Autonomous Real Time Requirements Tracing

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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

Tank 1
- Tank 2
- Controller
- Recirculation Pump
- Three way valve
- Filter
- MV4
- Return Pump
- Primary
- Backup
- G1
- V4
- G2
- Pump 1
- Pump 2
- P2
- P4
- P1
- P6
- Data/Pwr
- V1
- V2
- F1
- F2
- F3
- H1
- H2

NASA logo

Recirculation Pump
Three way valve
Filter
MV4
Return Pump
Primary
Backup
G1
V4
G2
Pump 1
Pump 2
P2
P4
P1
P6
Data/Pwr
V1
V2
F1
F2
F3
H1
H2
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

Install Tracker Bundle/Sequence

Install Test Bundles

(1) Bundle Active

(2) Sequence Active

Exeception Cycle

(3) Range within Sequence Statement

(4) Record Requirement Encountered
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
  - 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
• 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
• ----- COMPLILER 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>
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<td>1309200832450151 HAL: Are the Manual Valves One and Two in the On Position?</td>
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<tr>
<td>09/20/13 09:22:02</td>
<td>AWTS_HAL_MAIN</td>
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<tr>
<td>09/20/13 09:22:31</td>
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<td>ACKNOWLEDGED</td>
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<td>TRACKER</td>
<td></td>
<td>1309200917150151 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