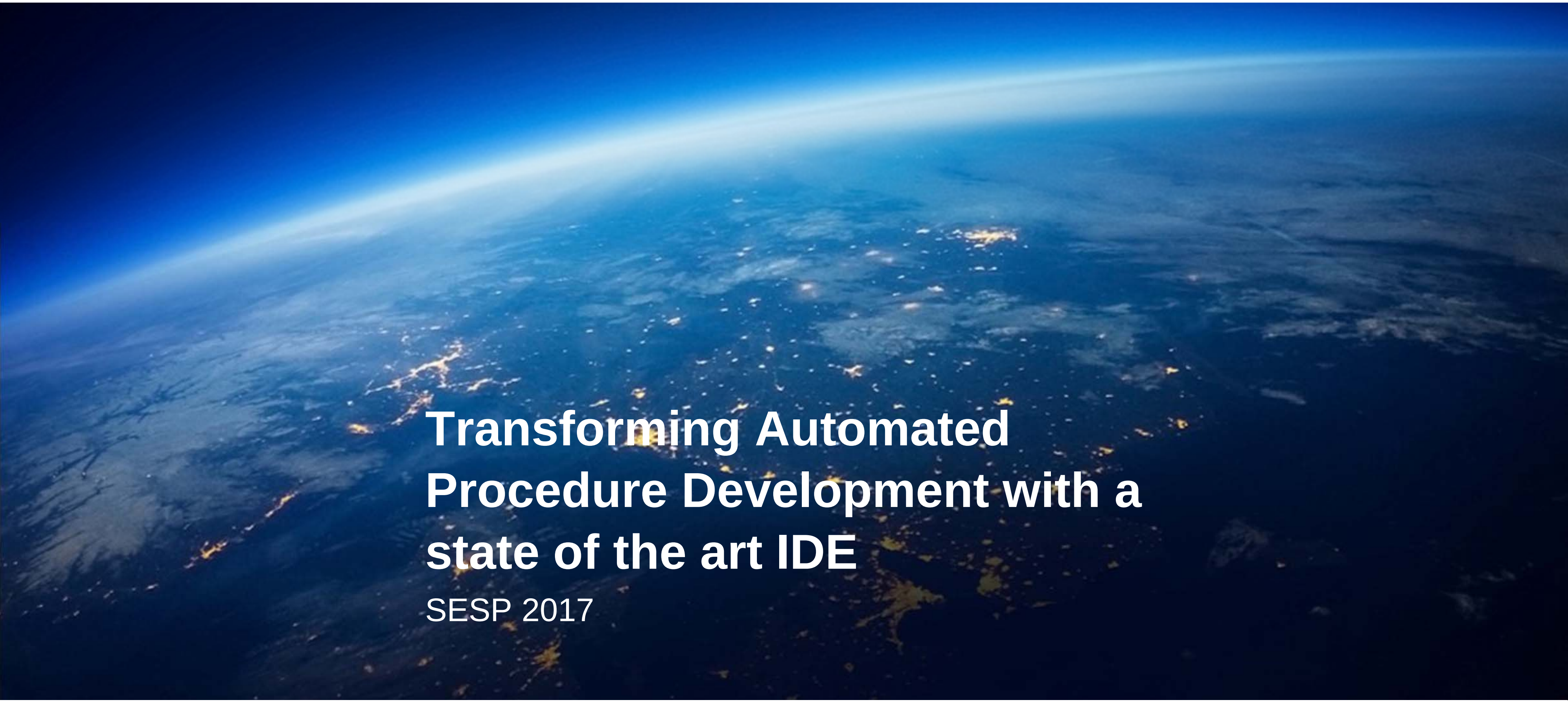


Transforming Automated Procedure Development with a state of the art IDE

SESP 2017

DEFENCE AND SPACE

Bjoern Kircher, Colin Borrett

30 March 2017

AIRBUS

Agenda

- Context
- Digitalization
- Data Continuity
- Update / Change Propagation
- Technologies
- Summary

Problem

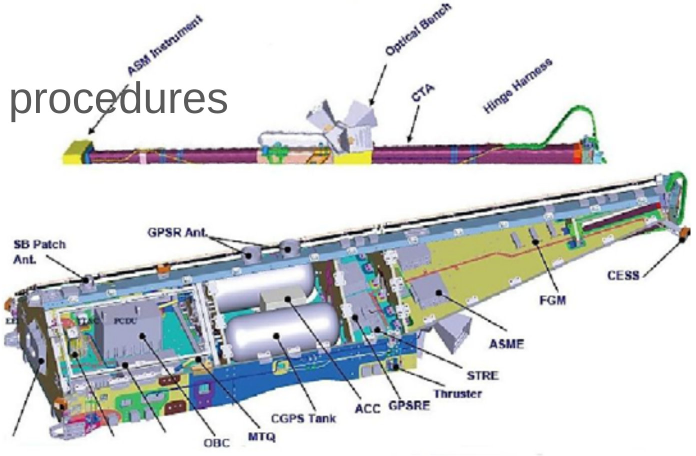
- Existing development environments for automated monitor & control procedures are poorly integrated in the overall spacecraft design & development process
  - Continuity/use of design & configuration data is hardly integrated
    - Process to update configuration data changes implemented manually
  - Limited digitalized transfer from procedure specification environment to development environment

- High level of maintenance effort to follow system data changes
  - Early Development Phases: Baseline not stable
  - Development: Overall status not visible
  - Maintenance Phase: Impact of data changes not identified

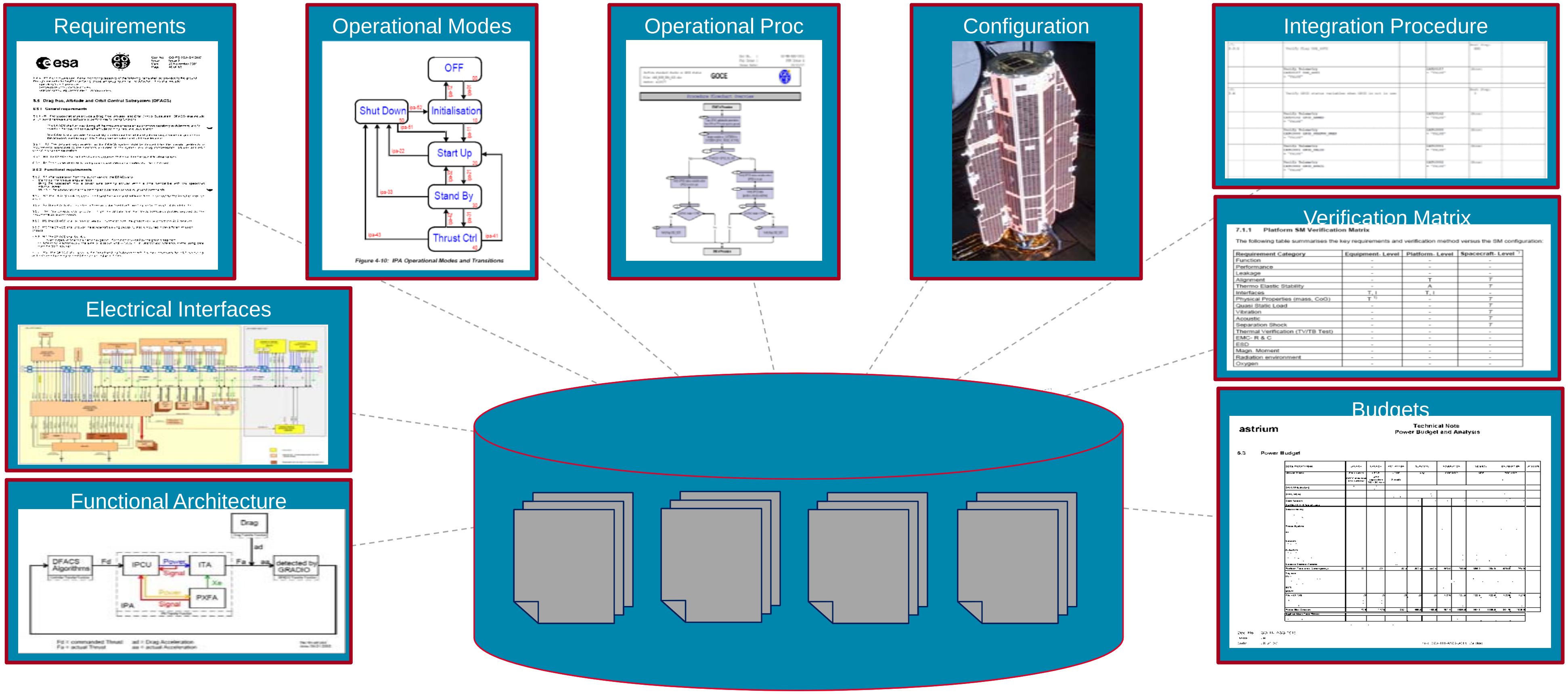
Problem – Needed Information

Development of automated monitor & control procedures requires information about:

- Detailed knowledge of how to operate the spacecraft & EGSE needed
  - Mainly TM/TC definitions
- Detailed knowledge of spacecraft design
- Detailed knowledge of actual configuration
  - Spacecraft & EGSE
- Detailed knowledge of planned verification activities / operation procedures



Digitalization – Starting with VSD …



Requirements

Operational Modes

Operational Proc

Configuration

Integration Procedure

Electrical Interfaces

Functional Architecture

Verification Matrix

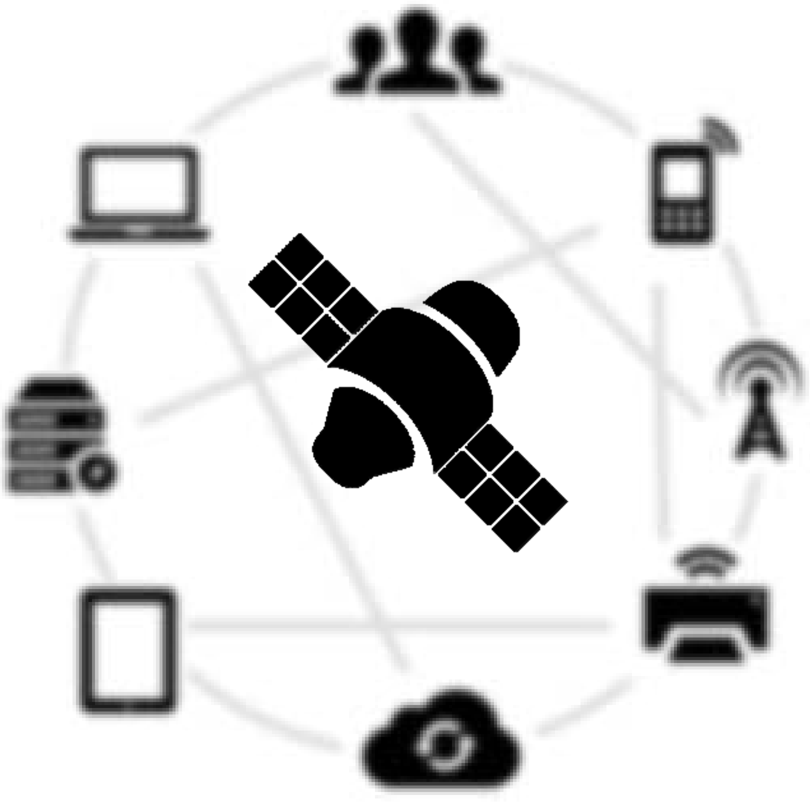
7.1.1 Platform SM Verification Matrix

The following table summarises the key requirements and verification method versus the SM configuration:

Requirement Category	Equipment- Level	Platform- Level	Spacecraft- Level [*)]
Function	-	-	-
Performance	-	-	-
Leakage	-	-	-
Alignment	-	T	T
Thermo Elastic Stability	-	A	T
Interfaces	T, I	T, I	-
Physical Properties (mass, CoG)	T [1)]	-	T
Quasi Static Load	-	-	T
Vibration	-	-	T
Acoustic	-	-	T
Separation Shock	-	-	T
Thermal Verification (TV/TB Test)	-	-	-
EMC- R & C	-	-	-
ESD	-	-	-
Magn. Moment	-	-	-
Radiation environment	-	-	-
Oxygen	-	-	-

Budgets

… to Factory/Space 4.0



- Digitalization: Integration of digital technologies into everyday life by the digitization of everything that can de digitized.

- Several initiatives running internally & externally
  - Factory 4.0
  - ENS Digitalization
  - E2E PLM
  - Space 4.0
  - …

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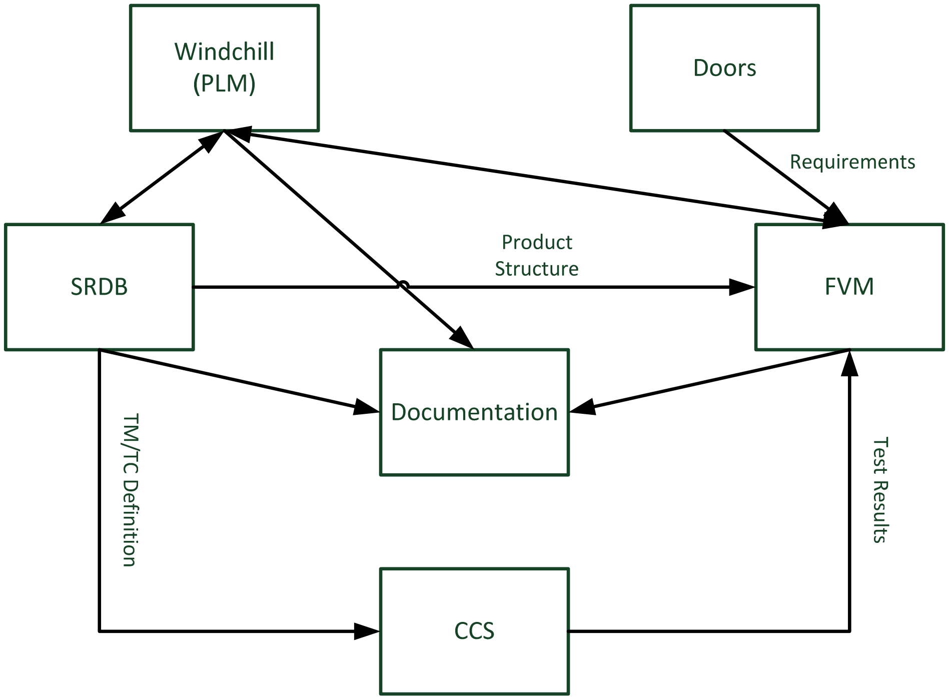
Overall Data Flow

- Management of design and system data is well managed today!
- Shared data and common processes well-established & integrated
  - SRDB: Central data set and repository containing the definitions & operational data utilized during engineering & development
  - FVM: Definition of test documentation such as verification tasks, specifications, procedures or reports. Requirement traceability to test specifications and procedures, to execution and archive and generation of VCD



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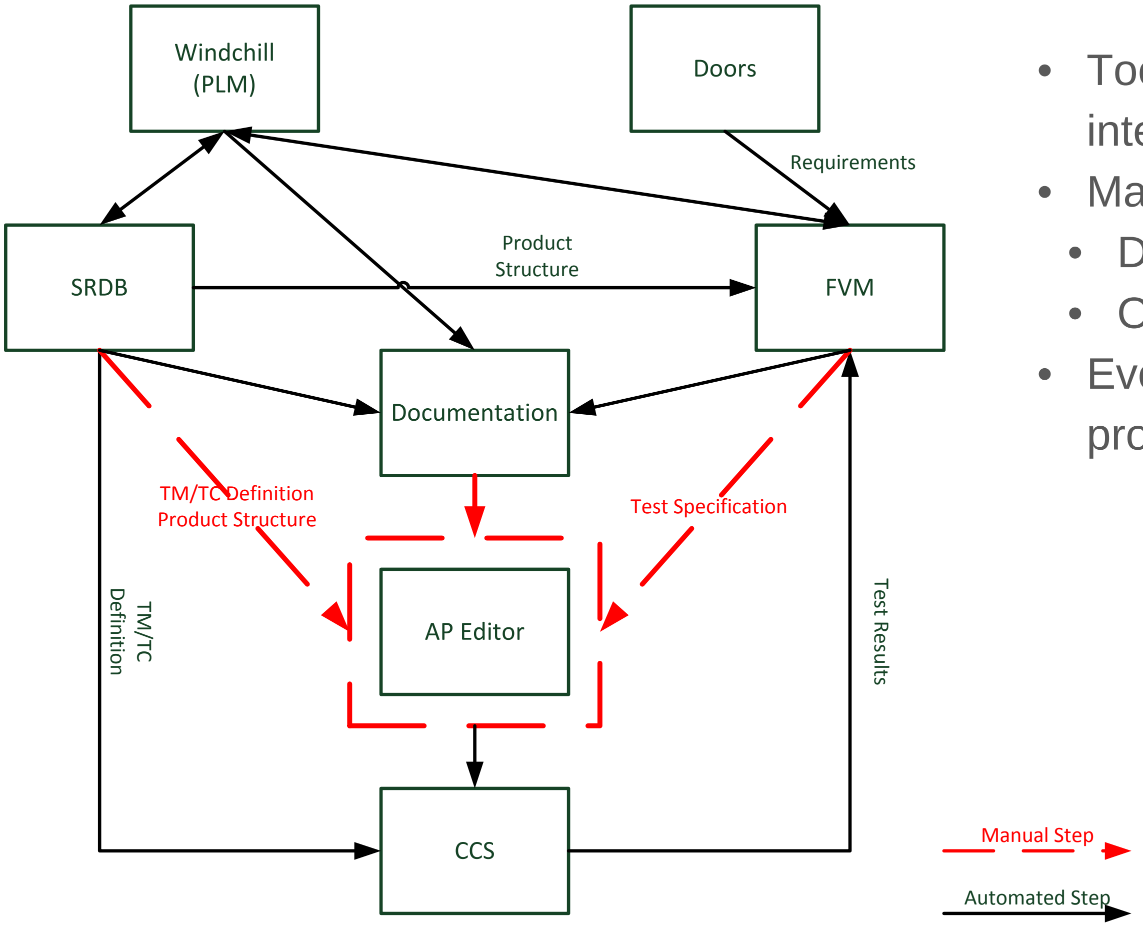
Overall Data Flow – Dark Spots



- Tool to develop automated procedures not integrated
- Mainly manual tasks to get / access the data
  - Documents are still used
  - Overall version set not guaranteed
- Evolution of system data not automatically propagated

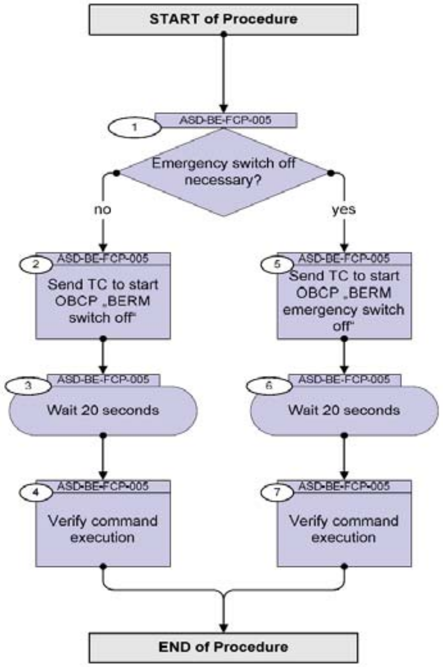
Goal - Procedures Development Environment that is fully integrated in the already available tool landscape

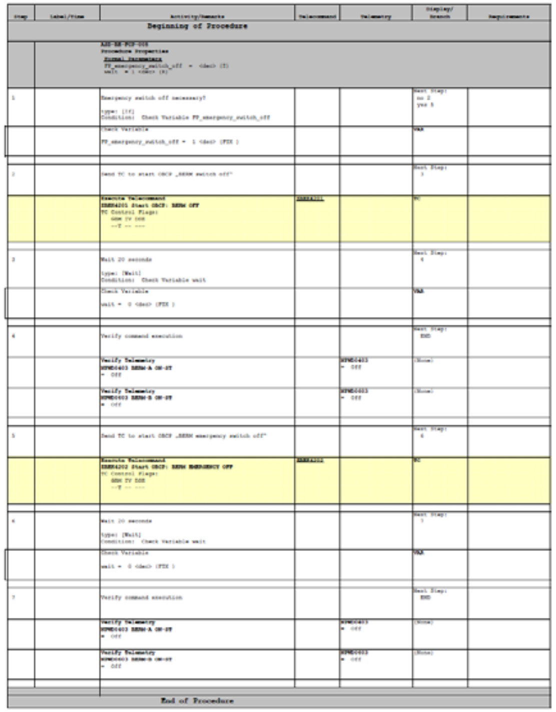
- Usage of coherent data baseline release (from SRDB and FVM)
  - All tools, developers, testers are using the same data baseline
- Full digitalized process from design data (e.g. TM/TC), link to verification requirements and related test specification, up to the automated procedure running on CCS/MCS
- Automated generation of AP documentation and generation of the overall AP manual
- Common tool used by all users and for all use cases (AIT, FV, Operations)
- State of the art IDE supporting features like:
  - Auto completion
    - Related to procedure language
    - Related to items in the spacecraft product structure
- Tool tips
- Syntax highlighting
- Online help

Automated Procedure (AP)

- Def: A fixed, step-by-step sequence of activities or course of action (with definite start and end points) that must be followed in the same order to correctly perform a task. Repetitive procedures are called routines.

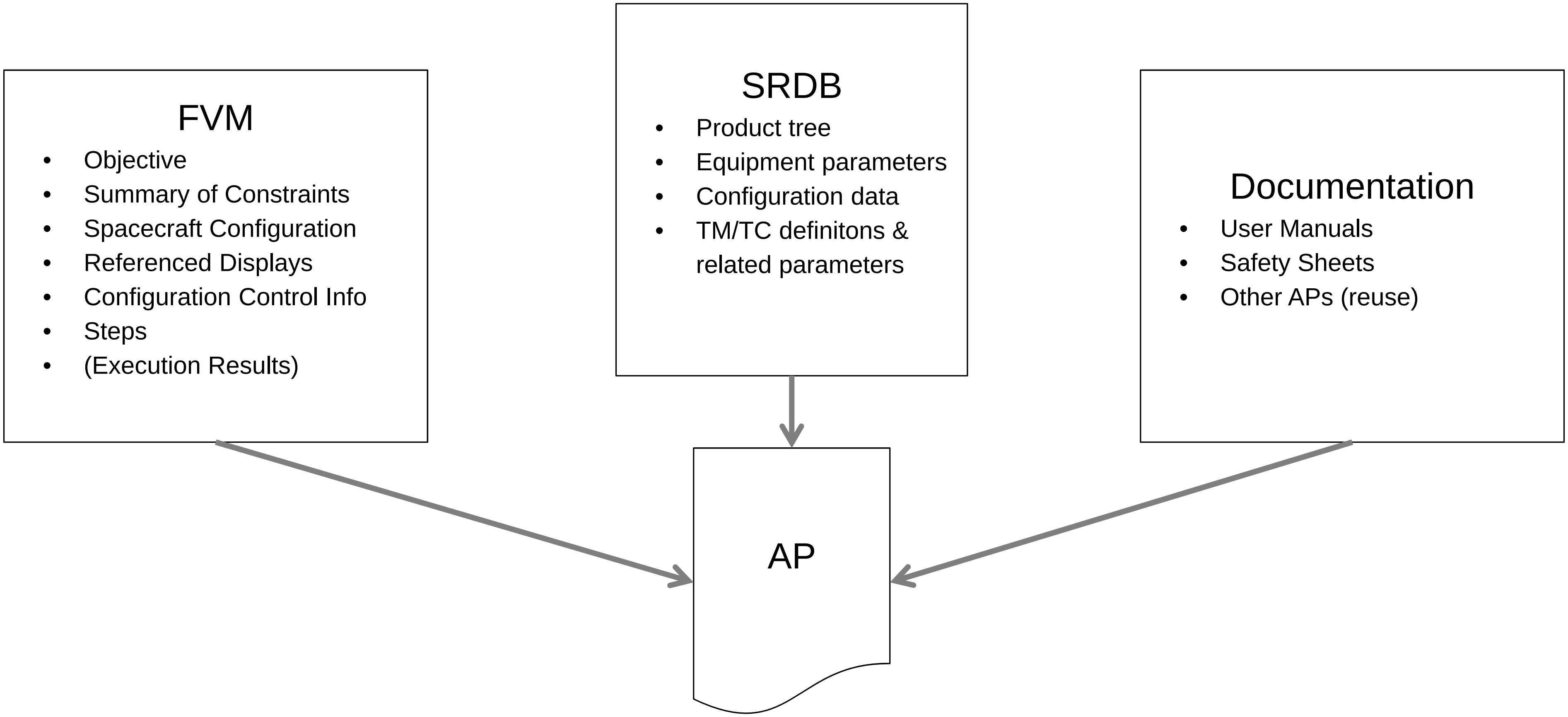
- Used mainly for AIT/FV but also spacecraft operations and onboard procedures
  - Send TC & receive TM
  - Control structures to manage the procedure flow





Step	Label/Time	Activity/Remarks	Telecommand	Telemetry	Display/ Branch	Requirements
		Beginning of Procedure				
		ASD-BE-FCP-005 **Procedure Properties** **Formal Parameters** FP_emergency_switch_off = <dec> (I) wait = 1 <dec> (R)				
1		Emergency switch off necessary? type: [If] Condition: Check Variable FP_emergency_switch_off			Next Step: no 2 yes 5	
		Check Variable FP_emergency_switch_off = 1 <dec> (FIX)			VAR	
2		Send TC to start OBCP „BERM switch off"			Next Step: 3	
		Execute Telecommand **ZBER4201 Start OBCP: BERM OFF** TC Control Flags: GBM IV DSE --T -- ---	ZBER4201		TC	
3		Wait 20 seconds type: [Wait] Condition: Check Variable wait			Next Step: 4	
		Check Variable wait = 0 <dec> (FIX)			VAR	
4		Verify command execution			Next Step: END	
		Verify Telemetry **NPWD0403 BERM-A ON-ST** = Off		NPWD0403 = Off	(None)	
		Verify Telemetry **NPWD0603 BERM-B ON-ST** = Off		NPWD0603 = Off	(None)	
5		Send TC to start OBCP „BERM emergency switch off"			Next Step: 6	
		Execute Telecommand **ZBER4202 Start OBCP: BERM EMERGENCY OFF** TC Control Flags: GBM IV DSE --T -- ---	ZBER4202		TC	
6		Wait 20 seconds type: [Wait] Condition: Check Variable wait			Next Step: 7	
		Check Variable wait = 0 <dec> (FIX)			VAR	
7		Verify command execution			Next Step: END	
		Verify Telemetry **NPWD0403 BERM-A ON-ST** = Off		NPWD0403 = Off	(None)	
		Verify Telemetry **NPWD0603 BERM-B ON-ST** = Off		NPWD0603 = Off	(None)	
		End of Procedure				

Data used in an AP – where is it from



FVM

- Objective
- Summary of Constraints
- Spacecraft Configuration
- Referenced Displays
- Configuration Control Info
- Steps
- (Execution Results)

SRDB

- Product tree
- Equipment parameters
- Configuration data
- TM/TC definitons & related parameters

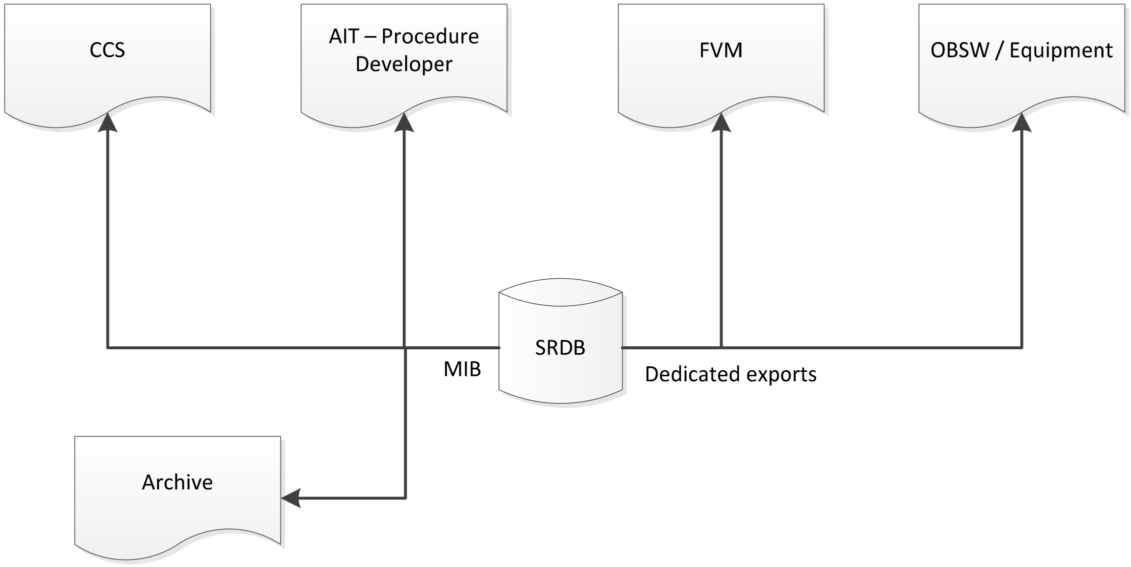
Documentation

- User Manuals
- Safety Sheets
- Other APs (reuse)

AP

Data Continuity

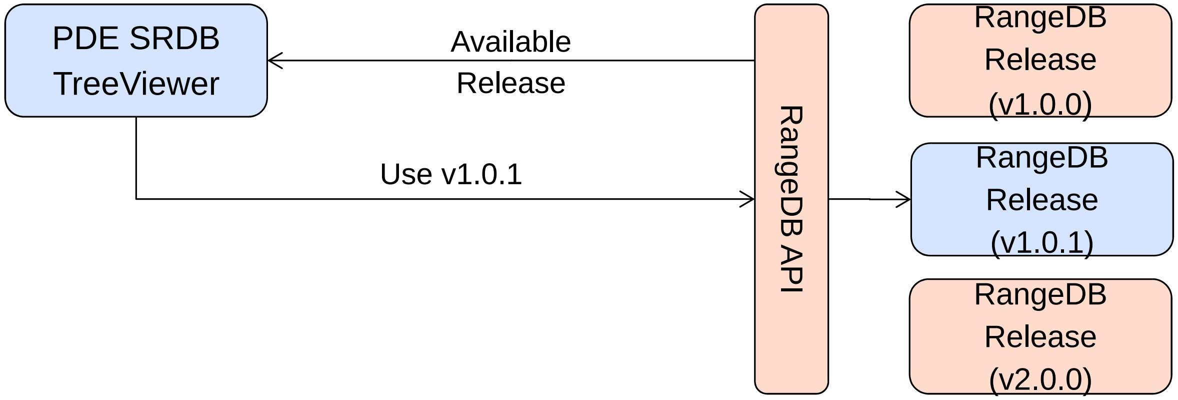
- Digitalization
  - Exchanging data between the referenced tools is currently a manual task of import / export!
  - Clearly identifying changes between versions of data is time-consuming depending on the format
  - Ensure a consistent working baseline for the AP developer



Change Propagation - SRDB

- The world is **not** perfect, and hence the latest version of the database may not always be installed on the test bench, or different versions will be available on different benches

- Direct integration utilising the RangeDB SRDB product
  - Available released versions
  - User selection of version for procedure editing
  - Enables content within the TreeViewer (available TM parameters, descriptions, documentation for example)

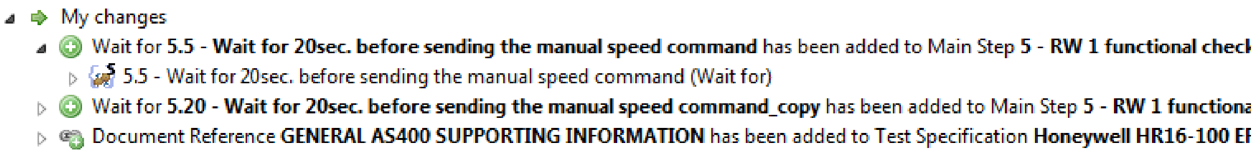


Change Propagation - SRDB

- With close integration of the SRDB, a background syntax check can be performed on the elements within an automated procedure
- Determine the compatibility of the procedure against the version of the database selected, particularly:
  - Removed elements (i.e. deleted User Defined TM parameters or synoptics)
  - Modified elements (i.e. added parameter within a TC)
- Allows the developer to identify required modifications to the procedure, ahead of time
- With most existing editors, this kind of check requires a manual action on the part of the developer (Run/Validate/Check Script or similar)

Change Propagation - FVM

- Connect to the project FVM instance to provide access to the digital data of a test specification
- Using the close integration of FVM (itself based on the RangeDB infrastructure), it is possible to identify changes between revisions of the test specification (not change bars!!)

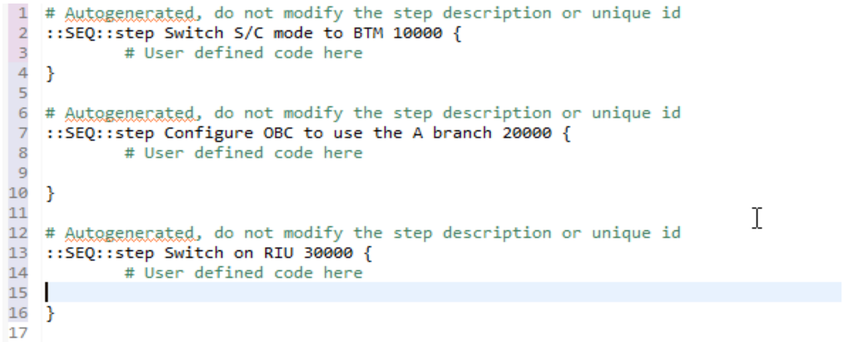


- My changes
  - Wait for **5.5 - Wait for 20sec. before sending the manual speed command** has been added to Main Step **5 - RW 1 functional chec**
    - 5.5 - Wait for 20sec. before sending the manual speed command (Wait for)
  - Wait for **5.20 - Wait for 20sec. before sending the manual speed command_copy** has been added to Main Step **5 - RW 1 functiona**
  - Document Reference **GENERAL AS400 SUPPORTING INFORMATION** has been added to Test Specification **Honeywell HR16-100 E**

- Highlight potential changes in the procedure, for example
  - Added or modified test step descriptions
  - Modified requirements to be verified
  - Changes in step success criteria, or in configuration to be used
- A future goal will be to use this revision information to identify these changes clearly in the procedure editor, further automating the change process

Change Propagation - FVM

- Within FVM, a so-called “master” ATP procedure is defined which will implement all of the test specification steps
  - Provides a clear link between a test step defined in the procedure and in the specification (and the mapping to the requirements verified with the step)
- From the specification, an Automated Test Procedure “Skeleton” can be generated in the native language
  - Simplifies procedure development with a standard structure that can then be populated by the test engineer
  - Eases requirement close-out as steps can be identified with run-time or post-processing of the test logs



```
# Autogenerated, do not modify the step description or unique id
::SEQ::step Switch S/C mode to BTM 10000 {
        # User defined code here
}

# Autogenerated, do not modify the step description or unique id
::SEQ::step Configure OBC to use the A branch 20000 {
        # User defined code here

}

# Autogenerated, do not modify the step description or unique id
::SEQ::step Switch on RIU 30000 {
        # User defined code here

}

```

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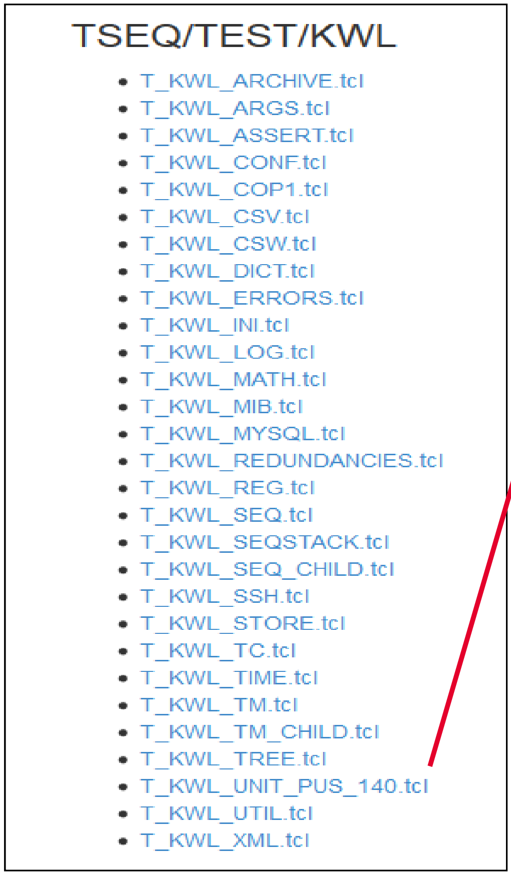
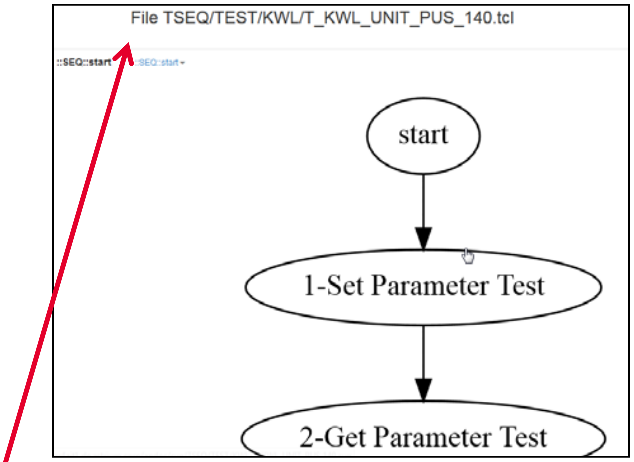
Change Propagation - Documentation

- Provide integration of the latest documentation links (User Manual, Design Document, DASY sheets)
- Clearly identify APs developed in the scope of the project plus any comments or documentation that is available to help the user
- Generate HTML documentation using automated tools, providing information such as available APs and their content



TSEQ/TEST/KWL

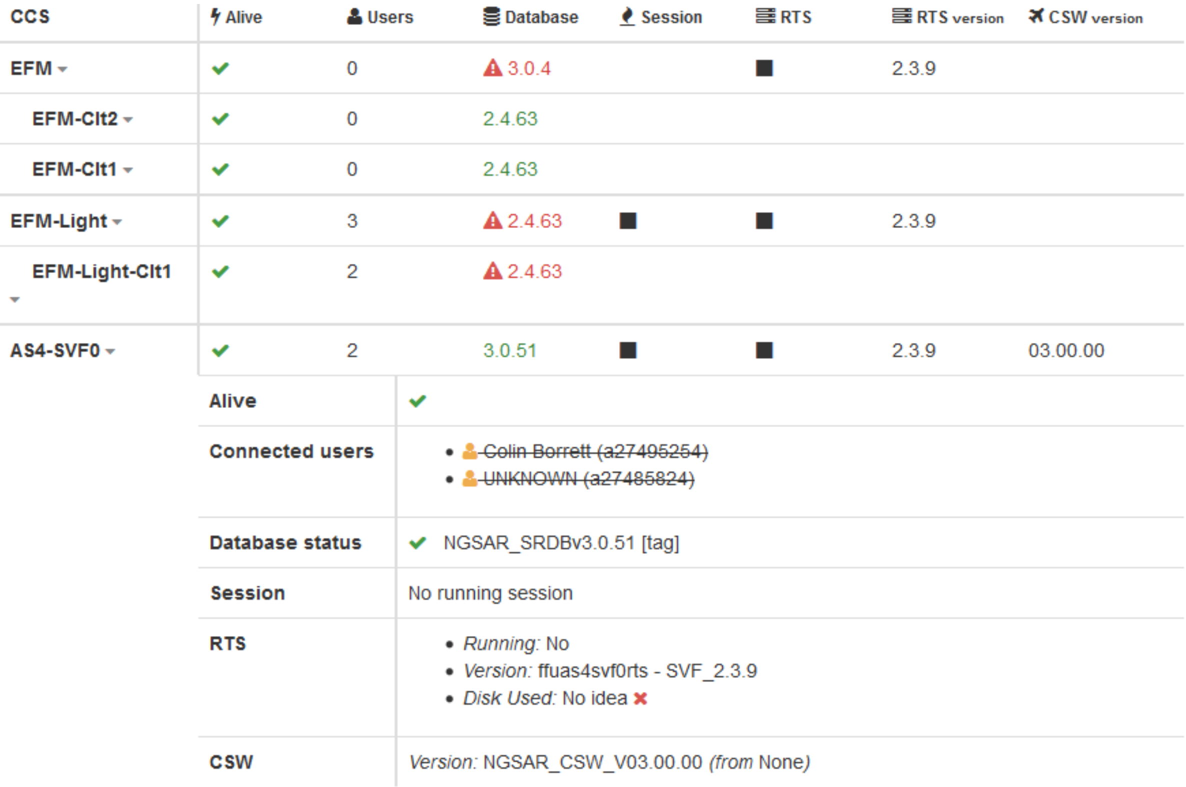
- T_KWL_ARCHIVE.tcl
- T_KWL_ARGS.tcl
- T_KWL_ASSERT.tcl
- T_KWL_CONF.tcl
- T_KWL_COP1.tcl
- T_KWL_CSV.tcl
- T_KWL_CSW.tcl
- T_KWL_DICT.tcl
- T_KWL_ERRORS.tcl
- T_KWL_INI.tcl
- T_KWL_LOG.tcl
- T_KWL_MATH.tcl
- T_KWL_MIB.tcl
- T_KWL_MYSQL.tcl
- T_KWL_REDUNDANCIES.tcl
- T_KWL_REG.tcl
- T_KWL_SEQ.tcl
- T_KWL_SEQSTACK.tcl
- T_KWL_SEQ_CHILD.tcl
- T_KWL_SSH.tcl
- T_KWL_STORE.tcl
- T_KWL_TC.tcl
- T_KWL_TIME.tcl
- T_KWL_TM.tcl
- T_KWL_TM_CHILD.tcl
- T_KWL_TREE.tcl
- T_KWL_UNIT_PUS_140.tcl
- T_KWL_UTIL.tcl
- T_KWL_XML.tcl



File TSEQ/TEST/KWL/T_KWL_UNIT_PUS_140.tcl

Run & Debug

- Final stage of AP development, move the AP to the CCS
- Provide online access to determine the current status of all available test benches (numerical, or HIL)
- Display the outcome and logs of the executed test session
- The future goal is to provide Run and Debug capability from within the same tool
  - Successfully prototyped with CCS5



CCS	Alive	Users	Database	Session	RTS	RTS version	CSW version
EFM	✓	0	⚠ 3.0.4		■	2.3.9	
EFM-Clt2	✓	0	2.4.63				
EFM-Clt1	✓	0	2.4.63				
EFM-Light	✓	3	⚠ 2.4.63	■	■	2.3.9	
EFM-Light-Clt1	✓	2	⚠ 2.4.63				
AS4-SVF0	✓	2	3.0.51	■	■	2.3.9	03.00.00

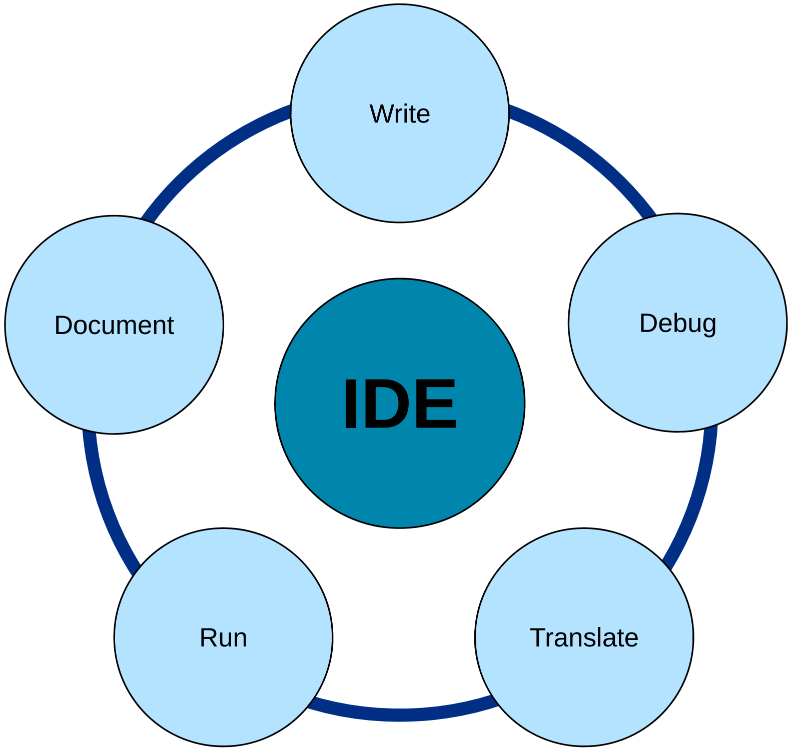
Alive	✓
Connected users	• ~~Colin Borrett (a27495254)~~ • ~~UNKNOWN (a27485824)~~
Database status	✓ NGSAR_SRDBv3.0.51 [tag]
Session	No running session
RTS	• *Running:* No • *Version:* ffuas4svf0rts - SVF_2.3.9 • *Disk Used:* No idea ✖
CSW	*Version:* NGSAR_CSW_V03.00.00 *(from* None*)*

PDE – A state of the art IDE

- PDE is integrated in terms of process and data continuity!

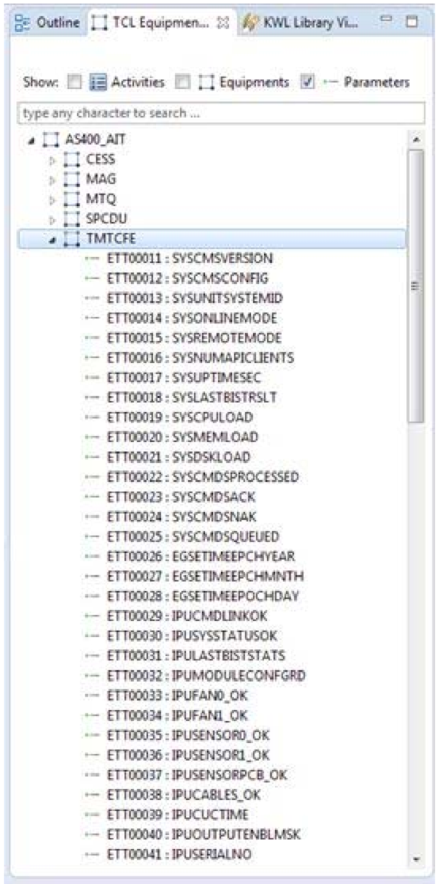
- PDE is based on Eclipse
  - Dynamic Languages Toolkit, Subversion/Git

- Main focus on usability and user support functions
  - Use of features from classical SW development IDEs
    - Code completion
    - Syntax highlighting
    - Error checking
    - Refactoring capabilities
    - Easy source navigation (to and from references)
    - Tool tips



Using SW development features for system data

- Features of modern SW development IDEs are used to ease the writing of target specific source code.
- Using system data as additional kind of meta information to support the developer
- Tooltips also show information based on data from SRDB or FVM
- Auto completion also works for data items like TM, TC packets and related parameters
- Search functions based on product tree
  - Spacecraft –> subsystem -> equipment -> commands -> „on“
- Specific navigators based to product tree allowing drag & drop of TM/TC



Show: ☐ Activities ☐ Equipments ☑ Parameters

type any character to search ...

```
AS400_AIT
  CESS
  MAG
  MTQ
  SPCDU
  TMTCFE
    ETT00011 : SYSCMSVERSION
    ETT00012 : SYSCMSCONFIG
    ETT00013 : SYSUNITSYSTEMID
    ETT00014 : SYSONLINEMODE
    ETT00015 : SYSREMOTEMODE
    ETT00016 : SYSNUMAPICLIENTS
    ETT00017 : SYSUPTIMESEC
    ETT00018 : SYSLASTBISTRSLT
    ETT00019 : SYSCPULOAD
    ETT00020 : SYSMEMLOAD
    ETT00021 : SYSDSKLOAD
    ETT00022 : SYSCMDSPROCESSED
    ETT00023 : SYSCMDSACK
    ETT00024 : SYSCMDSNAK
    ETT00025 : SYSCMDSQUEUED
    ETT00026 : EGSETIMEEPCHYEAR
    ETT00027 : EGSETIMEEPCHMNTH
    ETT00028 : EGSETIMEEPOCHDAY
    ETT00029 : IPUCMDLINKOK
    ETT00030 : IPUSYSSTATUSOK
    ETT00031 : IPULASTBISTSTATS
    ETT00032 : IPUMODULECONFGRD
    ETT00033 : IPUFAN0_OK
    ETT00034 : IPUFAN1_OK
    ETT00035 : IPUSENSOR0_OK
    ETT00036 : IPUSENSOR1_OK
    ETT00037 : IPUSENSORPCB_OK
    ETT00038 : IPUCABLES_OK
    ETT00039 : IPUCUCTIME
    ETT00040 : IPUOUTPUTENBLMSK
    ETT00041 : IPUSERIALNO
```

CCS/MCS Target language support

- PDE is based on a flexible concept to support different CCSs/MCSs
- Several target languages can be supported
  - TCL is mainly used today
  - Prototype to support EGS-CC APPG already available
- Target language editors independent of the link to system data

- Additional target specific support libraries included to ease writing of APs
  - Keyword Library – Common used functions (sendTC, receiveTM, log, …)

Using a DSL to define Procedures

- Why not using a DSL?
  - Need of using the target language instead of DSL mainly driven by complexity of procedures used for AIT and FV

But

- Different complexity in the scope of procedures for flight- or onboard operations
  - Simplified and generic language possible
  - Transformation from DSL to target specific language
    - Transformation to different targets possible (different CCS and MCS)

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Conclusion

- ✓ Introduction of a harmonized PDE has shown that an integrated approach provides a lot of advantages
  - ✓ Used in NGSAR, Sentinel4, Sentinel5, OneWeb, METImage
- ✓ Closing the gap in the dataflow from system design and TM/TC towards PDE is one the most beneficial improvements
- ✓ Thanks to a close link all information needed is available
- ✓ Defined / common data baseline
- ✓ Having additional meta-information from SRDB and FVM
- ✓ Update / notification process established
  - ✓ Changes / inconsistencies directly highlighted
- ✓ Status of APs visible, what is already implemented

Thank you!

Any Questions?