Autonomous Real Time Requirements Tracing
Autonomous Real Time Requirements Tracing

George Plattsmier
Marshall Space Flight Center

Howard Stetson
Teledyne Brown Engineering

Paper Authors

George L. Plattsmier
Marshall Space Flight Center
Huntsville, AL 35812
256-544-3963
George.l.Plattsmier@nasa.gov

Howard K. Stetson
Teledyne Brown Engineering
Huntsville, AL 35812
256-961-0399
howard.k.stetson@nasa.gov
Outline

• Introduction
• AFTS Test Bed
• AFTS SRS
• Auto Procedures to Flight Software
• Tracker Sequence
• Timeliner Coding Standard
• Configuration Management
• Summary
Introduction

- Autonomous Mission Operations (AMO), part of NASA’s Advanced Exploration Systems (AES) Program, is using inter-center cooperation to develop new technologies and techniques to enable deep space exploration with an emphasis on procedure development and execution.

- The Autonomous Fluid Transfer System (AFTS) uses Draper Labs supplied Timeliner-TLX software for command, control, and planning for top level execution and monitoring.
AFTS Test Bed

- The AMO team designed the AFTS Test Bed as a means to demonstrate Autonomous command and control capabilities.
AFTS SRS

- 5.1 %AAFTS-0001 The software system shall be capable of performing quarter tank fluid transfers over the primary flow path with a single crew action.
- 5.2 %AAFTS-0002 The software system shall be capable of performing quarter tank fluid transfers over the backup flow path with a single crew action.
- 5.3 %AAFTS-0003 The software system shall be capable of performing quarter tank fluid transfers over the return flow path with a single crew action.
- 5.4 %AAFTS-0004 The software system shall be capable of performing half tank fluid transfers over the primary flow path with a single crew action.
Auto-Procedures to Flight Software

• Auto-Procedures will be a “must use” for deep space missions with communication delays.

• Currently, Auto-Procedure development does not require Software Requirement Specifications Or Software Detail Design documents.

• Only validation of testing required is from peer review and test plans/results showing all paths of execution have been tested.
Auto-Procedures to Flight Software

- Timeliner-TLX proven with use on-Board ISS for payload and core cadre operations (proven reliable commander and flight qualified).
- Timeliner-TLX was selected and used for the Autonomous Mission Operations Autonomous Fluid Transfer Test-bed (Intelligent procedures with embedded FDIR).
- Timeliner-TLX chosen for ISS AMO EXPRESS experiment (Single commanded EXPRESS Rack activation and de-activation).
Auto-Procedures to Flight Software

- With the advancement of intelligent auto-procedures, auto-procedures move into the realm of flight software
- Flight Software must meet NASA Software development and engineering requirements
- The Tracker capabilities will assist in qualification for this movement of auto-procedures to flight software
Tracker Sequence

- Software Requirements Specification (SRS)
- Timeliner Compiler Listing Files (TLL)

- SRS / Timeliner Parser

- Requirement Tracer File (TLS)

- Compiler

- Timeliner TLL
Tracker Sequence

1. Install Tracker Bundle/Sequence
2. Sequence Active
3. Range within Sequence Statement
4. Record Requirement Encountered

Install Test Bundles
Tracker Sequence

- **Sequence TRACKER Active**
  - --***
  - --*** We start our control loop to monitor every second
  - --***
  - **Every 1.0 then**
    - -- *** First we scan the HAL_MAIN Bundle
      - If AWTS_HAL_MAIN.BUNSTAT = BUN_ACTIVE Then -- Is the bundle active?
        - If AWTS_HAL_MAIN.Initialize.SEQSTAT = SEQ_ACTIVE Then -- Is the Initialize Sequence active?
          - If AWTS_HAL_MAIN.Initialize.SEQSTMT IN 25..38 then -- Current line number within the req range?
            - Message "GAFTS-0001 Manual Valve Status Query Requirement"
          - End If
          - If AWTS_HAL_MAIN.Initialize.SEQSTMT IN 56..81 then -- Current line number within the req range?
            - Message "GAFTS-0006 Autonomous Procedure Installation Requirement"
          - End If
        - End If
      - End If
    - -- *** Next we scan the Safety Bundle
-- GAFTS-0001 Manual Valve Status Query Requirement
25 confirm "HAL: Are the Manual Valves One and Two in the On Position?"
26 when RESPONSE RECEIVED WITHIN 1:00 then -- Crew one minute to respond
27 if OPERATOR RESPONSE = AFFIRMATIVE THEN
28 MESSAGE "HAL: AFTS Test Bed is Ready for Operations!"
29 Set ReadyForOps = TRUE
30 else
31 WARNING "HAL: AFTS Test Bed is Not Ready for Operations!"
32 Set ReadyForOps = FALSE
33 end if
34 otherwise
35 disregard "HAL: Manual Valve Inquiry timeout!"
36 WARNING "HAL: Automatic Bundle Installation Inhibited"
37 Set ReadyForOps = FALSE
38 end when
-- GAFTS-0001 Manual Valve Status Query Requirement
Configuration Management

- ---- TRACKING TAG : 1304031037540151
- 13 04 03 10 37 54 0151
- YY MM DD HH MM SS Version

- ---- BUNDLE NAME: AWTS_HAL_MAIN
- ---- BUNDLE USER INFO:
- ---- BUNDLE EXECUTION SIZE (BYTES): 2508

- ---- VERSION: TLX 5.1

- ---- FILE: MSLSRC/AWTS_HAL_MAIN.TLS
- ---- COMPILER OPTIONS:
- ---- NETWORK: txnetwork.txt
- ---- TIDB: TIDB/
- ---- MSLSRC: MSLSRC/
- ---- MSIBIN: MSIBIN/
- ---- MAX_BUNDLE_FILE_SIZE: 65536
- ---- DATABASE_SEARCH: GDB ONLY
- ---- SQL_DATABASE_DRIVER: oracle.jdbc.driver.OracleDriver
- ---- SQL_DATABASE_URL: jdbc:oracle:thin:@localhost:1521:TLX
- ---- SQL_DATABASE_USERNAME:
- ---- SQL_DATABASE_PASSWORD:
- ---- MAX_BUNDLE_BUFFER_SIZE: 1000000

- ---- SEQUENCE 1: INITIALIZE
## Tracker log file

<table>
<thead>
<tr>
<th>TIME TAG</th>
<th>BUNDLE NAME</th>
<th>SEQUENCE NAME</th>
<th>TRACKING TAG</th>
<th>MESSAGE TEXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/20/13 09:21:53</td>
<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: Are the Manual Valves One and Two in the On Position?</td>
</tr>
<tr>
<td>09/20/13 09:21:55</td>
<td>REQUIREMENT_TRACER2</td>
<td>TRACKER</td>
<td>1309200917150151</td>
<td>GAFTS-0001 Manual Valve Status Query Requirement</td>
</tr>
<tr>
<td>09/20/13 09:22:01</td>
<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: AFTS Test Bed is Ready for Operations!</td>
</tr>
<tr>
<td>09/20/13 09:22:02</td>
<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: Enter the Minimum Temperature (Degrees F) for the Supply Tank?</td>
</tr>
<tr>
<td>09/20/13 09:22:13</td>
<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: Enter the Maximum Temperature (Degrees F) for the Supply Tank?</td>
</tr>
<tr>
<td>09/20/13 09:22:31</td>
<td>AWTS_ECLSS</td>
<td>INSTALLATION</td>
<td>1309191306550151</td>
<td>BUNDLE INSTALLATION</td>
</tr>
<tr>
<td>09/20/13 09:22:33</td>
<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200917150151</td>
<td>GAFTS-0006 Autonomous Procedure Installation Requirement</td>
</tr>
<tr>
<td>09/20/13 09:22:34</td>
<td>AWTS_ECLSS</td>
<td>EC LSS_INSTALL</td>
<td>1309191306550151</td>
<td>EC LSS: EC LSS Bundle Installed</td>
</tr>
<tr>
<td>09/20/13 09:22:35</td>
<td>REQUIREMENT_TRACER2</td>
<td>TRACKER</td>
<td>1309200917150151</td>
<td>GAFTS-0006 Autonomous Procedure Installation Requirement</td>
</tr>
</tbody>
</table>
Summary

- Tracker capability is unique to the Timeliner-TLX Language.
- The Autonomous Real Time Requirements Tracer provides real time code coverage.
- The Tracker Sequence can aid in program development by assisting hardware and software designers.
- Automates the software quality process that before was unreliable and difficult to test.
- Configuration Management is built into the Autonomous Real Time Tracer.
Acronyms

- AES – Advanced Exploration Systems
- AFTS – Autonomous Fluid Transfer System
- AMO – Autonomous Mission Operations
- SDD – Software Design Document
- SRS – Software Requirements Specification
- TLX - Timeliner Executor