Novel and Effective Applications of Non-invasive Electrophysiology of Astronauts' Resting state and Sleep (NEA²RS)

European Space Agency

AAI Scientific Cultural Services Ltd, Nicosia, Cyprus

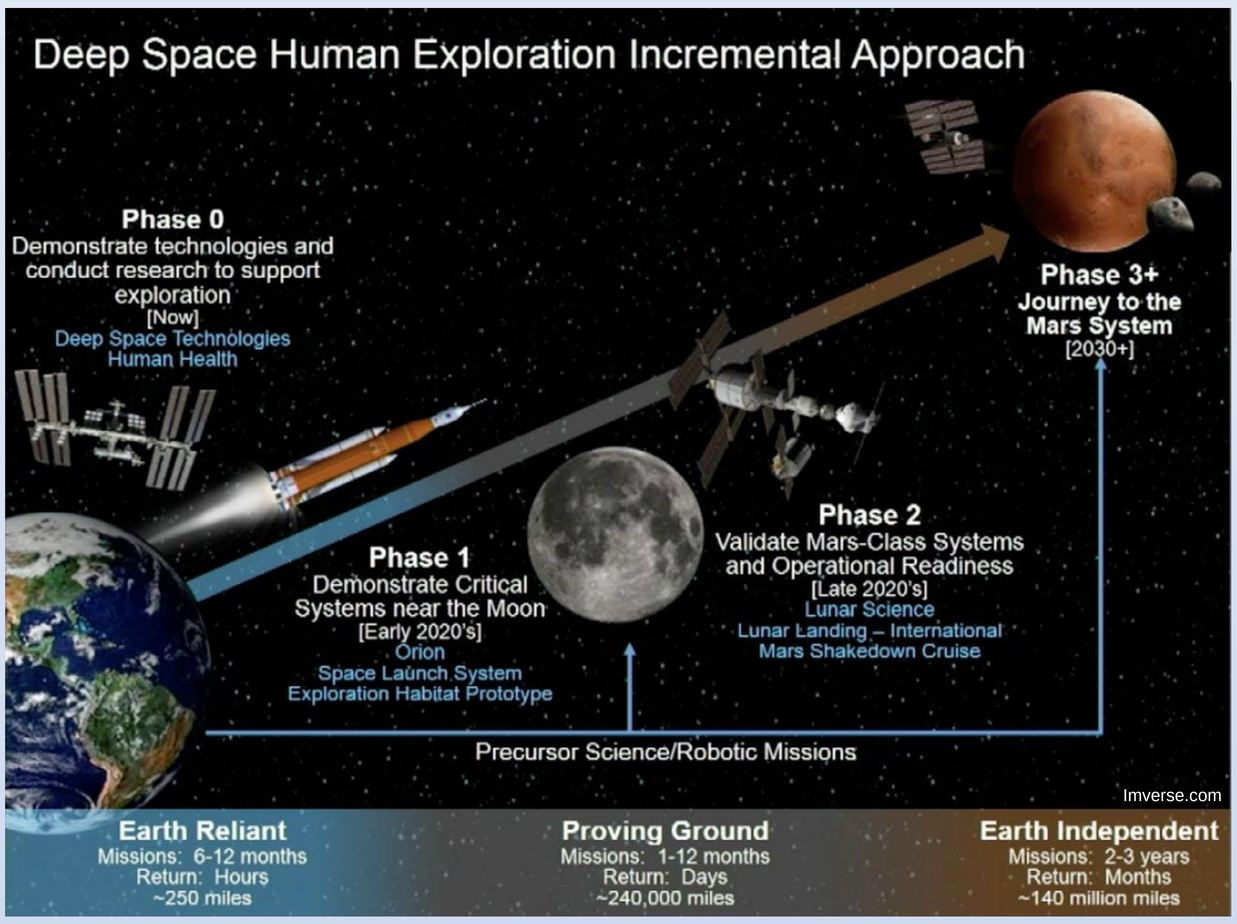

Figure 1: Human planet exploration is a technical challenge, which is likely to be tackled in an incremental approach to minimize the huge risks involved.

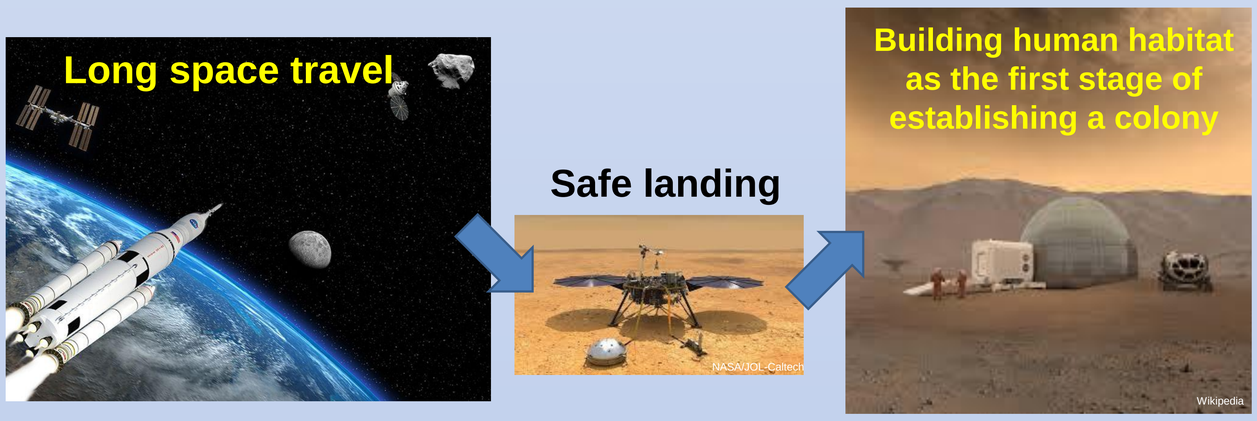

Figure 2: Even after all technical problems are solved, and all concerns about the physical safety of astronauts are taken care off one more challenge remains: the astronauts must arrive at their destination in good mental state and remain so to complete the missions' tasks. This human factor challenge must be successfully tackled soon, well before the time of the first mission. This is where NEA2RS will contribute.

Figure 3: EEG measurements in space are feasible as the examples above show [1]. However, with conventional systems they are cumbersome to use in an unobtrusive way and almost impossible to use during sleep.

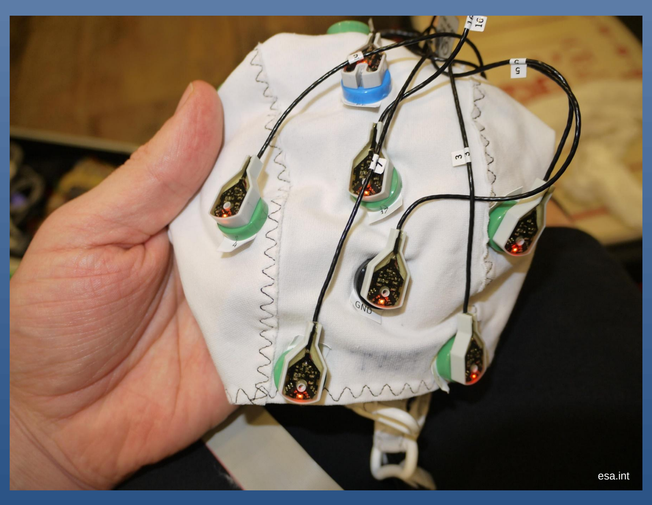

Figure 4: The long-term aim of NEA2RS project is to develop a monitoring system of mental health in space. The monitoring will rely on comparing sleep EEG features in space with those of a personalized model of astronaut's sleep. Also, new awake state protocols will be added, based on our recent results [2]. Non-pharmacological interventions for preventive problems are also under development based on neurofeedback [3, 4].

How do astronauts sleep in space?

- Humans can sleep in space but not easily
- Sleep recordings during missions can be an invaluable source to monitor mental state

The NEA2RS methods will also provide an evaluation of the efficacy of interventions dealing with psychological problems that may arise during long space missions. These methods will draw on our tomographic analysis of electrophysiological data, which will be able to monitor activity from specific brain areas with few EEG electrodes. The goal is to go beyond today's methods that can only indicate if sleep (the hypnogram) is normal. The NEA2RS tools will probe deviant local sleep patterns, which can be eventually linked to the current, or even future emergence of, specific pathologies, e.g. anxiety or depression. A successful conclusion of the work will have huge repercussion on the treatment of these disorders and even problems of old age on earth. The foundation of the approach is the identification of the neural representation of the self (NRS), mapping its activity during awake state and sleep, and understanding how sleep ensures its integrity and renewal when environmental changes demand it [3,4].

Monitoring mental state & evaluation of interventions:

From sleep data: If sleep recording is possible and convenient during long space missions, then the even a few EEG electrodes can provide longitudinal monitoring of mental state through the first and second differential of changes in activity over time in specific brain areas. They can also provide objective measures for the effectiveness of interventions [5, 6]. The NEA2RS work will focus on local changes of sleep so the monitoring can be meaningful, not only through the hypnogram but also when sleep is so disturbed that no hypnogram can be constructed.

From awake state data: Performing a carefully planned sequence of resting states before and after a set of carefully designed active tasks can yield measures of brain's reactivity to these tasks. Repeating the same experiment before and after intervention provides first and second differential of changes that can quantify correlates of changes in mental state and the effectiveness of intervention used to treat them [6].

References

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Acknowledgements

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