Design and Planning of Field Trials for the Integrated Breadboard 3 (IBB3):

Towards the Demonstration of an Integrated Rover System in the SFR Mission Context

ASTRA 2023 Oral Presentation

DEFENCE AND SPACE

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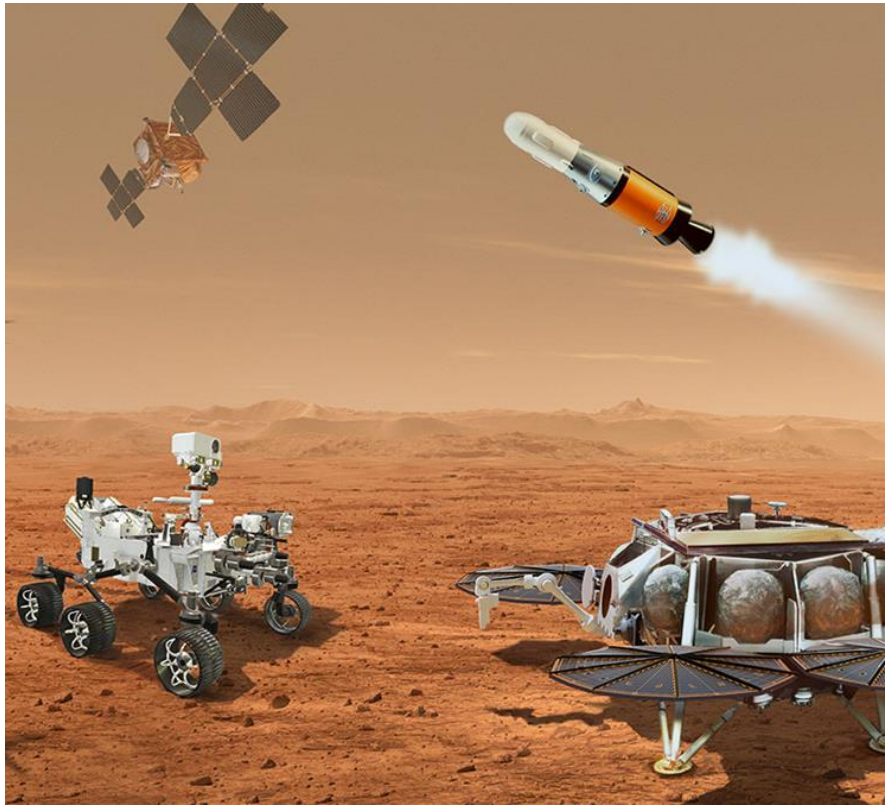
Background & history

Mission Context: Mars Sample Return (MSR)

- Collaboration between the NASA and ESA, with the objective to return samples from the surface of Mars for scientific study on Earth.
- Perseverance is collecting surface samples and leaving some on the surface of Mars for retrieval.
- In the 2018 MSR architecture, the retrieval mission consisted of a lander carrying the Sample Fetch Rover (SFR) and the Mars Ascent Vehicle (MAV).
- SFR should have returned 30 sample from the depot & deliver them to MAV.
- However in 2022, the retrieval part of the campaign underwent major revision
    - Leading to the removal of SFR and termination of its development.

- Despite the SFR mission cancellation ESA elected to continue development of the key technologies with the aim of demonstrating an end to end autonomous traverse and fetch capability

Image credit; https://mars.nasa.gov/msr/#Returns-Samples



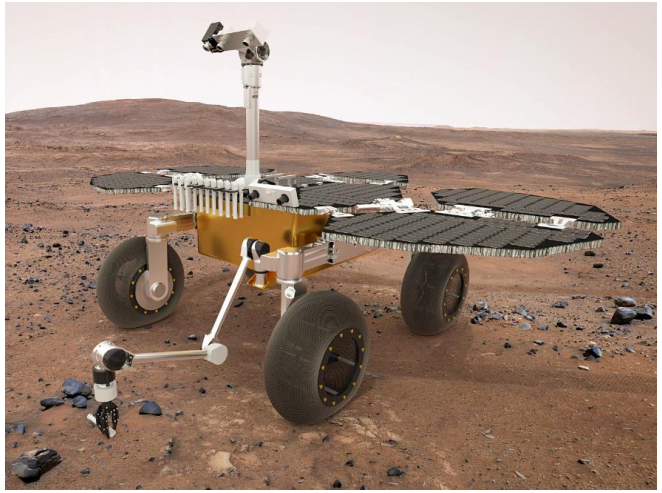


Image credit; Airbus

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Integrated Breadboard 3 (IBB3)

Scope

Starting development in March 2023, trials in September.

The current IBB3 scope has grown from previous BBs:

- RSTA Acquisition System (RAS) integration (mechanical, electrical, SW)
- GNC: Closed loop RelLoc, AGL-D performance with Islands of Data, FOPSA->AutoNav transition, Navigation Corridors
    - **New modes:** Sun Sensing Heading Estimation (SSHE), Efficient Navigation
- Mission Management System (MMS) interface
- Upgraded GNSS solution for ground truth
- Swappable wheels for locomotion subsystem
- Testing:
    - Airbus' Mars Yard
    - Car Park
    - Quarry - Field Trials

Objective

- To perform end-to-end operations with an integrated rover platform working as a mobile manipulator.
- Shall serve to demonstrate rover navigation and robotic arm manipulation capabilities
- Using SFR mission requirements and scenarios as reference.

Rovers at Field Trials

Codi

- the main event for IBB3
- Full formality (test procedures, brief / debrief each day, planned order of use cases).

Charlie

- secondary rover for EffNav development, RFM-R representative locomotion - runs in parallel

Leo

- R&D to extend GNC Rover group’s capabilities

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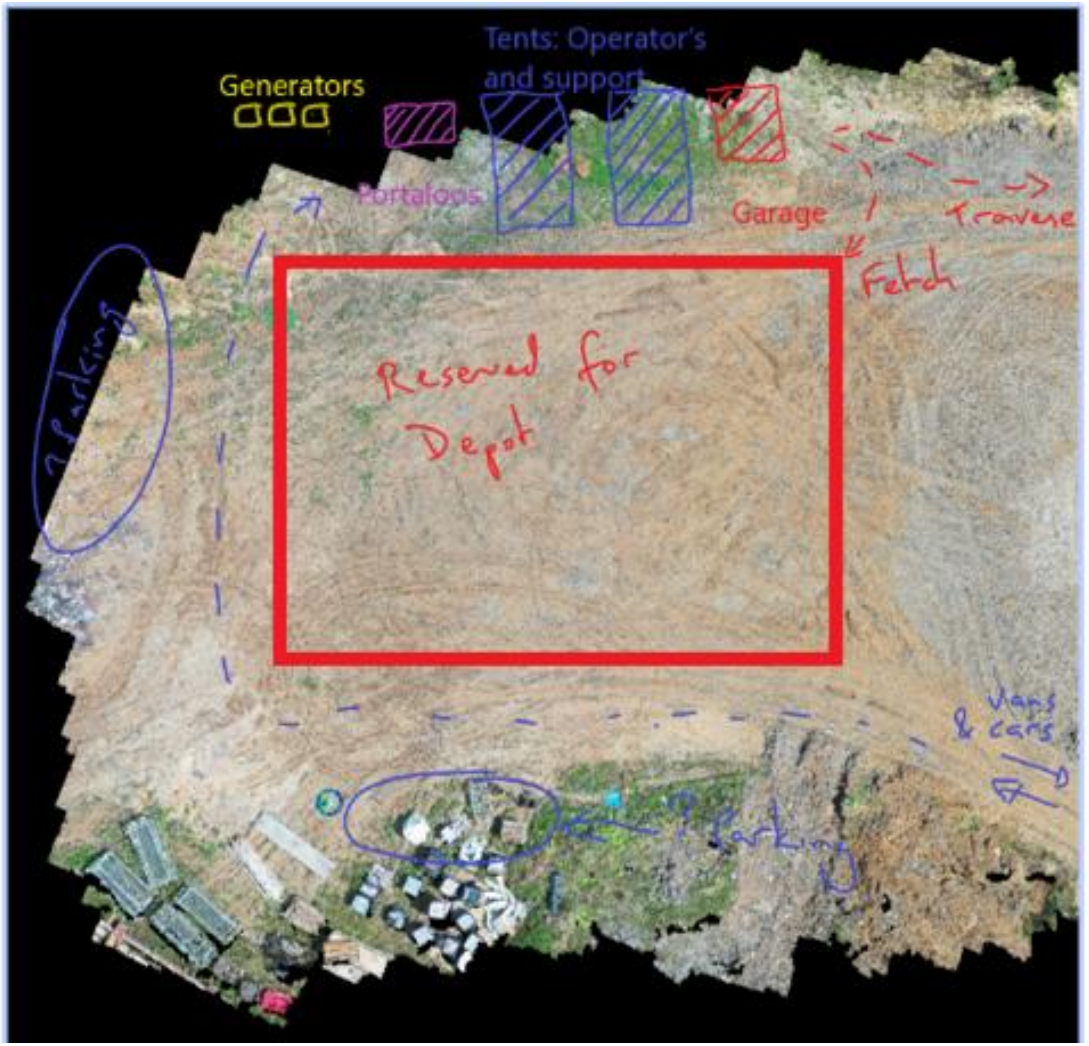
Objectives: Use Cases of IBB3 Field Trials

ID	Use Case	Primary Objectives
UC-1	Long Traverse	Demo long range autonomous traverse
UC-2	Long Traverse Corner Cases	Demo a subset of corner cases behaviours, complementing demonstrations of robustness carried out in simulation.
UC-3	Human Directed Drive	Demo HDD operations
UC-4	Pick-up multiple tubes autonomously	Demo autonomous pickup
UC-5	Tube Pickup Corner Cases	Demo drive to alternative depot
UC-6	Human Directed Pickup	Demo Tube Pickup mixing human directed and autonomous operations for pre-planned HDP
UC-7	Sun Sensing at Various Sun Elevations.	Demo accuracy of sun vector based heading corrections
UC-8	Time Based Operations	Demo time based operations

Base Camp Scouting & Setup



Schedule (we've been lucky with the weather)

Monday 28th	Tuesday 29th	Wednesday 30th	Thursday 31st	Friday 1st
• UK Bank Holiday	• Car park rehearsal	• Car park rehearsal	• Car park rehearsal	• **Finish packing** • **Load van**
Monday 4th	**Tuesday 5th**	**Wednesday 6th**	**Thursday 7th**	**Friday 8th**
• **Transport Codi and Charlie and ec rry** • **Ca** • **St de** • **Dr or AGL-T**	• **Camera calibration (?)** • **Depot setup** • **for** • **tests**	• **UC-1 Long range traverse nominal**	• **UC-7 Sun sensing**	• **UC-4 RSTAs fetching nominal**
Monday 11th	**Tuesday 12th**	**Wednesday 13th**	**Thursday 14th**	**Friday 15th**
• **U**	•	• **UC-2 Tra cases** • ESA • Visit of va	• **U ching c** • E • V	• Con
Monday 18th	**Tuesday 19th**	**Wednesday 20th**	**Thursday 21st**	**Friday 22nd**
•)	• Contingency day Packing	• Continge	• AM: C norning • **PM: S** • **PM: T di and equip o Stevenage**	• **Camp t d clean up** • **Transpo d equipment back to Steve**

Lessons Learned

- Plan ahead, hope for the best but prepare for the worst
- Field trials are complex
  - Shakedown testing is important, you should spend the time
  - Non-linear increase in interfacing and testing effort as the number of SW layers increases
- Have a controlled environment for early phase: Mars Yard - controlled lights, no rain, repeatable conditions
- People who enable and unblock testing: food couriers, generator fixer, volunteer onsite mechanics, rock hoarders, terrain generation specialists, video choreographers, timelapse experts
- 80% of the field trials are enablers
- 20% of it is high pressure tech activity (e.g. finding alternative fixes/debugging)
- Having a robust testing infrastructure, which enables recovery after failures or anomalies
  - Avoid blocking debugging activities on site, the aim of the game is to get the tests completed
- Test the system, not the people - shakedown activities are important

Timelapse Day 9

Fixing while Driving

Life at Field Trials

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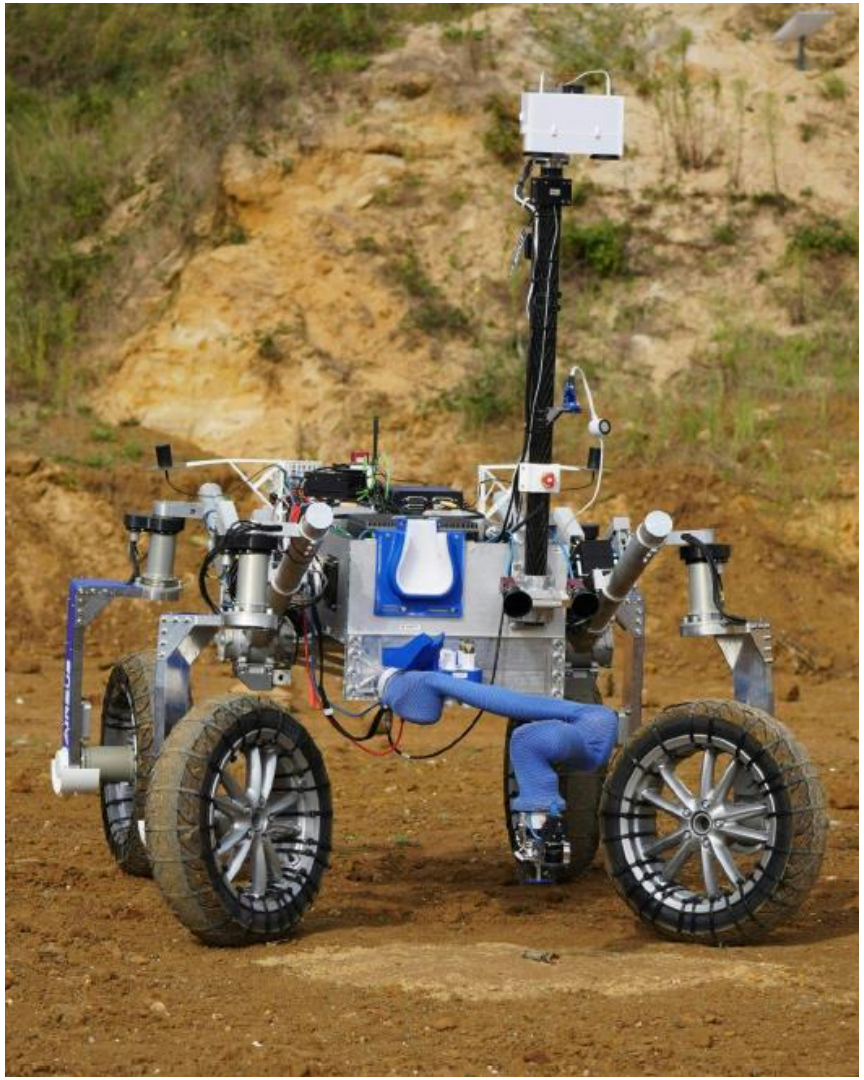
Conclusions, Lessons Learnt, and Next Steps

- Significantly more complex than previous BB activities: e.g. IBB2, including the FTRS, GNC, SW, and location/logistics.
- Demonstrated depot operations, SSHE, AGL-D, SFR-like RSTA pick-up, MMS emulator, OPS layer including integration of Trasys' 3DROCS/ROV tools.
- The IBB3 team has successfully executed all use cases, most with great success → Indicates the robustness and performance of the GNC design
- Key enablers: reliable GT system, and high resolution mapping capabilities, AND great team effort.
- Airbus is building capability for in-field test execution (1 per year)
- Plan for 2024: another set of field trials



Further Material & Acknowledgement

Field trials: https://www.esa.int/ESA_Multimedia/Images/2023/09/Ready_for_collection_lightsabres_for_Mars
(Credit: ESA/Airbus)

V. Schaefer - Integrated Breadboard 3: Rover Capability Evolution Within Sfr Mission Context And Future Planetary Technology Testing Platform, As A Service
P. Weclewski - TRL6 demonstration of the SFR mission Mobility concept on a LEON4 processor
C. Hackett - Reusable Sample Tube Assembly (RSTA) Acquisition System: Pickup and Stowage System Developments in SFR Mission Context

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Q&A