Ingeniería y Sistemas S.A.

Modular and Incremental Framework for GNC Subsystem Validation and Verification

ESTEC – Noordwijk
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Modular and Incremental Framework

SCOPE: Overall GNC/AOCS Validation and Verification process

- early prototyping with generic pre-validated models
- an effective validation of the GNC/AOCS application software
- incremental development of the hardware-in-the-loop (HITL) facility

1. **Algorithm Design Environment:** design of the GN[illegible] ased in generic pre-validated models
2. **Functional Engineering Simul[illegible]** [illegible] acility fully tailored to the specific project needs and allows both design p[illegible] tro-fit of the developed GNC/AOCS application software. Final tuning process i[illegible] rmed in this facility.
3. **Avionics Test Bench:** design qualifica[illegible] of incremental approach and provides an hybrid (fully simulate vs HW stimuli) hardware [illegible]. (High Fidelity Models replace long leads items or units not allowing HW in the loo[illegible]
4. **System Verification:** final verification of t[illegible] tem for those aspects that cannot be verified in previous stages.

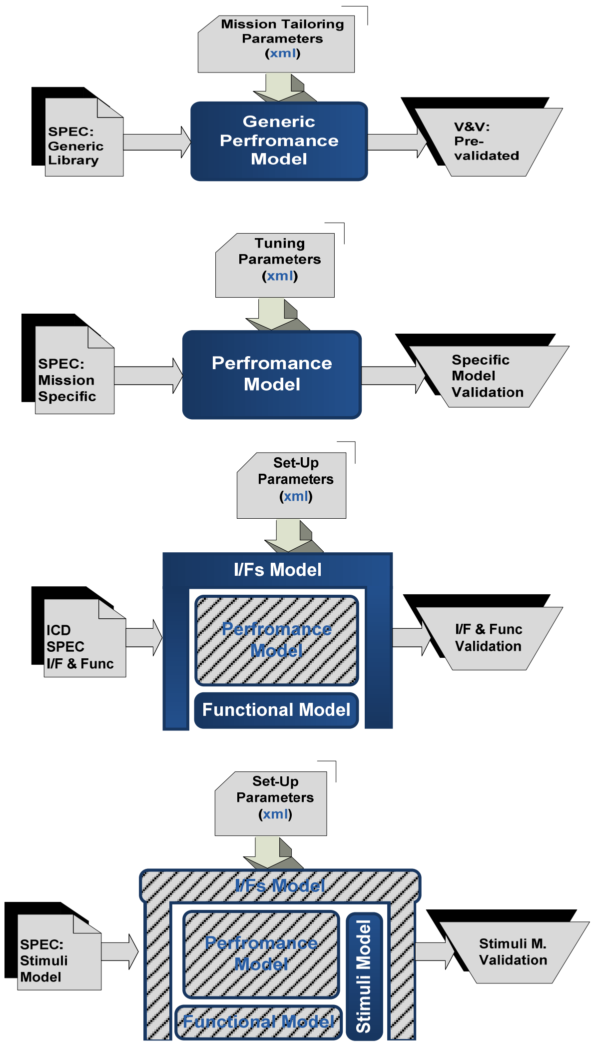
Major Simulator models types, with respect to the item function

- Sensors and Actuators
- On-board computer
- Subsystem Models (such as Thermal SS, Power SS, etc..)
- Dynamics, Kinematics and Environment Models (including Flexible dynamics)
- Mass, Centring and Inertia Models
- Ground segment model

Applicability Domain of the Validation and Verification Models

- **DESIGN PHASE:**
  - Generic set of simulator models and rapid prototyping tools like Matlab Simulink.
  - In-house development.
  - Project to project reuse and improvement (lessons learnt).
- **DESIGN VALIDATION PHASE:**
  - Representative of real units' performance with validation against
    - real unit data or
    - mission specific high-fidelity simulated data.
  - Hardware chain latency and jitter.
  - On-board software scheduling.
- **MODEL-BASE VERIFICATION:**
  - High Fidelity models interfacing:
    - Application Software
    - OBC Emulator or electrically to OBC
- **HW–IN–THE–LOOP VERIFICATION:**
  - Enhance the model with the ability:
    - to monitor actuator
    - Stimulate sensors' electronics
  - Hybrid configuration of with both Simulation Models and HW models (modularity & real-time)

Different Models need, re-usability and impact on system validation



GENERIC PERFORMANCE MODELS:

- **These models are oriented to preliminary design and analysis.**

Mission tailoring parameters are in xml.

PERFORMANCE MODELS:

- **Mission specific for detailed design validation at CDR level,**
- **Its re-usability as a core of the H-F Models.**

Tuning parameters are in xml.

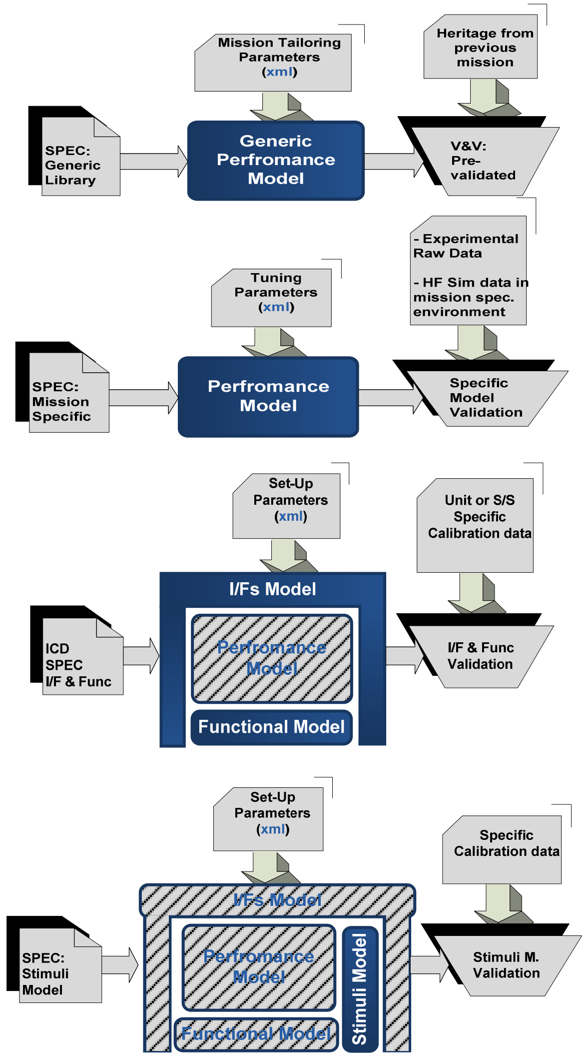
HIGH FIDELITY MODELS:

- **Fulfill part of qualification when no further stage is possible or**
- **Advance/Prepare avionics qualification with HITL**
- **Enhance with interfaces and functional model to allow a Mode-Based Verification**. *(Set-Up Param. xml)*

HITL MODELS:

- **Confirm that electrical interfaces and real units interaction is not affecting functional and performance behavior of the system.**
- **Enhanced to allow hardware stimulation and monitoring of both sensors and actuators**

Models validation needs throughout the system and subsystem lifecycle



GENERIC PERFORMANCE MODELS:
- Generic library derived on in-house heritage from previous missions.

PERFORMANCE MODELS VALIDATION BASED ON:
- Experimental raw data provided by units' supplier
- High fidelity simulation data applicable to the specific mission environment

H-F MODELS VALIDATION PERFORMED AGAINST:
- Specific calibration data obtained on dedicated test campaign or
- Measurement performed at system, subsystem and units level on mission dedicated hardware.

HITL MODELS VALIDATION ARE ACHIEVED ON:
- Specific calibration data and
- reference cases

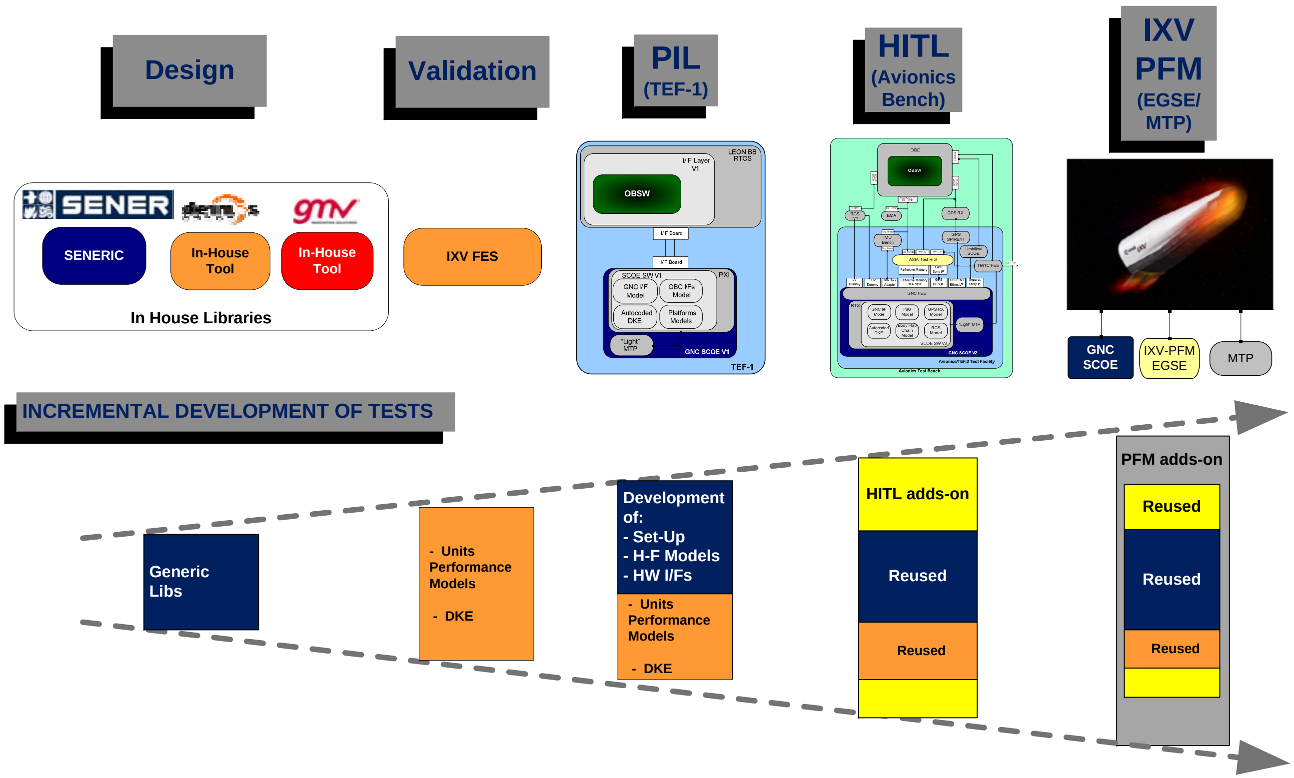
Most relevant systems properties required in each stage of the V&V process and their function in the applicable domain

System Properties	*Design*	*Design Validation*	*Model-Based Verification*	*HITL Verification*
Mass, Centring and Inertia data	X	X	X	X
Control Mode Architecture	X	X	X	X
Equipment Matrix	X	X	X	X(*)
Functional System Properties	X	X	X	X
Measured Mounting data				X(*)
Software parameters		X	X	X
Mission specific performance model data		X	X(**)	X(**)
Calibration data			X(**)	X(**)
TM/TC database			X	X
Electrical ICDs				X

- (*) Equipment Matrix data are partially replace by Measured Mounting data.
- (**) Mission specific performance model data are mostly replace by Calibration data.

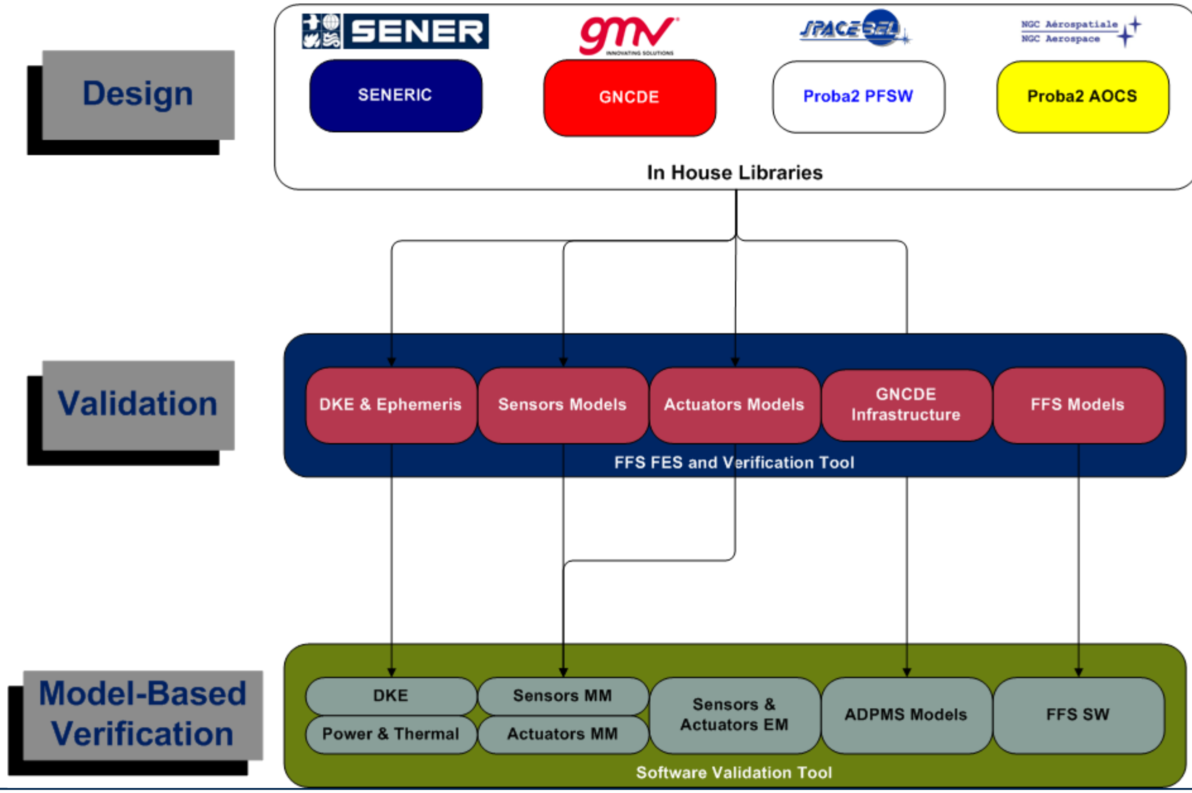
IXV: V&V Approach to Model-Based Validation

- Incremental Development allow early verification and preparation of the HITL
- Model-Based Verification allow to accommodate for verification in absence of Long Leads Items (Body Flap Chain).



Proba-3: V&V Approach to Model-Based Validation

- Three Phases are applicable for a design to cost approach:
  - Design
  - Design Validation
  - Model-Based Verification
- The Formation Flying System SW is verified at closed loop level in pure numerical Model-Based simulator facility named SW based test bench (SBTB)



Thanks for your attention