Autonomous Real Time Requirements Tracing
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Outline

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• AFTS SRS
• Auto Procedures to Flight Software
• Tracker Sequence
• Timeliner Coding Standard
• Configuration Management
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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 Test Bed
5.1 %AFTS-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 %AFTS-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 %AFTS-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 %AFTS-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
  - Timeliner TLL
Tracker Sequence

Install Tracker Bundle/Sequence

Install Test Bundles

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

Exection Cycle
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
- **YY MM DD HH MM SS Version**
- **Bundle Name**: AWS_HAL_MAIN
- **Bundle Execution Size (Bytes)**: 2508
- **Version**: TLX 5.1
- **File**: MSLSRC/AWS_HAL_MAIN.TLS
- **Compiler Options**: tlxnetwork.txt
- **Network**: tlxnetwork.txt
- **TIDB**: TIDB/
- **MSLSRC**: MSLSRC/
- **MSLBIN**: MSLBIN/
- **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
- **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>
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<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>
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<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>
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<td>TRACKER</td>
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<td>GAFTS-0006 Autonomous Procedure Installation Requirement</td>
</tr>
<tr>
<td>09/20/13 09:22:31</td>
<td>AWTS_ECLSS</td>
<td>BUNDLE INSTALLATION</td>
<td>1309191306550151</td>
<td>BUNDLE INSTALLATION</td>
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<tr>
<td>09/20/13 09:22:32</td>
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<td>TRACKER</td>
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<td>GAFTS-0006 Autonomous Procedure Installation Requirement</td>
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<tr>
<td>09/20/13 09:22:33</td>
<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: EC LSS Bundle installed</td>
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<tr>
<td>09/20/13 09:22:34</td>
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<td>EC LSS_INITIALIZED</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 – TimeLine Executor