SAVE: Simulation for Analysis and Validation of Energy for ATV

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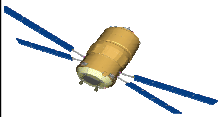
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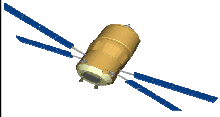*EADS LV - ATV project*

SUMMARY

- The ATV project
- SAVE platform context
- SAVE platform overview
- SAVE Thermal Mathematical Model (STMM)
- STMM integration into SAVE
- Conclusion / Remarks

Automated Transfer Vehicle

4,5 m

10,3 m

First flight: mid 2004

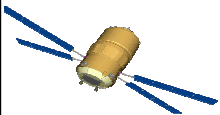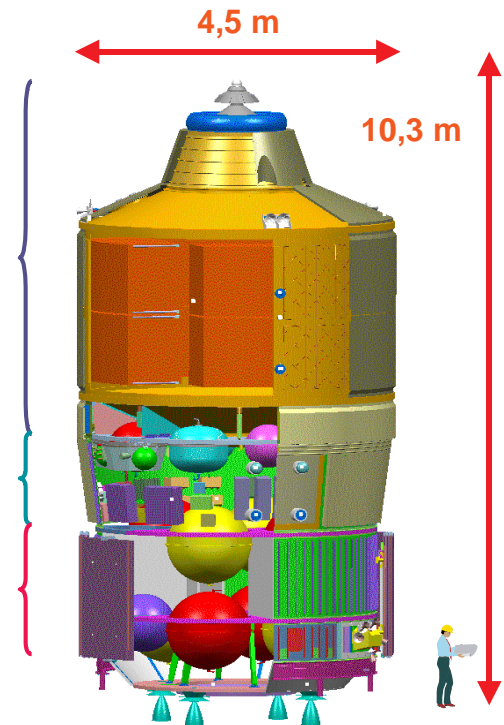Integrated Cargo Carrier (pressurised)
- supply for ISS crew: dry cargo
- water, gas

Equipped Avionics Bay (EAB)

Avionics, batteries

Equipped Propulsion Bay
- propulsion for ATV
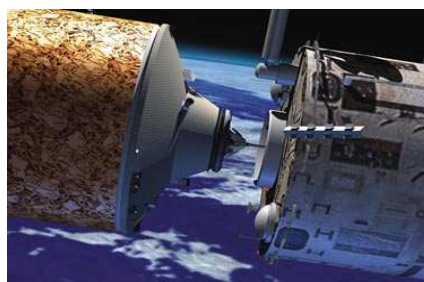- ISS reboost

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ATV mission

Phasing with ISS RDV
with ISS

Docking

Docked

Launch - A5

6 months mission

- ISS orbit control
- ISS refuelling
- Retrieval of waste
- Destruction

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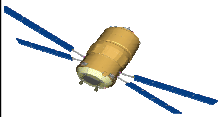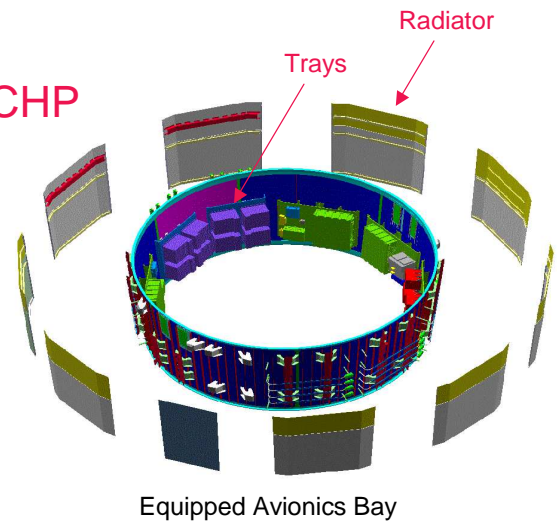VEHICLES
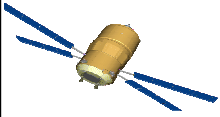
ATV thermal control concept

- Keep a "warm" EAB in cold phases

- Cool the EAB in warm phases

ACTIVE THERMAL CONTROL with VCHP

- 4 VCHP per trays

- 10 trays

- 10 AFCU: Active Fluidic Cooling Unit

3 WORKING MODES:

- OFF mode

- ON mode

- Control Conductance

Radiator

Trays

Equipped Avionics Bay

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SAVE platform

On-board power users:

- Equipment items

- Thermal control

Thermal control is the main user of the power (VCHP control, heated items)

$\Rightarrow$ A platform simulator has been developed to couple thermal and electrical aspects

$\Rightarrow$ SAVE[mgt]: Simulation for Analysis and Validation of Energy management

$\Rightarrow$ Main software: SABER, used in electrical engineering

OBJECTIVE: to demonstrate on-board available power covers the vehicle needs

SAVE: main tool of the thermal/electrical coupling verification on ATV

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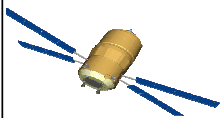
SAVE Overview

SAVE integrates on-board prototype software:

Thermal Control Chain Function Unit

- Controls the VCHP,
- Controls the heated items,
- Distributes the thermal control on the 4 power chains,
- Manages the day heating, Energy Saving,
- Prioritises the activation of heaters.

Power Supply Function Unit

- Manages the battery Depth Of Discharge,
- Prioritises the 4 power chains on board,
- Manages the solar arrays current,
- Manages the ISS power,
- Reduces the items power consumption in case of energy saving.

SAVE interface
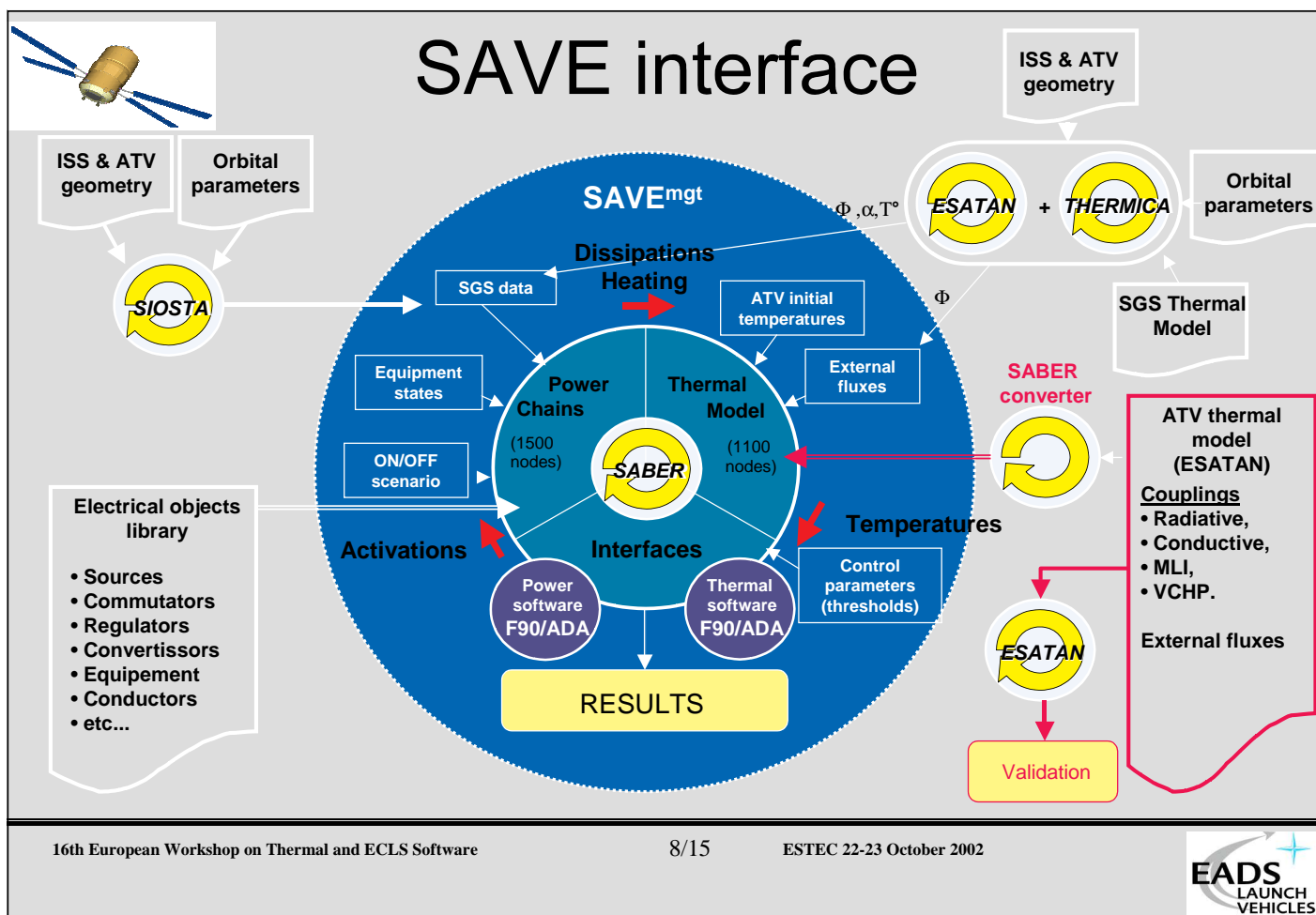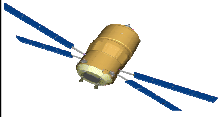
ATV thermal model

STMM: Save Thermal Mathematical Model

Used software: ESATAN, THERMICA

≈ 20,000 Radiative couplings
(compressed to ≈ 9 000 for time calculation)

≈ 1,300 Conductive couplings
(constant or variable)

≈ 1,100 nodes with ISS

>300 internal dissipations

≈ 150 external fluxes

≈ 175 item temp. Heat balance
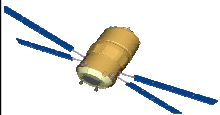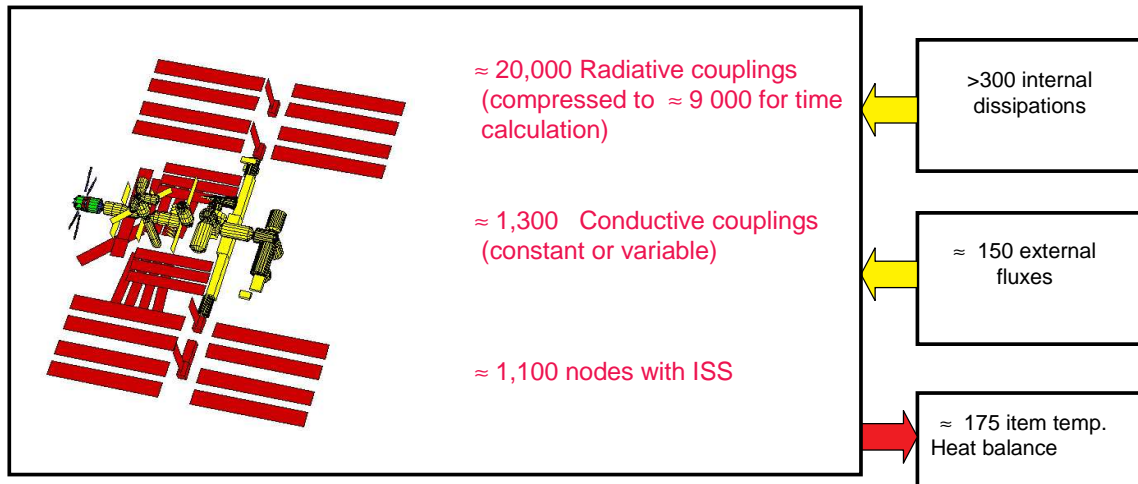
Thermal model Validation

Validation process before integration into the platform

• Validation on temperatures

• Validation on heat balance

Thermal model Validation

Structural Thermal Model (STM)data:
- Test stand
- Dummies equip
- Test sequence

STM Test results

Correlation

STM TMM

Thermal Mathematical Model of the Structural Thermal Model

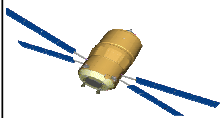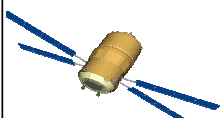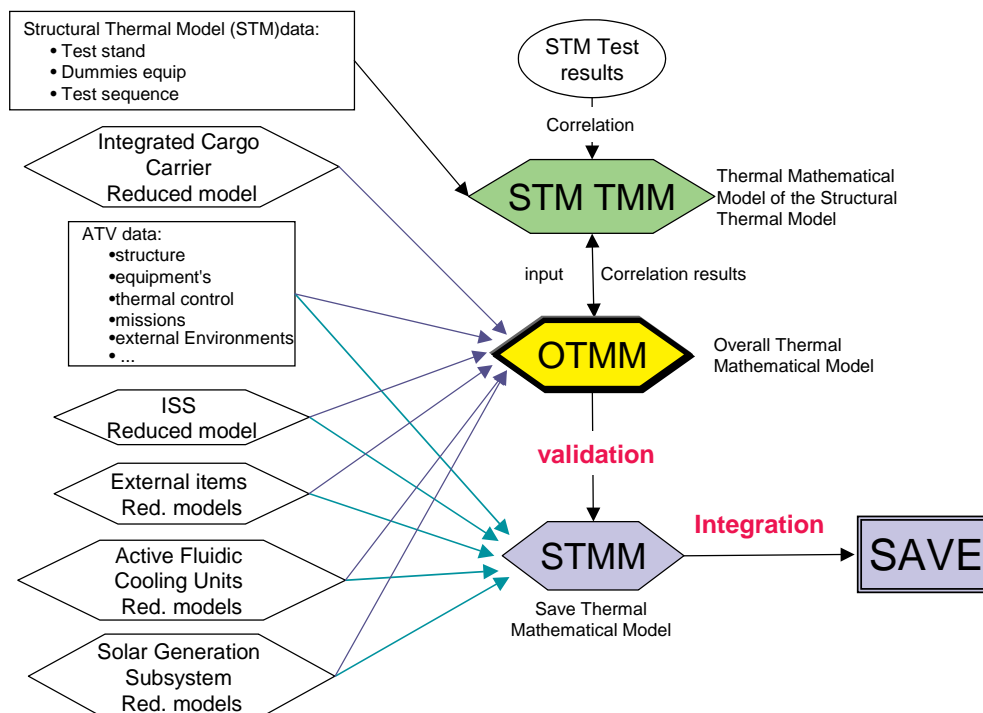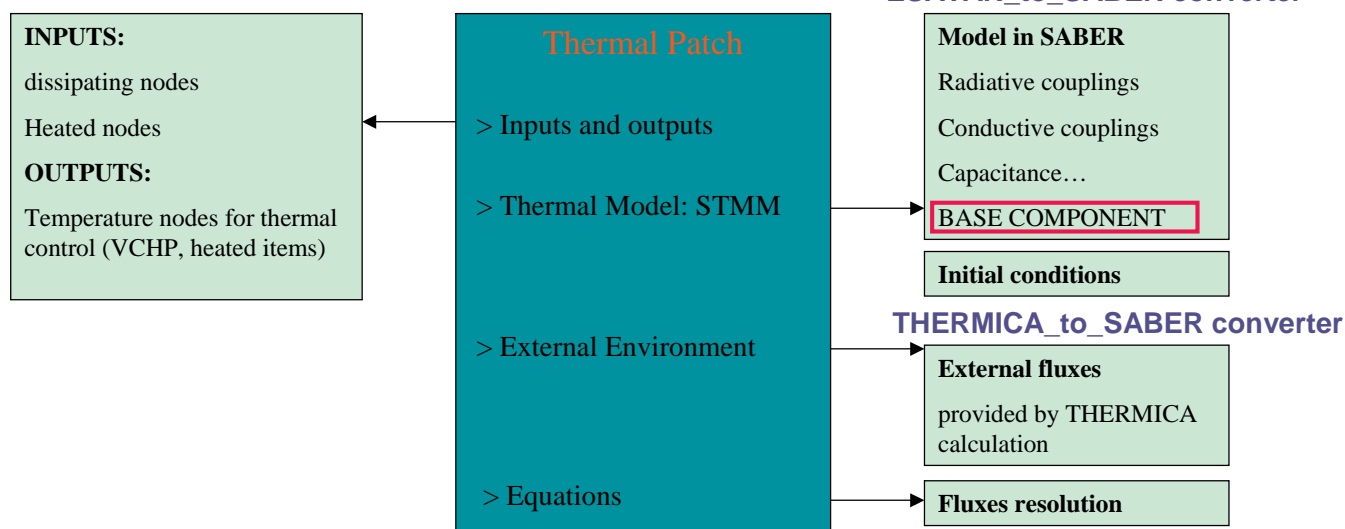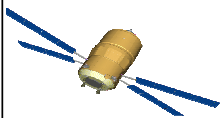Integrated Cargo Carrier Reduced model

ATV data:
- structure
- equipment's
- thermal control
- missions
- external Environments
- ...

input   Correlation results

OTMM

Overall Thermal Mathematical Model

ISS Reduced model

External items Red. models

validation

Active Fluidic Cooling Units Red. models

STMM

Integration

SAVE

Solar Generation Subsystem Red. models

Save Thermal Mathematical Model

Thermal patch

Interfaces the thermal model with the platform
- SABER language
- Validates the thermal software

ESATAN_to_SABER converter

INPUTS:

dissipating nodes

Heated nodes

OUTPUTS:

Temperature nodes for thermal control (VCHP, heated items)

Thermal Patch

> Inputs and outputs

> Thermal Model: STMM

> External Environment

> Equations

Model in SABER

Radiative couplings

Conductive couplings

Capacitance…

BASE COMPONENT

Initial conditions

THERMICA_to_SABER converter

External fluxes

provided by THERMICA calculation

Fluxes resolution

ESATAN_to_SABER converter

The converter translates the thermal model from ESATAN to SABER language

- Re-creation of SABER 'BASE COMPONENT' (for transparency)
  - to simulate radiative and conductive couplings
  - to simulate constant capacitance
- Creation of new base components
  - to simulate VCHP function
  - to simulate MLI efficiency variation
  - to simulate capacitance variation

→ VALIDATION OF EACH COMPONENT comparing ESATAN with SABER

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SAVE results
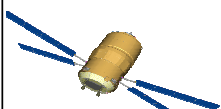
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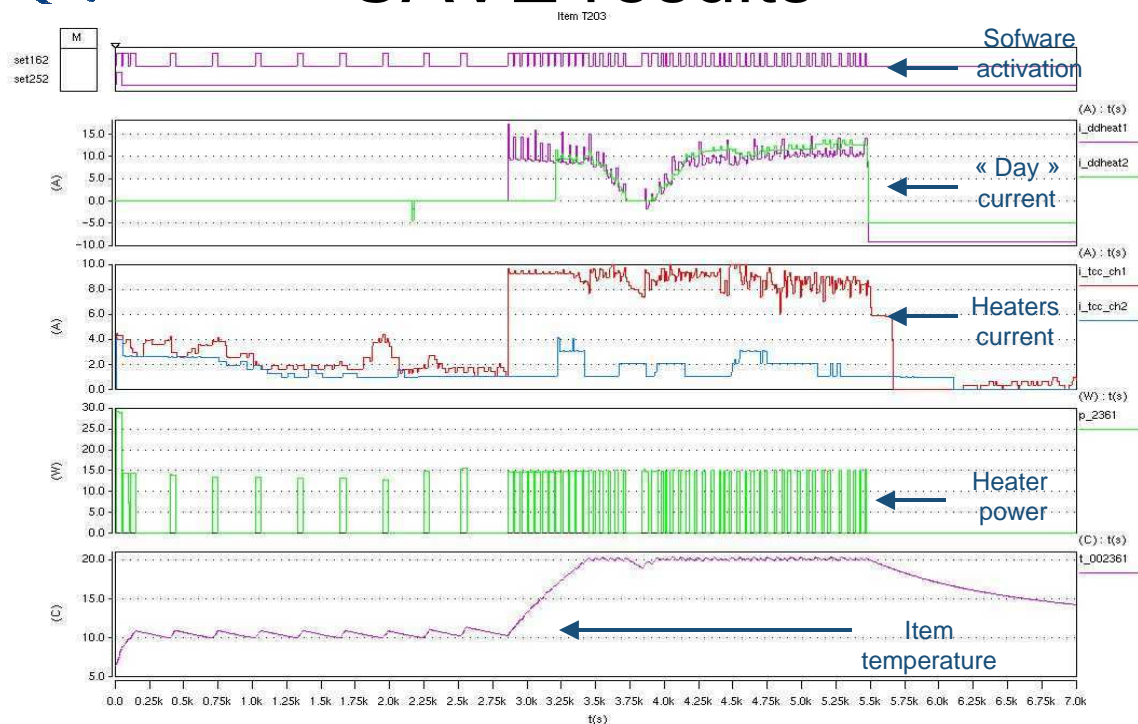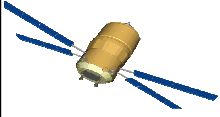
Conclusion

- **First simulations have been performed in 2001 with a beta version**

- **Software (thermal control and power supply) has been introduced in 2002**

NEXT STEPS :

- **Validation of STMM with ATV system thermal tests results performed in 2002**

- **Algorithms prototypes validation**

- **Platform expected to be fully operational in June 2003**

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