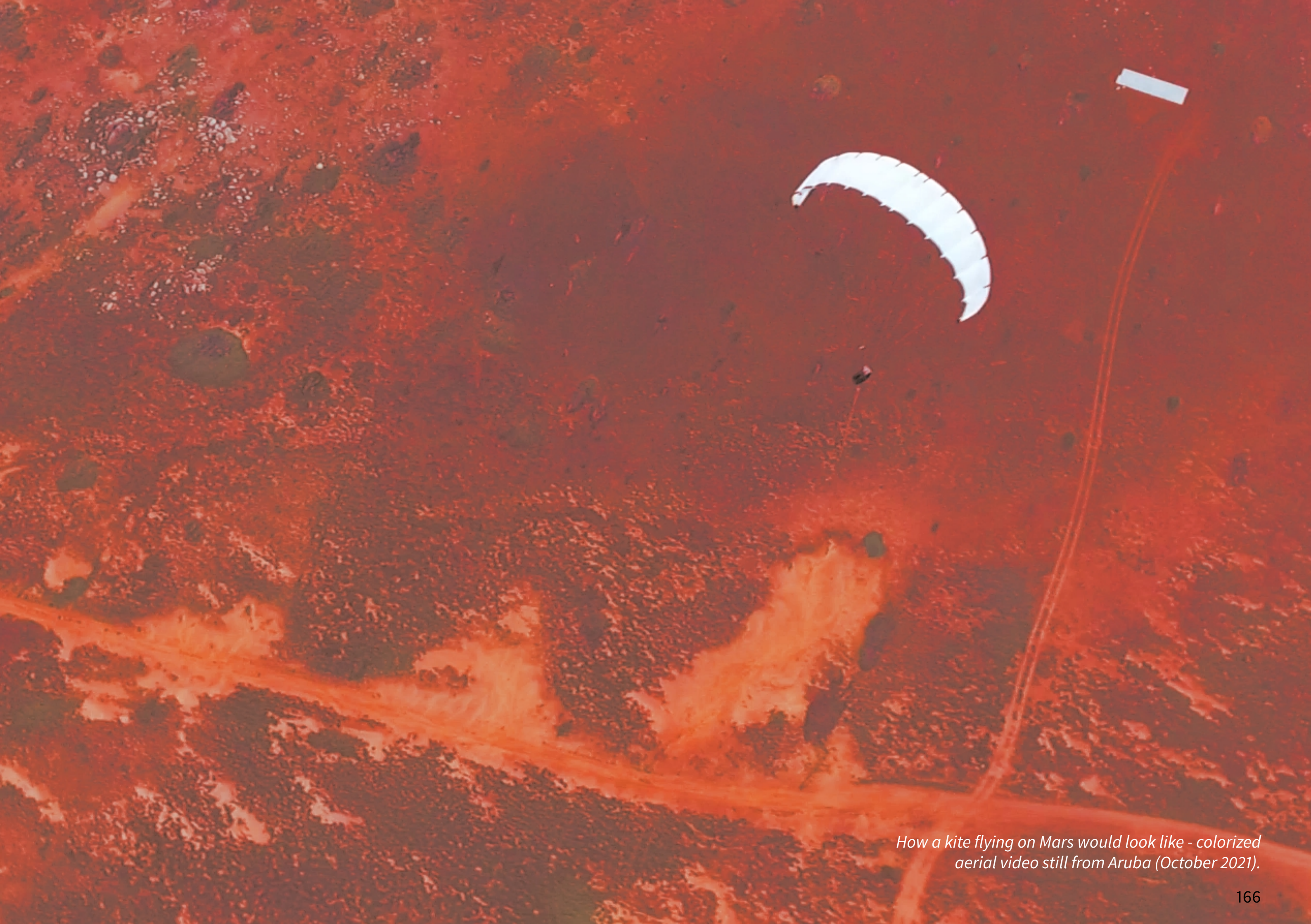

How a kite flying on Mars would look like - colorized aerial video still from Aruba (October 2021).

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Design of an Airborne Wind Energy System for Mars Habitats

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Renewable energy for a Mars habitat is a technological challenge. Resources such as solar and wind are weaker than on Earth because the atmosphere is 70 times less dense, solar irradiation is roughly half and global dust storms can sometimes render photovoltaic (PV) panels useless for months. The requirements on reliability and robustness are demand- ing. Martian gravity is a third of that on Earth. It is crucial to combine resources for an effective renewable energy solution. Wind and solar resources are complimentary and result in a more consistent power supply. Batteries are used to store excess energy for periods of exceptionally low energy production. Airborne wind energy (AWE) was selected as a solution because of its low mass-to-wing-surface-area ratio, compact packing volume, and high capacity factor which enables it to endure strong dust storms in an airborne parking mode. This work investigates the feasibility of a pumping kite power system in combination with solar PV modules to power the construction as well as the subsequent use of a Mars habitat. A scaling study assesses how AWE on Mars differs from that on Earth, performing dimensional analysis.

The present study builds on an earlier design project for a 10-kW Mars habitat [1]. The Luchsinger model [2] and the higher fidelity quasi-steady model (QSM) [3] are used to simulate the performance of the AWE system located North of Arsia Mons at the Tharsis bulge. The QSM is used for validation and also allows accounting for the mass of airborne system components. Due to the lack of in situ observations of meteorological data, the Mars Climate Database (MCD) is used to retrieve wind data and Weibull probability distribution functions. The MCD is based on numerical simulations of the Martian atmosphere using a General Circulation Model and validated with available observational data. Seasonal vertical wind profiles are generated from the meteorological data. An optimiser wrapper around the QSM is used to refine the free parameters of the pumping cycle operation to maximize energy production for the determined wind profiles.

To meet the requirement of 10 kW continuous power supply to the habitat for each Martian day, throughout the year, the AWE system is combined with solar PV and battery storage. The performance model is used to size the different components. The study shows how AWE can be used in combination with solar PV to provide a stable renewable energy supply to a habitat on Mars. This is similar to remote off-grid solutions on Earth, with the additional challenge of having lower resource availability, both for wind and solar.

References:

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