RADIOSONDES FOR CHARACTERIZING THE MARTIAN ATMOSPHERE. D. M. Schumacher[1], D. J. Dorney[1], M. A. McGrath[1] [1]NASA MSFC, MSFC, AL 35812 daniel.j.dorney@nasa.gov

Introduction: The National Weather Service (NWS) releases approximately 75,000 radiosondes each year to measure pressure, altitude, temperature, relative humidity, wind and cosmic radiation [1]. The data obtained from these measurements have led to a more thorough understanding of the Earth's lower atmosphere. On the contrary, there have been only six fully successful landings on Mars, and there is much less known about the variations in winds, density, etc., in the mid-regions of the Martian atmosphere (see Fig. 1). This data is vital to understanding Martian weather and the development of Mars landers for larger payloads [2,3,4]. Mars has too much atmosphere to land like is done on the moon, and too little atmosphere to land like is done on Earth. It is suggested that radiosondes could be added as secondary payloads on Mars missions and used to map physical properties in the different regions of the Martian atmosphere.

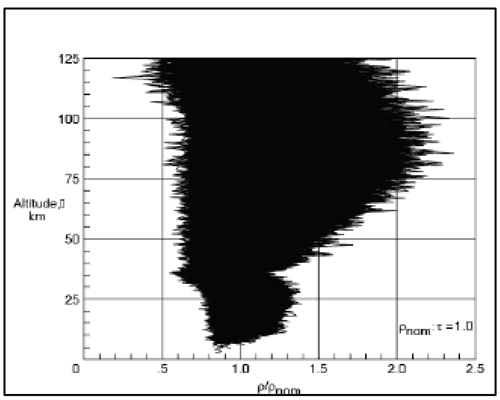

Figure 1. Mars Atmospheric Density Uncertainty, Ref [2].

Radiosondes: Typical terrestrial radiosonde flights last two hours, reach altitudes of 35 km and encounter temperatures as cold as -90° C. The balloons are usually made of rubber or latex and can weigh from 0.1 to 3 kg. The thickness of the balloon dictates the altitude it can reach before bursting. The weight of a typical radiosonde is less than 250 g (8.8 oz). The Graw DFM-09 radiosonde (see Fig. 2), for example, weighs less than 90 g (3.2 oz), is 200 mm x 42 mm x 60 mm (~7.9 in x 1.7 in x 2.4 in) and measures the atmospheric profile of pressure, temperature, humidity, wind speed, and wind direction [6]. The shelf storage life of the dry lithium battery is several years. Helium or hydrogen filled balloons are normally used for terrestrial radiosonde applications. The Martian atmosphere consists of 95% carbon dioxide and is much thinner than that around the Earth. Although gaseous methane would be a desirable choice because it aligns with many proposals for in-situ methane production and is used by some propulsion systems, it does not provide sufficient buoyancy without using excessively large balloons. Therefore, helium is the likely choice for the balloons.

Figure 2. Graw DFM-09 radiosonde (Ref 6).

Mars Radiosondes: Conservatively, the mass of each landed system (radiosonde, balloon, tether, helium, gas tank and accessories) would be approximately 15 kg. The mass of the launched balloon system (radiosonde, balloon, helium and tether) would be approximately 4.5 kg and require an 8 m diameter balloon. As a secondary payload, a mission might carry a total of 3 balloon systems (45 kg total). The balloons could be released either at different times of the day/month/year or, if combined with a rover, could be released from different locations. Once released, the balloons would rise up to 5 km and would record temperature, density, altitude, wind speed and radiation. Alternately, if only two balloon systems were carried (each weighing 22.5 kg), the balloons could be made thicker. This would allow more expansion and higher altitudes would be obtained. The data recorded during ascent could be relayed through ground assets, or directly to orbiting assets. Position could be determined through ground and/or orbiting assets.

The balloons would like be made of a mylar film material. The mylar can be coated with another material (e.g., silicone, aluminum, etc.) for extra strength, which may be needed in the abrasive (dust-filled) Martian environment.

The footprint of each landed system is estimated to be roughly 0.3-0.4 m^3, depending on the final size and thickness of the balloon. The systems could be carried on the bus of a lander or rover similar to those flown in the past, or could be landed independently of the lander/rover. In this way the systems could be dropped around the planet to increase spatial resolution. Note, however, that if the systems are landed independently then additional mass would be necessary for landing systems.

The cost of the radiosondes could be minimized by leveraging off the production of the components used by the NWS. The temperature on Mars can reach a high of about 20 degrees Celsius at noon, at the equator in the summer, and a low of about -153 degrees Celsius at the poles. In the mid-latitudes, the average temperature would be about -50 degrees Celsius with a night-time minimum of -60 degrees Celsius and a summer midday maximum of about 0 degrees Celsius. Thus, the temperatures in the mid-latitudes fall within the qualification levels of current NWS components, while the low temperatures at the poles may require further qualification of existing components. The radiation levels on Mars, as measured by the Mars Radiation Experiment (MARIE) on the Odyssey spacecraft is approximately 2.5 times higher than on the International Space Station (about 100-200 mSv/a). Levels at the Martian surface might be closer to the level at the ISS due to atmospheric shielding, but still above the levels encountered by terrestrial radiosondes. Thus, additional hardening of the components may be required.

Conclusions: Characterizing the atmosphere of Mars is a critical priority in preparing for human exploration as outlined in the MEPAG goals and the Strategic Knowledge Gaps documents. A program for vertically mapping the Martian atmosphere could be accomplished by leveraging the large number of terrestrial radiosondes launched each year. Radiosondes could be added as secondary payloads on upcoming Mars missions, and the data used to improve atmospheric distribution models, weather prediction models and large-mass lander designs.

References:

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