CARRIER FOR RELOCATING ADVANCED FIELD TEST EQUIPMENT AND ROVERS: A FIELD TEST VAN FOR ESA

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ABSTRACT

Planetary robotics research depends on field test campaigns, where researchers and engineers bring not only their robotic assets, but also essential infrastructure, like mobile base control stations and maintenance equipment. This paper highlights the key design drivers, features, and future upgrades of ESA's specialized field testing van CRAFTER, as well as our experience during a test campaign.

1. MOTIVATION

Field test campaigns are an essential part of planetary robotics research. They are a chance to test in outside conditions, which are much more demanding than a laboratory environment. In the field, there is usually a lack of infrastructure to monitor and control the robot, so this needs to be brought to the test site. Previously, we used to rent a van and load the same equipment every time. This is a common approach, especially when field tests are not done regularly. It means however that the infrastructure is not very refined and can be inefficient and uncomfortable to work with (e.g. temporary work spaces, noisy power generators with exhaust fumes, higher likelihood of forgetting something with the need for an extensive packing list). At ESA, we have therefore decided to develop a permanent field test van called CRAFTER (Carrier for Relocating Advanced Field Test Equipment and Rovers), which serves as a mobile mission control center for test campaigns.

2. CONCEPT

Previous field tests drove the definition of functional requirements that would transform the van into a mobile mission control center. Additionally, a CAD drawing was created to visualize the concept. These were handed over to Wittebrug Leiden, a company with experience in the customized outfitting of utility vans. They carried out the final part selection and installation of fixtures. Fig. 1 shows the van with deployed equipment in the outfitting company's yard. Afterwards, the outfitting was completed internally with the procurement of tools and installation of network equipment.

Figure 1: CRAFTER at the outfitting company Wittebrug in Leiden

Figure 2: CAD drawing of CRAFTER used to visualize the concept to the outfitting company

3. EQUIPMENT AND FEATURES

This section presents the essential equipment and features of our field test van, which greatly enhance our testing experience and efficiency.
The most prominent features are the following:

- 4x4 drive with all-terrain tires (Fig. 3a),
- two workspaces, each with a foldable desk, two screens, a laptop docking station (for power, screens, Ethernet) and additional power outlets (Fig. 3c),
- 230 V on-board power system (12.8 V / 200 Ah battery, 2400 W inverter) with solar power,
- 4G LTE router with integrated Ethernet switch, and
- outside outlets for charging, power and a cable feed-through (for Ethernet or antenna cables) (Fig. 3f)

Working outside the confines of the van is at times necessary. This is the case if we are working on larger rovers that do not fit inside the van while deployed, calibration procedures may have to be conducted on the ground, or in case the desk space inside does not suffice for the amount of parallel tasks at hand. For this reason, the CRAFTER features

- a retractable awning for a shaded and dry work area outside and
- camping desk and chairs.

Storage is addressed by

- a large shelf with drawers for tools and safe storage for boxes while driving (Fig. 3b) and
- overhead lockers for storage of additional equipment and network infrastructure (Fig. 3e).

During the Bardenas field test, we relied on the Martian Rover Testbed for Autonomy (MaRTA) [1] to host all ground-based sensors. This rover is relatively compact and light-weight such that it can easily be loaded into and unloaded from the van by two people. For our section's larger and heavier rovers, however, this is not the case. Instead, we have included ramps which are stored and secured on the inside of the rear doors. This design minimizes space usage and ensures that the ramps are always available. Both the Interact rover [4, 5] and the Heavy Duty Planetary Rover (HDPR) [3] can climb the ramps by themselves for transport to relevant test sites.
Other amenities include a cooler for cold drinks. Since analogue sites tend to be in deserts, this is not negligible. Of course, no robotic test setup is complete without a fire extinguisher rated for electrical fires, which is why we always have one within reach, positioned next to the large sliding door for quick and easy access.

(a) All-terrain tires for better off-road traction

(b) Shelf with drawers, tool boxes, and cooler

(c) Workspace with foldable desk and screens

(d) Side view into CRAFTER work area

(e) Overhead lockers for storage of equipment

(f) Outlets for power and cable feed-through

Figure 3: CRAFTER equipment and features

4. POWER AUTONOMY

One of the main benefits of CRAFTER is its power autonomy. Through a state-of-the-art power management system, installed under the passenger seat, it provides a 230 V power system to use regular electronic equipment and provides enough power for a full day of use in the field.
Power is provided by a 12.8 V DC, 200 Ah Li-ion battery, which is converted to 230 V AC by a Victron MultiPlus inverter rated at 2400 W. With an estimated inverter efficiency of 90 percent and a maximum depth of discharge of 80 percent, this means the system can provide 216 W for 8 h of use, enough to run two laptops, four screens and network equipment continuously.
The system can be charged by three different means: (1) Through the car alternator while the motor is running, (2) connected to the regular power grid while parked, and (3) through a solar panel. The solar panel (Fig. 4b) extends the autonomy of the van and is the most environmentally friendly way to provide extra power and recharge the battery. Depending on the weather, time of day and positioning of the van towards the sun, the panel provides up to 80 W. Additionally, it allows the system to recharge and stay topped-up while parked for longer periods of time.
A monitoring panel in the rear of the van (Fig. 4c) shows the system's state of charge, battery voltage, current draw and estimated remaining time of use.

5. EXPERIENCE IN THE FIELD

We used the van extensively during a field test campaign in the semi-desert of Bardenas Reales in Spain in

(a) Power management system with Li-ion battery, solar charger, and inverter (below)

(b) Solar panel on the roof of the van

(c) Monitoring panel

Figure 4: Power system components

July 2023 [2]. This was a remote location, with no access to the power grid during the day and adverse environmental conditions.

The van enabled us to control and monitor the rover while being sheltered from sun and wind, as well as to charge our equipment. It also provided access to the Internet and even cold drinks. The van provided a productive working environment, in which up to four people could work comfortably. Thanks to its storage and fixed installations we could set up and tear down within less than 30 minutes. Because every tool was in a well defined place, there was no need to browse through boxes.

During the tests, the rover was driven through terrain that was inaccessible for road vehicles, so the van had to be stationed up to 200 m away. To connect to the rover, a dedicated setup with Ubiquiti Bullet AC 2.4 GHz WiFi radios was used, together with an extender made up of two additional Bullets (one receiver, one transmitter), which were placed at strategic locations in the field to maintain line of sight. The extender was powered by a power bank and Power over Ethernet (PoE).

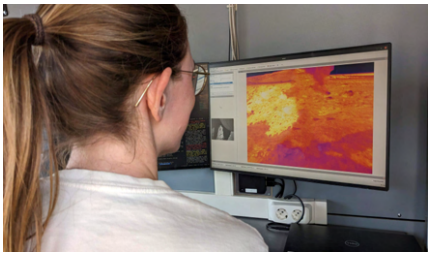
With the van's power system, we were able to work off the grid for more than a full working day, without the need for noisy and less eco-friendly generators. Instead of the solar panel on the roof, which was noticed to be broken shortly before the field test, we had to use a substitute panel that was placed next to the van (Fig. 5e), with the advantage that we could orient it towards the sun over the course of the day. It was another item to set up and store though, which can only be recommended as a temporary workaround.

Because there were no power outlets available at the hotel parking, we were not able to charge the van overnight. The relatively short drive to and from the test area (ca. 20 min one way) only charged the battery by around

(a) The van in Bardenas Reales

(b) MaRTA rover in the back

(c) Recording datasets



(d) Thermal camera monitoring

(e) Substitute solar panel

Figure 5: CRAFTER in the field

20 percentage points. Thus, we were depleting the battery over the course of the field test and were forced to idle the van in the field to recharge. We will therefore upgrade the van with more solar panels to extend its autonomy even further.

6. FUTURE UPGRADES

Based on the experience gained in the Bardenas field test, we are planning to upgrade CRAFTER with the following additional features:

- Seven additional solar panels on the roof, for extended power autonomy
- A 5G industrial router, to increase connection speed and reception in areas with poor signal
- 12 V outlets for low-voltage devices, to avoid transformation losses
- A compact 3D printer, for quick repairs in the field
- Bins for waste collection and holders for personal items

The last item may seem benign at first glance, but those small things quickly add up and affect for example where tools are placed, and contribute to a tidy and organized work environment. Especially during field trials, it is crucial to minimize clutter as much as possible.

7. CONCLUSION

The objective of the project was the conversion of a transport van to a mobile mission control center for test campaigns. CRAFTER was put to first use in a field test in a semi-desert and proved highly useful in terms of working efficiency and comfort for the participants. It was a significant improvement over a setup with a rental van with gazebo and generator. Future upgrades will improve the power autonomy, the Internet reception and the mechanical repair capabilities. Also, we are exploring options to make CRAFTER available to other ESA activities for use in their test campaigns.

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