ExoFiT: ExoMars-Like Field Trials – a Mission Simulation

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ExoFiT: ExoMars-Like Field Trials – a Mission Simulation. A. Hall[1], B. Dobke[1], M. Lisle[1], M. Shilton[1], E. Allouis[1], , L. Waugh[1], J. Carroll[1]; G. Doignon[1]; M. Azkarate[2], M. van Winnendael[2], L. Duvet[2], D. Martin[2], J. Delfa[2], J. Vago[2]; S. P. Schwenzer[3], M. Balme[3], P. Fawdon[3], S. Turner[3], C. Bedford[3]; H. Sargeant[3]; D. Pegg[3], M. Mirino[3], T. Barrett[3], A. Ladegaard[4], F. Rull[5], M. Veneranda[5], T. Bontognali[6], T. Josset[6], J.-L. Josset[6], M. Josset[6], V. Ciarletti[7], D. Plettemeier[8], A. Le Gall[7], Y. Hervé[7], C. Corbel[7], A-J. Vieau[7], N. R. Oudart[7], V. Trainer[7], V. Ciarletti[7], W-S. Benedix[8], S. Hegler[8], W.-S. Henedix[8], D. Plettemeier[8], G. Lopez[9], J. Saiz[9], L. Preston[10], C. Cousins[11], E. Allender[11], S. Banham[12], R.Barnes[12], G. Northwood-Smith[12], K. Sangwan[12], P. Grindrod[13], J. Davis[13]; S. Motaghian[13]; Z. Dickeson[13]; S. Boazman[13]; C. Schröder[14], E. Hauber[15]; N. Schmitz[15], A. Parkes-Bowen[16], R. Bahir[17]; R. Barcenilla[18], C. Leff[19], D. Persaud[19], A. Coates[19], A. Griffiths[19], R. Stabbins[19], E. Bohacek[19], N. Kuhn[20], F. Westall[21].
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Introduction: The success of rover operations critically depends on the versatility of the operation team to efficiently conduct the mission while managing the respective constraints arising from the engineering and science activities. As such, it must work in an efficient manner to operate the hardware, negotiate and agree on plans to achieve the mission objectives, while managing the status of the rover (health, data volume, power constraints), maximising science opportunities, and managing the challenges of the site under investigation. To train for those conditions – and at the same time to test critical instrument and hardware components, space agencies regularly hold field trials. Here, we focus on the ExoMars-Like Field Trial (ExoFiT), a series of realistic mission simulations based on the ESA ExoMars rover mission slated to be launched in 2020. The mission will carry a suite of instruments to carry out its mission objectives focused on geological and exobiological research [1].

The ExoMars rover – recently named Rosalind Franklin [2] – is planned for landing at Oxia Planum, Mars [3], a site at which orbital investigations have revealed a wide range of clay minerals [4], and which recently has been interpreted as a fluvial catchment area [5]. The ExoMars rover will be equipped with a wide range of instruments ranging from cameras (PanCam, CLUPI), spectrometers (ISEM, Ma-MISS; MicroOmega, RLS Raman Spectrometer), two instruments for the investigation of the subsurface (WISDOM, Adron) and the mass spectrometer MOMA as well as the capability to drill up to 2 m deep.

Trials prior to ExoFiT: Leading up to the ExoFiT trials were a series of engineering and operations trials, of which SEEKER [6], SAFER [7] and MURFI [8] are mentioned here. SEEKER and SAFER were carried out in the Atacama desert (Paranal, Chile), in an area close to the ExoFiT site, and MURFI near Hanksville, Utah (USA). SEEKER's objectives were to demonstrate long range autonomous navigation capabilities, reaching over 5 km of distance in one day [6]. SAFER was focused on remote operations with a remote control team, who operated the rover platform 'Bridget' [7]. MURFI was a trial organised by the UK Space agency together with the sample return trial of the Canadian Space agency [8].

ExoFiT: ExoFiT is an ESA funded, AIRBUS led field trial activity, carried out in two different 'missions' of two weeks each.

Fig. 1. Charlie on its way onto the landing platform in the Tabernas (Spain). PanCam is mounted on the mast, the drill box also containing CLUPI visible at the front and WISDOM at the back of the rover.

Set-up: ExoFiT uses the 'Charlie' rover (Fig. 1) built by AIRBUS based on a Bluebotics rover platform, as well as a lander mockup. The rover is equipped with representative ExoMars GNC navigation, the capability for wheel walking, and instrument payloads. Both trials simulated rover operations on Mars through a remote control team located at Harwell (RCC). The RCC team performed the rover planning on the basis of 'orbital' information at the resolution realistic for Mars missions and the data generated by the rover. For this, they analysed all available images and data and created DEMs. The planning was divided into long-term and sol-by-sol planning. For each sol a plan was delivered to the field team (LCC). LCC set up the site, produced the 'orbital' image by acquiring an image mosaic with a drone, maintained the hardware and executed the commands sent to the rover platform in the RCC sol plans. Unlike other field trials, ExoFiT was the first to have a full scale landing platform in the field that could be used to simulate the full egress and cross-commissioning process. This also provided the RCC with the unique vantage point from which to perform longer term tactical planning.

Instruments: The rover Charlie was equipped with a range of ExoMars instruments or emulations thereof to make for a realistic experience in the RCC:

- CLUPI imager, provided by Space-X
- an emulator of the ISEM IR spectrometer, provided by Aberystwyth University
- the AUPE-3 PanCam emulator provided by Aberystwyth University
- the WISDOM ground penetrating radar provided by LATMOS

A COTS drill was used to acquire subsurface samples, however it was not accommodated on the rover.

The following payloads were used in a dedicated tent in the field to analyse samples:

- MOMA, provided by MPI für Sonnensystemforschung
- RLS, provided by Universidad de Valladolid/CAB.

Aims during simulation: The aims of ExoFiT are to egress from the lander safely, navigate away from the area of potential rocket fuel contamination, check the instruments and conduct the investigation of the area. The 'reference mission' is to find, approach and drill an outcrop identified by the science team as being of key scientific interest. To support the science, the optical payloads and the ground penetrating instruments are used to characterize the geomorphology at and below the surface, and the spectral instruments are used to gain insight into the mineralogy. Once a sample is drilled, it will be imaged by CLUPI and investigated by RLS.

Field test 1 (Tabernas, Spain). The first two-week trial was carried out in the Tabernas desert in Spain, ~7 km straight line distance SW of the village of Tabernas. An area was chosen which is comprised of a sedimentary sequence of sedimentary rocks and shows a wide range of geomorphological and mineralogical features typical for clay-rich desert surfaces. This includes erosional features, mud cracks and salt efflorescence.

Field test 2 (Atacama, Chile). The second two week trial was carried out in the Atacama desert, about 11 km W of the Paranal observatory. This site is comprised of very dry desert pavement made of gravel and boulders, interspersed with finer grained, coarse sand patches that can reach a considerable depth. The boulders are made of the diorite found in the area and can be seen in large concentrated boulder fields, which are likely linked to surface outcrop. Of exobiological interest are mainly clays and salts crusts.

Conclusions: At the time of writing, the second trial is still ongoing. The first field trial in the Tabernas demonstrated the challenges of being outside of a laboratory environment at the mercy of the elements. As such, the remnant of a tropical storm passed the area with high levels of rainfall, highly untypical for the area, preventing the team from performing the planned shake-down and site set-up activities. However, for the Tabernas, a successful egress was performed into a region with multiple, and obvious features for the RCC team to survey. While unseasonably wet at times, the RCC team successfully navigated the rover to an outcrop, performing GPR soundings, and extracted multiple core samples for CLUPI imaging and Raman analysis. The second ExoFiT trial aims to go beyond this, by traversing larger distances in a more representative environment, performing further egress and cross-commissioning tasks, and testing wheel walking techniques that could be used to help in difficult mobility scenarios on Mars.

In the Tabernas, the RCC team successfully found and characterized the most prominent outcrop in the area. The approach was through image investigation and WISDOM sounding, although the latter was compromised by the wetness of the underground. Subsurface coring was carried out and the core successfully characterised. The second trial is ongoing at the time of writing, but has already traversed over 70 m through a complex, boulder-strewn terrain. The RCC team found a target of interest despite the fact that the trial is set in an area, which gives very little visual clues of those areas from a distance, a realistic scenario at any Martian landing site.

Both trials offered a wide range of experience in remote operations, critical insight into constraints and opportunities of operations in a complex, natural environment, and for operations of the specific payload of the ExoMars rover in preparation for the 2021 landing.

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