



EXTENDING THE SCALE OF OUR MODELLING ENVIRONMENTS WITH CFS AND SEDS

MBSE2021 – Thales Alenia Space

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///Introduction  CCMSpace 

///cFS 

///SEDS 

///Conclusion

EXTENDING THE SCALE OF OUR MODELLING ENVIRONMENTS WITH CFS AND SEDS

OUTLINE

///Introduction

/ Context

/ CCM4Space

///cFS

/ Presentation

/ cFS applications modelling

/ Supporting tooling

/ Modelling choices : pros & cons

///SEDS

/ Presentation

/ SEDS->CCM bridge

///Conclusion

/ Concepts and tools

/ Benefits and costs

/ Challenges ahead

INTRODUCTION - CONTEXT

Thales Alenia Space contribution to Gateway station



Gateway Elements

Power and Propulsion Element (PPE)

Power, communications, attitude control, and orbit transfer capabilities for Gateway

Habitat and Logistics Outpost (HALO) Module

Pressurized volume providing docking hub, life support, VV and Lunar communications, and limited utilization capabilities

Logistics Module(s)

Cargo deliveries of consumables, outfitting, and providing additional utilization volume

International Habitation Module (I-HAB)

Pressurized habitation volume with environmental control, augmented life support, docking hub, and utilization capabilities

Robotic Arm

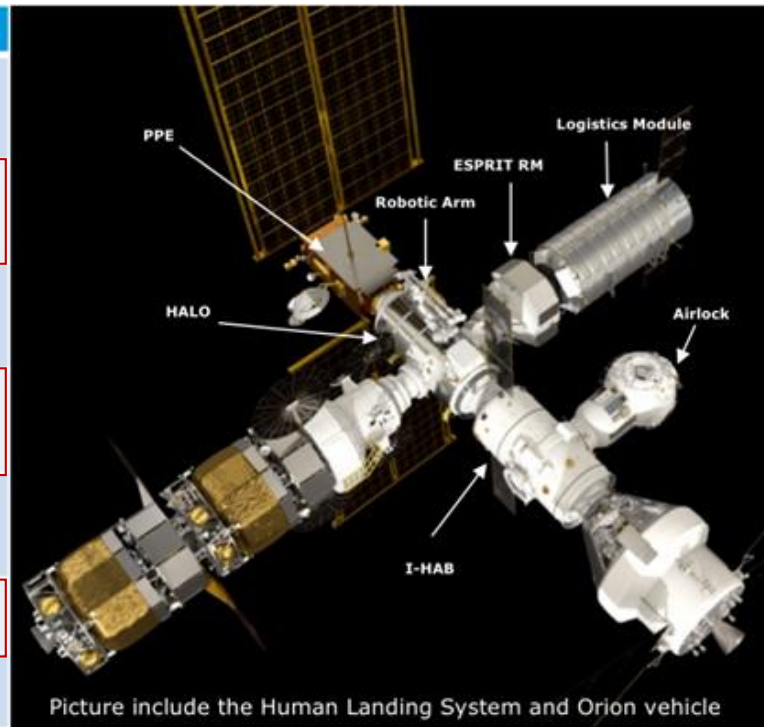
Mechanical arm for maintenance, to berth and inspect vehicles, install science payloads

ESPRIT Refuelling Module (ESPRIT RM)

Refuelling of PPE, all-around Window, pressurised tunnel

Airlock

Enables spacewalks and potential to accommodate docking elements

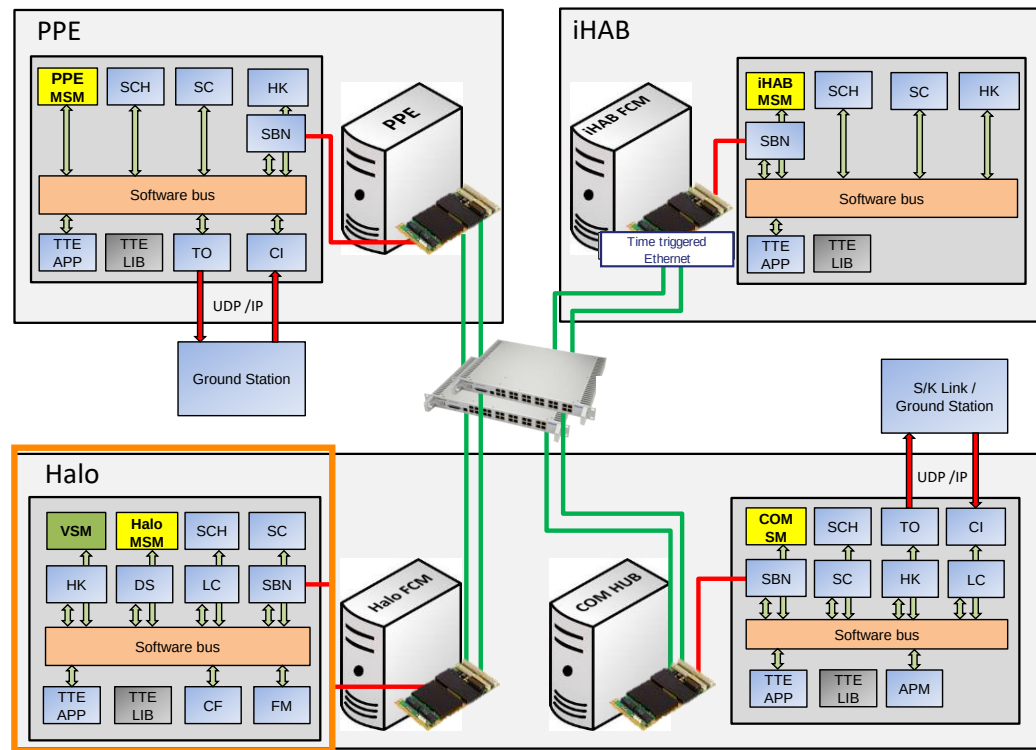


INTRODUCTION - CONTEXT

Gateway modules Flight Software architecture

/// cFS framework instances
for each module Flight Software

/// Time-triggered Ethernet
for inter-modules communication



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INTRODUCTION – CCM4SPACE

MelodyCCM and CCM4Space



CCM4Space



OMG CCM

- Design of datatypes, interfaces, events, component types

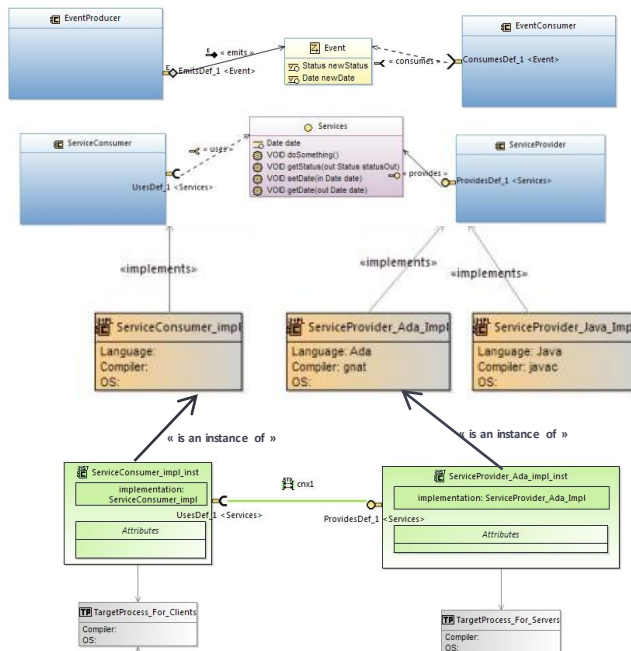
OMG UML

- Definition of Component implementations

OMG D&C

- Definition of Component instances and deployments

CCM = Corba Component Model



Modelling extensions

- Design of Extended Data types (= Ada Typing expressivity)
- Interfaces/Events <> PUS mapping
- Definition of the Ground<>Board Interface

Code generators

Doc and interface export generators

INTRODUCTION – CCM4SPACE

PUS standard compliance

/// CCM interfaces <-> PUS services

/// CCM operations <-> PUS subservices

/// CCM events <-> PUS service 5 (event reporting)

/// HK parameters <-> PUS service 3 (housekeeping)

/// ...

/// **With Gateway programs, evolutions have been needed to cope with PUS-equivalent cFS standard.**

service type	
name	ID
request verification	1
device access	2
housekeeping	3
parameter statistics reporting	4
event reporting	5
memory management	6
(reserved)	7
function management	8
time management	9
(reserved)	10
time-based scheduling	11
on-board monitoring	12
large packet transfer	13
real-time forwarding control	14
on-board storage and retrieval	15
(reserved)	16
test	17
on-board control procedure	18
event-action	19
parameter management	20
request sequencing	21
position-based scheduling	22
file management	23

Note: The reserved service type identifiers were used in previous versions of this Standard. This Standard no longer promotes the use of these service types but does not preclude that existing implementations are reused for new missions.

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CFS - PRESENTATION

cFS concepts : apps, libs and services

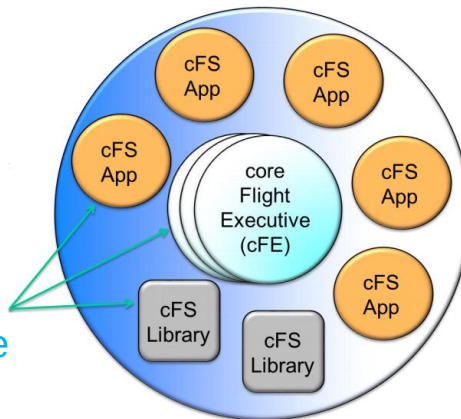


/// cFS : core Flight System

/// cFE : core Flight Executive



/// Each element is a separate loadable file

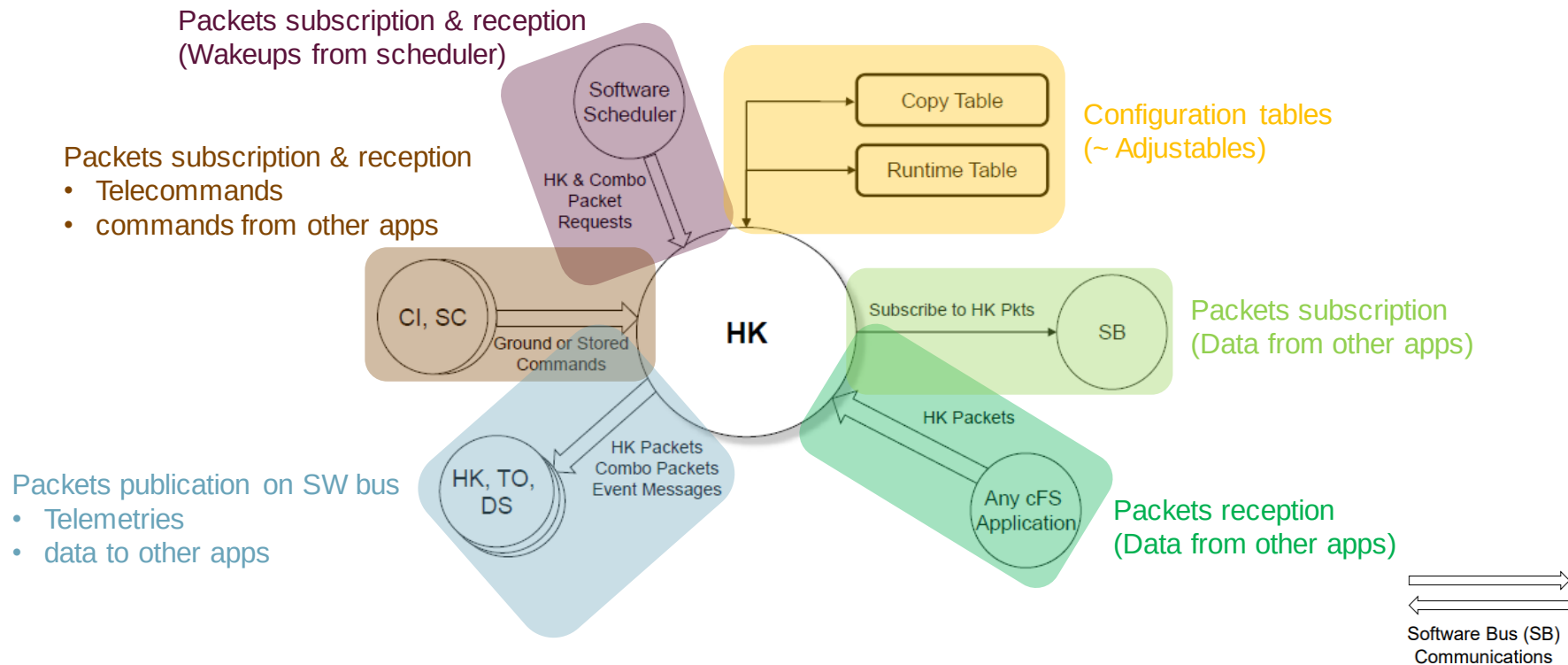


/// Open-source cFS apps :

Application
CFDP
Checksum
Command Ingest Lab
Data Storage
File Manager
Housekeeping
Health and Safety
Limit Checker
Memory Dwell
Memory Manager
Software Bus Network
Scheduler
Scheduler Lab
Stored Command
Telemetry Output Lab

CFS - PRESENTATION

cFS app content



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- / **cFS applications modelling**

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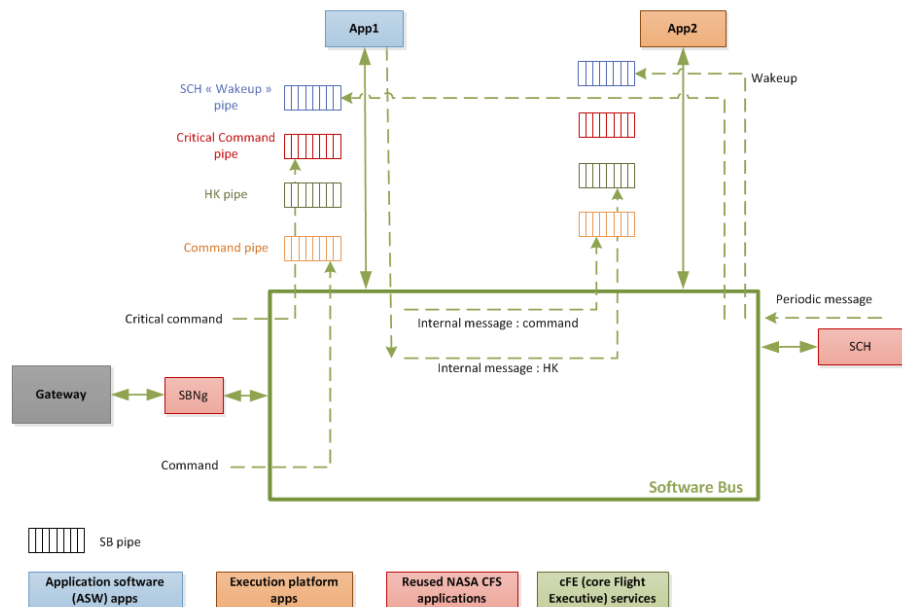
- / Concepts and tools

- / Benefits and costs

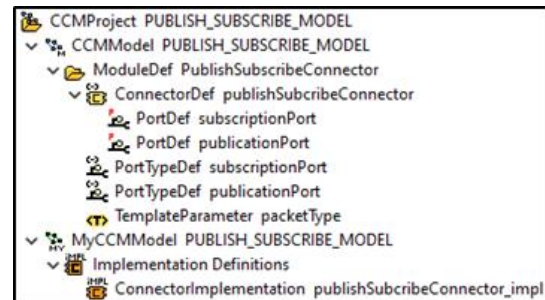
- / Challenges ahead

CFS – CFS APPLICATIONS MODELLING

Software bus interactions – Publish/Subscribe pattern



/// Generic Publish/Subscribe connector definition, with a template parameter <T> (*packetType*)



CFS – CFS APPLICATIONS MODELLING

Workspace structure for cFS architectures

/// For each application

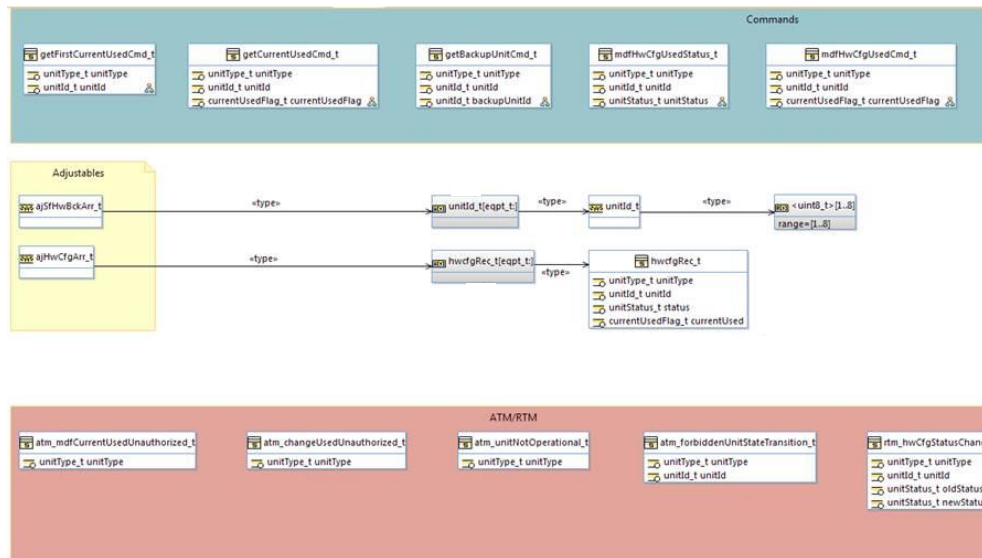
■ 4 layers of models

- PACKETS : packets content definition

⇒ This is the only one that is modelled manually

CFS – CFS APPLICATIONS MODELLING

Packets content modelling



CFS – CFS APPLICATIONS MODELLING

Workspace structure for cFS architectures

/// For each application

/ 4 layers of models

- PACKETS : packets content definition (see next slide)

⇒ This is the only one that is modelled manually

- INTERFACE : SW bus connectors definition

- COMPONENT : application ports (publication or subscription) definition

- (LOCAL) DEPLOYMENT : application instance, connector instances and connections

⇒ Connections between application instance ports and connector instances ports

/// Common to all applications

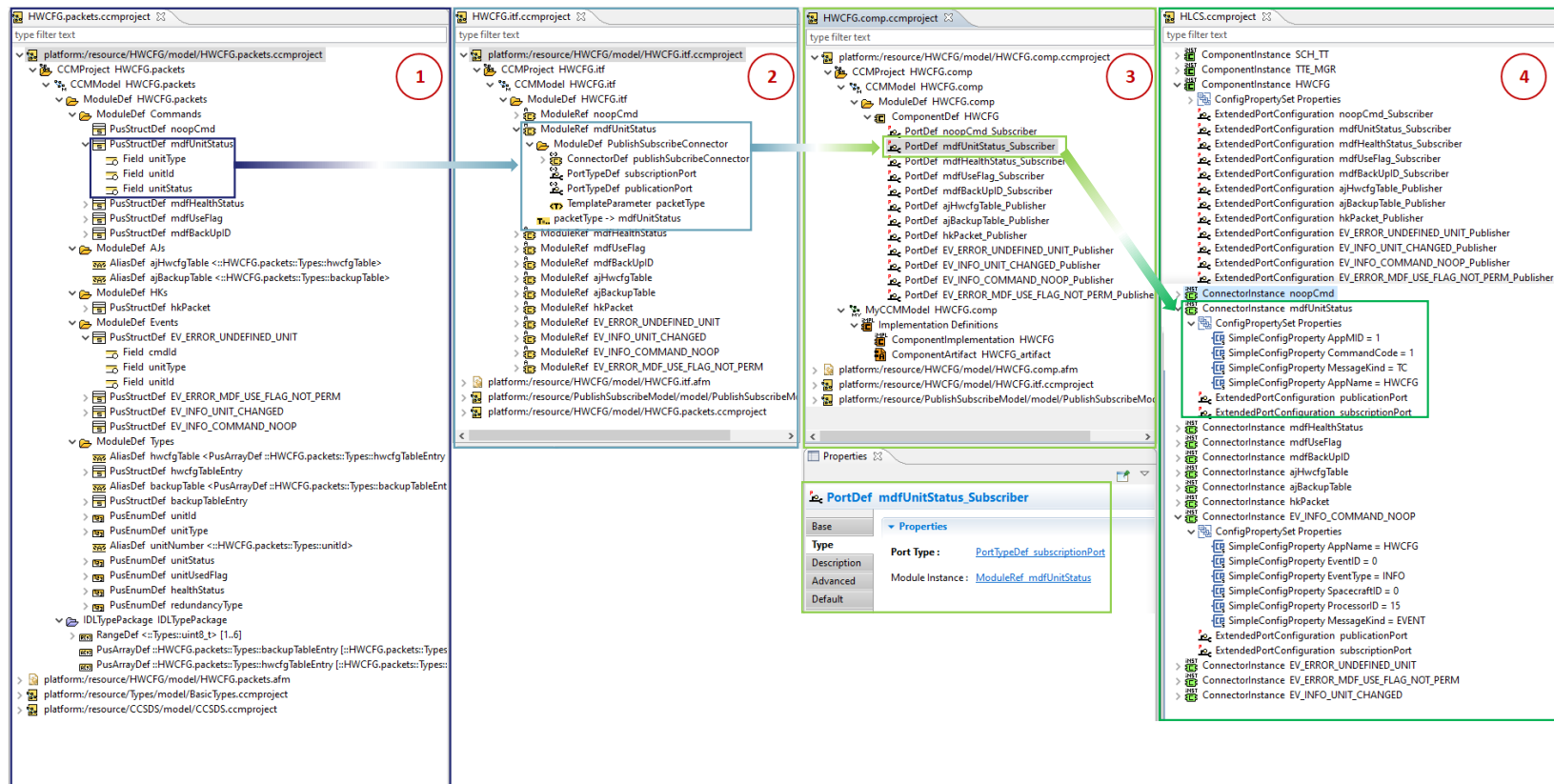
- / PUBLISH SUBSCRIBE MODEL : definition of the generic connector

- / COMMON TYPES definition models

- / MAIN DEPLOYMENT : concatenation of all local deployments

CFS – CFS APPLICATIONS MODELLING

Correspondance between model layers



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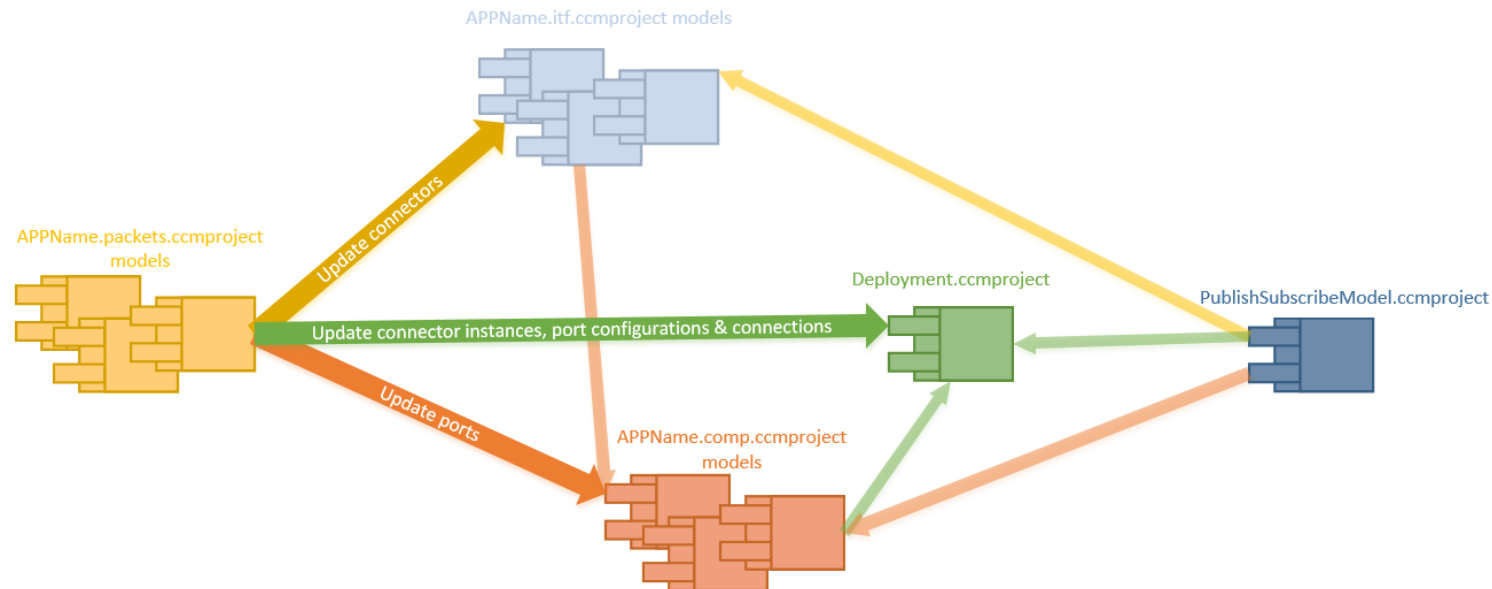
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CFS – SUPPORTING TOOLING

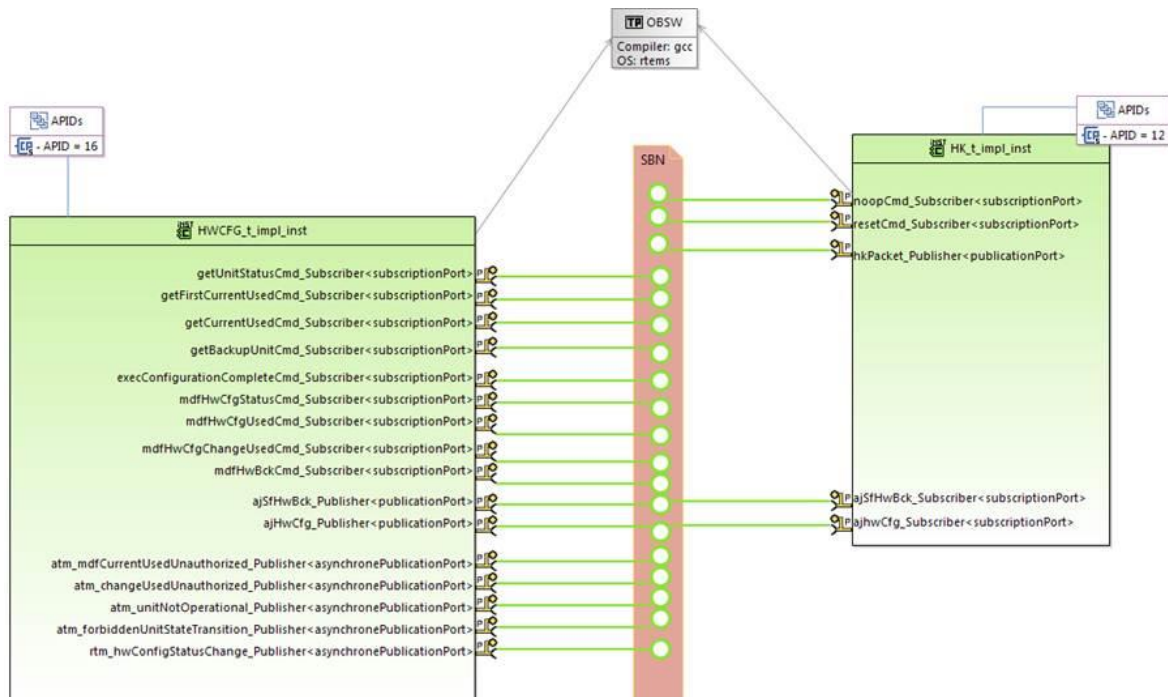
Model layers automatic generation and update

/// All models are automatically (and iteratively) generated/updated from each application « packets » model



CFS – SUPPORTING TOOLING

SW bus interactions view



CFS – SUPPORTING TOOLING

cFS messages edition table

/// Easy way to define messages metadata

/ Message IDs (CCSDS header part)

/ Command codes

/ Event IDs

/ Descriptions

CCMProject HLCS	cFS Messages Table	ProcessorID	AppID	CommandCode	EventID	EventType	Description
TargetProcess HLCS_FSW							
CPE_EVS [EVS] - AppID = 129							
HWCFG [HW] - AppID = 24							
CPE_ES [ES] - AppID = 128							
TCS							
NOOP		1		0			This command performs no other function than to increment the command execution counter. The command may be used to verify
SEND_HK		2		0			This command is to be sent to ask for CFE ES to send its HK telemetry packet.
RESET_COUNTERS		1		1			<p>
RESTART		1		2			<p>
START_APP		1		4			This command starts the specified application with the specified start address, stack size, etc options.
STOP_APP		1		5			This command halts and removes the specified Application from the system. Is NOTE. This command should never be used on the
RESTART_APP		1		6			This command halts and restarts the specified Application. This command does not reload the application from the onboard
RELOAD_APP		1		7			This command halts and removes the specified Application from the system. Then it immediately loads the Application.
QUERY_ONE		1		8			This command takes the information kept by Executive Services on the specified application and telemeters it to the ground.
QUERY_ALL		1		9			This command takes the information kept by Executive Services on all of the registered applications and writes it to the
CLEAR_SYSLOG		1		10			This command clears the contents of the Executive Services System Log.
WRITE_SYSLOG		1		11			This command causes the contents of the Executive Services System Log to be written to a log file.
CLEAR_ER_LOG		1		12			This command causes the contents of the Executive Services Exception and Reset Log to be cleared.
WRITE_ER_LOG		1		13			This command causes the contents of the Executive Services Exception and Reset Log to be written to the specified file.
START_PERF_DATA		1		14			This command causes the Performance Analyzer to begin collecting data using the specified trigger mode.
STOP_PERF_DATA		1		15			<p>
SET_PERF_FILTER_MASK		1		16			This command sets the Performance Analyzer's Filter Masks.
SET_PERF_TRIGGER_MASK		1		17			This command sets the Performance Analyzer's Trigger Masks.
OVERWRITE_SYSLOG		1		18			This command allows the user to configure the Executive Services to either discard new System Log messages when it is full
RESET_PR_COUNT		1		19			This command allows the user to reset the Processor Reset Counter to zero. The Processor Reset Counter counts the number of
SET_MAX_PR_COUNT		1		20			This command allows the user to specify the number of Processor Resets that are allowed before the next Processor Reset is
DELETE_CDS		1		21			This command allows the user to delete a Critical Data Store that was created by an Application. Services are now no longer
SEND_MEM_POOL_STATS		1		22			This command allows the user to obtain a snapshot of the statistics maintained for a specified memory pool.
DUMP_CDS_REGISTRY		1		23			This command allows the user to dump the Critical Data Store Registry to an onboard file.
QUERY_ALL_TASKS		1		24			This command takes the information kept by Executive Services on all of the registered tasks and writes it to the specified
TMs							
OneAppTm		4	0				Single Application Information Packet.
MemStatsTm		3	1				Memory Pool Statistics Packet.
HKS							
HK		1	2				
Events							
INIT_INF					1	INFO	This event message is always automatically issued when the Executive Services Task completes its initialization.
INITSTATS_INF					2	INFO	This event message is always automatically issued when the Executive Services Task completes its initialization.
NNOOP_INF					3	INFO	This event message is always automatically issued in response to a CFE Executive Services #CPE_ES_NNOOP_CC NO-OP command.
RESET_INF					4	INFO	This event message is always automatically issued in response to a CFE Executive Services #CPE_ES_RESET_COUNTERS_CC Reset
START_INF					5	INFO	This event message is automatically issued upon successful completion of a CFE Executive Services #CPE_ES_START_APP_CC
D_STOP_DBG					7	DEBUG	This event message is issued upon successful processing of the CFE Executive Services #CPE_ES_STOP_APP_CC Stop Application
STOP_INF					8	INFO	This event message is issued when the CFE finishes deleting the CFE Application that was started when the link
D_RESTART_APP_DBG					9	DEBUG	This event message is issued upon successful processing of the CFE Executive Services #CPE_ES_RESTART_APP_CC Restart
RESTART_APP_INF					10	INFO	This event message is issued when the CFE finishes Restarting the CFE Application that was started when the link
D_RELOAD_APP_DBG					11	DEBUG	This event message is issued upon successful processing of the CFE Executive Services #CPE_ES_RELOAD_APP_CC Reload
RELOAD_APP_INF					12	INFO	This event message is issued when the CFE finishes Reloading the CFE Application that was started when the link
EXIT_APP_INF					13	INFO	This event message is issued when the CFE finishes exiting/cleaning up an application that called the CFE_ES_ExtAppAPI
LEREXIT_APP_INF					14	INFO	This event message is issued when the CFE finishes exiting/cleaning up an application that called the CFE_ES_ExtAppAPI
D_ONE_APP					15	DEBUG	This event message is issued upon successful completion of the CFE Executive Services #CPE_ES_QUERY_ONE_CC Query One
D_ALL_APPS					16	DEBUG	This event message is issued upon successful completion of the CFE Executive Services #CPE_ES_QUERY_ALL_CC Query All
SYSLOG1_INF					17	INFO	This event message is generated upon successful completion of the CFE Executive Services #CPE_ES_CLEAR_SYSLOG_CC Clear
SYSLOG2					18	DEBUG	This event message is generated when the System Log has been successfully written to a file after receiving the CFE
D_ERLOG2					19	INFO	This event message is generated upon successful completion of the CFE Executive Services #CPE_ES_CLEAR_ERLOG_CC Clear
E_MID_ERR					20	ERROR	This event message is generated when the Exception Reset Log has been successfully written to a file after receiving the
E_CC1_ERR					21	ERROR	This event message is generated when a message has arrived on the CFE Executive Services Application's Message Type that
E_LEN_ERR					22	ERROR	This event message is generated when a message with the #CPE_ES_CMD_MID message ID has arrived but whose Command Code is
					23	ERROR	This event message is generated when a message with the #CPE_ES_CMD_MID message ID has arrived but whose packet length does

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CFS – SUPPORTING TOOLING

Application code skeleton generation

nasa_cfs_app_sample

▸ cmds

▸ doc

▸ fsw

▸ mission_inc

▸ platform_inc

▸ src

▸ core

▸ sample_app_events.h

▸ sample_app_init.c

▸ sample_app_init.h

▸ sample_app_msg_router.c

▸ sample_app_msg_router.h

▸ sample_app_msg.h

▸ sample_app_tbl.h

▸ sample_app_utils.c

▸ sample_app_utils.h

▸ sample_app_version.h

▸ sample_app.c

▸ sample_app.h

▸ services

▸ tables

▸ unit-test

CMakeLists.txt

README.md

```
1 /-----/
2 @/**
3  * \author Thales Alenia Space - France \n
4  *
5  * \copyright Copyright 2021 THALES ALENIA SPACE FRANCE. All rights reserved
6  *
7  * \ingroup HWCFG
8  *
9  * \file hwcfg_utils.h
10  *
11  * \brief This file is header file for the utils functions.
12  */
13 /-----/
14
15 #ifndef HWCFG_UTILS_H
16 #define HWCFG_UTILS_H
17
18 /**
19  *-----
20  * Includes
21  *-----
22  */
23 #include "cfe.h"
24
25 /**
26  *-----
27  * Public Defines
28  *-----
29  */
30
31 /**
32  *-----
33  * Public Structure Declarations
34  *-----
35  */
36
37 /**
38  *-----
39  * Public Function Prototypes
40  *-----
41  */
42
43 //-----
44 /**
45  * \ingroup hwcfg
46  *
47  * \name HWCfg_VerifyCmdLength
48  *
49  * \brief Verify command packet length
50  *
51  * \traceability GTW-SR-xxx
52  *
53  * \param CFE_MSG_Message_t *msgPtr *
54  * \param size_t expectedLength
55  *
56  * \return true if the command length is KO, false otherwise
57  */
58 //-----
59 bool HWCfg_VerifyCmdLength(const CFE_MSG_Message_t *msgPtr, size_t expectedLength);
```

CFS – SUPPORTING TOOLING

Interface Control Document generation



Reference:

Date: April 29, 2021
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4. HWCFCG application

Application ID : 5

4.1 TC

4.1.1 HWCFCG_noopCmd

Processor Message ID : 265

Command Code : 0

This command sends an event message feedback with following information : Major version of the application
Minor version of the application Revision number of the application Mission revision number of the application

4.1.2 HWCFCG_mdUnitStatus

Processor Message ID : 265

Command Code : 1

This command is used to modify the current status (off/init/operational/on_control) of a unit in the hardware configuration table.

Parameters :

The parameters of the mdUnitStatus shall be defined according to the following:

Parameter	Description	Type	Size
unitType	Type of the unit whose status is to be modified.	enum unitId	8 bit(s)
unitId	Number (index) of the unit whose status is to be modified.	enum unitId	8 bit(s)
unitStatus	New unit status.	enum unitStatus	5 bit(s)

CFS – SUPPORTING TOOLING

Additionnal tooling

/// Satellite database inputs generation

/// Architecture Design Document generation

/// Native applications validation

/// Unit Tests skeletons generation

/// ...

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CFS – MODELLING CHOICES : PROS & CONS

Pros – Modelling « hybrid » architecture

/// cFS apps : SW bus messages publication/subscription

/ Model elements

- Datatypes <-----
- Packets content definition <-----
- Components with generic ports <-----
- Connector definitions
- Component and connector instances <-----

/// cFS libs : direct calls to services (modelled as classical « PUS-style » components)

/ Model elements

- Datatypes
- Interfaces with operations and attributes
- Components with facets, receptacles and event ports
- Component instances

CFS – MODELLING CHOICES : PROS & CONS

Pros – Fully independant application models

/// App

- / PACKETS model
- / INTERFACE model
- / COMPONENT model
- / DEPLOYMENT model

/// Indepent outputs production

- / Code skeletons
- / Database inputs (IDS) preview
- / ICD preview
- / SEDS export (see next part)

Application
design

- / App1 models
- / App2 models
- / ...
- / AppN models

Automatic
generation /
update

/ Main
deployment
model

/// « Release » outputs production

- / Database inputs (IDS)
- / ICD
- / ADD

FSW
integration

CFS – MODELLING CHOICES : PROS & CONS

Manually modelled

Pros – -50% elements to be modelled

/// App

- / PACKETS model
- / INTERFACE model
- / COMPONENT model
- / DEPLOYMENT model

/// Indepent outputs production

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FSW
integration

CFS – MODELLING CHOICES : PROS & CONS

Automatically
generated

Pros – -50% elements to be modelled

/// App

- / PACKETS model
- / INTERFACE model
- / COMPONENT model
- / DEPLOYMENT model



Automatic
generation /
update

/// Independent outputs production

- / Code skeletons
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- / ADD

FSW
integration

CFS – MODELLING CHOICES : PROS & CONS

Cons – Limited reuse of existing tooling

/// Benefiting/Reusing

- / Specific connector design (CCM Generic Interraction Services)

/// Adaptations to new modelling style

- SDB inputs generation
- Documents generation
- Exports for software validation
- Software missionization

/// New developments

- / Model updater (itf, comp, depl)
- / Code skeleton generation

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SEDS - PRESENTATION

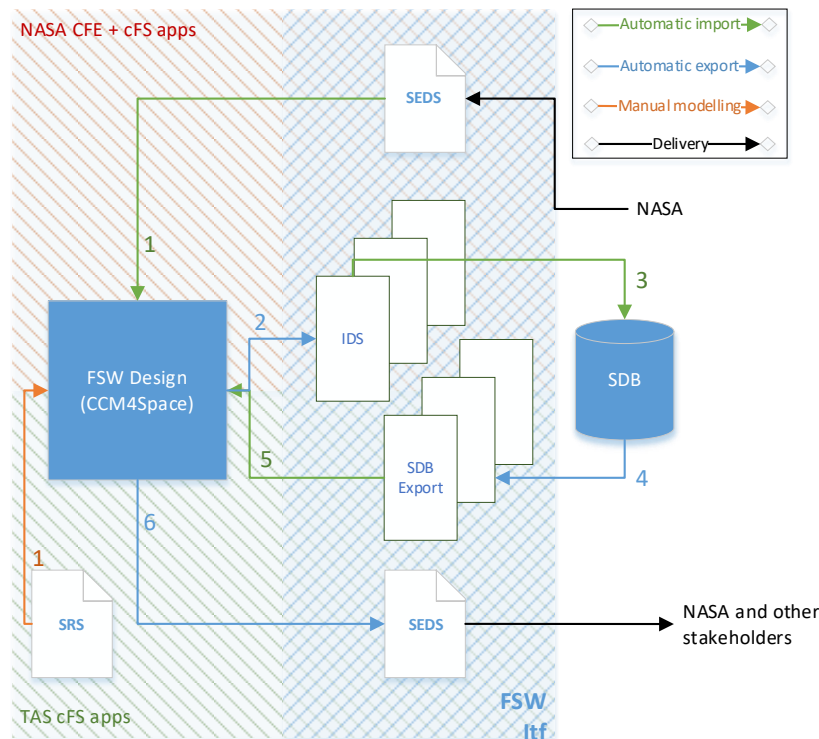
SOIS (Spacecraft Onboard Interfaces Services) Electronic DataSheets

/// General purpose and format

- SEDS describe data interfaces for flight hardware, using machine-readable XML to support the lifecycle of space vehicles.

/// SEDS format adaptations and use case for Gateway

- On Gateway programs HLCS, I-HAB and ERM, SEDS standard is used to share cFS applications interfaces between the stakeholders.



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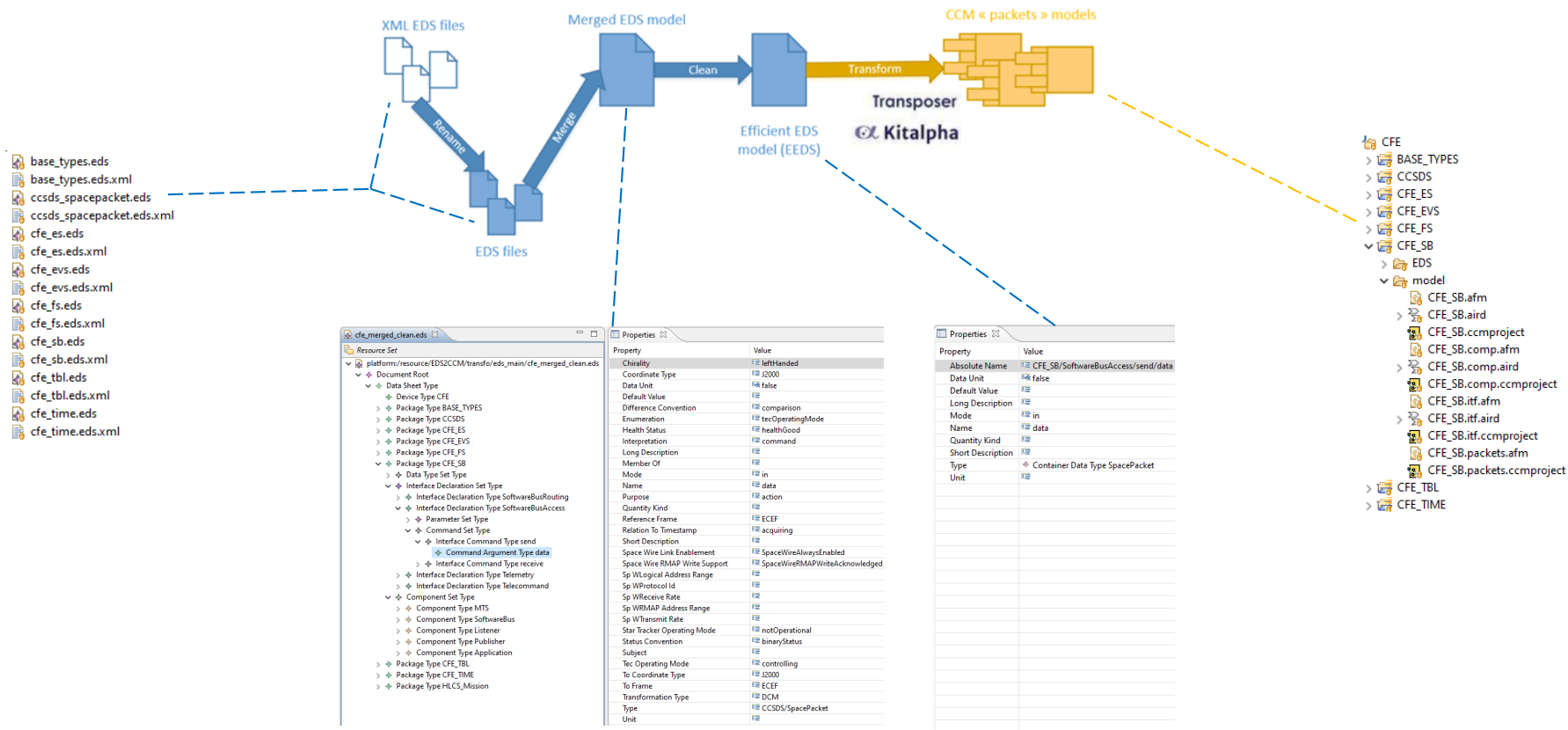
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SEDS – SEDS->CCM BRIDGE



OUTLINE

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- / Concepts and tools

- / Benefits and costs

- / Challenges ahead

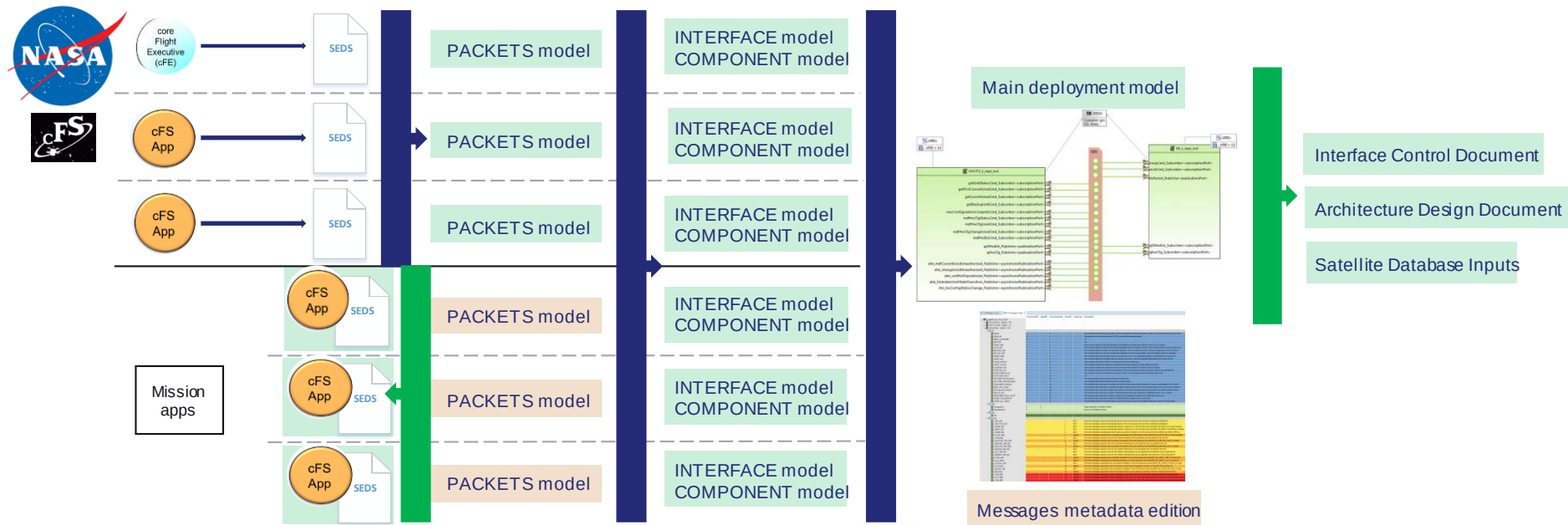
CONCLUSION – CONCEPTS AND TOOLS

Recap on developed features

Generated

Manual

Delivery



CONCLUSION – BENEFITS AND COSTS

Costs – 6 months

/// Analysis and architecture specification – 1 month

/// Adaptations to new modelling style – 2 months

- SDB inputs generation
- Documents generation
- Exports for software validation
- Software missionization

/// New developments – 3 months

- / Model updater (itf, comp, depl)
- / Code skeleton generation
- / SEDS import/export

CONCLUSION – BENEFITS AND COSTS

Benefits

/// New module for Publish/Subscribe-based architectures

/ Features

- Architecture baseline
- Modelling support
- Documents generation

/ Gains

- Modelling effort reduced by 50%
- Fully independant application modelling

/// Modelling environment targeting PUS and cFS

/// SEDS support in modelling environment

- / Gateway-specific import/export bridges
- / Generic SEDS import/export bridges

CONCLUSION – CHALLENGES AHEAD

Operational usage and return on experience

/// Beginning of Gateway projects at Thales Alenia Space

! End-2020

/// Beginning of tooling evolutions

! Spring 2021

/// End of tooling evolutions

! This month

/// Beginning of modelling activities on Gateway projects

! This month

Extending the scale of our modelling environments with cFS and SEDS

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/// References

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Thales Alenia Space





EXTENDING THE SCALE OF OUR MODELLING ENVIRONMENTS WITH CFS AND SEDS

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