European Technology Harmonisation on Command Procedures

Simon Reid, Rhea System S.A.

s.reid@rheagroup.com

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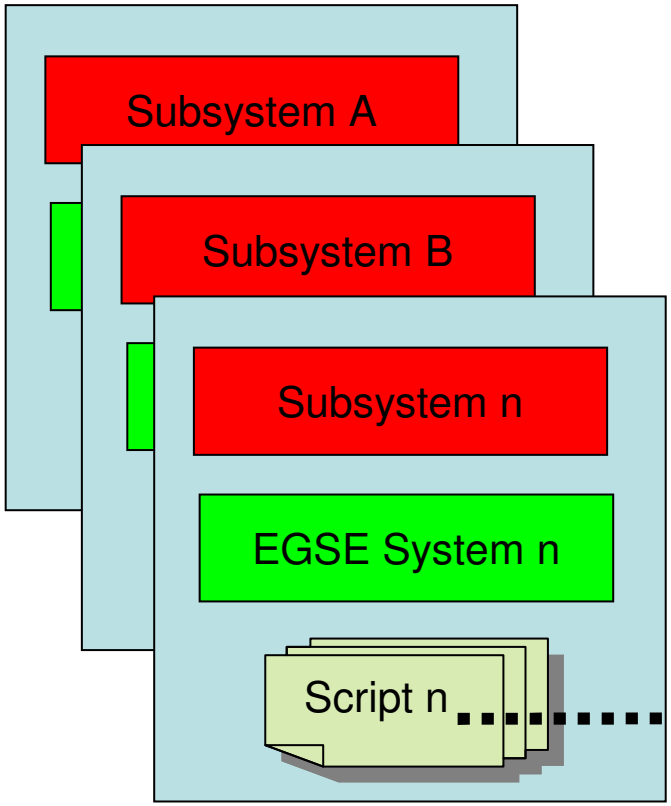
Overview

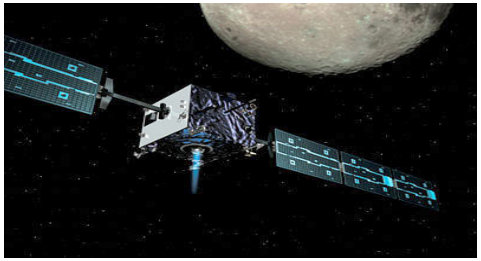
- Context Today
  - Typical Procedure Implementation Lifecycle
  - Procedure Model Concept
- Harmonisation of Command Procedure Execution (CPE) Interfaces
  - Objectives
  - Approach
  - Corresponding Standards & Standardisation Activity
- Conclusions

Mission Statement

*"CPE Harmonization should focus on enabling **cross domain** and **cross lifecycle** application of control procedures **to reduce overall procedure development and validation effort.**"*

Typical Mission – Procedure Lifecycle





AIT System

M&C System

Test

Ops

Manual

Auto

MOIS

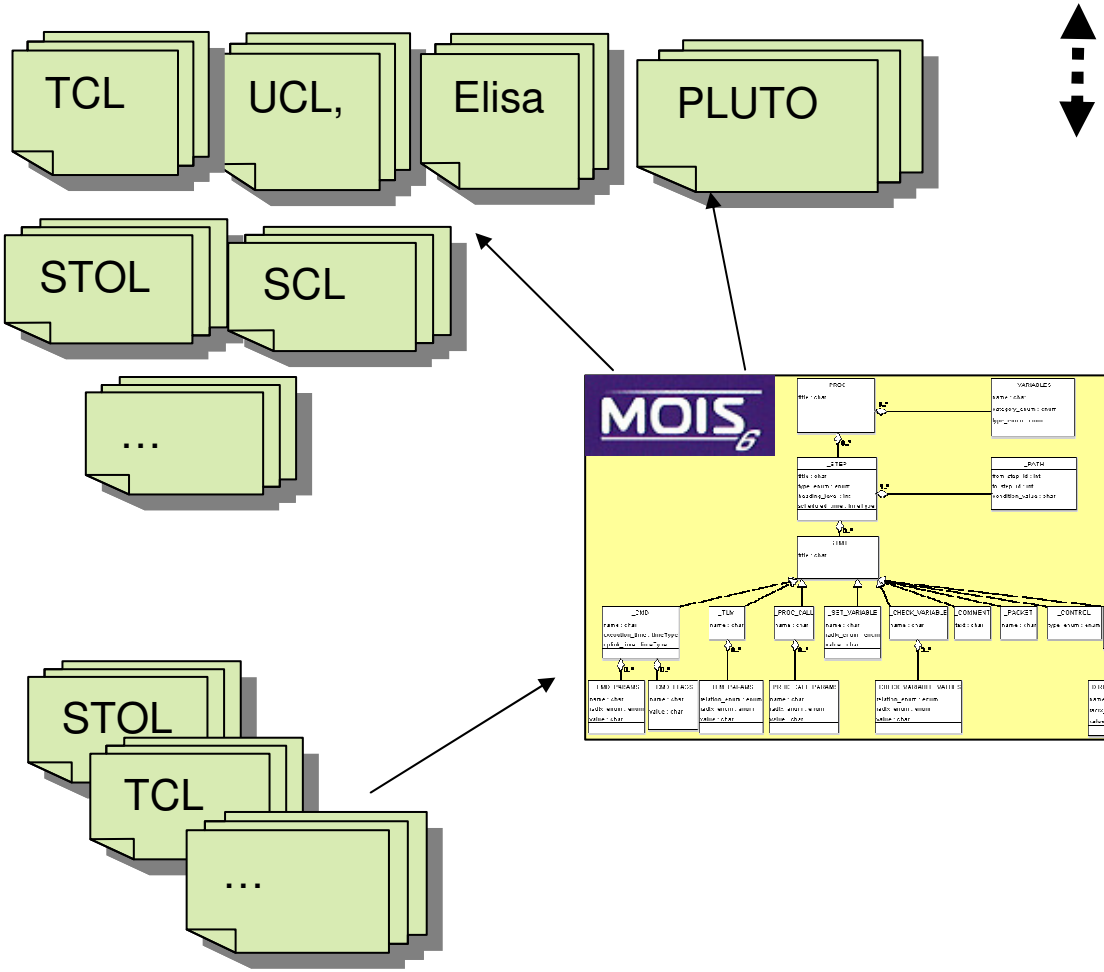
MOIS

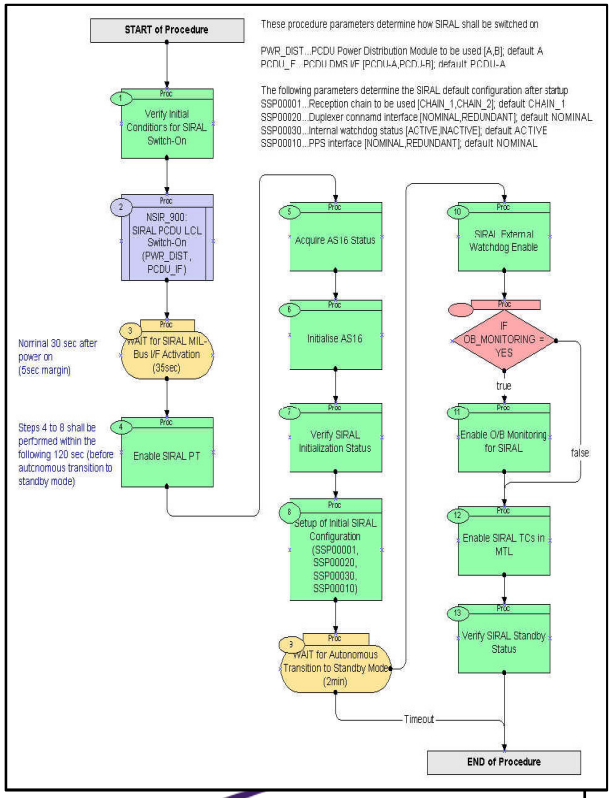
MOIS

Images © ESA

MOIS Procedure Model Concept

EGSE, AIT, Mission Operation System





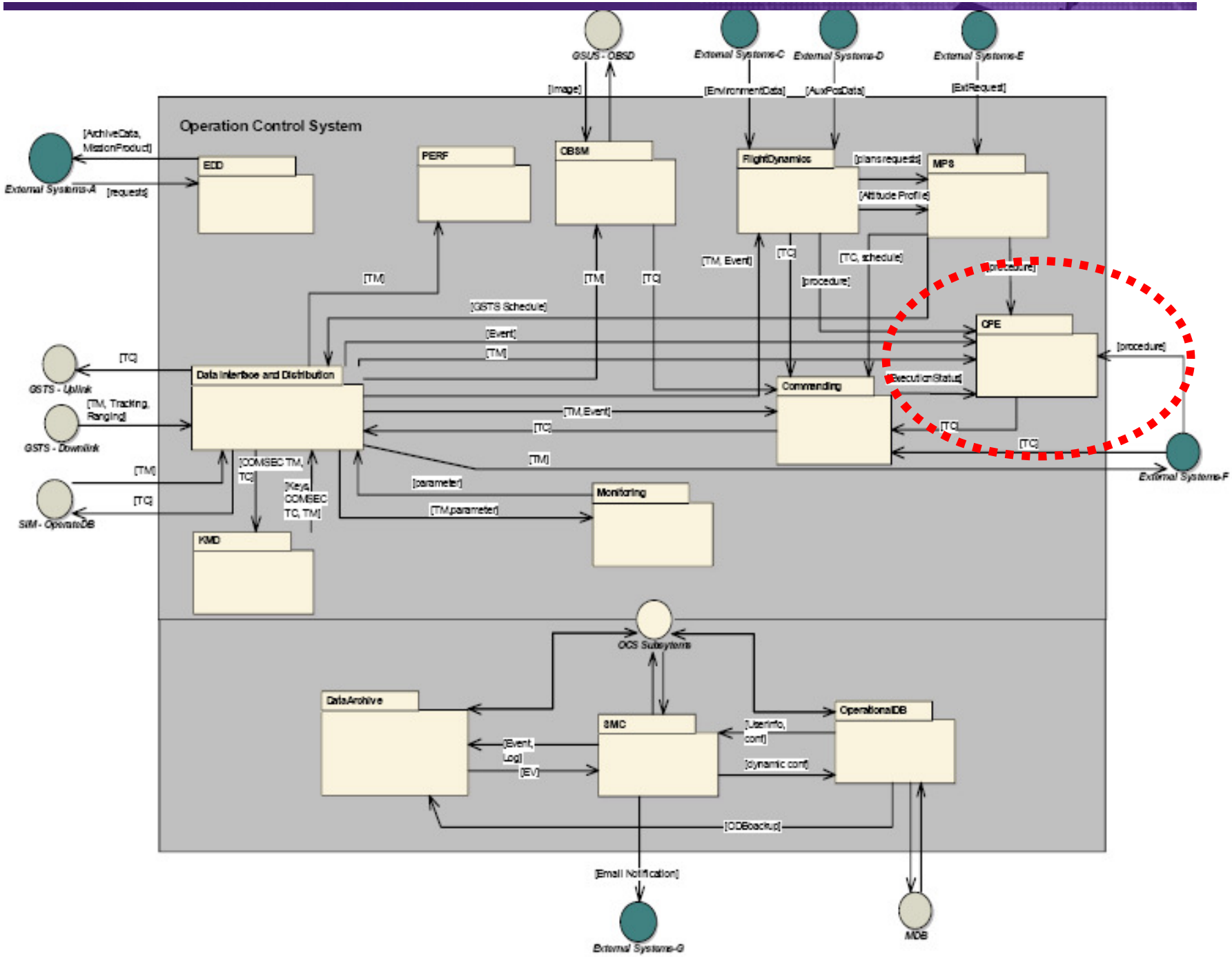
Current Outlook

- Numerous Different Operators
  - ESA, Eumetsat
  - National Agencies (DLR, CNES, ASI, …)
  - Commercial (Inmarsat, SES,…)
- Many Different System Suppliers and Supply Methods
  - Primes, System Integrators, SME
  - Open Source, COTS, Turnkey, Consultancy
- Many Different Systems
  - …and their Interfaces!
- Many Different Procedure Languages or Formats
  - PLUTO, TOPE/TCL, STOL, UCL, SPEL, Elisa….
- Different Standards & Standards Bodies
  - ECSS: European Cooperation for Space Standardization
  - CCSDS: Consultative Committee for Space Data Systems
  - OMG: Object Management Group

HARMONISE

HARMONISATION GOALS

- Define a framework for ground segment systems operability
- Establish commonality between ground system elements from different organisations
- Allow systems from different organisations to be more easily plugged together


GSUS - OBSD
External Systems-C
External Systems-D
External Systems-E
[Image]
[EnvironmentData]
[AuxPosData]
[ExtRequest]
Operation Control System
[ArchiveData, MissionProduct]
External Systems-A
[requests]
EDD
PERF
OBSM
FlightDynamics
[plansrequests]
MPS
[Attitude Profile]
[TM, Event]
[TC]
[TC, schedule]
[procedure]
[TM]
[TM]
[TC]
[GSTS Schedule]
[Event]
[TM]
OPE
[procedure]
[TC]
GSTS - Uplink
Data Interface and Distribution
Commanding
[ExecutionStatus]
[TM, Tracking, Ranging]
GSTS - Downlink
[TM,Event]
[TC]
[TC]
[TC]
[TM]
External Systems-F
[TM]
[COMSEC TM, TC]
[parameter]
Monitoring
[TC]
[Keys, COMSEC TC, TM]
[TM,parameter]
SIM - OpsimDB
KMD
OCS Subsystems
DataArchive
SMC
OperationalDB
[UserInfo, conf]
[Event, Log]
[EV]
[dynamic conf]
[ODBbackup]
[Email Notification]
External Systems-G
MDB

CPE Harmonisation Project Overview

- Determine needs of Users (Actors)
  - Questionnaire and Workshops: EGSE and Operations
- Normative Standards
  - ECSS-E-ST-70-32C: Test and Operations Procedure Language (PLUTO)
  - ECSS-E-ST-70-31C: Monitoring and Control data definition
- Analyse Impact of existing/emerging standards
  - ECSS-E-TM-10-23: Engineering Database
  - ECSS-E-ST-70-01: On Board Control Procedures
  - CCSDS 660.0.G-1: XML Telemetric and Command Exchange XTCE
  - CCSDS 520.0.G-2: Mission Operations Services
  - OMG SOLM: Spacecraft Operations Language Metamodel
- Refine Harmonisation Reference Architecture

ECSS-E-ST-70-32C (E32) : PLUTO

Test and Operations Procedure Language

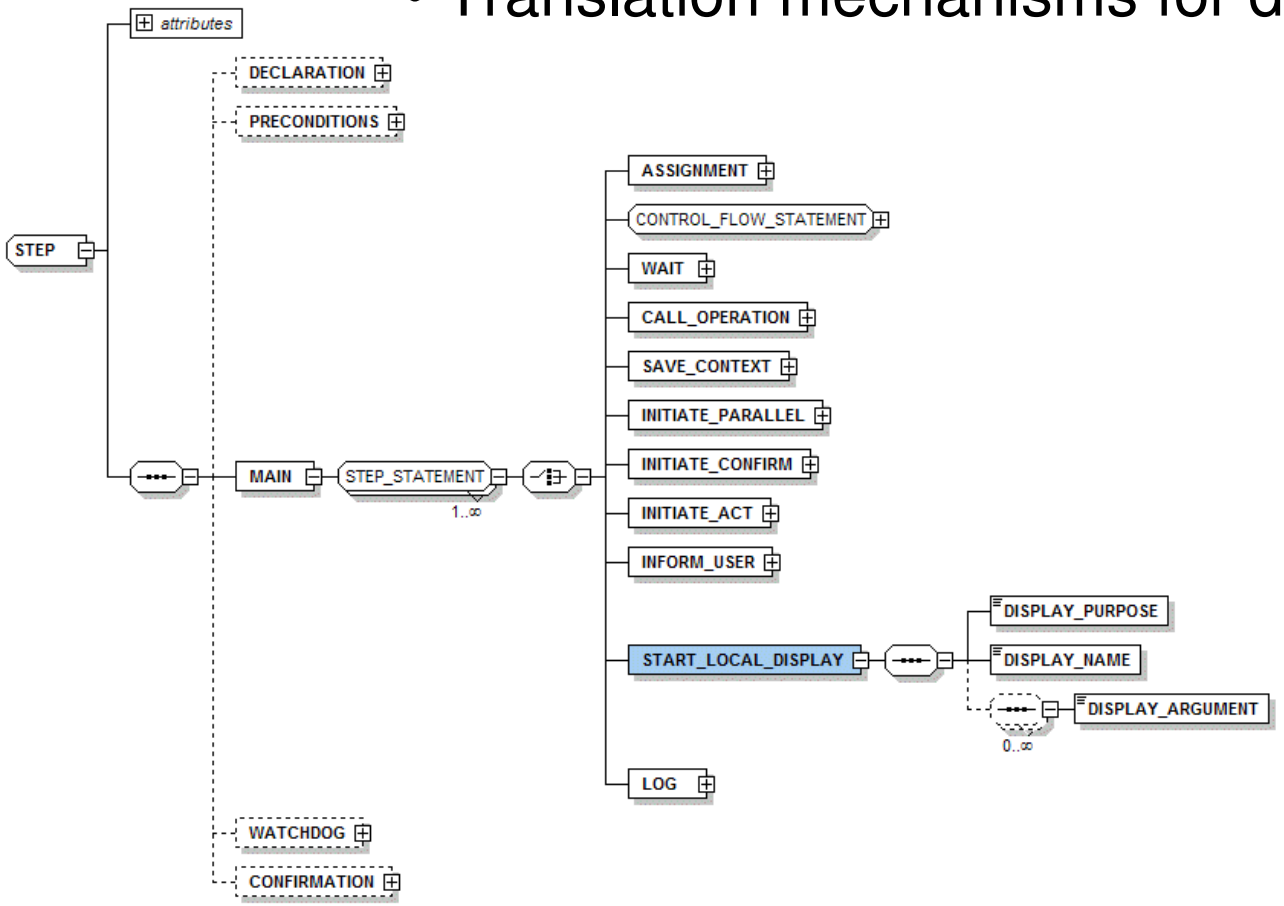
1. Requirements to be satisfied by CPE System (Normative)

2. PLUTO Language (Non-Normative)

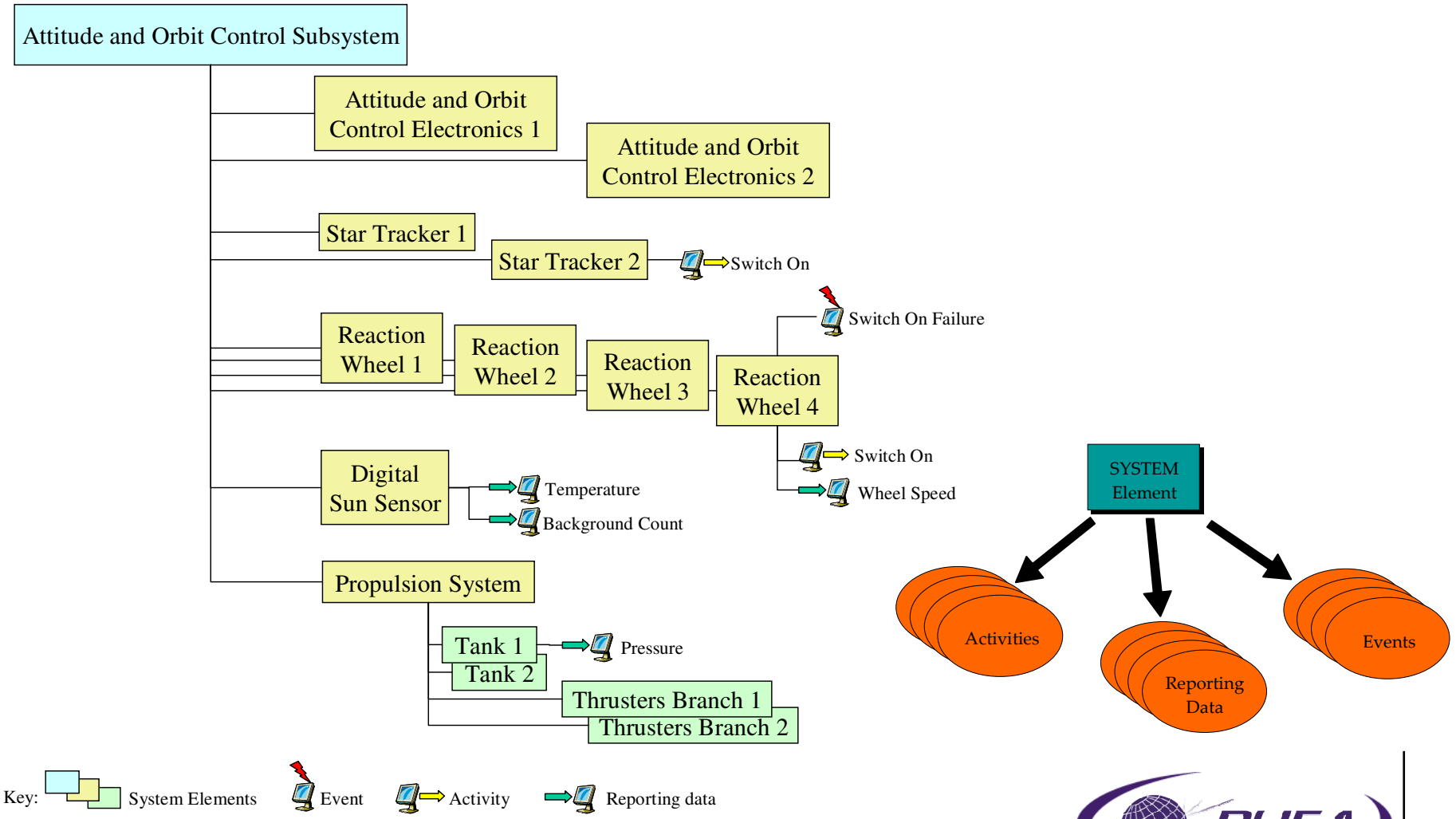
```
get validity status of Pump of Freon Loop1
in case Temperature of Biolab Experiment
    is < 5 degC : Switch On Heater1; Switch On Heater2;
    or is < 10 degC :  Switch On Heater1;
```

Proposed Approach – Procedure Model

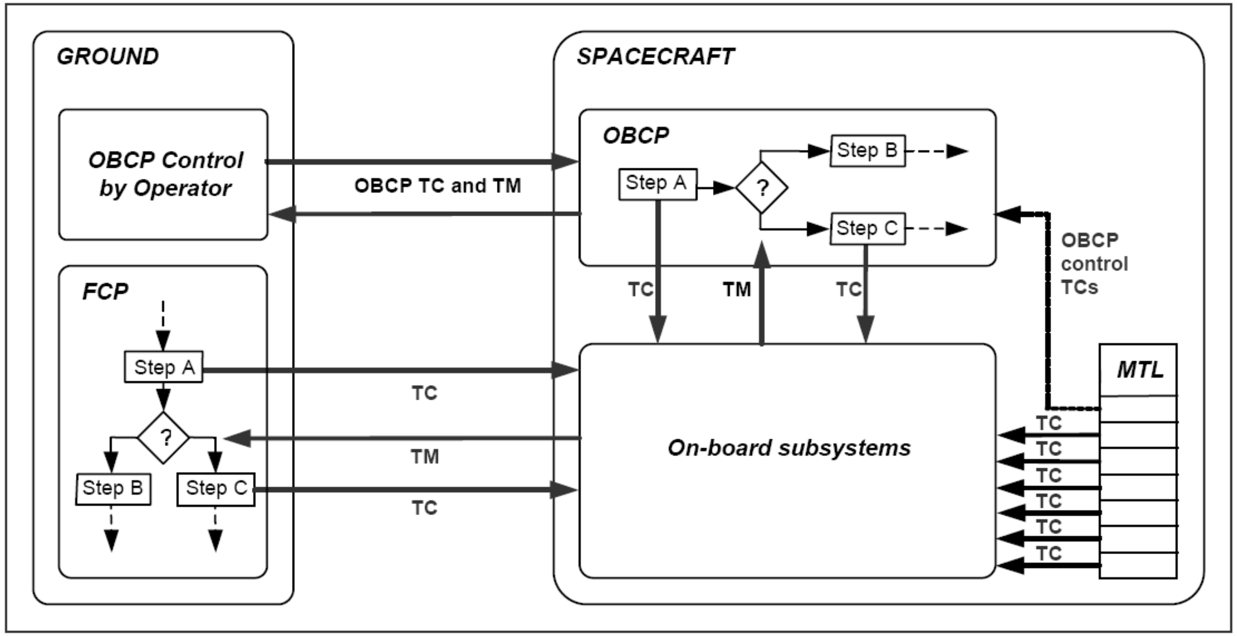
- PLUTO based, but without the syntax
- Incorporate proposed enhancements
- Translation mechanisms for data interchange

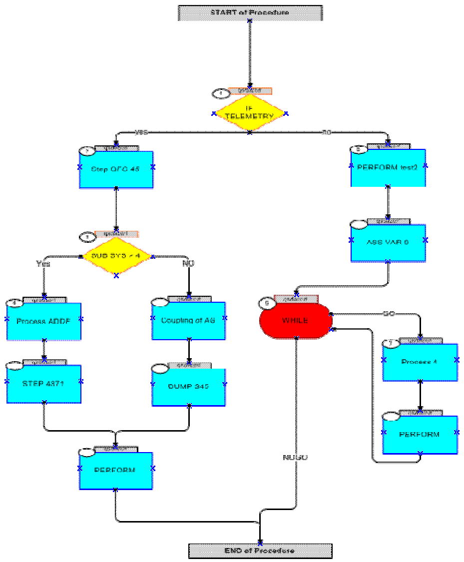


Monitoring and Control data defn: **Space System Model (SSM)**



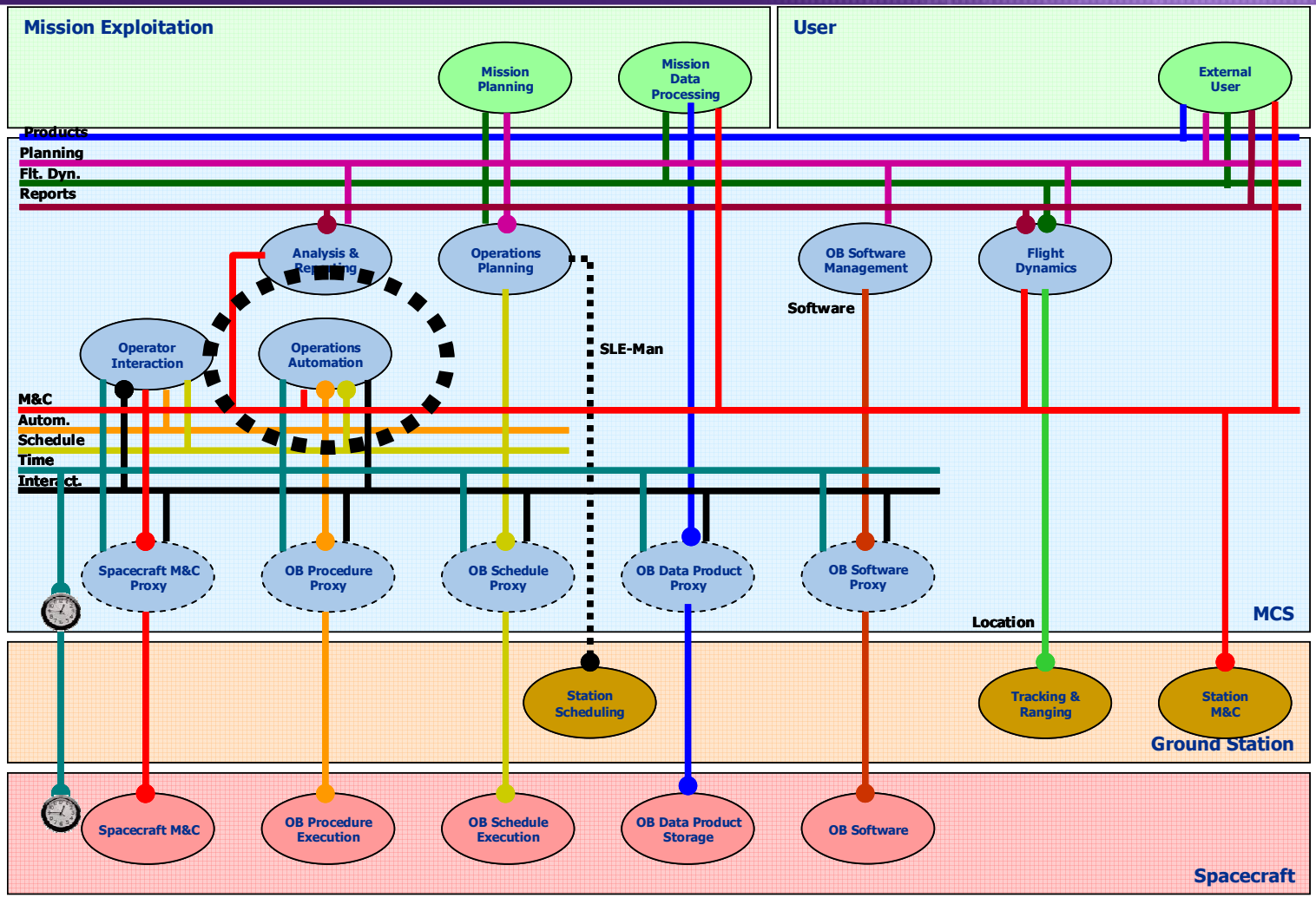
ECSS-E-70-ST-01C: On Board Control Procedures





```
obcp OBCP_6820 is

//##GENERATE(GEN_TYPE=DECL_INIT, OBJ_NAME=DP_ACCESS_DESCRIP)
##GENERATE(GEN_TYPE=DECL_INIT, OBJ_NAME=LABEL_CC_LIST)
##GENERATE(GEN_TYPE=DECL,      OBJ_NAME=TC_BUFFER_INFO)
##GENERATE(GEN_TYPE=DECL_INIT, OBJ_NAME=TC_CONST_INIT)
##GENERATE(GEN_TYPE=DECL_INIT, OBJ_NAME=TC_PARAM_LIST)

// Sent Event definitions. The values are:
// Event ID; Event subtype; param buffer length
constant K_EVENT_1  : array [3] of UNSIGNED_INTEGER := [9021, 1, 1];
constant K_EVENT_2  : array [3] of UNSIGNED_INTEGER := [9022, 3, 2];
constant K_EVENT_3  : array [3] of UNSIGNED_INTEGER := [9023, 1, 0];

// Received Event definitions. The values are:
constant K_EVENT_STR_MODE_TRANSITION
                    : array [2] of UNSIGNED_INTEGER := [2100, 1];

// Empty parameter list for events
constant K_EMPTY_EVENT_PARAM_LIST : array [2] of UNSIGNED_INTEGER := [0, 0];

CURRENT_MODE: INTEGER;
ABORT_OBCP: BOOLEAN;

interface
  TM_TC
    DEV__P : INTEGER; // Device CAM/STR, A or B
    STATE__P: INTEGER; // Initial mode of the CAM/STR: OFF, INIT or STANDBY
    TRANSITION__P: INTEGER; // CAM/STR Mode Transition to be carried out by OBCP
end interface;

function AWAIT_MODE_TRANSITION(
   P_TRANSITION: in INTEGER; // which mode transition
   P_TRANSITION_WAIT: in INTEGER; // how long to wait for a mode transition
   P_NEW_MODE: In INTEGER // mode entered of transition successful
) return BOOLEAN is
   EVENT_RESULT      : BOOLEAN;   // Event result
   EVENT_RECEIVED    : BOOLEAN;  // event waited for received
   WAIT_EVENT_STATUS : BOOLEAN;  // status of wait event function
   EVENT_2_PARAM_LIST : array [2] of UNSIGNED_INTEGER;  // event parameter list
begin
   MSG.WAIT_EVENT (K_EVENT_STR_MODE_TRANSITION[0], K_EVENT_STR_MODE_TRANSITION
[1], P_TRANSITION_WAIT, WAIT_EVENT_STATUS, EVENT_RECEIVED);

   if not (EVENT_RECEIVED) then
      // STR mode transition failed
      EVENT_2_PARAM_LIST[0] := H_LINT_2_UNSIGNED_INTEGER(LONG_INTEGER
(P_TRANSITION));
      EVENT_2_PARAM_LIST[1] := H_LINT_2_UNSIGNED_INTEGER(LONG_INTEGER
(CURRENT_MODE));

      EVENT_RESULT := MSG.SEND_REPORT (K_EVENT_2[0], K_EVENT_2[1], K_EVENT_2[2],
                                       EVENT_2_PARAM_LIST);
      return FALSE;
   else
      CURRENT_MODE := P_NEW_MODE;
      return TRUE;
   end if;
end AWAIT_MODE_TRANSITION;

//---------------------------------------------------------------------------
// STEP P2: Mode Transition STANDBY -> SELFTEST -> STANDBY
//
function TRANSITION_STB_ST_STB() return BOOLEAN is
   TC_RESULT         : BOOLEAN;         // TC result
   EVENT_RESULT      : BOOLEAN;         // Event result
begin
```

CCSDS SM&C Mission Operations Services



Questionnaire and Workshops (EGSE/OPS)

- EADS Astrium Satellites
- EADS Astrium ST - Launchers
- **EADS Astrium ST - Orbital Systems**
- CNES
- Dutch Space
- ESA / ESOC
  - OPS-OE Operations EO Missions
  - OPS-OP Operations Planetary Missions
  - OPS-GD Mission Data System Managers
  - OPS-GI Data Systems Infrastructure
  - OPS-GF Flight Dynamics
- ESA/ESTEC
  - TEC-SW Technology Division
- EUMETSAT
- GMV
- DLR / GSOC
- Inmarsat
- **Rhea System**
- **SciSys**
- Siemens Austria
- Thales Alenia Space, France
- Thales Alenia Space, Italy
- **Terma**
- VCS AG

Summary

- To Date
  - Enthusiastic and constructive input/feedback from users
  - Apparent consensus on general approach (Tailorable Model)
  - Several Common Questions / Issues arising

- Next Steps
  - Present results of workshops to Harmonisation Steering Board
  - Key decisions to be taken
  - Continue detailed analysis and production of technical notes
  - First part expected to complete mid-2010