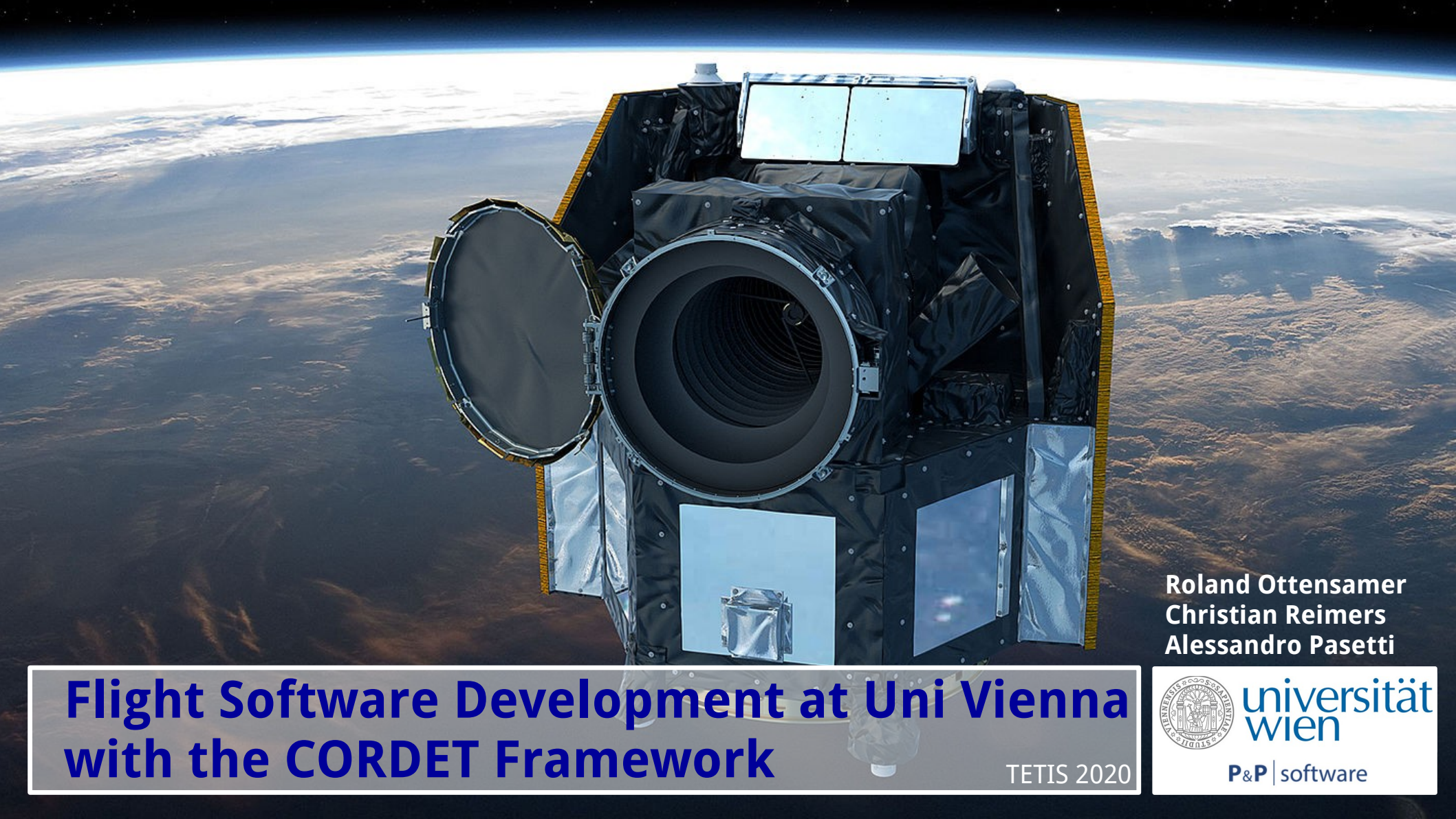

Flight Software Development at Uni Vienna with the CORDET Framework

TETIS 2020

Roland Ottensamer
Christian Reimers
Alessandro Pasetti

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P&P | software

UVie: What we are doing

- **Flight SW development for Space instrumentation**
  started 20 years ago with HERSCHEL/PACS
- our ***"Special Power"*** is on-board data reduction
- we're now on every other ESA mission
- meanwhile we have developed our own ...
  - EGSE SW (CCS, MIB generation, ...)
  - Flight SW OS
  - Framework add-ons, SW Generators
  - Requirements management, Doc generation
  - flexible simulators
  - SpW Brick + Gresb replacement
  - GRMON replacement (in progress)

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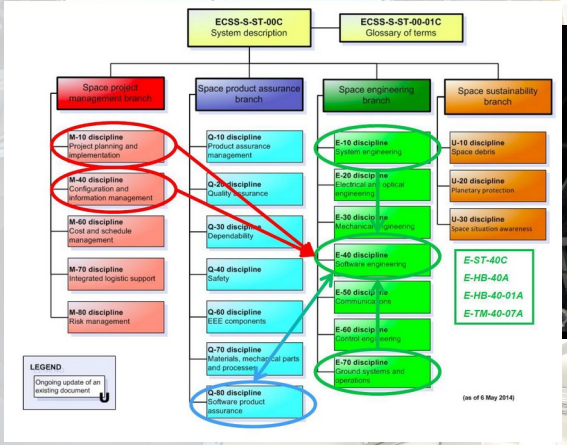
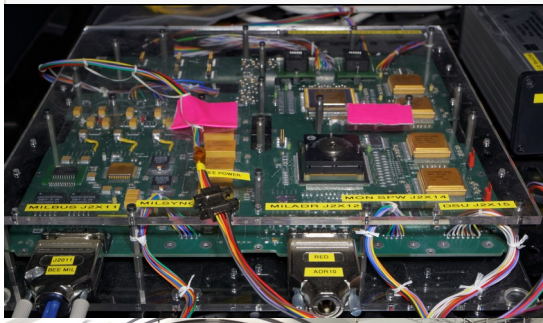
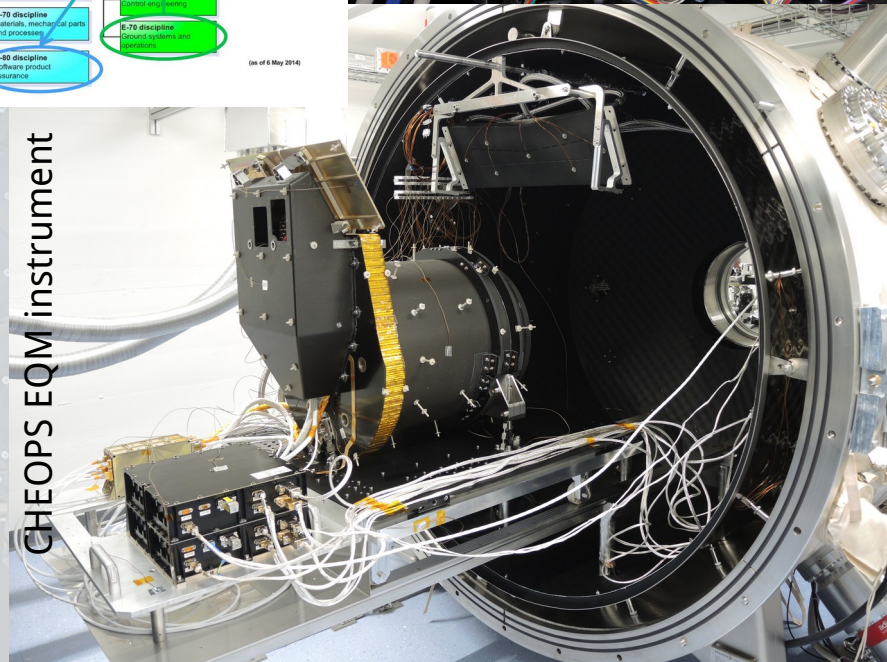
Flight SW for Space Instrumentation

- developed using the ECSS-Standard
  - 125 Documents
  - most work is documentation
  - traceability from requirements – design – implementation – testing and back is mandatory
- tasks: **instrument control** and **real-time science data processing** with little-to-no Ground contact
  - FDIR (Fault Detection, Isolation and Recovery)
- **very little** hardware resources
  - typically 50 MHz, 32 MiB RAM
- typically 25 person-years, 20-60 kloc



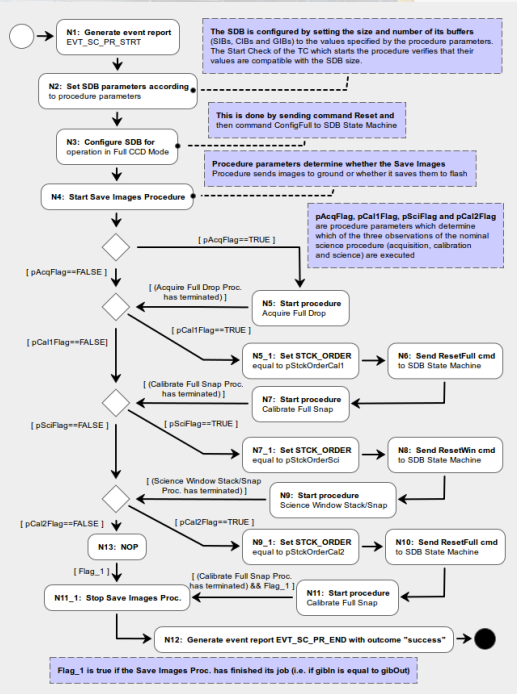




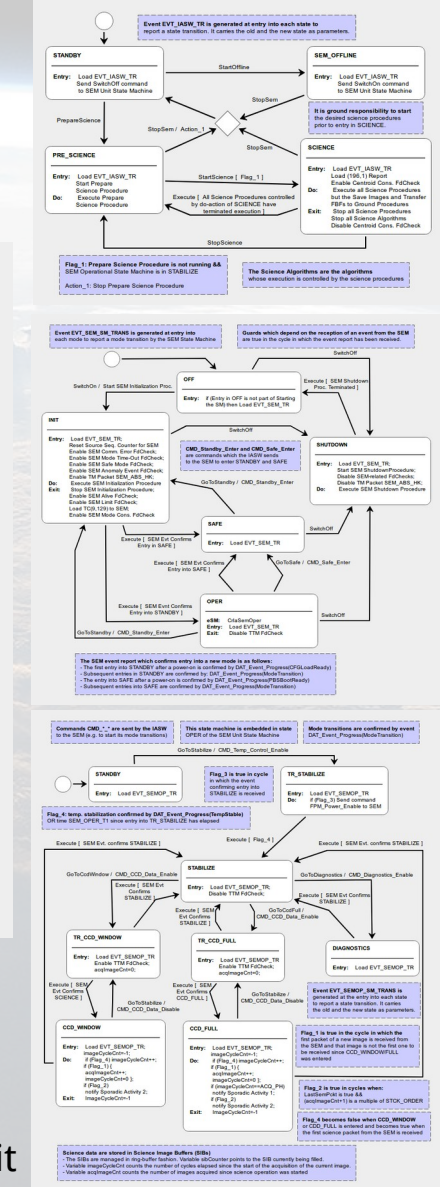
CHEOPS EQM instrument

Why use a framework?

- **ECSS**: Communication is formalized into “**services**“ consisting of **command** and **report** packages
  - typically up to 100 (sub-) services
  - TM/TC packet management
  - TM/TC ICD generation
  - MIB generation
- Formal way to implement **state machines** and SW **procedures**
  - needed to establish a bridge between requirements, documentation and code



science procedure



nested state machine for detector unit

Key Requirements for a Framework

In addition to providing the requested functionality, it shall ...

- be qualified for Space Applications
- be written in ANSI C with no external dependencies
- have a tiny footprint (kilobytes for the run-time component)
- be open source (and free)

Enters...

CORDET FW The CORDET Framework

- **CORDET FW is a SW library + a set of tools**
  - **Cordet Editor** to manage configuration, specifications and requirements
  - **FwProfile** is a Design tool for SM and procedures (activity diagrams)
- Input:
  - configuration, design of procedures and state machines
- Output:
  - source code skeleton, documentation, instrument database
- **How it works:**
  - during runtime the CORDET library controls the program flow between the adaptation points / called functions from the skeletons

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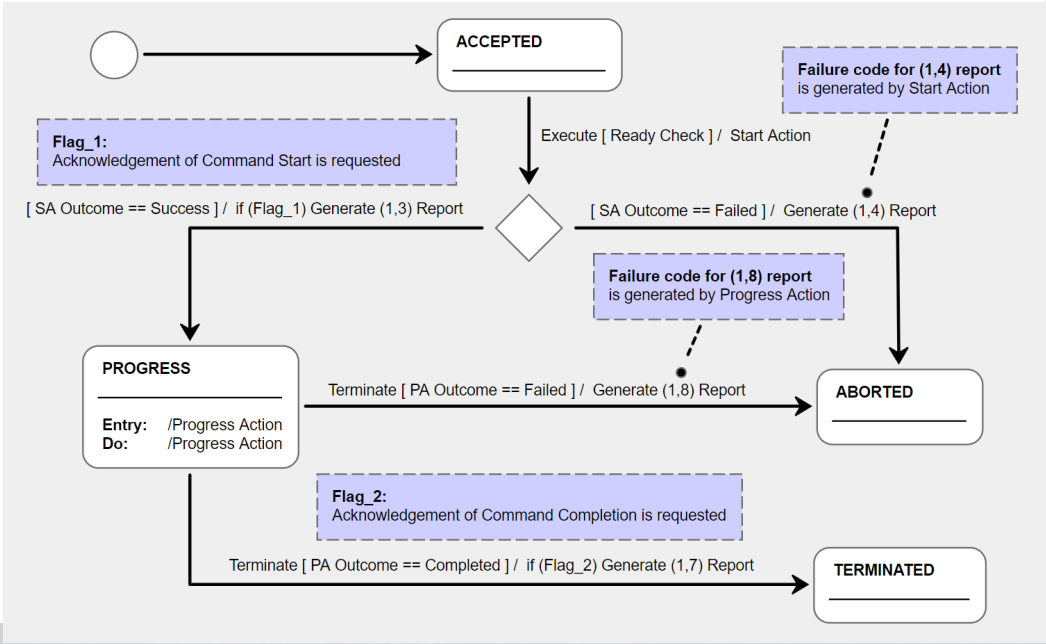
CORDET: example of command handling

- User provides functionality of checks and actions

In-coming Messages/Services – e.g. Commands

consecutive execution:

- Validity Check
- Ready Check
- Start Action
- **Progress Action:** process data
- **[Termination Action]**
- **[Abort Action]**



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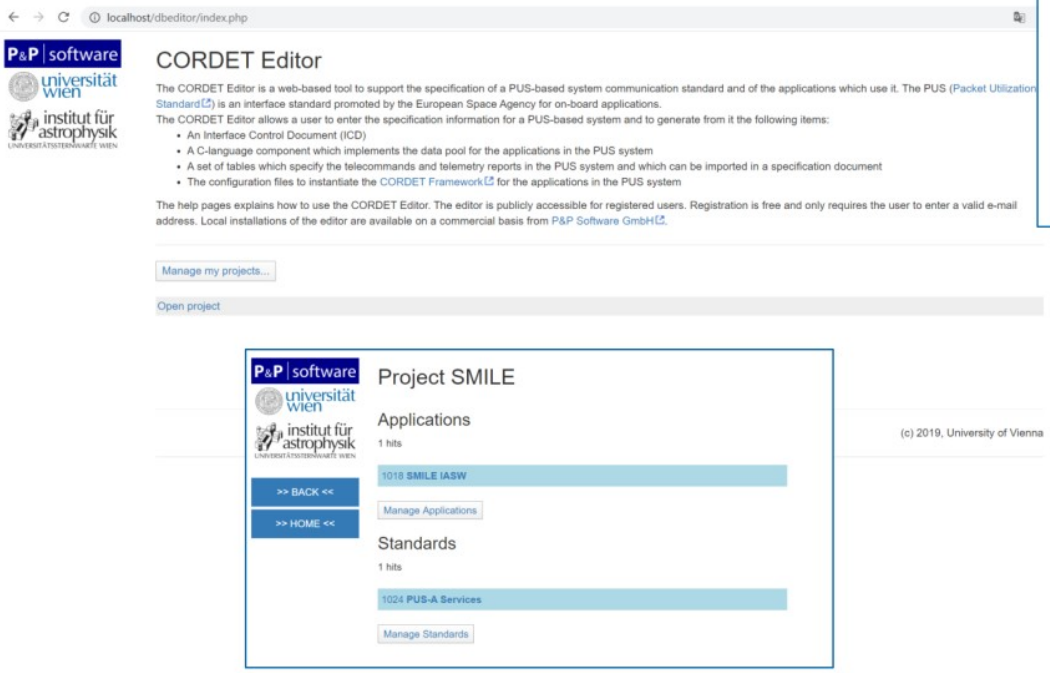
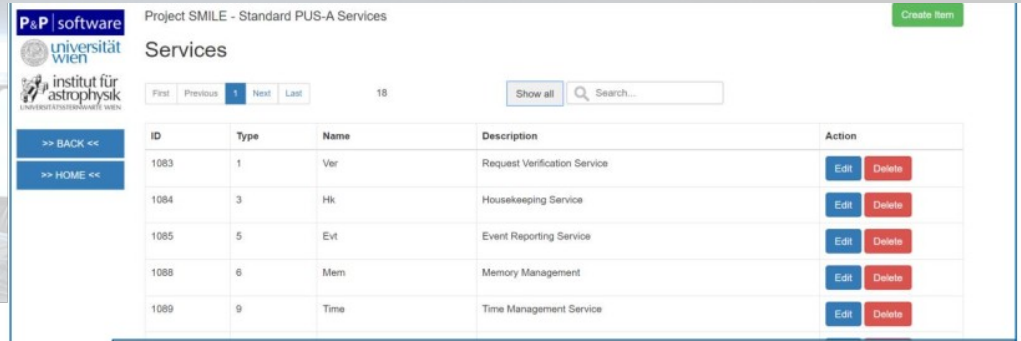
Master the ECSS PUS with CORDET

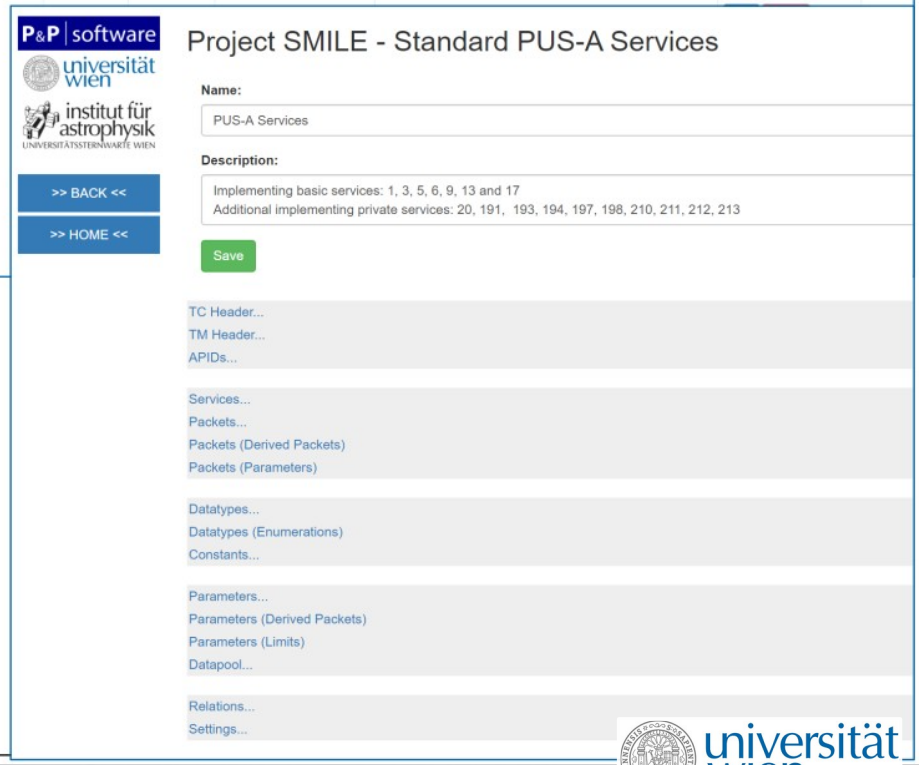
- **ECSS Packet Utilization Standard (PUS) Services - we used so far**
  - **Standard services**
    - Service 1 (Request Verification)
    - Service 3 (Housekeeping)
    - Service 5 (Event Reporting)
    - Service 6 (Memory Management)
    - Service 9 (Time Management)
    - Service 11 (Time Based Scheduling)
    - Service 12 (On Board Monitoring)
    - Service 13 (Large Data Transfer)
    - Service 17 (Test)
    - Service 20 (Parameter Management)
  - **Private services**
    - Service 191 (FDIR)
    - Service 192 (SEM Management)
    - Service 193 (IASW Mode Control)
    - Service 194 (Algorithm Control)
    - Service 195 (Heartbeat)
    - Service 196 (AOCS)
    - Service 197 (Boot Report)
    - Service 198 (Procedure Control)
    - Service 210 (DPU Management)
    - Service 211 (Parameter Update)
    - Service 212 (Data Operation)
    - Service 213 (SW Maintenance)

The tools

The CORDET Editor







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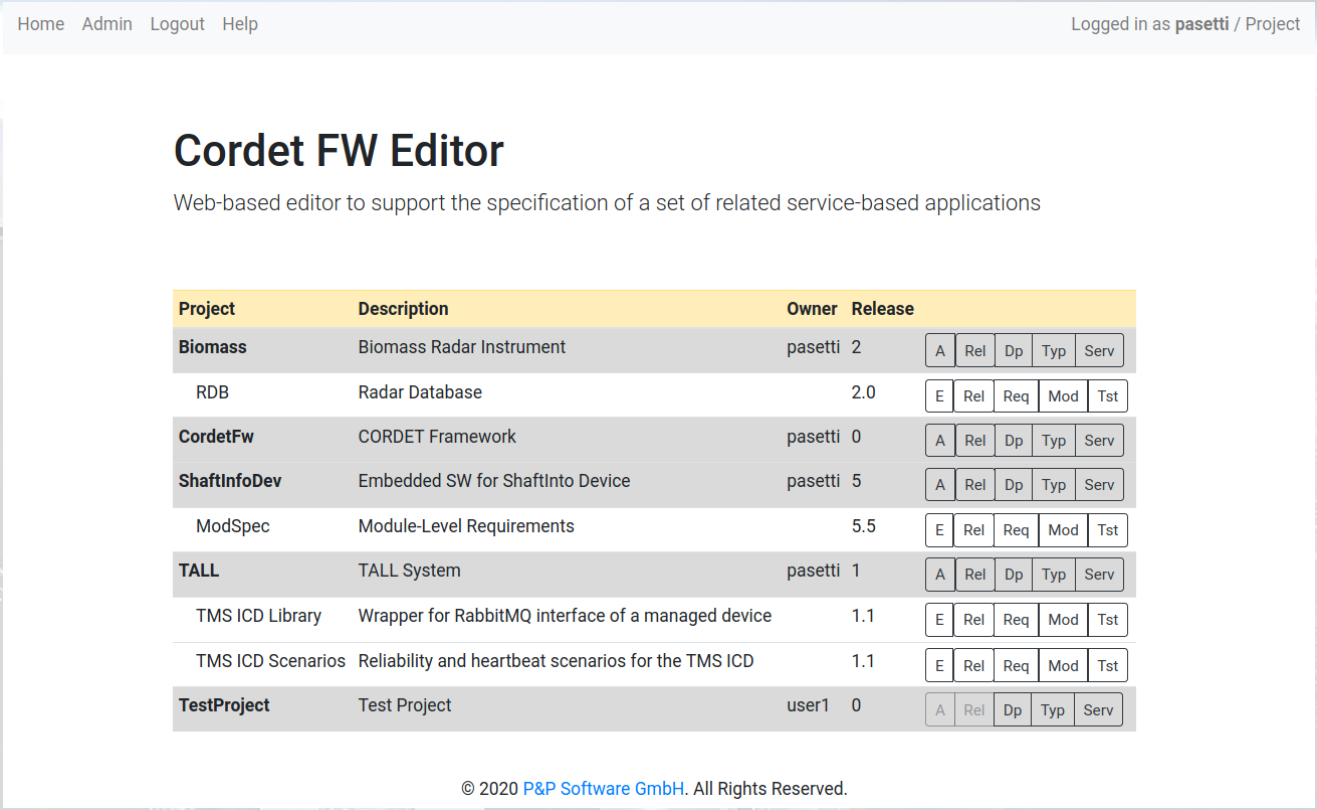
The tools



- Requirements definition
- Data Items
- Test Cases
- Traceability information among the three items

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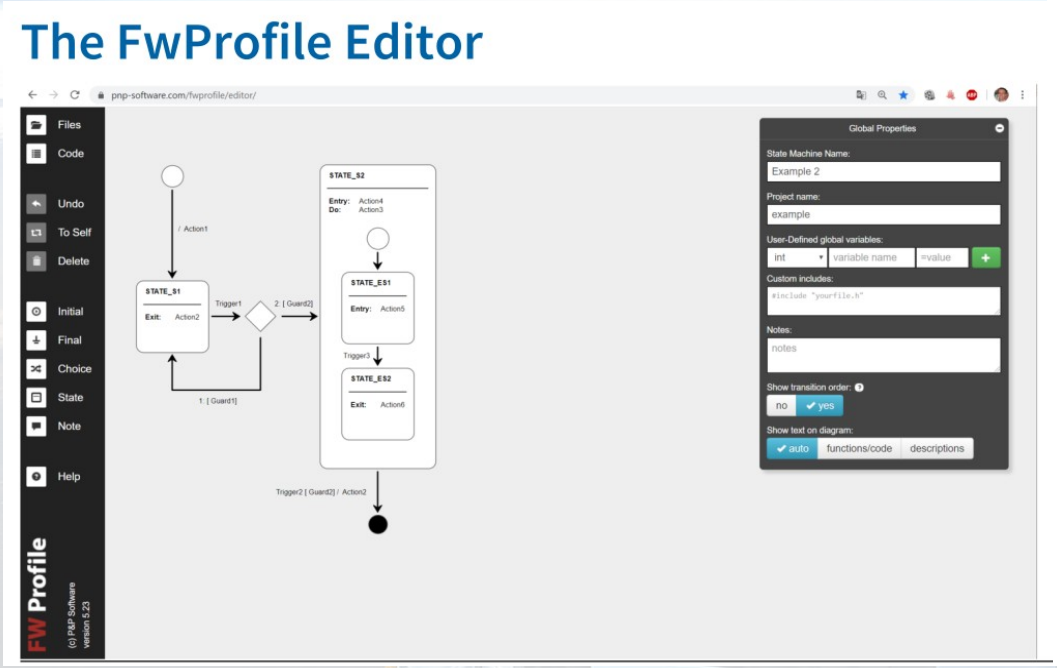
Tools

The FwProfile Editor



- … is a specification-level modelling language for software applications
- The core modelling constructs of the FW Profile are
  - **state machines**,
  - **procedures** (equivalent to UML's Activity Diagrams), and
  - **RT Containers** (encapsulation of threads).

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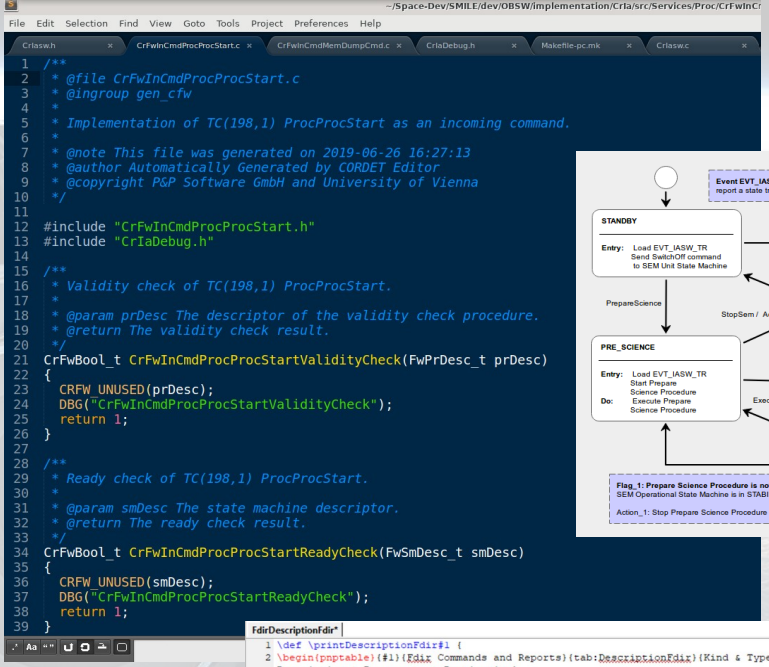
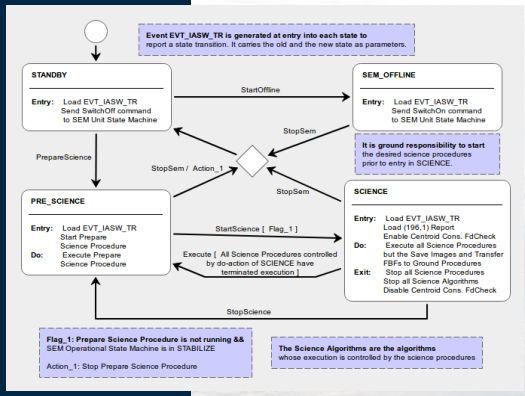
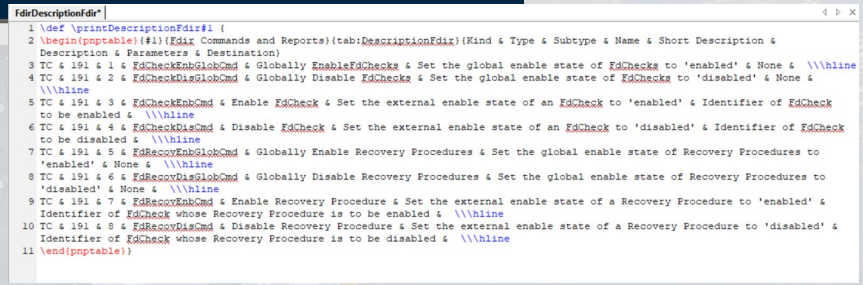
The outputs

- Source Code (*.c, *.h)
- Documentation (csv, tex)
  - TM/TC ICD
  - Specification
- Instrument Database
  - MIB tables for Mission Control e.g. SCOS2000







1	DPC50007	CreHkCmd	Create a Housekeeping Parameter Report Structure	N	Pus-ASer	3	1	321	4	N	Y	N	C	1	N	0		
2	DPC50008	DelHkCmd	Delete a Housekeeping or Diagnostic Parameter Report Structure	N	Pus-ASer	3	3	321	1	N	Y	N	C					
3	DPC50009	EnbHkCmd	Enable Periodic Generation of a Housekeeping Parameter Report St	N	Pus-ASer	3	5	321	1	N	Y	N						
4	DPC50010	DisHkCmd	Disable Periodic Generation of a Housekeeping Parameter Report S	N	Pus-ASer	3	6	321	1	N	Y	N						
5	DPC50011	RepStructHkCmd	Report Housekeeping Parameter Report Structure	N	Pus-ASer	3	9	321	1	N	Y	N	C	1	N	0		
6	DPC50015	ReqHkRepCmd	Request a Housekeeping Report	N	Pus-ASer	3	128	321	1	N	Y	N	C	1	N	0	9	
7	DPC50016	ModHkPeriodCmd	Modify the Period of Housekeeping Parameter Report Structures	N	Pus-ASer	3	131	321	2	N	Y	N						
8	DPC50089	EnbCmd	Enable Generation of Event Identifiers	N	Pus-ASer	5	5	321	2	N	Y	N	C	1	N	0	9	
9	DPC50090	DisCmd	Disable Generation of Event Identifiers	N	Pus-ASer	5	6	321	2	N	Y	N	C	1	N	0	9	
10	DPC50091	LoadCmd	Load Memory using Absolute Addresses	N	Pus-ASer	6	2	321	4	N	Y	N	C	1	N	0	9	
11	DPC50092	DumpCmd	Dump Memory using Absolute Addresses	N	Pus-ASer	6	5	321	4	N	Y	N	C	1	N	0	9	
12	DPC50094	TimeUpdt	Update Time	N	Pus-ASer	9	128	321	2	N	Y	N	C	1	N	0	9	
13	DPC50099	DownAbortCmd	Abort Downlink	N	Pus-ASer	13	8	321	3	N	Y	N	C	1	N	0	9	
14	DPC50100	UpFirstCmd	First Uplink Part	N	Pus-ASer	13	9	321	4	N	Y	N	C	1	N	0	9	
15	DPC50101	UpInterCmd	Intermediate Uplink Part	N	Pus-ASer	13	10	321	4	N	Y	N	C	1	N	0	9	

Status and Roadmap, the Licensing

- CORDET aims to become a community project
  - presently using GitHub, moving to a new home
- community-implemented protocols:
  - PUS A, PUS C (incl. several standard services)
- new back-end for EGS-CC
- also the editors are web-based and will be released as open source
- support licenses are available via PnP

First steps for new CORDET users

P&P | software https://www.pnp-software.com/cordetfw/index.html

- What you need and where to find ... CORDET FW The CORDET Framework
- Take your time to understand what it is and what it does
- Start with ...
  - demo example
  - own configuration + reqs
  - specify first service

... and then start hacking!

(... and if you feel really brave, check out the CHEOPS-SW!)

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