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Flight Software Development at Uni Vienna with the CORDET Framework

TETIS 2020



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P&P | software

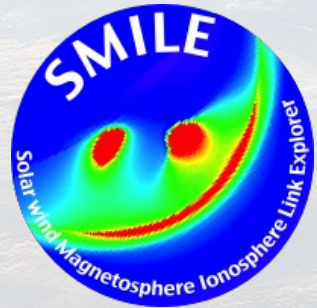
UVie: What we are doing

- **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)



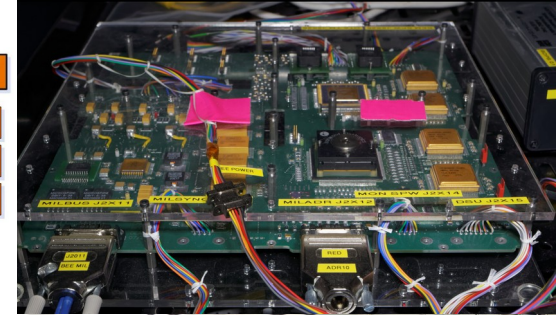
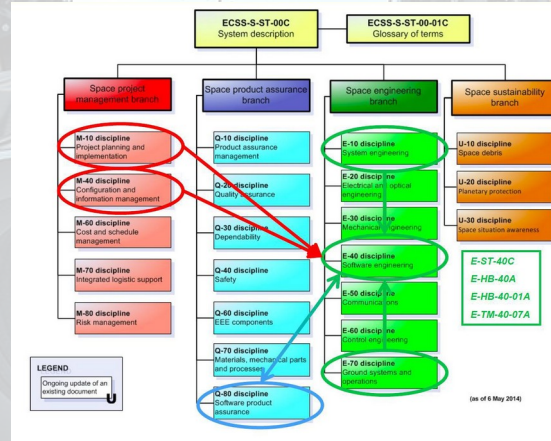
HERSCHEL

CHEOPS

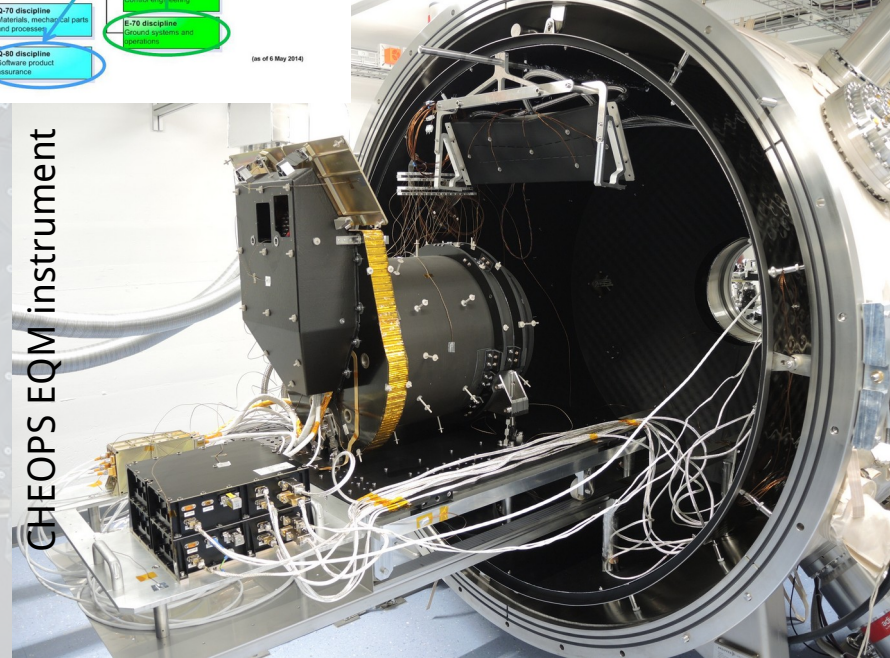


Flight SW for Space Instrumentation

- 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



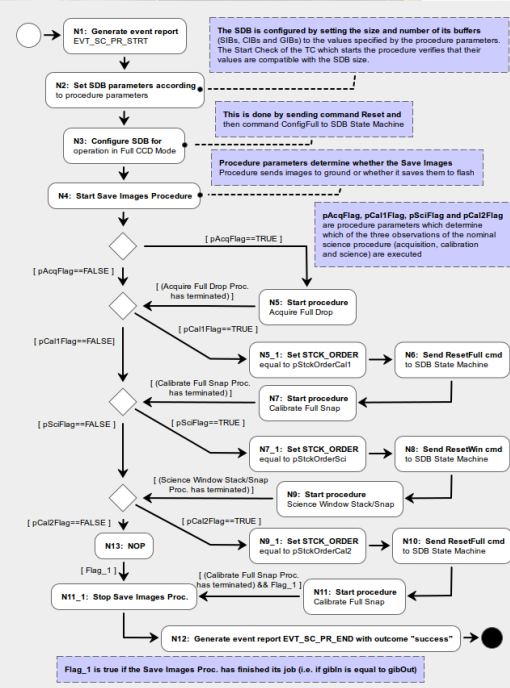
Why use a framework?

■ **ECSS:** Communication is formalized into **“services”** consisting of **command and report packages**

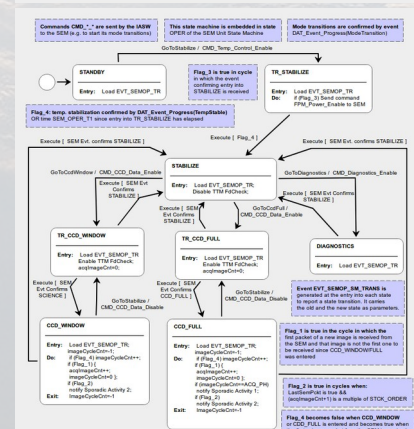
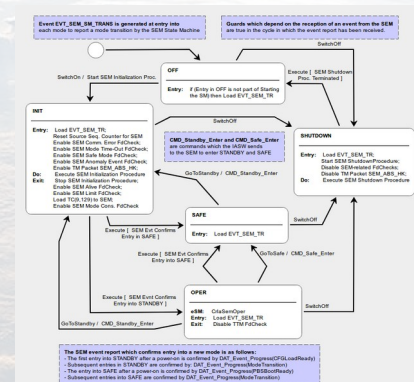
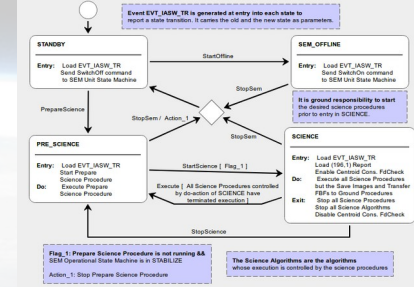
- typically up to 100 (sub-) services
- TM/TC packet management
- TM/TC ICD generation
- MIB generation

■ Formal way to implement **state machines** and **SW procedures**

- needed to establish a bridge between requirements, documentation and code



science procedure



Science data are stored in Science Image Buffers (SIBs).
 - Visible image(s) is/are the number of images acquired since the start of the acquisition of the current image.
 - Visible image(s) is/are the number of images acquired since science operation was started.

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...



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



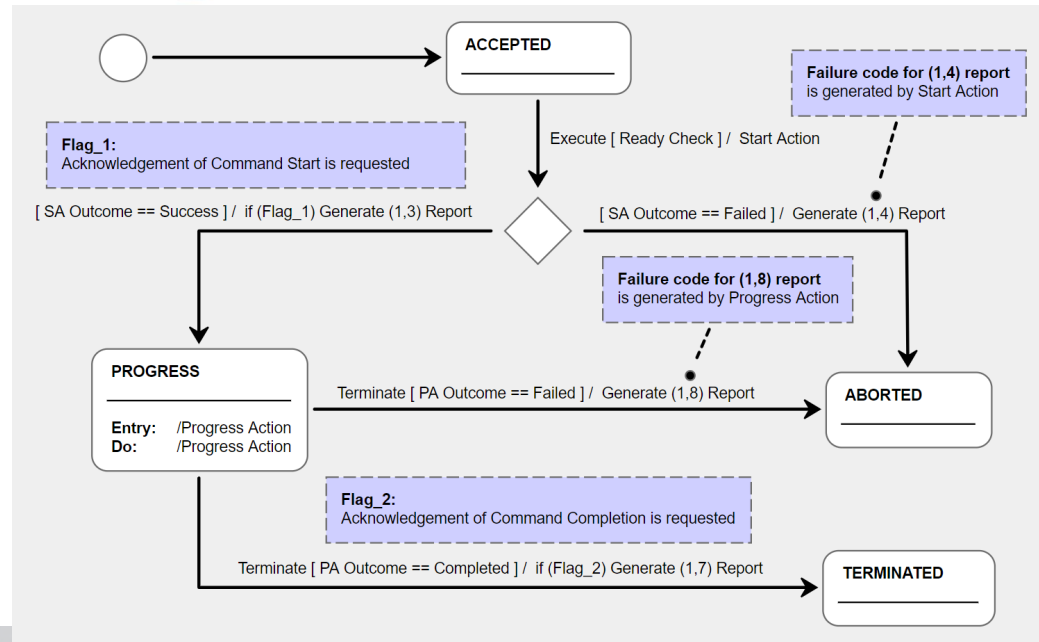
CORDET: example of command handling

- 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]**



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

localhost/dbeditor/index.php



CORDET Editor

The CORDET Editor is a web-based tool to support the specification of a PUS-based system communication standard and of the applications which use it. The PUS (Packet Utilization Standard) is an interface standard promoted by the European Space Agency for on-board applications.

The CORDET Editor allows a user to enter the specification information for a PUS-based system and to generate from it the following items:

- An Interface Control Document (ICD)
- A C-language component which implements the data pool for the applications in the PUS system
- A set of tables which specify the telecommands and telemetry reports in the PUS system and which can be imported in a specification document
- The configuration files to instantiate the CORDET Framework for the applications in the PUS system

The help pages explain how to use the CORDET Editor. The editor is publicly accessible for registered users. Registration is free and only requires the user to enter a valid e-mail address. Local installations of the editor are available on a commercial basis from P&P Software GmbH.

Manage my projects...

Open project

Project SMILE

Applications
1 hits

1018 SMILE IASW

Manage Applications

Standards
1 hits

1024 PUS-A Services

Manage Standards

(c) 2019, University of Vienna



Project SMILE - Standard PUS-A Services

Create Item

Services

First Previous 1 Next Last

18

Show all Search...

ID	Type	Name	Description	Action
1083	1	Ver	Request Verification Service	Edit Delete
1084	3	Hk	Housekeeping Service	Edit Delete
1085	5	Evt	Event Reporting Service	Edit Delete
1088	6	Mem	Memory Management	Edit Delete
1089	9	Time	Time Management Service	Edit Delete

>> BACK <<

>> HOME <<



Project SMILE - Standard PUS-A Services

Name:

PUS-A Services

Description:

Implementing basic services: 1, 3, 5, 6, 9, 13 and 17
Additional implementing private services: 20, 191, 193, 194, 197, 198, 210, 211, 212, 213

Save

TC Header...

TM Header...

APIDs...

Services...

Packets...

Packets (Derived Packets)

Packets (Parameters)

Datatypes...

Datatypes (Enumerations)

Constants...

Parameters...

Parameters (Derived Packets)

Parameters (Limits)

Datapool...

Relations...

Settings...



The tools

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

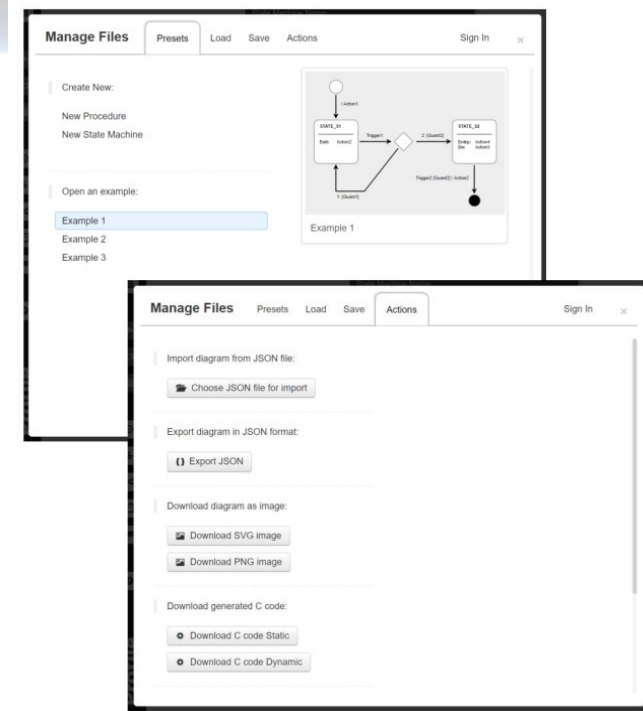
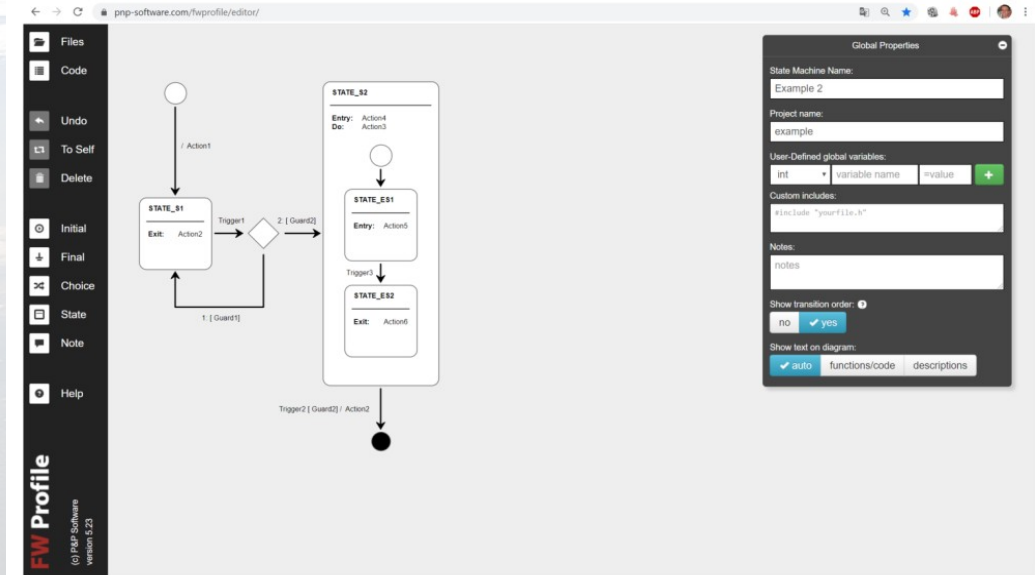
Cordet FW Editor

Web-based editor to support the specification of a set of related service-based applications

Project	Description	Owner	Release					
Biomass	Biomass Radar Instrument	pasetti	2	A	Rel	Dp	Typ	Serv
RDB	Radar Database		2.0	E	Rel	Req	Mod	Tst
CordetFw	CORDET Framework	pasetti	0	A	Rel	Dp	Typ	Serv
ShaftInfoDev	Embedded SW for ShaftInfo Device	pasetti	5	A	Rel	Dp	Typ	Serv
ModSpec	Module-Level Requirements		5.5	E	Rel	Req	Mod	Tst
TALL	TALL System	pasetti	1	A	Rel	Dp	Typ	Serv
TMS ICD Library	Wrapper for RabbitMQ interface of a managed device		1.1	E	Rel	Req	Mod	Tst
TMS ICD Scenarios	Reliability and heartbeat scenarios for the TMS ICD		1.1	E	Rel	Req	Mod	Tst
TestProject	Test Project	user1	0	A	Rel	Dp	Typ	Serv

Tools

The FwProfile Editor



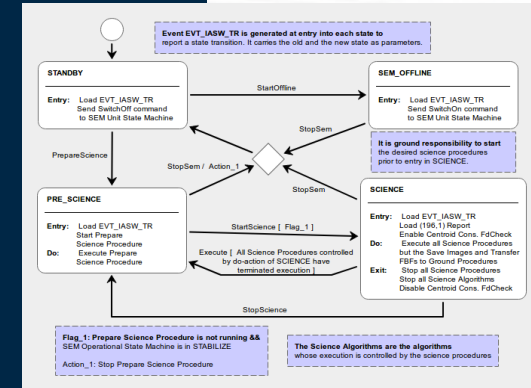
- ... is a specification-level modelling language for software applications
- The core modelling constructs of the FW Profile are
 - **state machines**,
 - **procedures** (equivalent to UML's Activity Diagrams), and
 - **RT Containers** (encapsulation of threads).

The outputs

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

```

File Edit Selection View Tools Project Services Help
CrFwInCmdProcStart.c CrFwInCmdMemDumpCmd.c CrIaDebug.h Mallette-pcmx CrIaSwc
1 /**
2  * @file CrFwInCmdProcStart.c
3  * @ingroup gen_cfw
4  *
5  * Implementation of TC(198,1) ProcProcStart as an incoming command.
6  *
7  * @note This file was generated on 2019-06-26 16:27:13
8  * @author Automatically Generated by CORDET Editor
9  * @copyright P&P Software GmbH and University of Vienna
10  */
11
12 #include "CrFwInCmdProcStart.h"
13 #include "CrIaDebug.h"
14
15 /**
16  * Validity check of TC(198,1) ProcProcStart.
17  *
18  * @param prDesc The descriptor of the validity check procedure.
19  * @return The validity check result.
20  */
21 CrFwBool_t CrFwInCmdProcStartValidityCheck(FwPrDesc_t prDesc)
22 {
23     CRFW_UNUSED(prDesc);
24     DBG("CrFwInCmdProcStartValidityCheck");
25     return 1;
26 }
27
28 /**
29  * Ready check of TC(198,1) ProcProcStart.
30  *
31  * @param smDesc The state machine descriptor.
32  * @return The ready check result.
33  */
34 CrFwBool_t CrFwInCmdProcStartReadyCheck(FwSmDesc_t smDesc)
35 {
36     CRFW_UNUSED(smDesc);
37     DBG("CrFwInCmdProcStartReadyCheck");
38     return 1;
39 }
    
```



```

FdrDescriptionFdr1
1 /def /printDescriptionFdr1 {
2 /begin(pnttable) {#1 {FdrCmds Commands and Reports} (tab: {DescriptionFdr} (Kind & Type & Subtype & Name & Short Description &
3 Description & Parameters & Destination)
4 TC & 191 & 1 & FdCheckEnbGlobCmd & Globally Enable FdChecks & Set the global enable state of FdChecks to 'enabled' & None & \\hline
5 TC & 191 & 2 & FdCheckDisGlobCmd & Globally Disable FdChecks & Set the global enable state of FdChecks to 'disabled' & None & \\hline
6 TC & 191 & 3 & FdCheckEnbCmd & Enable FdCheck & Set the external enable state of an FdCheck to 'enabled' & Identifier of FdCheck to be enabled & \\hline
7 TC & 191 & 4 & FdCheckDisCmd & Disable FdCheck & Set the external enable state of an FdCheck to 'disabled' & Identifier of FdCheck to be disabled & \\hline
8 TC & 191 & 5 & FdRecoyEnbGlobCmd & Globally Enable Recovery Procedures & Set the global enable state of Recovery Procedures to 'enabled' & None & \\hline
9 TC & 191 & 6 & FdRecoyDisGlobCmd & Globally Disable Recovery Procedures & Set the global enable state of Recovery Procedures to 'disabled' & None & \\hline
10 TC & 191 & 7 & FdRecoyEnbCmd & Enable Recovery Procedure & Set the external enable state of a Recovery Procedure to 'enabled' & Identifier of FdCheck whose Recovery Procedure is to be enabled & \\hline
11 TC & 191 & 8 & FdRecoyDisCmd & Disable Recovery Procedure & Set the external enable state of a Recovery Procedure to 'disabled' & Identifier of FdCheck whose Recovery Procedure is to be disabled & \\hline
12 /end(pnttable)}
    
```

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



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 ...
- 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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