is only as useful as the data it describes

Lessons Learned Cont...

- It's important to understand the pros and cons of various XML parsers
  - Parsers using DOM are good if you need to randomly access the document elements
  - Parsers using SAX are good if you are processing a very large XML file
    - In the case of our telemetry dictionary, we are talking ~100,000 tags!
  - Some are more mature than others and newer ones may not have certain capabilities, look for parsers that adhere to the W3C XML Recommendation

Future Work

- Complete conversion of tools to become a standard toolkit for new missions
- Investigate automatic generation of XSL stylesheets and report definitions

Conclusion

- XML has greatly improved our ability to quickly propagate changes in the flight system to the ground system
- We have developed a highly configurable system that has improved our ability to define and process information efficiently and accurately
- We have developed and supported this system with minimal staffing and have designed a system that will be applied to future missions, thus reducing the cost to this and future projects