Autonomous Real Time Requirements Tracing

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- AFTS SRS
- Auto Procedures to Flight Software
- Tracker Sequence
- Timeliner Coding Standard
- Configuration Management
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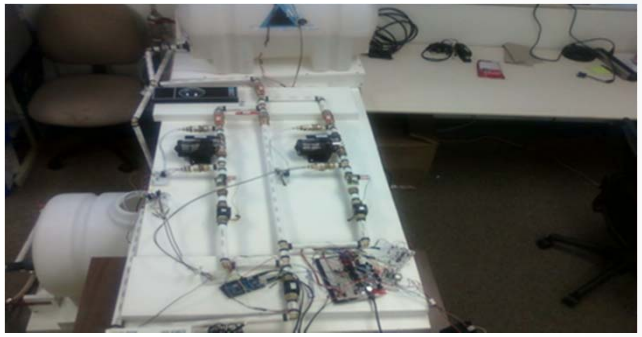
Introduction

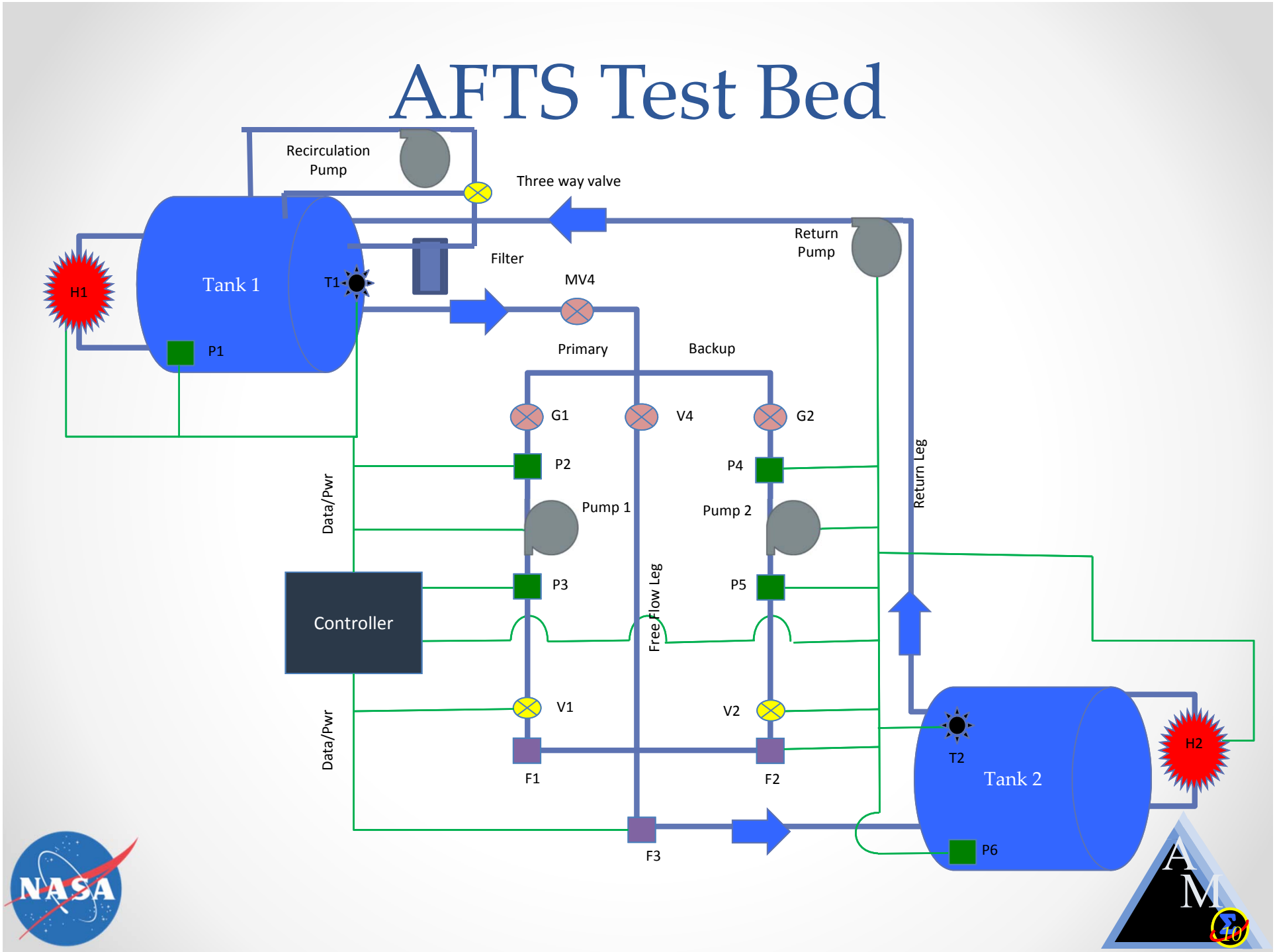
- Autonomous Mission Operations (AMO), part of NASA's Advanced Exploration Systems (AES) Program, is using inter-center cooperation to develop new technologies and techniques to enable deep space exploration with an emphasis on procedure development and execution.
- The Autonomous Fluid Transfer System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



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.

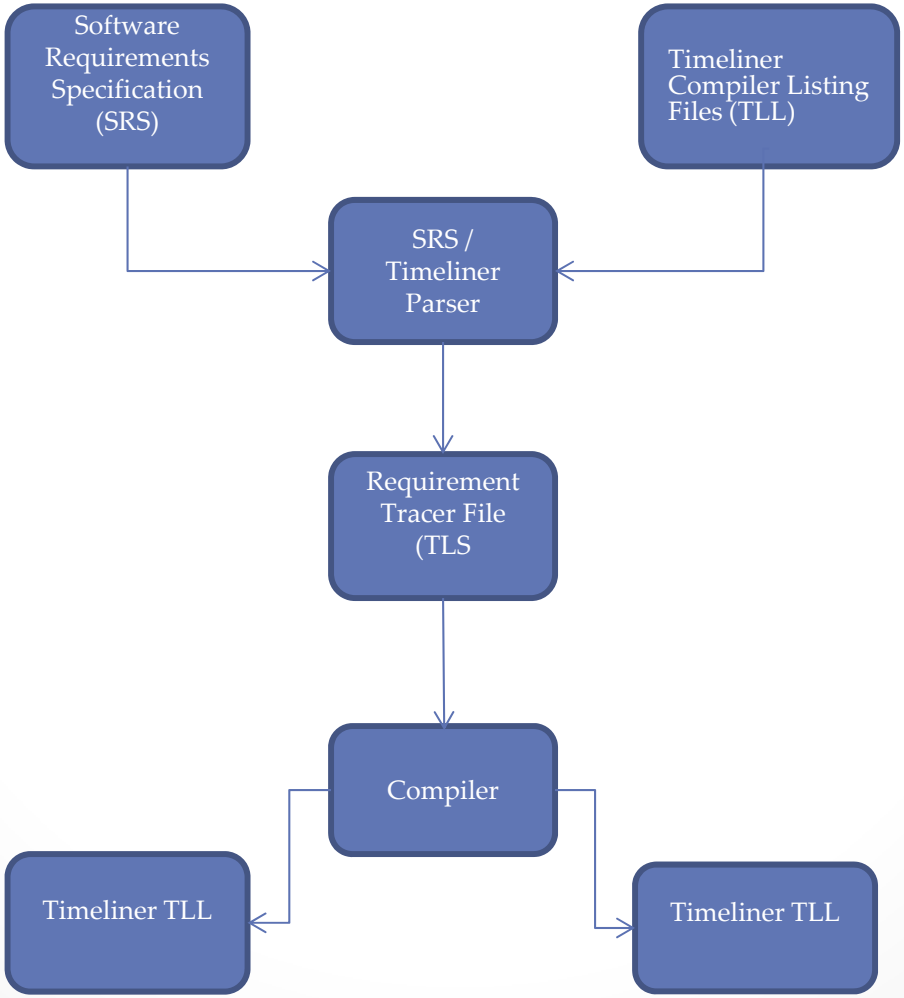
Auto-Procedures to Flight Software

- 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).

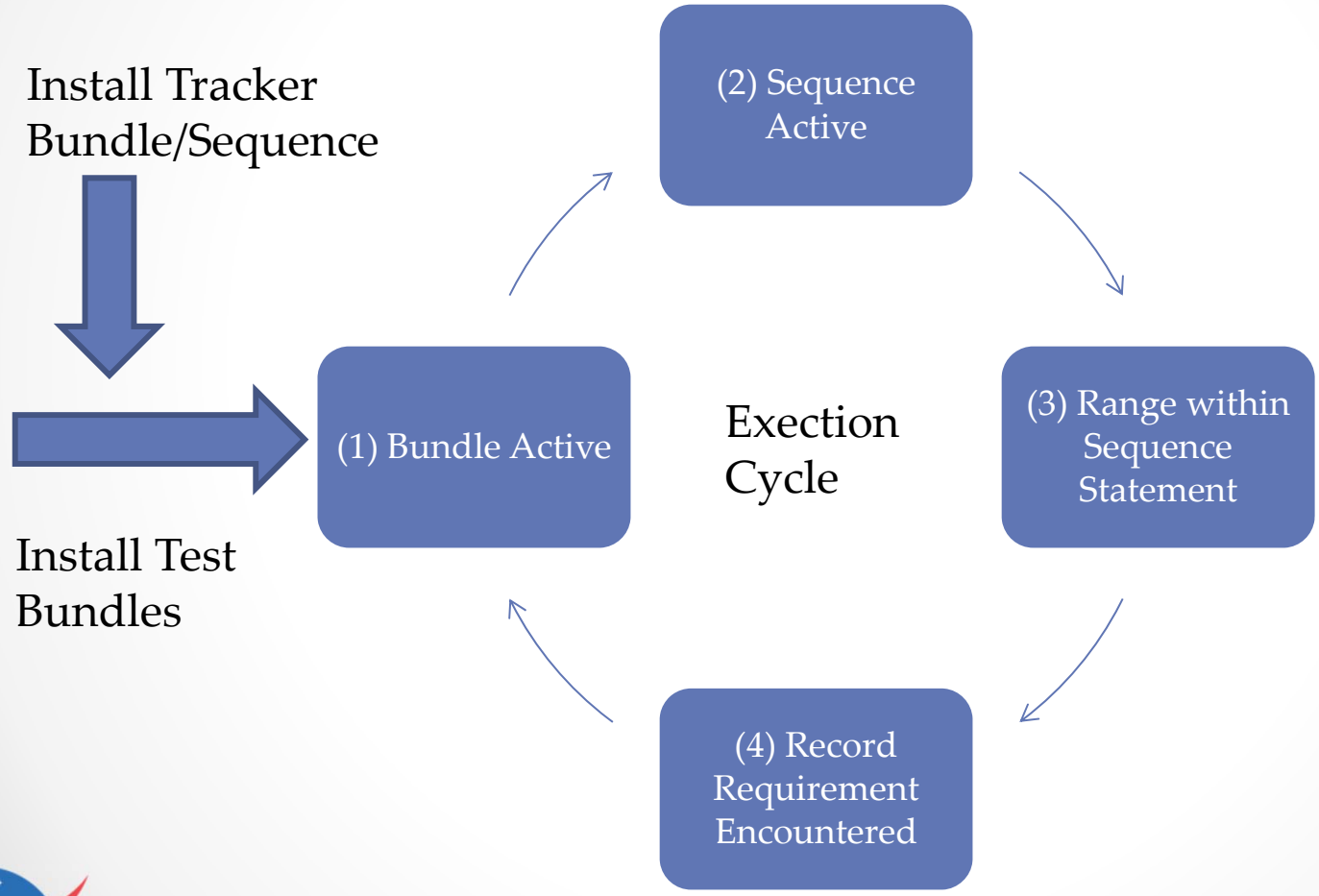
Auto-Procedures to Flight Software

- 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



Tracker Sequence



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

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**
- **------ 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

TIME TAG	BUNDLE NAME	SEQUENCE NAME	TRACKING TAG	MESSAGE TEXT
09/20/13 09:21:53	AWTS_HAL_MAIN	INITIALIZE	1309200832450151	HAL: Are the Manual Valves One and Two in the On Position?
09/20/13 09:21:55	REQUIREMENT_TRACER2	TRACKER	1309200917150151	GAFTS-0001 Manual Valve Status Query Requirement
09/20/13 09:22:01	AWTS_HAL_MAIN	INITIALIZE	1309200832450151	HAL: AFTS Test Bed is Ready for Operations!
09/20/13 09:22:02	AWTS_HAL_MAIN	INITIALIZE	1309200832450151	HAL: Enter the Minimum Temperature (Degrees F) for the Supply Tank?
09/20/13 09:22:13	AWTS_HAL_MAIN	INITIALIZE	1309200832450151	HAL: Enter the Maximum Temperature (Degrees F) for the Supply Tank?
09/20/13 09:22:30	REQUIREMENT_TRACER2	TRACKER	1309200917150151	GAFTS-0006 Autonomous Procedure Installation Requirement
09/20/13 09:22:31	AWTS_ECLSS		1309191306550151	BUNDLE INSTALLATION ACKNOWLEDGED
09/20/13 09:22:32	REQUIREMENT_TRACER2	TRACKER	1309200917150151	GAFTS-0006 Autonomous Procedure Installation Requirement
09/20/13 09:22:33	AWTS_HAL_MAIN	INITIALIZE	1309200832450151	HAL: ECLSS Bundle installed and active
09/20/13 09:22:34	AWTS_ECLSS	ECLSS_INITIALIZE	1309191306550151	ECLSS: ECLSS Bundle Installed Initialize Sequence is Active
09/20/13 09:22:35	REQUIREMENT_TRACER2	TRACKER	1309200917150151	GAFTS-0006 Autonomous Procedure Installation Requirement

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