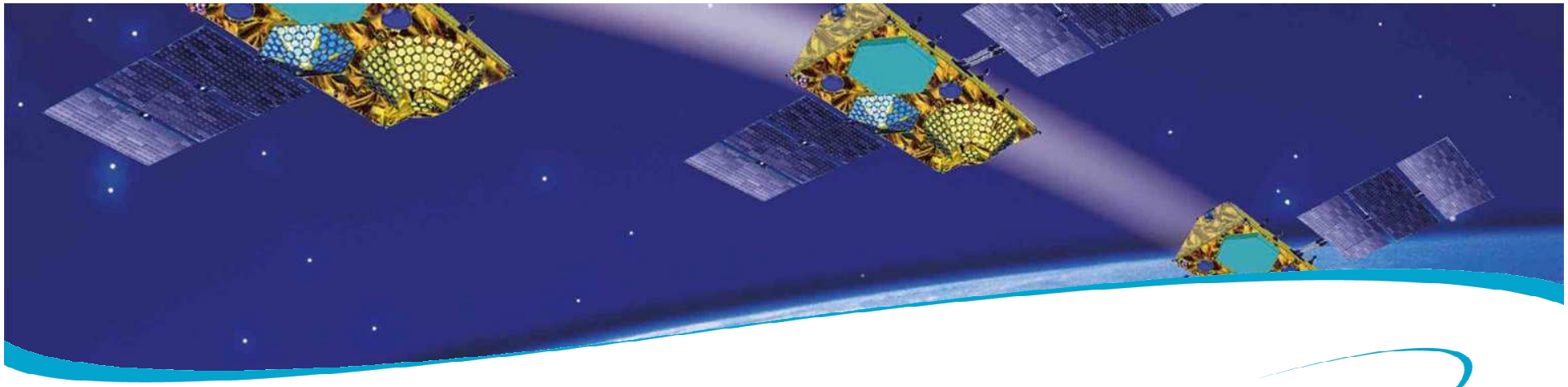

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# A Component-based Framework for Space Flight Software

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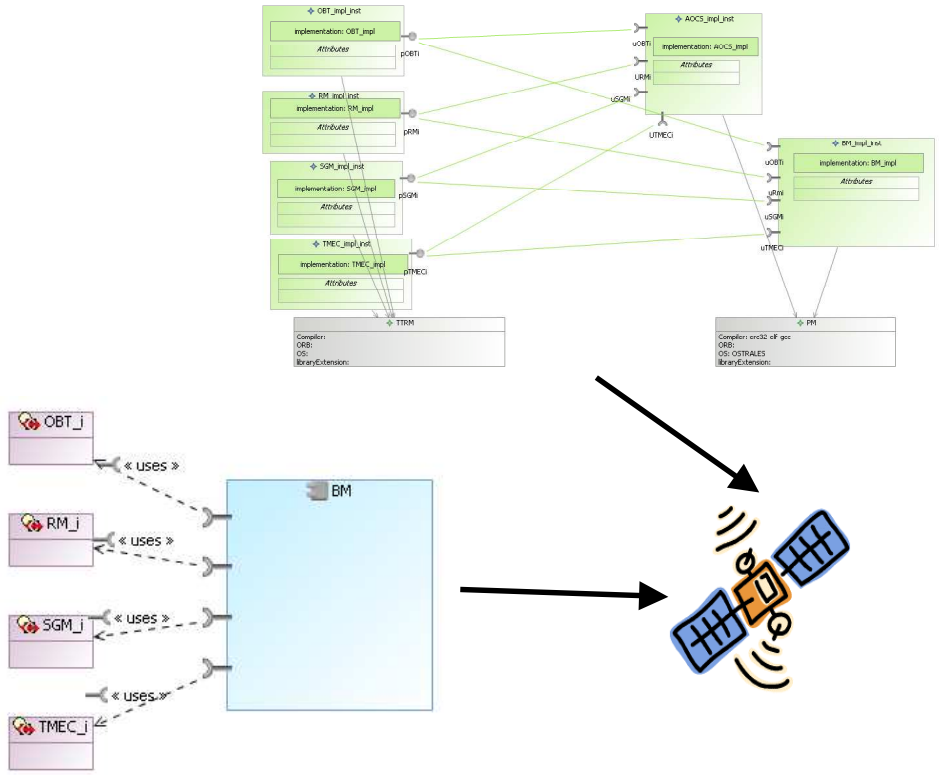
THALES

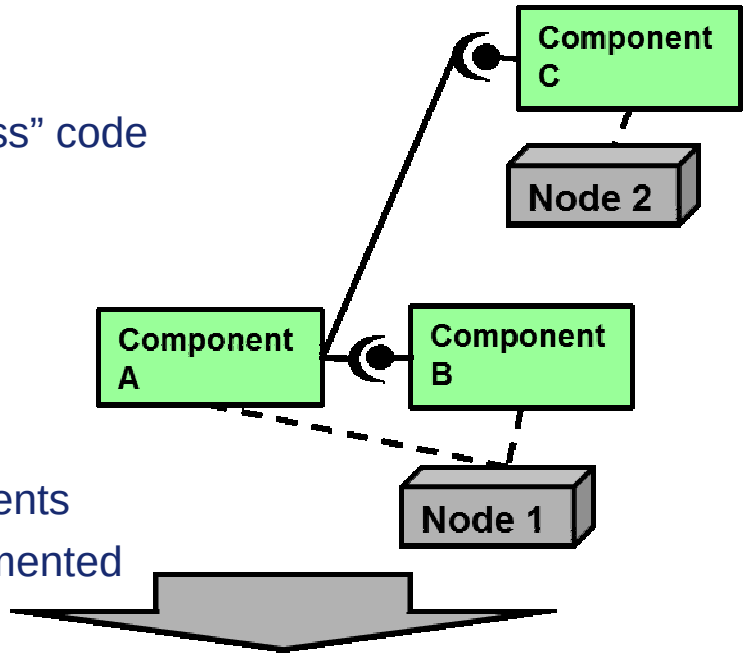
# A Component-based Framework for Space FSW

- SEMS Component model
- Process overview
- Code structure
- First feedback from GB2
- Perspectives
- Conclusion



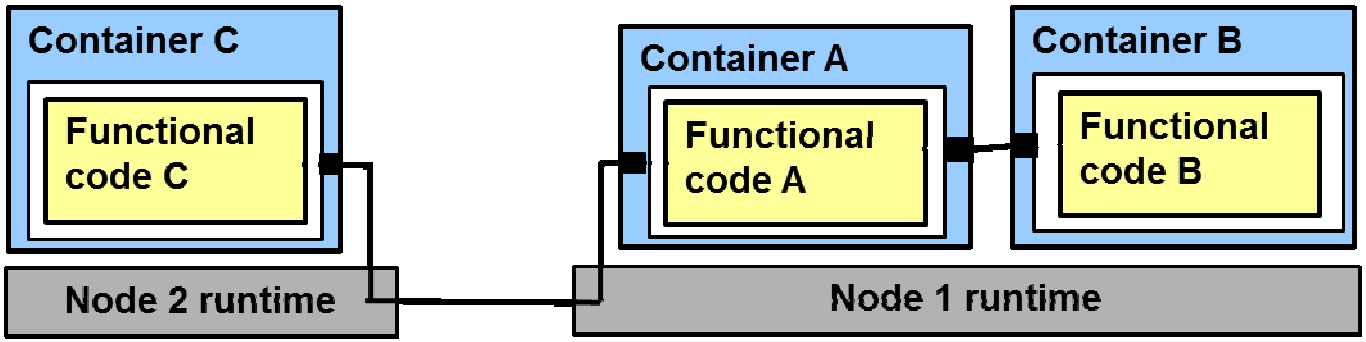
## A FSW is a set of components

- Components encapsulate application “business” code
- Components are managed by containers
- Underlying runtime provides execution and communication mechanisms




## Separation of concern

- Functional: Algorithms are inside the components
- Non-functional: Runtime resources are implemented in the container

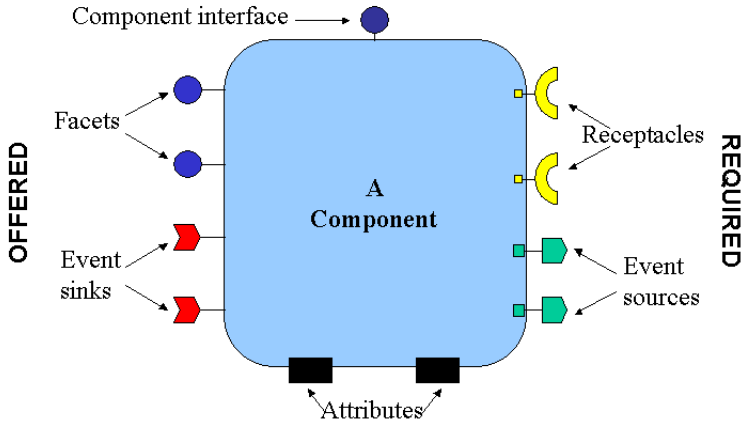


## System Engineering and Middleware for Space domain (SEMS):

- Based on LwCCM
  - Subset of the Corba Component Model
  - Designed for embedded domain
  - Official OMG specification

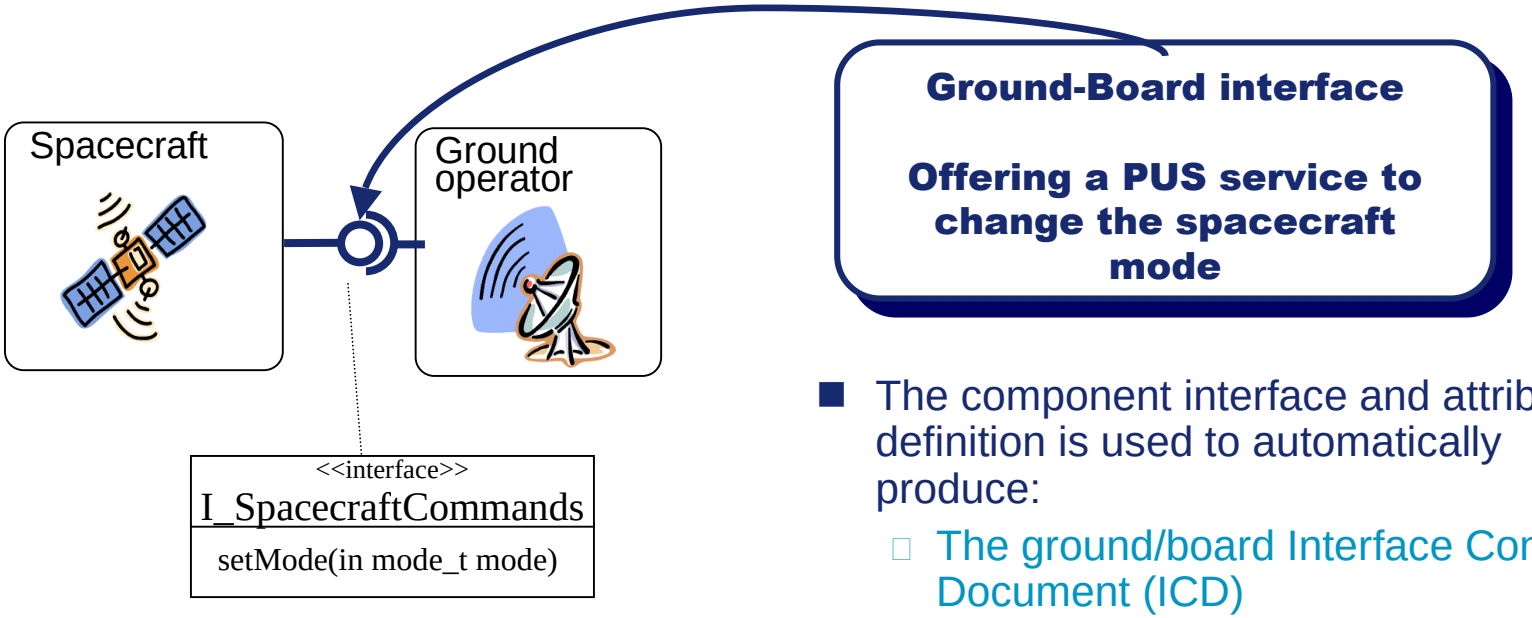
- Components are defined by:
  - Provided and required services
  - Published and consumed events
  - Attributes

- Components provide services to:
  - Other components
  - The ground station/operators



## Some “space-oriented” extensions have been added:

- Data types extensions (engineering data types, constrained types…)
- Specific communication standard (CCSDS)
- Standardized identification of spacecraft services (PUS)
- Customized communication schemes between components to optimize resources




- The component interface and attribute definition is used to automatically produce:
  - The ground/board Interface Control Document (ICD)
  - TM/TC/Event handling code

## SEMS Process

1. Component types definition:
   - Definition of specific types (arrays, ranges, structure…)
   - Definition of provided & required services
     - Identification of services callable from ground (PUS)
   - Definition of component attributes
     - Including visibility rules (visible from ground, adjustable from ground)
   - Published and consumed events

2. Component implementation:
   - Implementation language, RTOS, ports implementation
   - One component type can have several implementations

3. Component instantiation:
   - Creation of component instances

4. Component deployment and configuration
   - Allocation of the component instances on tasks
   - Definition of the connections between component instances
   - Definition of properties on components and ports

## Application code:

- Functional code of the component
- Hand-coded or generated from functional modeling tools
  - Simulink
  - …

## Containers code:

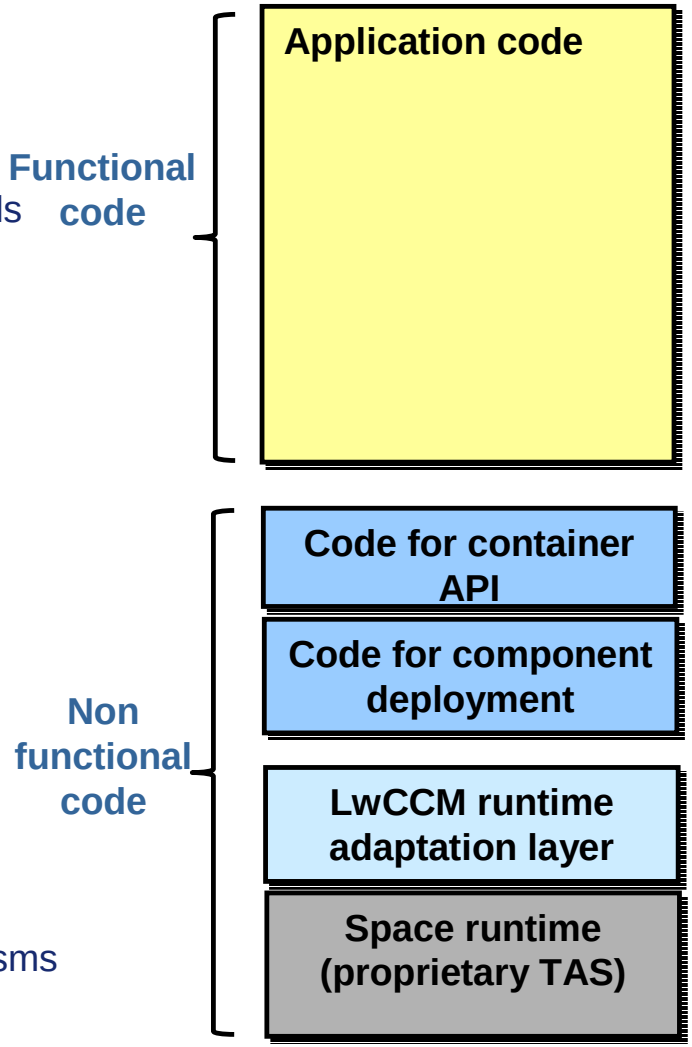
- Adapt component user code to the actual platform
- Implement communication between components
- Mediate between user code and technical services

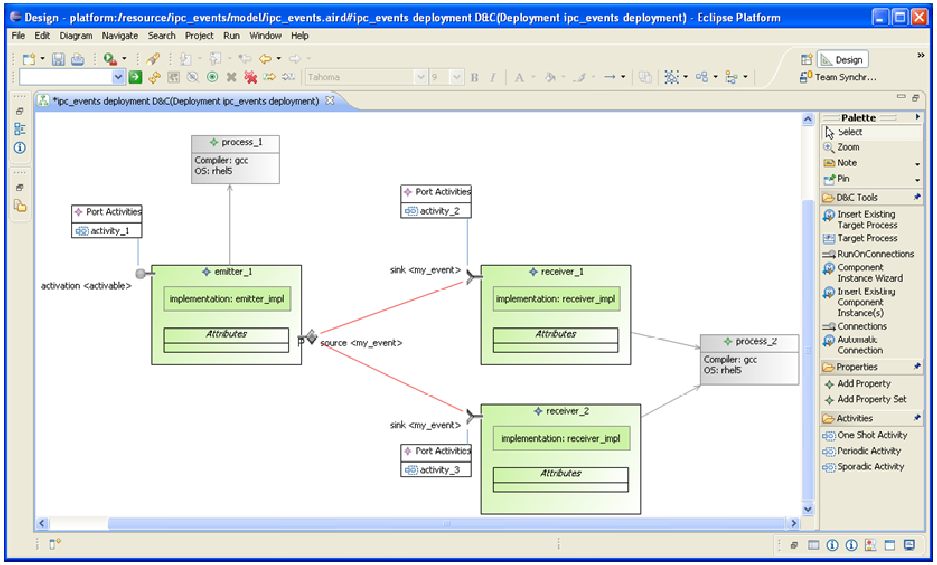
## Deployment code:

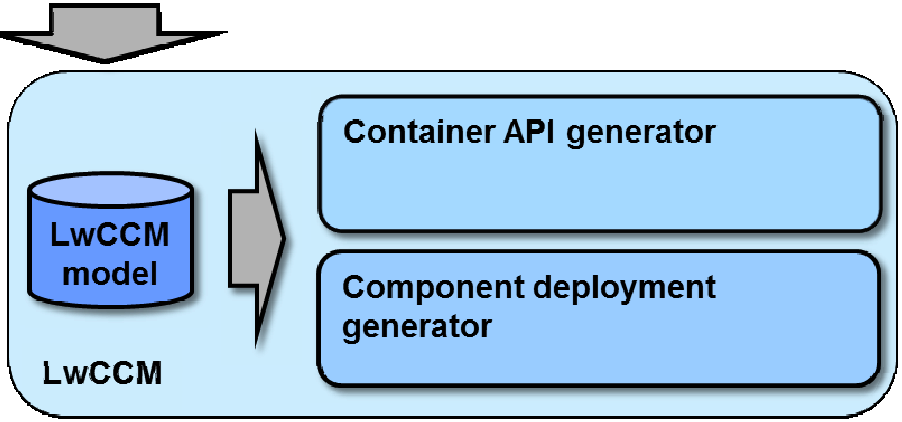
- Connect component instances
- Initialize component attributes

## SEMS runtime:

- Provides tasking (RTOS) and communication mechanisms (SwBus) for the container





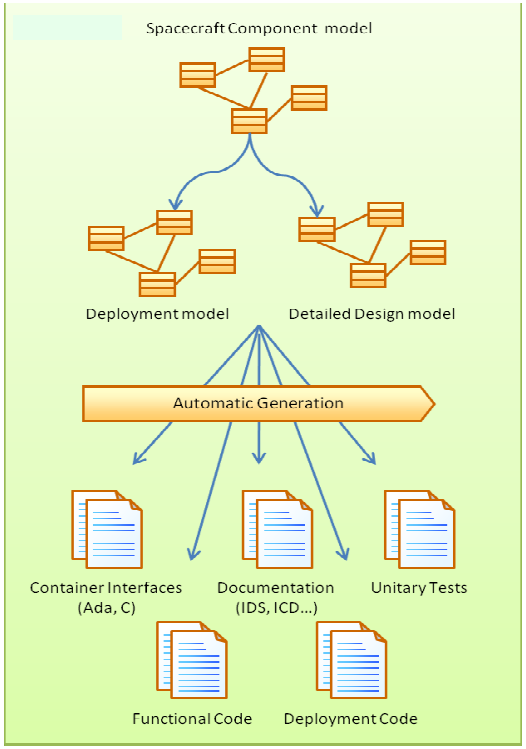

- Supports of several diagrams
  - Component type definition diagram
  - Component implementation diagram
  - Instantiation & Configuration diagram
  - Deployment Diagram

**Ada 95 files**

```
-- ============================================================================
-- This file is part of MyCCM (R)
-- Copyright (C) THALES 2007-2009. All rights reserved
   ----------------------------------------------------------------------------

with MCCM.RUNTIME_TYPES;

package body RECEIVER_2.EVENT_STUB is

 procedure PUSH_SOURCE (THE_EVENT : in DATA_MODEL.EVENT_T)
 is
   subtype EVENT_ARRAY_INDEX_T is MCCM.RUNTIME_TYPES.BYTE_FIELD_INDEX_T range 1 ..
DATA_MODEL.EVENT_T'VALUE_SIZE / 8;
   type EVENT_ARRAY_T is new MCCM.RUNTIME_TYPES.BYTE_FIELD_NC_T
(EVENT_ARRAY_INDEX_T range EVENT_ARRAY_INDEX_T'RANGE);
   function TO_EVENT_ARRAY is new UNCHECKED_CONVERSION (SOURCE =>
DATA_MODEL.EVENT_T,
                                                        TARGET => EVENT_ARRAY_T);
 begin
   -- send event to swbus
   MCCM.EVENTS.SEND_EVENT ((SEVERITY => MCCM.EVENTS.NORMAL_PROGRESS_REPORT,
                            EVENT_ID => 155254785,
                            PAYLOAD => MCCM.RUNTIME_TYPES.BYTE_FIELD_NC_T (TO_EVENT_ARRAY (S
-> THE_EVENT))),
 end PUSH_SOURCE;

 procedure INIT is
 begin
   null;
 end INIT;

end RECEIVER_2.EVENT_STUB;
```

## Code generation

- Generated code
  - TM/TC/Event handling code
  - Component skeletons
  - Component containers
- Based on Acceleo M2T transformation
  - ADA 95 or C language
  - Targeting LwCCM execution platform
- Good code quality level
  - designed by C/Ada experts
- Very homogeneous design
- Easiness to introduce new capabilities common to all the components:
  - Checks, behaviours, …




## Documentation generation

- Generation of the Interface Control Document (ICD)
- Generation of the Satellite Database Files

## Globalstar 2 return on experience

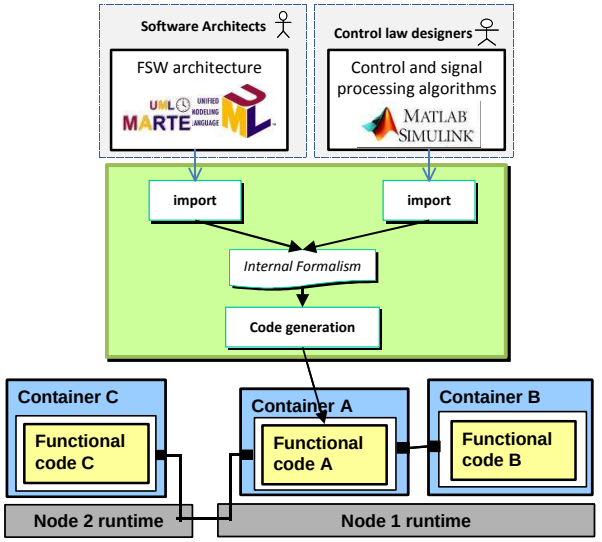
- 48 LEO satellite constellation
  - Personal phone/multi-media communications
  - To replace Globalstar 1 constellation
- CBSE process has been applied on GBS 2
  - OBSW based on TAS Generic OBSW design
  - Software bus and component model
- This process have lead to productivity gains
  - The design phase is not significantly longer
  - Reduction of the coding and UT phases
  - Reduction of the number of anomalies reported on software interfaces
- Code size: No difference with hand-written solution
- Little runtime overhead compared to non-modular applications

## Extension of the component model to support extra-functional properties

- Annotation of the component models with extra functional properties:
  - RT properties: deadlines, periods, WCET, bus load…
  - Dependability properties: Safety, integrity, reliability…
- Integration of tools for the analysis of the extra-functional at the model level
- Preservation of the extra-functional properties at runtime

## Functional code generation

- Generation of the components internal code from heterogeneous functional models:
  - Simulink, Scylab, UML
  - Other domain specific modelling tools
- Automatic integration in the component containers
- Definition of a unified process to make sure that the component designs and their implementations are consistent



## Functional code is independent from deployment code:

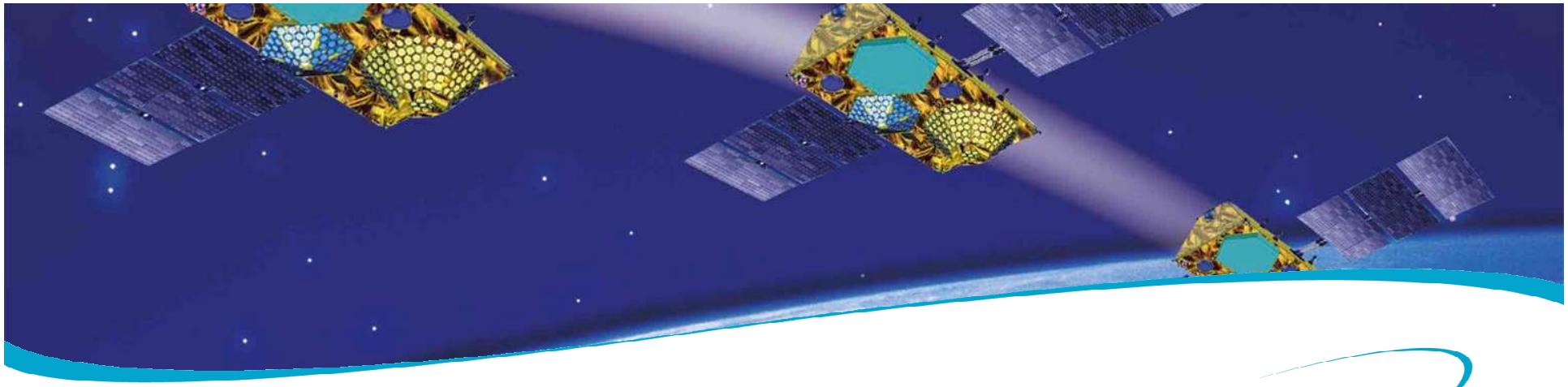
- Ease the reuse of code (consequence of the application design)
- Components can be redeployed easily

## SEMS Component model improves the code structure:

- Productivity improvement (automatic code generation)
- Makes the analysis of applications easier (scheduling, etc.)

## SEMS and MDE approach is the baseline for all our future projects:

- Sentinel-3
- O3B
- Iridium Next
- ...



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# Questions 



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