

Project:

**ESPSS-3 European Space Propulsion System
Simulation**

Title:

Executive Summary

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Contains information for the design of structures, systems or components: Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
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Issue 1

ESPSS Phase 3 – ABSTRACT

ESA Project: 4000103800/11/NL/CP (European Space Propulsion Simulation Tool Phase 3)

BACKGROUND

ESPSS is concerned with setting up a common European platform for propulsion system simulation. Such a common platform is identified as crucial in order to strengthen the European company's competence in propulsion system modelling. ESPSS is proposed as a framework for continuous cooperation on space propulsion systems between European industries working on such kind of systems.

In this context, a first version of the ESPSS was developed under Category 2 of the activities of a previous ESA contract (20004/06/NL/PM). The development of the tool ESPSS (European Space Propulsion System Simulation) aims at:

- Shared and standard software for performance modelling in Europe on a common platform with respect to space propulsion systems
- A reduction in development time and costs in all types of propulsive systems
- An industrial tool with core capabilities: an industrial tool shared with European companies, institutes and universities, providing modular model building, a standard components library and a standard interface

Once the first version of the tool was available, it was confirmed that it could be extended as an essential tool to develop new propulsion components and to prepare future missions. A second validation phase (ESPSS-2) was then proposed with the following targets:

- To upgrade the existing software tool into a common environment for the analysis and simulation of propulsion systems including chemical and electrical propulsion cycles, ground support equipment & operations, ground/qualification tests and,
- To evaluate the tool for realistic, industrial systems

The ESPSS library's components have been defined using the ECOSIMPRO software. It is the simulation tool recommended by ESA for ECLS and has been used successfully for the European activities of the ISS program. This basically incorporates the following features:

- A friendly Graphic User Interface (GUI).
- Encapsulation (object-oriented programming), which enables the abstraction of a component's behavior (equations and data) in abstract components.
- Inheritance and aggregation, which permits the creation of complex components (models) thanks to the connection of multiple instances of single components.
- State of the art solvers.

Main Objectives

After the successful conclusion of the validation phase (ESPSS-2), this third phase was proposed as:

- An upgrade on Tanks and Pipes modelling (PMD tanks and gas dissolution), in this way completing some of the requirements not implemented yet in phases 1 and 2.
- A starting point for direct steady and quasi-steady calculations dealing with parametric studies in combustion chambers.
- Inclusion of new validation cases in tanks & combustion chambers.
- Development of new turbo-machinery models.
- Integration of validated optimization routines.

Project Organization

Company	Position	Contribution
Empresarios Agrupados	Prime Contractor	Coordinator of the partners and main software developer of the ESPSS libraries
EADS Astrium	Subcontractor	Industrial user and evaluator of ESPSS under steady and transient conditions
VKI	Subcontractor	Development and validation of the software for the areas under its responsibility
KopooS	Subcontractor	Development and validation of the software for the areas under its responsibility
CNES	Subcontractor	Experimental data provider for evaluation

Project Deliverables

Empresarios Agrupados agreed with the Agency and the project partners to submit the following list of deliverables defining the main activities carried out during this project:

WP	Deliverable	Title	Responsible	Status
WP2100	TN2110	Implementation of Specific Upgrades	VKI / EA	Submitted
	SW2120	Updated version of the ESPSS ver. 2.2	EA	Submitted
WP2200	TN2210	Re-evaluation of the ESC-A Pressurization Systems Validation Cases	Astrium-Bremen / EA	Submitted
	SW2220	Updated version of the ESPSS ver. 2.4	EA	Submitted
WP3100	TN3110	Steady model specification	EA	Submitted
WP3200	TN3210	Adsorption and desorption in Pipes. Physical Model Specification	VKI	Submitted
WP3300	TN3310	Surface tension effects (PMD tank) specifications	VKI	Submitted
WP3400	TN3410	6/7 eqs two-phase models. Physical Model Specification	VKI	Submitted
WP3500	TN3510	Electrical Propulsion Components	KopooS	Submitted
WP3600	TN3610	Evolutionary Behavior of Components	KopooS	Submitted
WP3700	TN3710	Formulation of component database	EA	Submitted
WP4000	TN4110	Architectural Design for ESPSS-3 upgrade	EA	Submitted
	TN4120	Software Verification and Validation Plan Upgrades	VKI / EA	Submitted
	TN4130	User Manual Upgrades	VKI / EA	Submitted
	SW4110	ESPSS-3.0. Software Transfer Document	EA	Submitted
WP5100	TN5110	Adsorption and desorption Validation Cases	VKI	Submitted
	TN5120	Adsorption and desorption Validation Cases	KopooS	Submitted
WP5200	TN5210	HM7B Industrial Evaluation	Astrium-Bremen	Submitted
WP5300	TN5310	Steady Cases Industrial Evaluation	Astrium-Ottobrun	Submitted

WP5400	TN5410	Optimization Cases Industrial Evaluation	EA	Submitted
WP5500	TN5510	Mission Cases Industrial Evaluation	KopooS	Submitted
WP5600	TN5610	HM7B TCA Industrial Evaluation	Astrium-Ottobrun	Submitted

CONCLUSIONS

Most of the targets of the ESPSS Phase 3 project have been successfully achieved:

- Specific upgrades have been implemented for the different libraries such as new supported fluids, robustness improvements or new correlations
- The adsorption and desorption effects of non-condensable gases have been implemented in pipes and tanks
- Four new libraries have been added to ESPSS:
 - The STEADY library for the direct calculation of steady and quasi-steady models
 - The SATELLITE library for the calculation of motion and attitude of satellites
 - The EP library for the simulation of electric propulsion systems
 - The COMP_DATABASE library, as a basis for the users to create their customized new components from generic ones
- An industrial re-evaluation of the tool has been successfully carried out
- New validation cases has been added to the libraries and to the manuals, covering the new implementations and the upgrades

Despite the big effort carried out during the development of the project, it was not possible to get a functional version for the 6/7 equations scheme under two phase flow. The estimation of the work needed to implement this capability has proved to be insufficient and therefore it could not be completely finished. Nevertheless, the first steps have been performed and a procedure proposed as a basis for the future implementation of this capability during following phases.