

INTRODUCTION

The increasing number of objects in orbit makes accurate modelling essential to predict the evolution of the space environment. Although Space Traffic Management (STM) supports orbital monitoring and tracking, artificial threats and natural phenomena, such as Space Weather (SW) events, can increase orbital perturbations and collision risks for critical space assets. Predicting these cross-domain effects is essential to accelerate decision-making and prevent losses.

Addressing this challenge requires integrating data from multi-domain sensor networks to identify emerging threats and assess their potential impacts. AI/ML tools can support this process by enabling continuous monitoring and reliable risk assessment while reducing operator workload. However, ensuring the trustworthiness of these tools remains a key challenge.

WHAT IS SPEADIT?

SPEADIT is a **Decision Support System** powered by a Digital Twin, supporting users from threat identification to decision-making. It adopts a data-agnostic architecture to analyse the interactions between Space Weather and Space Traffic Management.

It is aligned with CMMI® and Artificial Intelligence Maturity AIM™ practices CMMI® and AIM™ are registered trademarks of CMMI Institute LLC.

WHAT DOES SPEADIT DO?



RECONSTRUCT

Environmental conditions with a multi-domain sensor network.



ANALYSE

Impending artificial or natural threats with multi-layered modelling.



PREDICT

The potential impacts on critical in-orbit assets using what-if scenarios.



ASSESS

Identify and prioritise critical situations and emerging hazards.

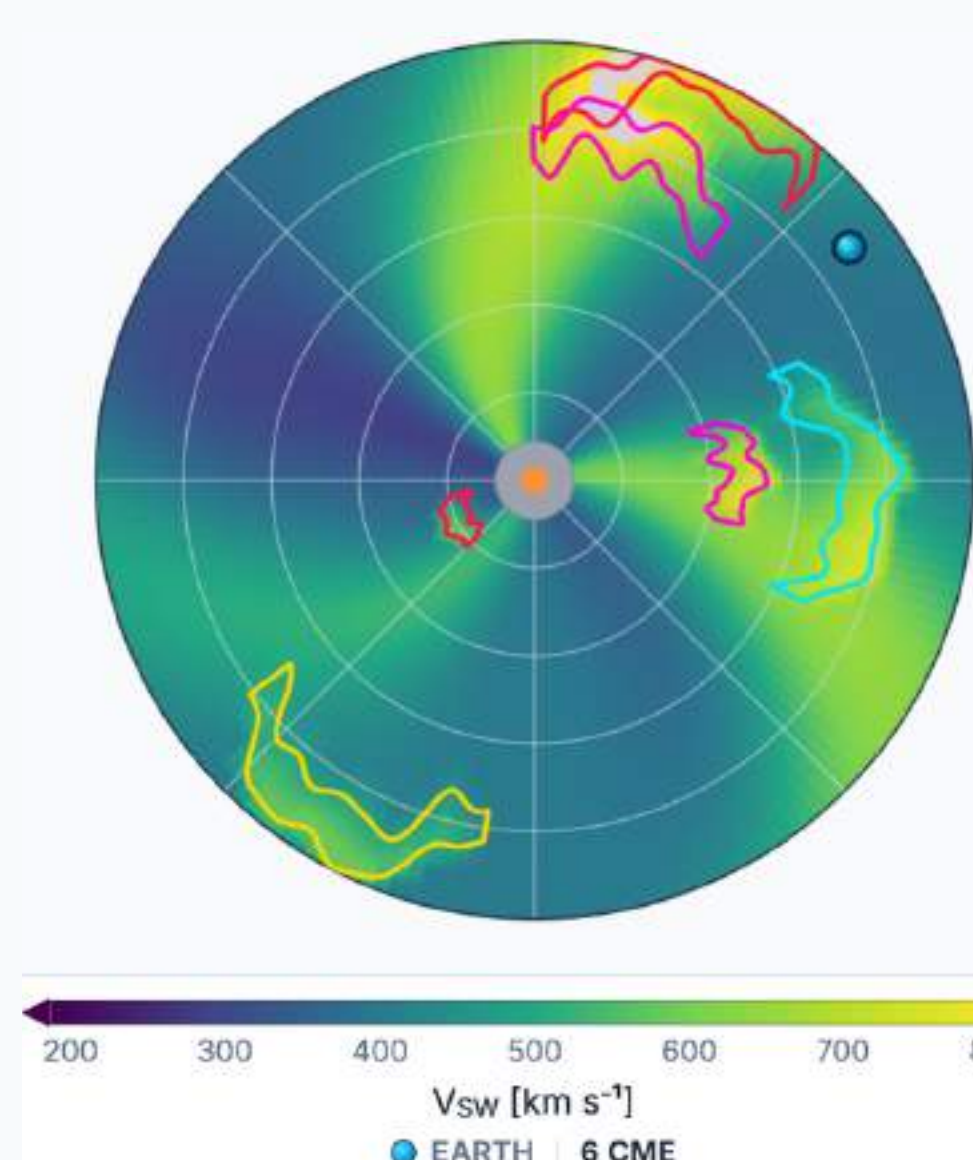


DECIDE

The best course of action and mitigation measures to protect your facilities.

SPEADIT Threat Analysis*

1) Solar wind propagation towards Earth



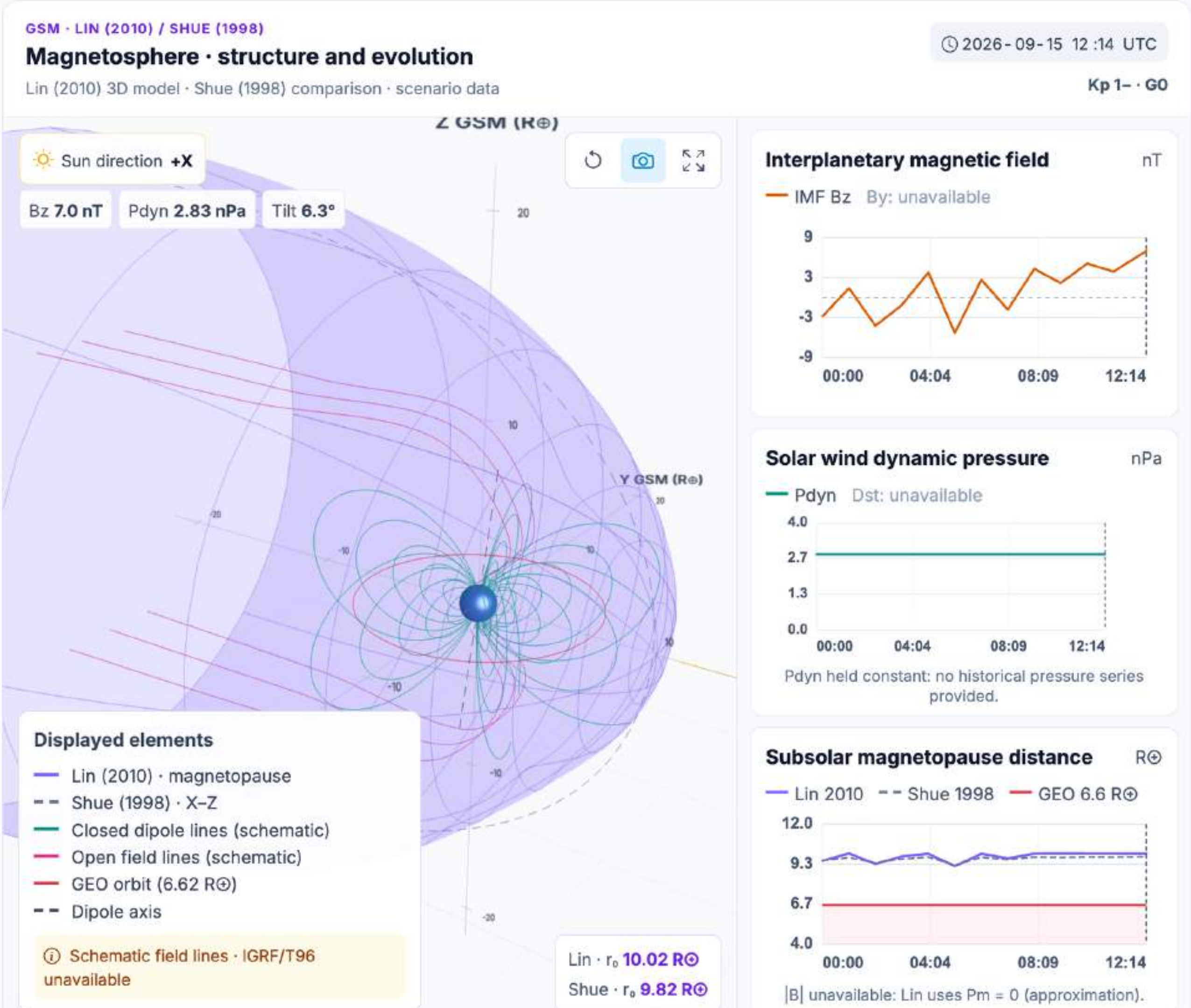
TOY MODELS

Reduced order equations for uncertainty predictions, lower computational cost.

COMPLEX MODELS

3D MHD equations for a more precise analysis, higher computational cost.

2) Dynamic magnetosphere evaluation



2) Space Weather Impact & Conjunction Analysis

Primary: ISS (NAUKA) Total: 4 CRITICAL: 0 HIGH: 0



Rank	Secondary	TCA UTC	d (km)	v _{rel} (km s ⁻¹)	Pc	Risk
1	ISS (ZARYA) NORAD 25544	2026-10-21T19:47:56Z	1.4700	7.200	4.627e-6	LOW
2	POISK NORAD 36086	2026-10-22T03:47:56Z	1.6100	7.650	3.857e-6	LOW
3	SZ-21 MODULE NORAD 66515	2026-10-22T11:47:56Z	2.1320	8.100	2.200e-6	LOW
4	CSS (MENGTIAN) NORAD 54216	2026-10-22T19:47:56Z	3.5410	8.550	7.974e-7	LOW

4) Maneuver Plan

Primary: ISS (NAUKA) Secondary: POISK TCA: 2026-10-22 04:35:55 UTC Pc: 3.86e-6

RANK	TYPE	ΔVR (M S ⁻¹)	ΔVT (M S ⁻¹)	ΔVN (M S ⁻¹)	ΔV (M S ⁻¹)	FUEL (KG)	NEW D (KM)	NEW PC
1	★ IN_TRACK (+)	0.000	0.010	0.000	0.010	0.005	1.646	3.69e-6
2	IN_TRACK (-)	0.000	-0.008	0.000	0.008	0.004	1.639	3.72e-6
3	COMBINED	0.000	0.006	0.200	0.200	0.093	1.632	3.76e-6
4	RADIAL	19.121	0.000	0.000	19.121	8.902	1.610	3.86e-6

5) Maneuver verification



*: Within the SPEADIT project, data analysis techniques are used to examine and interpret the heterogeneous dataset, leveraging a formal mathematical representation of both the physical system dynamics and the associated system boundaries [1,2,3,4].

CONCLUSIONS

SPEADIT is a Decision Support System powered by a Digital Twin that integrates multi-domain data to bridge SW and STM analyses. This approach enables continuous monitoring and reliable risk assessment, delivering informed, actionable insights. By adopting Agile development practices, SPEADIT promotes the adoption of best practices while leveraging a reliable AI/ML layer to support decision-making and reduce operator workload.

References:

- [1] Guzzi, R., Data Assimilation: Mathematical Concepts and Instructive Examples. SpringerBriefs in Earth Sciences, 2016
- [2] Hanslmeier, A., The Sun and Space Weather. Astrophysics and Space Science Library, Springer Netherlands, 2008,
- [3] Jones, D., et al, Characterising the Digital Twin: A systematic literature review. CIRP Journal of Manufacturing Science and Technology, Volume 29, Part A, 2020
- [4] Brans, A., & Esposito, G., Governing Space Traffic Management: A Systematic Literature Review. Contemporary Issues in Air and Space Power, 4[1], 2026