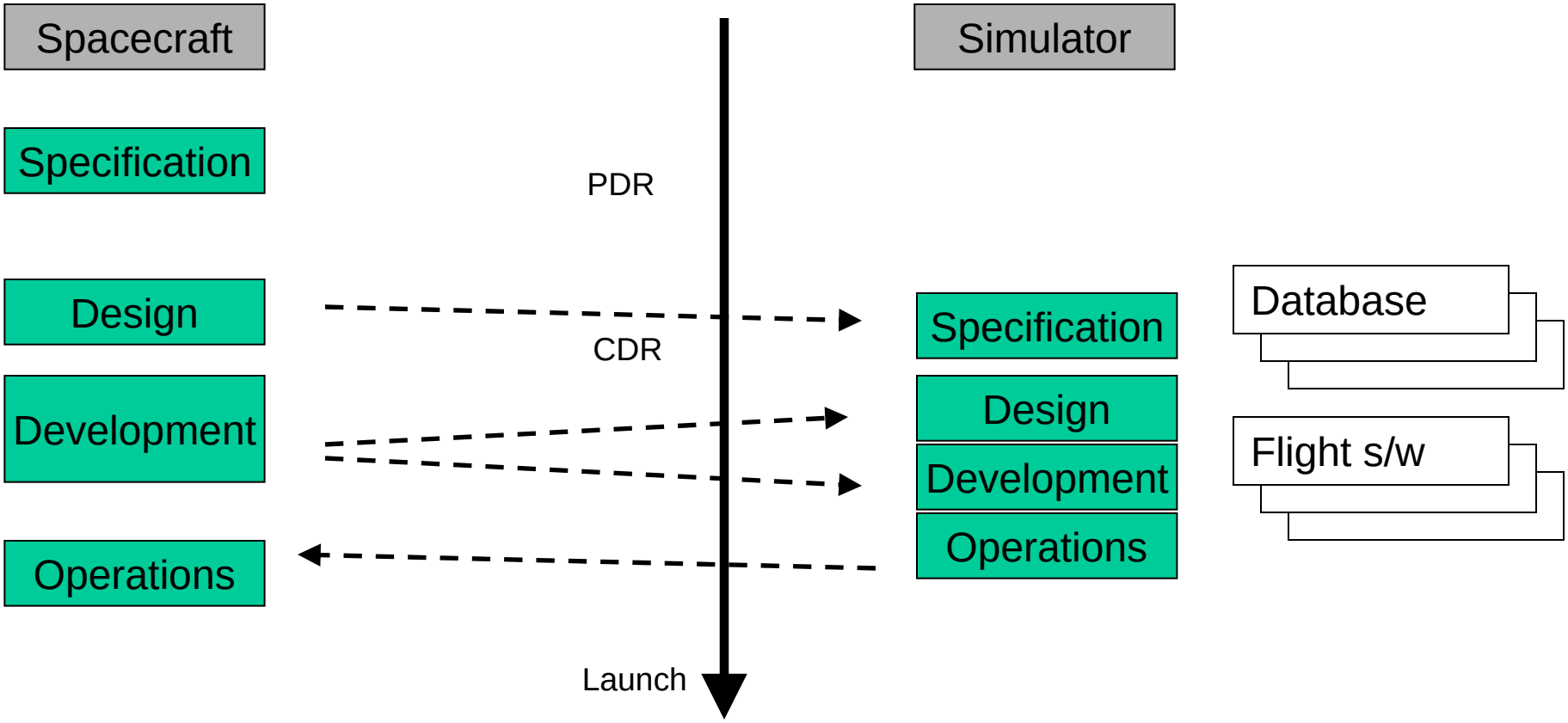
New Tools for Spacecraft Simulator Development

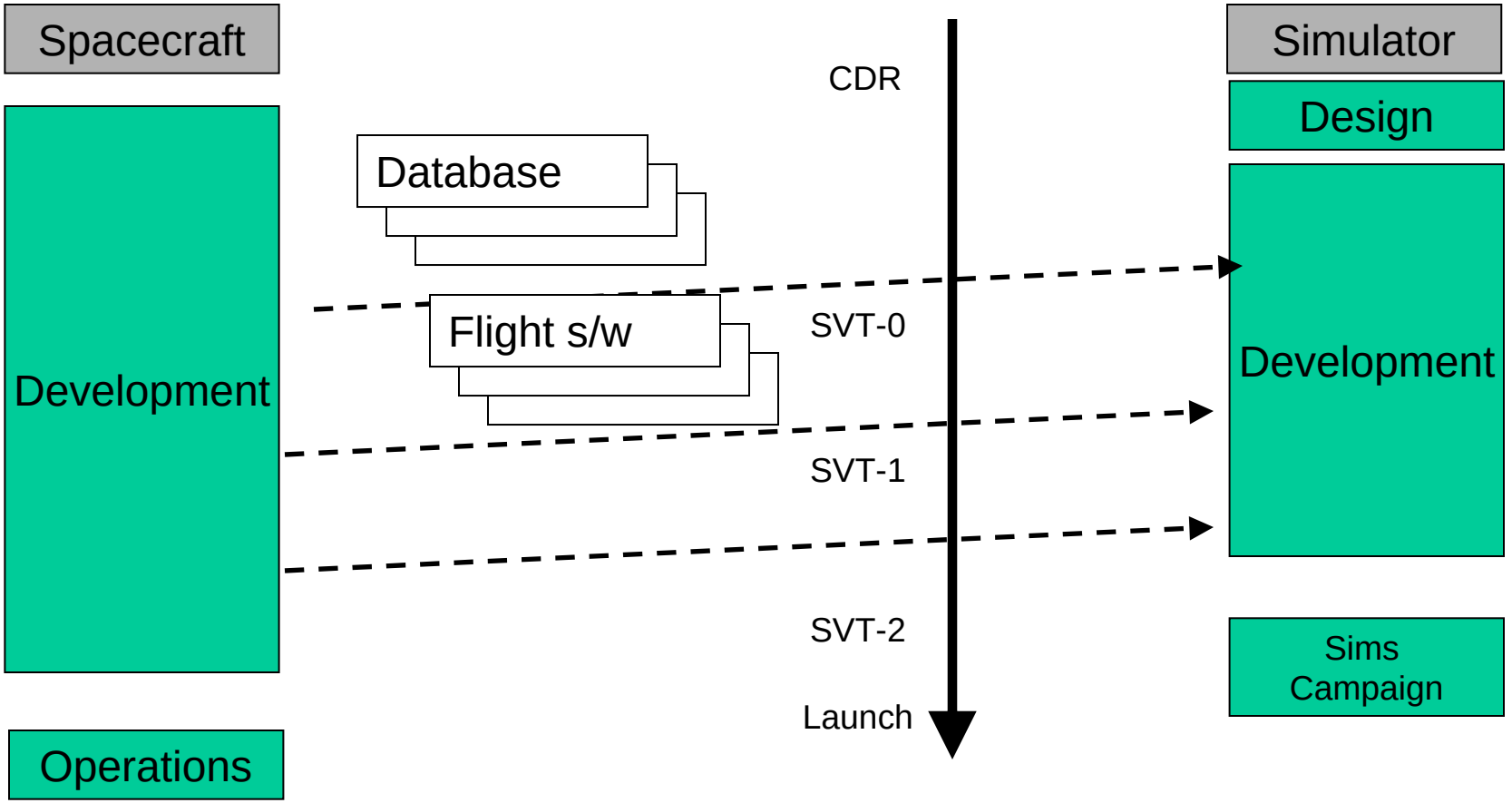
Why use Simulators?

- Replace the Spacecraft
- Support to design
- Support to testing
  - replacement of real equipment in destructive or expensive tests or when real equipment is unavailable
  - validation of embedded software
  - data source for control systems validation
- Support to training
- Support to failure investigation and correction

Concurrent Development



Development and Validation



Avoiding concurrent development: sim & MCS

- Historically, one of the first uses of the simulator was a data source/sink during Mission Control System development and testing
- Problem: the simulator was developed in parallel to the MCS, so if a problem occurred, difficult to isolate
- Solution: develop standard tools which are validated on previous missions and reuse them for new MCS
- Second advantage: permits delay to simulator development

Avoiding concurrent development: sim & spacecraft

- Impact from inputs from the satellite development on the simulator development. Dependency between Simulator and mission schedules for the ICDs, OBSW, SDB
- the provision of the OBSW typically end up on the critical path for the simulator
- Possible impact on Integration of the simulator
- Impossible to perform end-to-end test without OBSW

- Need to decouple from spacecraft schedule

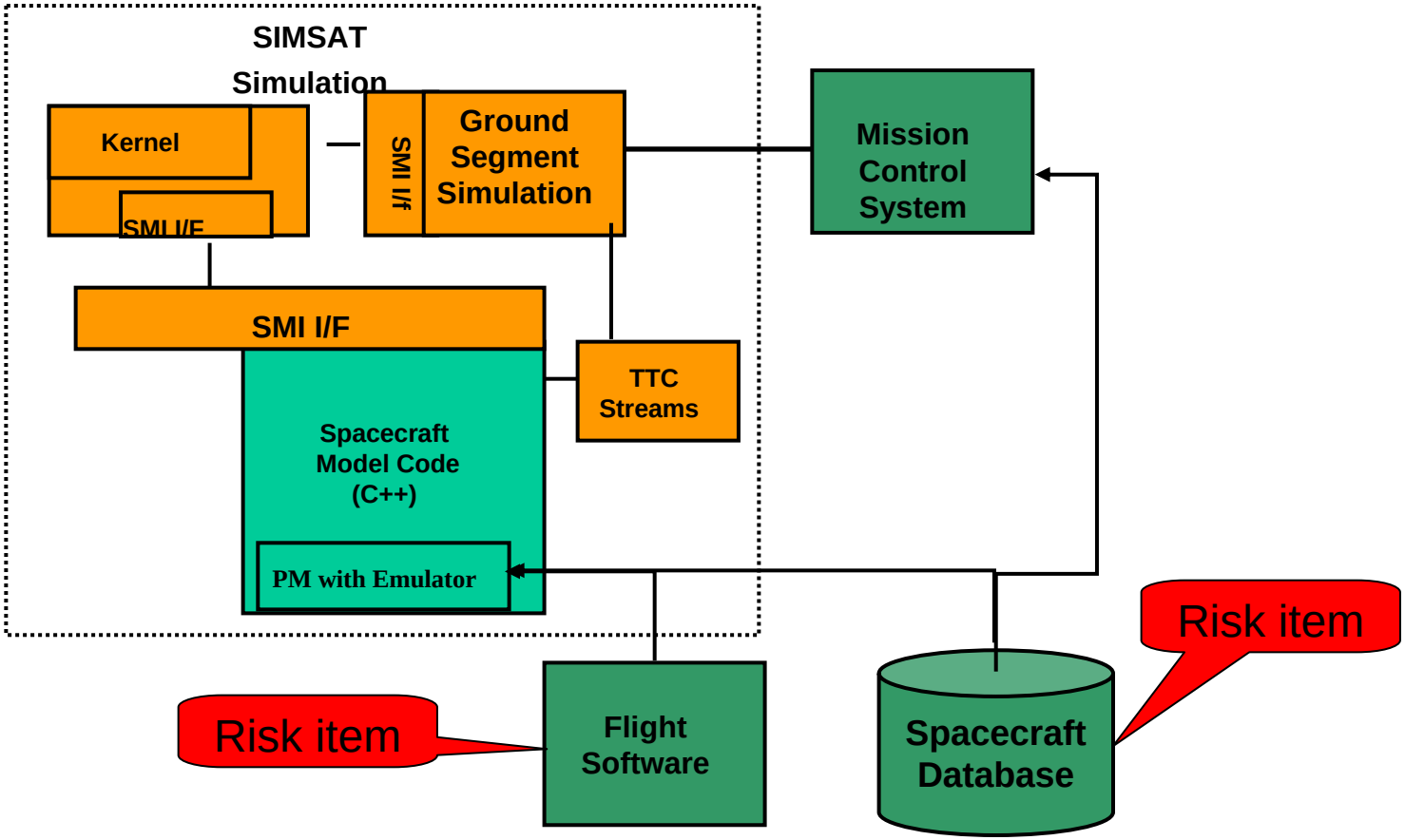
Standards

- Standards can be *de factor* or *de jure*
  - *De jure external standard (CCSDS, ECSS)*
    - Written telemetry and telecommand standards, utilisation std
  - *De jure* internal standards
    - Written TM/TC database standard
  - *De facto standard*
    - Few suppliers =>Hardware commonality for many units
    - Few space-qualified parts
    - Generic models (dynamics, orbit)
- Benefit from standards
  - Reusable models (ground station models, processor emulators)

Research and Innovate

- Small study to mitigate impact of late flight software
- Generic Emulator Test System - GETS
  - Standard packet format - syntax
  - Standard telemetry and telecommand packet services (semantics)
    - Configurable routing and addressing
  - Standard database to import from mission control system
  - Standard computer – ERC32 => standard emulator
  - Standard peripherals – OBDH bus & mil-std-1553
- Make own embedded software for test purposes
  - Generated source code including database and packet routing information
  - Use open source cross compiler for ERC32 (gcc)
  - Own validation simulator

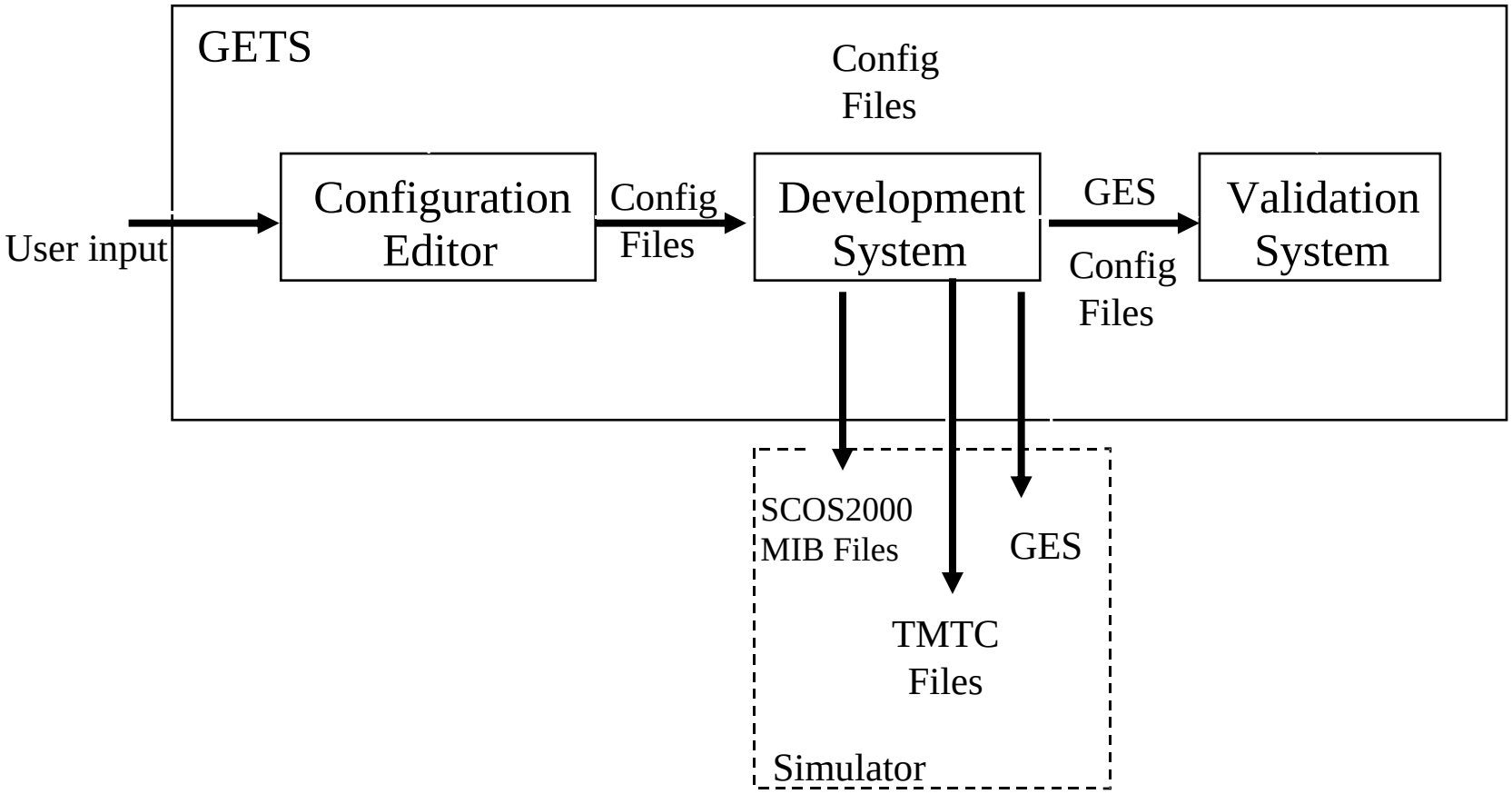
Typical Simulator Design



GETS Study

- Is it possible to produce a tool which allows the user the generate a replacement software?
- Which are the commonalties between OBSW for different missions?
  - The TC and TM packet structures / functionality's are defined by ECSS/PUS standard for the ESA mission -
  - The API are basically defined by the used hardware components
  - the interface types are similarly between the different missions even when the implementation is different.

GETS Overview



GETS - Configuration Editor

- The Configuration Editor is an off-line tool used to enter the mission-specific information including:
  - TM and TC packet and parameter definitions.
  - The relationship of TM packets to virtual channels.
  - Data bus interrogations.
  - Bus addresses.
  - The relationship of Application Packet ID to data bus addresses for external units.
  - Configuration are in XML-format
  - Support import of SCOS2000 MIB files
  - Java based

GETS - Development system

- The Development System is the component of the GETS system dedicated to the building of the Generic Emulator Software (GES).
- It performs the following main operations:
  - Imports the configuration files defining the TC/TM packet structure and the bus configuration (from Configuration Editor).
  - load its own configuration files defining the GES Memory Map I/O, the PUS constants definition and the list of telecommand APID codes reserved to high priority TC, GES and user code;
  - inserts the configuration data into the GES source code;
  - builds the GES onboard software image (Prototype in SREC format);
  - Exports a set of SCOS-2000 format MIB files.
  - XGC cross compiler for ERC 32 target platform used in the prototype

GETS - Generic Emulator Software

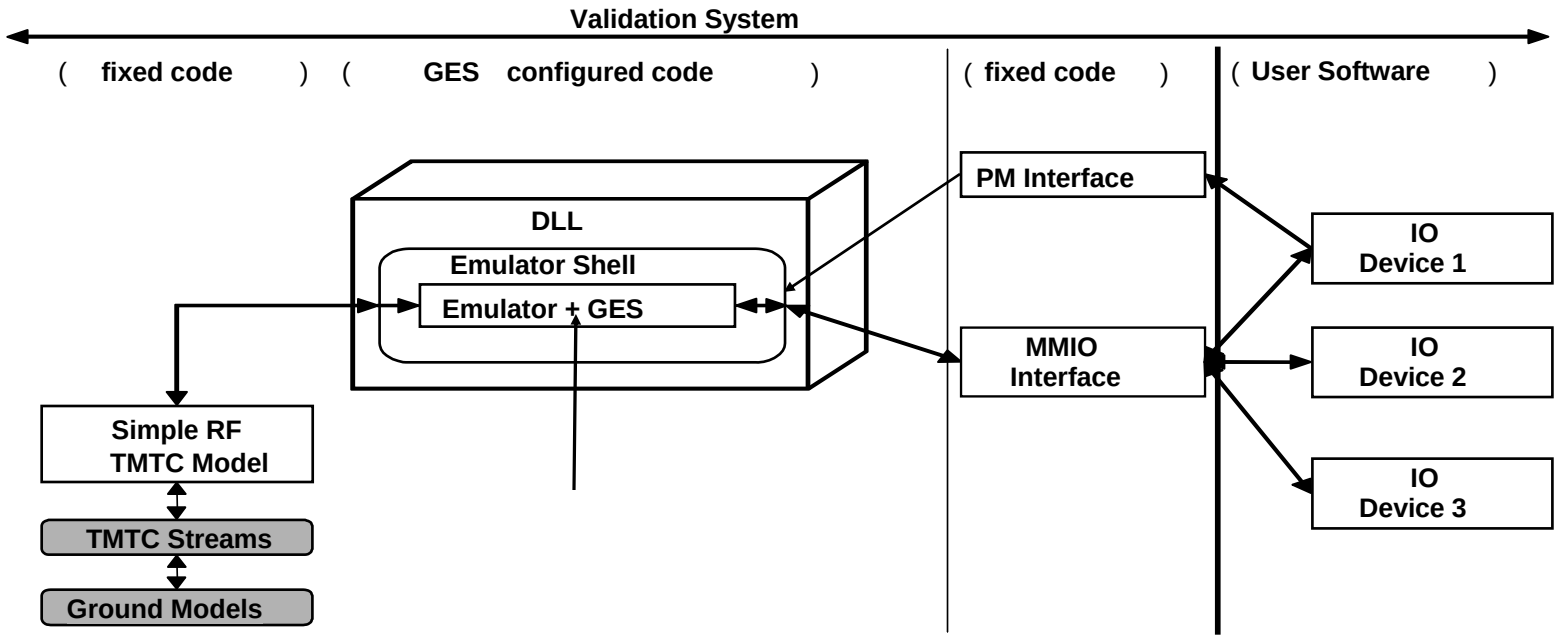
- The GES is an OBSW image generated by the Development System. It provides a subset of typical mission OBSW functionality aimed at supporting simulator integration activities.
- The main GES OBSW features are:
  - Implementation of many PUS TM and TC Standard Services.
  - GES is configured based on user input to CE and DS tools.
  - Interfaces to external I/O hardware devices are via GES API software.
  - Distribution of TCs using external bus interfaces (via GES API).
  - Acquisition of TM using external bus interfaces (via GES API).

GETS Validation System

- Real-time SIMSAT-2003 based simulator that loads and executes the GES in an ERC32 emulator.
  - ERC32 emulator embedded within a common interface
  - I/O device model layer handling the I/O operations performed by the GES software
  - Simple bus models linking the I/O layer to bus users
  - Simple Data Source/Sink models connected to the various data buses (External Models)

GETS Validation System

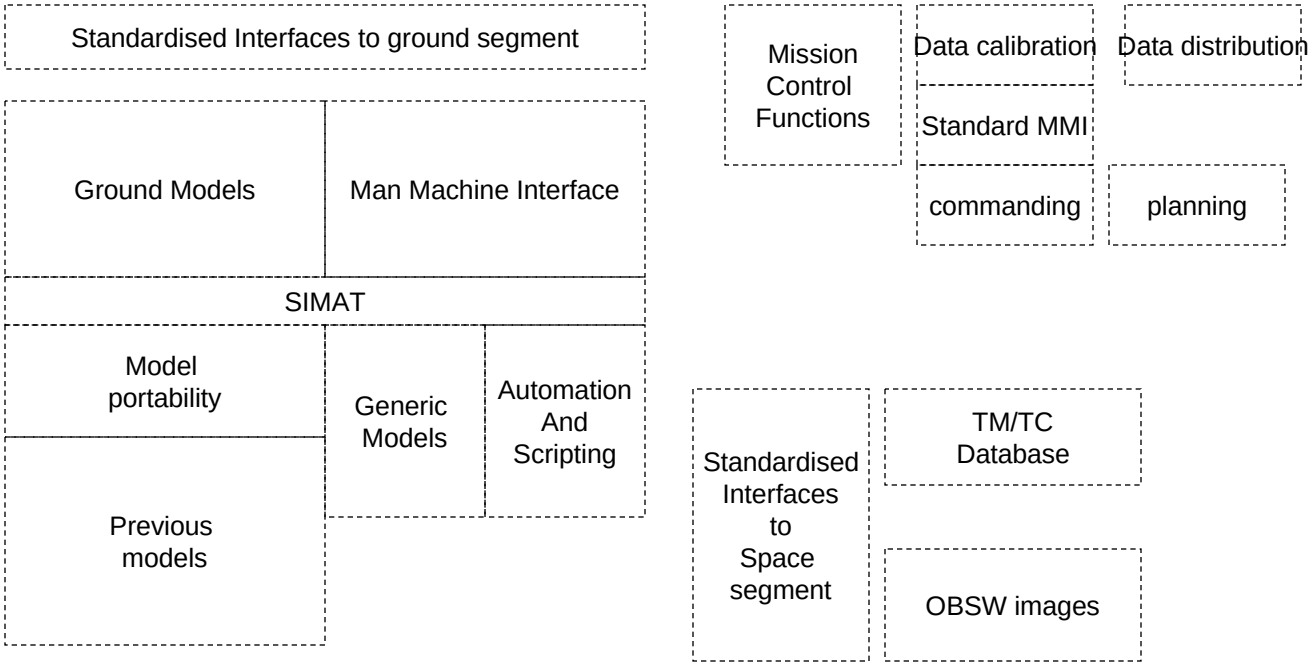
The Validation System (**VS**) is used to support validation of the GES software image generated by the Development System.



Benefits of GETS

- Simulator developer
  - Integration of the Simulator independent from the availability of the OBSW
- End customer
  - Schedule of the simulator delivery decoupled from the the OBSW schedule, reduces schedule risks
- Infrastructure
  - performance prediction of the simulator/emulator, before the real OBSW is arriving
  - Generic Emulator Software can be used as a test tool, e.g to compare processor emulators.

Pieces of the Puzzle



Questions ?