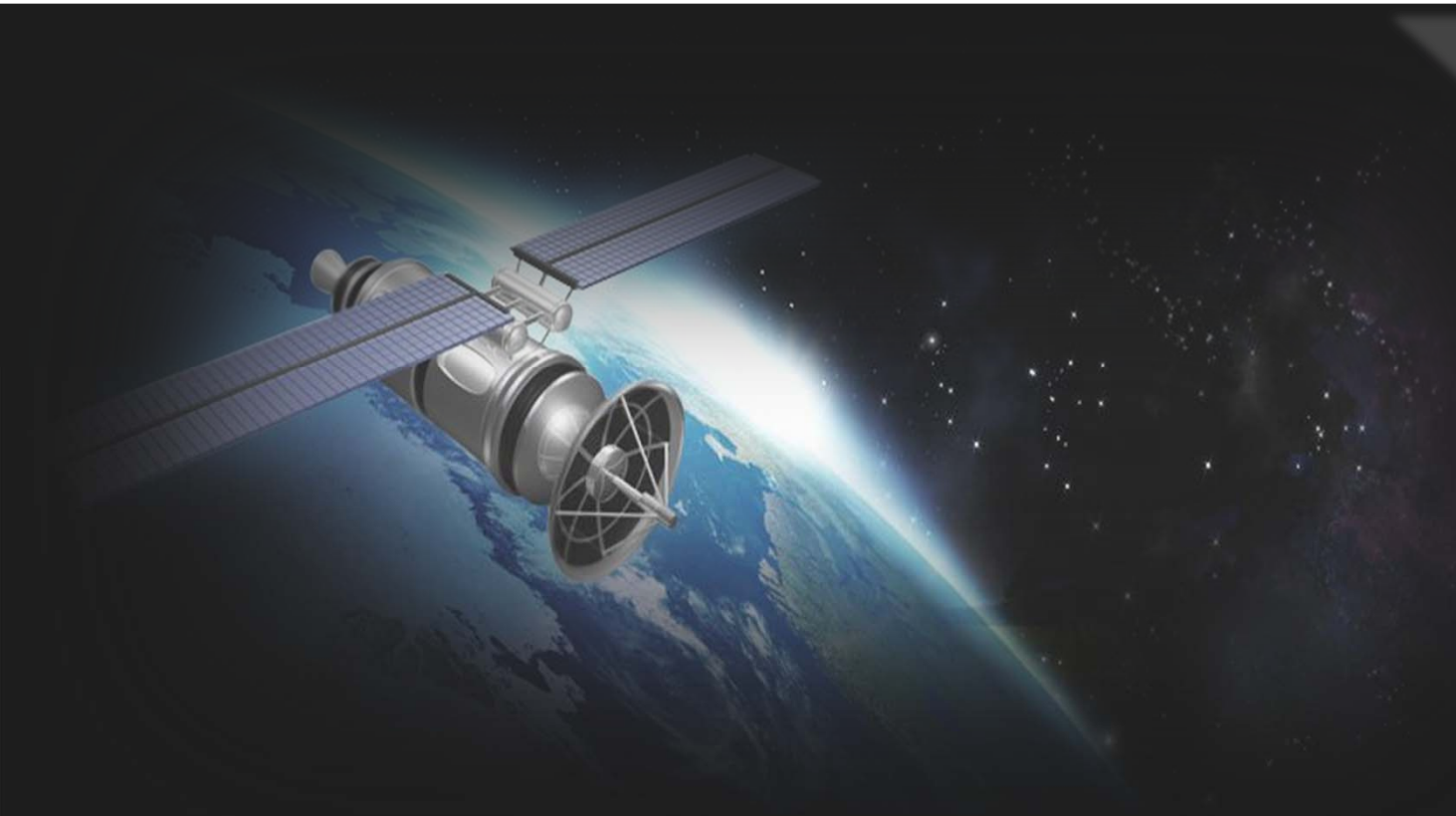


Reaching into space
TOGETHER

cnes

AIRBUS

ThalesAlenia Space
a Thales / Leonardo company

OHB

TERMA

MODEL EXCHANGE

ISIS and SMP2: from Prototype to Reality

SPACEBEL

Agenda

- Rationale & History
- Requirements & Specifications
- Feedback from ISIS based projects
- Conclusions

ISIS Specifications Rationale & History

The Need

- Model exchange with the Industrials (AIRBUS, TAS, …) is an important need for CNES
- Reuse in TOMS of SVF/AIT models developed by Industrials in different simulation infrastructures

- *Requirement of a common framework enabling effective model change between partners and between projects*

First Approach to Solution: SMP2

- Need is partially addressed by SMP2, that specifies a common modelling formalism (on the syntax level)
- But system aspects (semantics aspects for the space simulation domain) are not covered with SMP2
  - *Two SMP2 models developed by two industrials cannot be connected with each other unless the SMP2 interfaces are perfectly identical*
    - *There is the need of defining the interfaces between models*

Complete the Solution: ISIS initiative

- Initiative for Innovative Space Standard (ISIS)

- CNES, AIRBUS and TAS, with SPACEBEL support, to define a set of simple but representative SMP2 simulation interfaces
  - Between Equipment Models, focus on the system interfaces OBC Model – Equipment Models
  - Interfaces reflecting the behaviour of real electrical standard interfaces (Analog acquisition, Digital acquisition, M1553, UART, Spacewire, HPC, Power …)

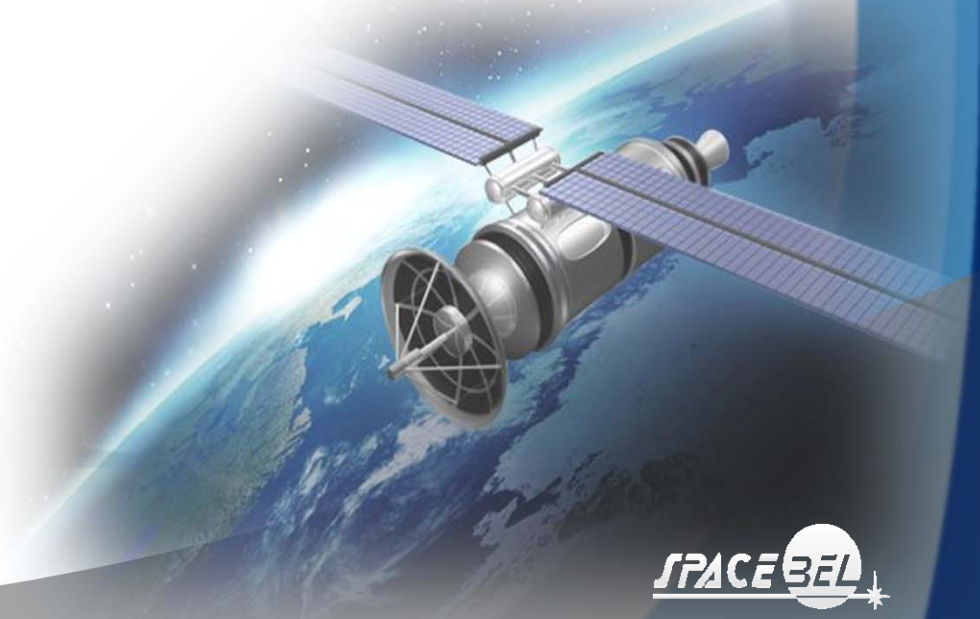
ISIS complete scope

- System Interfaces: by far, the most used in space simulation projects
- External TM/TC Interfaces

On going

- Physical Model Interfaces
- Central Solver Interfaces
- Model Configuration Data exchange (promoting SMP Configuration Files)
- Calibration Functions

ISIS System Interfaces Requirements & Specifications



Requirements: ISIS system interfaces

- SMP2 compliant.
  - Models developed in different environments can be executed unchanged in BASILES (CNES simulation infrastructure), in SimTG (AIRBUS simulation infrastructure) or in K2 (TAS simulation infrastructure).
- Representative of most simulation use cases (Functional, SVF and Operational simulators)
- Simple to use and easily understood by simulation engineers.
- Correspondence with standard I/O interfaces, i.e ASM, TSM, BSM, BDM, ISD, OSD, OBDH, M1553, UART, Serial, Spacewire, Power, HPC, …
  - Specific or non standard I/O interface can be simulated by choosing the closest existing interface in behaviour.

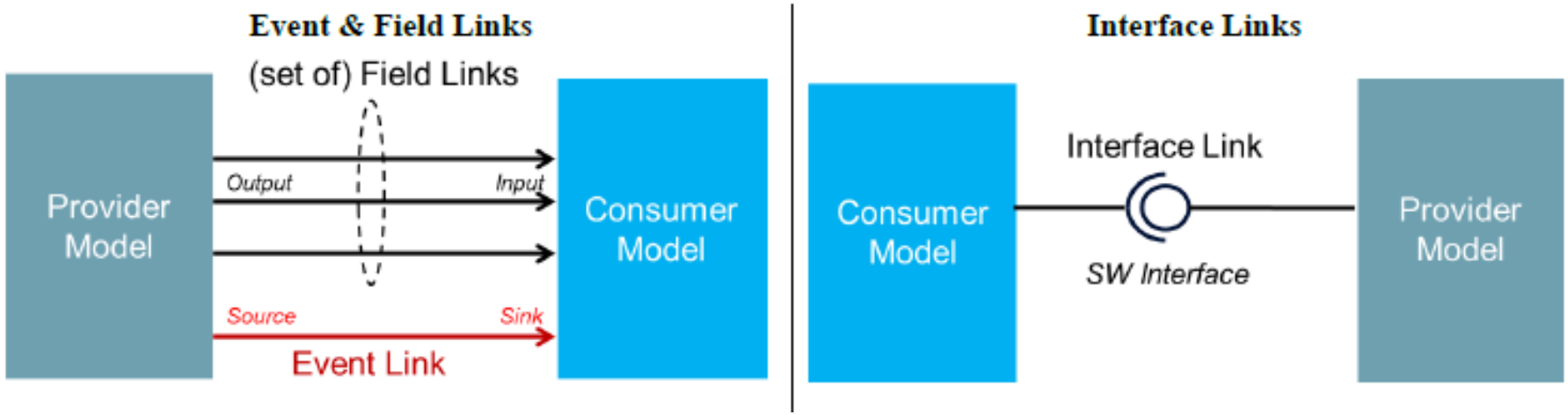
Supported Interfaces

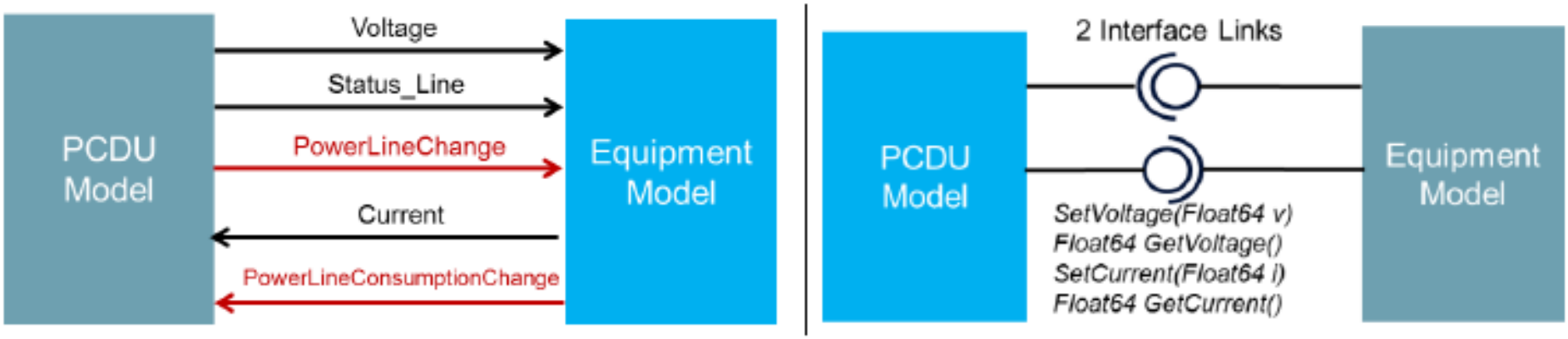
Electrical I/F	*Comments*	*ISIS interface*
ASM1 (Analog)	Analogue signal monitor (0/5V)	Analog acquisition
ASM2 (Analog)	Analogue signal monitor (-5/+5V)	Analog acquisition
ASM3 (Analog)	Analogue signal monitor (-10/+10V)	Analog acquisition
TSM1 (Thermistor)	Temperature sensor monitoring	Analog acquisition
TSM2 (Thermistor)	Temperature sensor monitoring Positive thermal coefficient	Analog acquisition
BDM (Digital bi-level)	Bi-level discrete monitor	Digital acquisition
BSM (Digital relay)	Bi-level switch monitor OPEN / CLOSED	Digital acquisition
HV-HPC	High Voltage HPC	HPC
LV-HPC	Low Voltage HPC	HPC
HC-HPC	High Current HPC	HPC
LPC-P (N/A ISIS)	Low Power Command (pulse)	Not supported
LPC-S (N/A ISIS)	Low Power Command (static)	Not supported
SBDLC	Signal Balanced Differential Line Command	Synchronisation / TC
SBDLA	Signal Balanced Differential Line Acquisition	Synchronisation / TM
PPS	PPS pulse	Synchronisation
H8	Synchronisation pulse (clock 8Hz)	Synchronisation
MIL 1553 data bus	3 models : BC, Bus, RT	M1553
Serial UART	Serial line	Serial
Spacewire link	SpaceWire link	Spacewire
LCL	Standard power line (Latching Current Limiter)	Power line
OP-LCL	ON protected power line	Power line
HL	Heater Line	Power line
HPL (ISIS option)	High Power Line	Power line
ACL pulse	Actuator Command Line (pulse)	Power pulse
Permanent ACL	Actuator Command line (permanent)	Power line
TM	Telemetries	TM (exchange of CADU)
TC	Telecommands	TC (exchange of CLTU)
OSD	16-bit output serial digital	Serial digital 16bits
ISD	16-bit input serial digital	Serial digital 16bits
BSD	16-bit bi-directional serial digital	Serial digital 16bits
Alarm activation	SBDLA (True: ACTIVATED, False: DEACTIVATED)	Digital alarm acquisition
Separation strap	SBDLA (True: SEPARATED, False: NOT SEPARATED)	Digital alarm acquisition
Umbilical presence	SBDLA (True: PRESENT, False: ABSENT)	Digital alarm acquisition
Watch dog inhibition	SBDLA (True: INHIBITION, False: UNINHIBITION)	Digital alarm acquisition

Design Approaches

- To cope with all the needs, two design approaches compliant with the SMP2 inter-model interfaces
  - Event & Field Links
    - Assume automatic propagation field links
  - Interface Links

Design Approaches

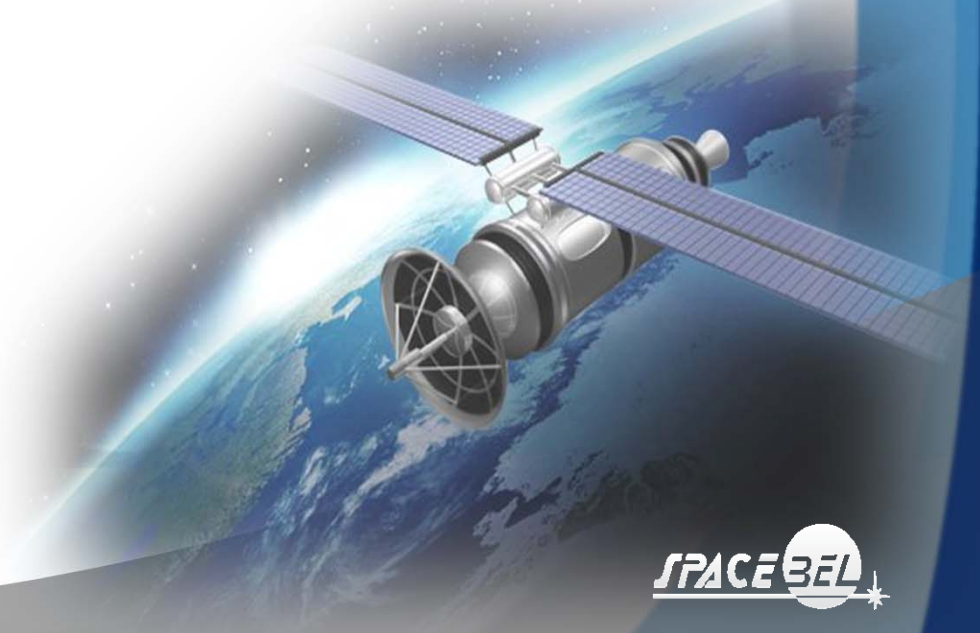




Reference

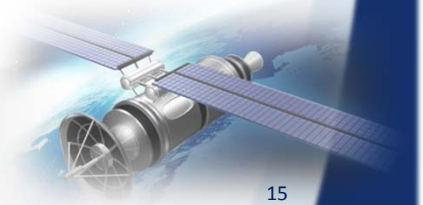
- ISIS Training Operations and Maintenance (TOMS) Interface Specification, ISIS-SIM-IF-305-CNES, Issue 6, 13.11.2015
- Set of SMP2 catalogues
- Set of C++ header files

Projects around ISIS Feedback



Projects using ISIS Interfaces

- ISIS Prototype
- A French National Program (CNES – AIRBUS)
- Another French National Program (CNES – AIRBUS - TAS)
- MYRIADE Evolutions (CNES – AIRBUS – TAS)
  - MERLIN (CNES – AIRBUS)
- MTG-SVF Simulation Framework (OHB – TERMA – SPACEBEL)
- EUCLID SVF & EGSE (TERMA – SPACEBEL)
- EUCLID RTS Simulator (ADSN)
- PROBA3 SVF (SPACEBEL)



ISIS Prototype

- Proof of concept prototype: power line, HPC, M1553 and analog acquisition
- AIRBUS develops an OBC model in the SimTG infrastructure, following the Interface Links approach
- TAS develops develops an OBC model in the K2 infrastructure, following the Event & Field Links approach
- SPACEBEL develops a Payload model integrated in the BASILES infrastructure, supporting both IF and EV&FL approaches

- Successful integration performed on top of BASILES

Myriade Evolutions

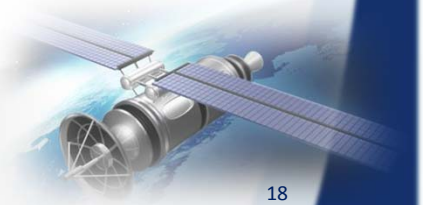
- Development and qualification of a platform for the 2015-2025 period
- Partnership CNES – AIRBUS – TAS
- Models developed by SPACEBEL using ESA tools and delivered to CNES for validation in BASILES
- Models integrated by TAS and ADS
- Same models for SVF/AIT and TOMS
- First mission MERLIN with AIRBUS Germany as a new model provider (3 different model providers!)

- Less efforts in specification phase
- ISIS/SMP2 is key element to promote model reuse in a really tight time schedule
- Validation difficulties due to different validation script languages
- Few technical issues not addressed by ISIS/SMP2 (on-going work in calibration functions)
- ISIS Documentation clarifications needed

A French National Program

- AIRBUS: a Satellite Simulator for Software Validation, System Tests and AIT support based on a set of Physical and Equipment models embedding SMP2 (SimTG)
- Integrated unmodified in CNES BASILES to build a TOMS
- Complemented with other models developed by CNES-SPACEBEL joint team for specific TOMS needs

- Efficient model exchange
- Cross validation of models between infrastructures (different test languages Java vs Tcl)
- Few technical issues not addressed by ISIS/SMP2



Another French National Program

- Models developed by TAS in K2 (Event & Field Links)
- Models developed by AIRBUS in SimTG (Interface Links)
- Models developed by CNES
- SPACEBEL contributes with a MDK supporting automatic field link propagation

- ISIS allows solving issues of recurrent interfaces at early stage
- Flexibility of ISIS for specific I/O interfaces
- Few technical issues not addressed by ISIS/SMP2

Euclid SVF & EGSE – MTG SVF SF

- TERMA develops the MTG SMU and EUCLID CDMU models
- Integrated in BASILES together with the equipment models
  - By SPACEBEL and OHB (MTG)
  - By SPACEBEL (Euclid)

Euclid SVF & EGSE – MTG SVF SF Feedback (TERMA)

- ISIS defines common interfaces that ease the communication between models
- Simple, no dependency on other products, standard model/subsystem for common HW functionalities

- Not obvious to identify which ISIS interface to use for specific situations. Insufficient documentation
- Project tailoring could be required (e.g. TM/TC line interfaces)
- Few technical issues not addressed by ISIS/SMP2

MTG-SVF SF Feedback (OHB)

- ISIS is the necessary building block for model exchange
- Simple use
- Integration of models from SPACEBEL/TERMA with little efforts

- Must select a design approach (IF or EV&FL). MTG uses the Interface Links approach
- Incompatibility between IF models and EV&FL models
- Documentation to clarify

EUCLID RTS Simulator

- ISIS interfaces are used to connect the ADSN RTS Simulator to the CDMU model (TERMA) and Equipment Models (SPACEBEL) (AOCS equipment models are replaced by the ones from ADSN)

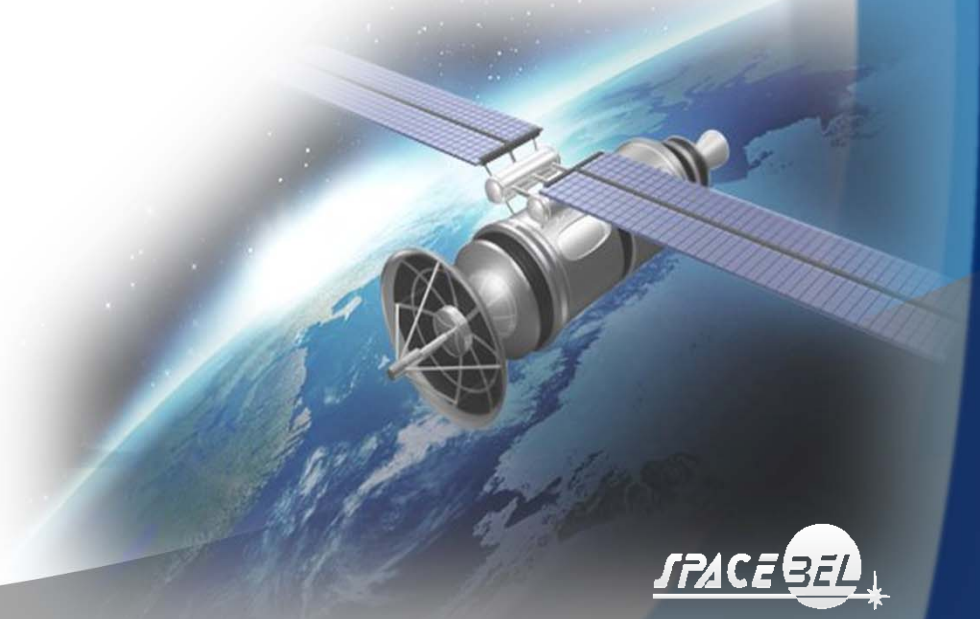
- Common interface ready for use, no design necessary

PROBA-3 SVF

- No model exchange as such in this case because SPACEBEL is the only model provider

- ISIS interfaces is a common interface library, no efforts spent on design
- No missing functionalities

Next Steps & Conclusions



Next Steps

- Consolidation of the current interfaces (System, Physical, Solver, Calibration Functions, Model Data).
- Major evolution of the Spacewire interfaces
- Support of new interfaces: LVDS, …
- Improved documentation
- Align with the upcoming ECSS SMP standard (where Automatic Dataflow has been integrated)
- Consideration of the feedback from the various projects.

- *ISIS system interfaces are promoted in all current and future CNES/SPACEBEL projects*

Conclusions

- ISIS Interfaces allow the effective model exchange between simulation models providers, working with different simulation infrastructures
- Wide support
- General feedback is positive
- Some concerns on the lack of documentation, clarifications of the interface use

- ISIS initiative shows that standardisation is crucial

Thank you for your attention!