EXOKITE, DESIGN OF AN AERIAL DECISION-SUPPORT PLATFORM IN A MARTIAN INHABITED SPACE EXPLORATION CONTEXT A. Tavernier[1], M. Demarzo[2], G. Pinto[3,4], C. Ulloa[1], A. Garcia[1] and B. H. Foing[5,6,7]

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Introduction : Recent years have seen an increase in the number of implementation of space analogue habitat in order to prepare for future manned space missions to the Moon and Mars [1]. These analogues habitats are associated to field-work simulations carried out in terrestrial environments similar to the martian and lunar ones. These simulations aim to better understand the technical, scientific, logistical, organizational and socio-medical constraints inherent in a perennial human settlement beyond Earth [2,3,4].

The EuroMoonMars program [5], by associating students, researchers and young professionals, places itself, on a participative mode, in a perspective of a better knowledge of these stakes of this new era of space exploration. In this context, the ExoKite project, aims to set up an aerial decision support-platform that can be deployed on Mars and facilitate scientific and technical field work. This aerial decision support-platform would enable a mobile advanced operational center to i) track (i.e visualize and locate) and ii) coordinate (i.e communicate) in near real time the deployment, in the field, of scientific protocols made by humans or robots.

The goal of this project would be to involve scientists, students and young professionals around an engineering project with applications in the field of space exploration.

Methodology : The implementation will follow the one use for kite aerial photography [6]. The effort will be devoted to simulations, field tests of the platform and to the development of information processing procedures. The field campaigns, planned to be organized in the Atacama Desert and the surrounding dry Central Andes (Puna), known as a potential analogue of Mars [7], will also provide an opportunity to compile an exhaustive list of sites of interest in the region with a view to develop future activities in planetary sciences or astrobiology and, in a longer term, to build a martian-analogue base in this region of Chile through the launch of a EuroMoonMars Atacama section (ChileMoonMars).

Five tasks will be privileged during this work :

1. *The development of the instrumental gondola and the choice of the best suited aircraft through Computer-Aided Design (CAD) and Computational Fluid Dynamics (CFD) simulations*

2. *The development of the data acquisition and processing chain*

3. *The test, on the field, of the aircraft, the instrumental gondola and the acquisition chain*

4. *The elaboration of a field campaign scenario*

5. *The implementation of the scenario on the field*

Task 1 will focus on aerodynamical (lift, drift & flight stability) and mechanical stress constraints simulations (CAD & CFD) to give an overview of the best-suited aircraft (tethered balloon, kite-balloon or kite) & tether structure and cable. Through these simulations it will be also possible to optimize the design of the different elements of this platform according to the Puna [8] and martian atmospheric conditions [9, 10]. A comparison with the use of drones would be done, especially in terms of flight stability under windy conditions.

For the gondola, the on-board instruments would be at first :

- *digital cameras (**visualization**)*
- *a radio repetitor (**communication**)*
- *a location system (**localization**)*

And following the implementation of a tethered balloon done in [11] :

- *a series of sensors to know the aircraft and platform status*
- *energy supply, data controller and wireless data transmission system between the kite and the ground*

This instrumental gondola will be suspended on the tether with a Picavet suspension. The ground equipment would consist of a winch and a cable (tether), a ballasted system allowing the aircraft to

be quickly installed & uninstalled and eventually a computer station for visualizing the data in near real time. All this Task 1 will be done in a space mission fashion way [12, 13].

Task 2 will allow the development of data processing procedures making the data usable in real time in an operational context. Priority will be given to the development to :

- *the on-board data processing and remote transmission on the ground*
- *an image processing algorithm including photogrammetry in order to get, locally, a Digital Elevation Model (DEM) [14]*
- *an adaptation of the Longley-Rice radio propagation modeling enabling to estimate, in near real time the radio coverage of a given radio network [15, 16, 17, 18]*
- *a local georeferencing and navigation model, centered on the aircraft and using GPS transceivers [19, 20, 21]*

Task 3 will involved equipment tests, on the field, of the most promising aircraft(s), intrumental gondola and equipment choosen and designed through Task 1. These tests in real conditions, associated for comparison with drone flights, will be carried out, in the Puna on a few predefined sites of logistical and scientific interest chosen like in a space mission landed-site scheduling [22]. The data collected will be used to refine the protocols and information processing chains (Task 2) in order to develop a coherent scenario to quantify the added value of using this decision support platform (***Task 4***). This scenario should follow a pattern where two different teams would carry out the same exploratory fieldwork in a martian planetary context. One team would benefit from the contribution of the decision support platform, the other would not. Performance indicators will have to be developed upstream in order to compare the two field campaigns drawing on works that have sought to evaluate analog field campaigns [23]. This scenario would be carried out in an educational framework with the participation of students from the Atacama region and the EuroMoonMars program.

Task 5 would be the realization of an analogue field campaign to set up the scenario

Conclusion : this ExoKite project set up within the EuroMoonMars program aims to federate young professionals around a multidisciplinary technical project oriented towards the design of an aerial decision-support platform for the simulation of scientific field campaigns in a martian analogue context. This technical and technological project is more generally placed in the perspective of installing several scientific accommodations at high-altitude in the Puna de Atacama [24], first steps to implement an analog martian base in the region.

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References: [1] Schlacht, I. L. et al. (2016) 46th International Conference on Environmental Systems. [2] Binsted, K. et al. (2010). *Planetary and Space Science*, *58*(7-8), 994-1006. [3] Groemer, G. et al. (2014) *Astrobiology*, *14*(5), 360-376. [4] Lim, D. S. et al. (2019*Astrobiology*, *19*(3), 245-259. [5] Foing, B. (2020) p. EPSC2020-14. [6] Aber, J. S. et al. (2019) Academic Press. [7] Preston, L. J., & Dartnell, L. R. (2014) *International Journal of Astrobiology*, *13*(1), 81-98. [8] Schween, J. H. et al. (2020) *Global and Planetary Change*, *184*, 103034. [9] Hess, S. L. et al. (1977) *Journal of Geophysical Research*, *82*(28), 4559-4574. [10] Murphy, J. R. et al. (1990). *Journal of Geophysical Research: Solid Earth*, *95*(B9), 14555-14576. [11] Coulombe-Pontbriand, P. (2005) (Doctoral dissertation, McGill University). [12] Wertz, J. R. et al. (2011) Microcosm Press. [13] Macdonald, M. et al. (2014) Springer. [14] Linder, W. (2016) Berlin: Springer. [15] Longley, A. G. (1968) Institute for Telecommunication Sciences Vol. 67. [16] Hufford, G et al. (1982). US Department of Commerce, National Telecommunications and Information Administration. [17] Foore, L., & Ida, N. (2007). [18] Chukkala, V. et al. (2005) *Computer Networks*, *47*(5), 751-763. [19] Stone, J. M. et al. (1999) *Proceedings of the 1999 Institute of Navigation National Technical Meeting, San Diego, CA*. [20] LeMaster, E. A. , & Rock, S. M. (2003) *Autonomous Robots*, *14*(2-3), 209-224. [21] LeMaster, E. A., & Rock, S. M. (2000) *Proceedings of the Institute of Navigation GPS-2000 Conference, Salt Lake City, UT* (pp. 1046-1055). [22] Grant, J. A., et al. (2011) *Planetary and Space Science*, *59*(11-12), 1114-1127.[23] Gruber, S. et al. (2020) *Astrobiology*. [24] Tavernier, A. et al. (2020) Boletín de la Asociación Argentina de Astronomía, vol. 61C, p.100