Autonomous Real Time Requirements Tracing

2014 IEEE Aerospace Conference

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ES52/EO40
December 16 2013
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Outline

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- AFTS Test Bed
- 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
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
- Timeliner TLL
Tracker Sequence

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

- Install Tracker Bundle/Sequence
- Install Test Bundles

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.SEQSTATE 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.SEQSTATE IN 56..81 then -- Current line number within the req range?
          • Message "GAFTS-0006 Autonomous Procedure Installation Requirement"
        • End If
      • 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: AWTS_HAL_MAIN
- BUNDLE USER INFO:
- BUNDLE EXECUTION SIZE (BYTES): 2508
- VERSION: TLX 5.1

- FILE: MSLSRC/AWTS_HAL_MAIN.TLS
- COMPILER OPTIONS:
- 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
- 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>
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<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>
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<td>REQUIREMENT_TRACER2</td>
<td>TRAC KER</td>
<td>1309200917150151</td>
<td>GAFTS-0001 Manual Valve Status Query Requirement</td>
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<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: AFTS Test Bed is Ready for Operations!</td>
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<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>
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<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: Enter the Maximum Temperature (Degrees F) for the Supply Tank?</td>
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<td>TRAC KER</td>
<td>1309200917150151</td>
<td>GAFTS-0006 Autonomous Procedure Installation Requirement</td>
</tr>
<tr>
<td>09/20/13 09:22:31</td>
<td>AWTS_ECLSS</td>
<td>ACKNOWLEDGED</td>
<td>1309191306550151</td>
<td>BUNDLE INSTALLATION</td>
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<td>GAFTS-0006 Autonomous Procedure Installation Requirement</td>
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<td>AWTS_HAL_MAIN</td>
<td>INITIALIZE</td>
<td>1309200832450151</td>
<td>HAL: EC LSS Bundle installed and active</td>
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<tr>
<td>09/20/13 09:22:34</td>
<td>AWTS_ECLSS</td>
<td>EC LSS_INITI ALIZE</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>TRAC KER</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

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