

# Spacecraft in Plasma Simulation Framework (concept)

In modern times, when Hollywood-grade special effects consisting of particle and fluid simulations can be created on a laptop by anyone with a high-school education after a short software course, space plasma science is lagging behind with outdated plasma environment simulation tools and specialized codes that require advanced programming knowledge to operate.

## Problem formulation:

Missions to outer planets are limited to one spacecraft, making measurements of current systems and particles difficult to interpret. Simulations can and have been used in combination with measurements to improve the data analysis, but the simulations are typically built on the case-to-case basis – a general simulation solution does not exist. Current plasma simulation options are highly specialized and require a specialist to run (not user-friendly), resulting in a very costly and time-demanding process. Swedish National Infrastructure for Computing's HPC capabilities are virtually not utilized for this purpose, significantly limiting the plasma environments that can be simulated.

Previously, a similar project was funded by ESA that resulted in the development of Spacecraft Plasma Interaction System (SPIS). SPIS is a powerful code but suffers from legacy issues and poor documentation (stemming in part from its modular open-source nature), making implementation unnecessarily challenging. It also has no HPC capabilities, putting limitations on the plasma environments that are possible to simulate.

## Proposed solution:

Allocate funding to create *and maintain* a user-friendly plasma simulation code (or re-purpose existing) that can be run either locally or parallelized for HPCs. Outsourcing to a software developer is fully viable (with inputs from physicists). Such a solution would also strengthen Sweden's international standing with respect to the space plasma science infrastructure.

The goal is a "toybox" kind of software that allows a user to set up basic plasma parameters, import a 3D model of a spacecraft or any celestial body if necessary, simplify the geometry for the simulation purposes, and run the simulation either on a local machine or an HPC, depending on the computational load (that is estimated before the simulation). The output of the simulation could then be used as aid in data analysis and interpretation, instrument and mission design, and fundamental physics.

Project length: 2 years for development plus maintenance further on

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Other actors:

- a software development company to be hired for the coding part
- SNIC staff may provide expertise for HPC and simulations in general

Investment estimate: ~ 3 000 000 SEK for development