Autonomous
Real Time Requirements Tracing
Autonomous Real Time Requirements Tracing

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Outline

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• Timeliner Coding Standard
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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 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

Install Tracker Bundle/Sequence

(1) Bundle Active

Execcion Cycle

(2) Sequence Active

(4) Record Requirement Encountered

(3) Range within Sequence Statement

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
  - Next we scan the Safety Bundle
Timeliner Coding Standard

-- 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: txnetwork.txt
- ------ TIDB: TIDB/
- ------ MSLSRC: MSLSRC/
- ------ MSLIB: MSLIB/
- ------ 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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<tbody>
<tr>
<td>09/20/13 09:21:53</td>
<td>AWTS_HAL_MAIN</td>
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<td>1309200832450151 HAL: Are the Manual Valves One and Two in the On Position?</td>
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<td>1309191306550151 BUNDLE INSTALLATION ACKNOWLEDGED</td>
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<tr>
<td>09/20/13 09:22:33</td>
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<td>1309200917150151 GAFTS-0006 Autonomous Procedure Installation Requirement</td>
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<tr>
<td>09/20/13 09:22:35</td>
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<td></td>
<td>1309200917150151 GAFTS-0006 Autonomous Procedure Installation Requirement</td>
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</tr>
</tbody>
</table>

**NASA**

[Logo]
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