WALKING ON THE MOON

EXTREME-DESIGN ILEWG 2016 18-20 MAY

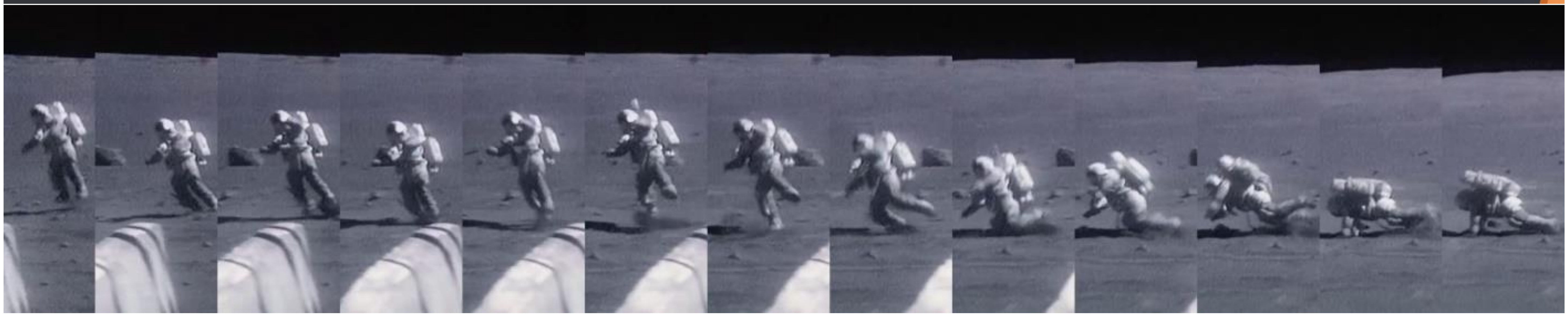

Fig. 1. Apollo astronaut tripping © NASA (Image elaboration Schlacht and Umhof)

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Fig. 3. Inclined Treadmill, Moon Buoyancy and Moon Parabolic Flight© DLR, NASA, ESA (Image elaboration Schlacht)

1. Introduction: A specific aspect of interaction on the Moon here approached is how the crew will walk inside and outside the habitat.

2. Mission Simulation: How high do we jump on the Moon? Should we build architecture with steps or should we support climbing? The hypogravity will lead to vestibular system malfunction, loss of muscular mass, and stiffness of the legs, negatively affecting a person's balance: Yes, we can climb, but we can also easily lose our balance and trip up. To avoid all of this, we need to better understand gait and balance on the Moon. This research will investigate a methodology that focuses on the collection of basic anthropometrical and postural data needed to develop interfaces for the Moon and Mars gravity environments and habitat.

3. The experiment: Walking on the Moon is an experiment that aims to measure the walking pattern of astronauts during EVA (Extra vehicular activity) and IVA (Intra-Vehicular Activity). It is developed with the support of German Aerospace Center (DLR), International Lunar Exploration Working Group (ILEWG), Politecnico di Milano (POLIMI) and Karlsruhe Institute of Technology (KIT).
On the Moon, it is very important to avoid tripping by increasing one's balance in order to assure the safety required in those extreme contexts. Balance is a factor that depends on many variables, such as: visual field, sensorimotor system, vestibular system. These variables are all affected by the different environmental constraints of Moon and Mars environments [1, 2, 3, 4].

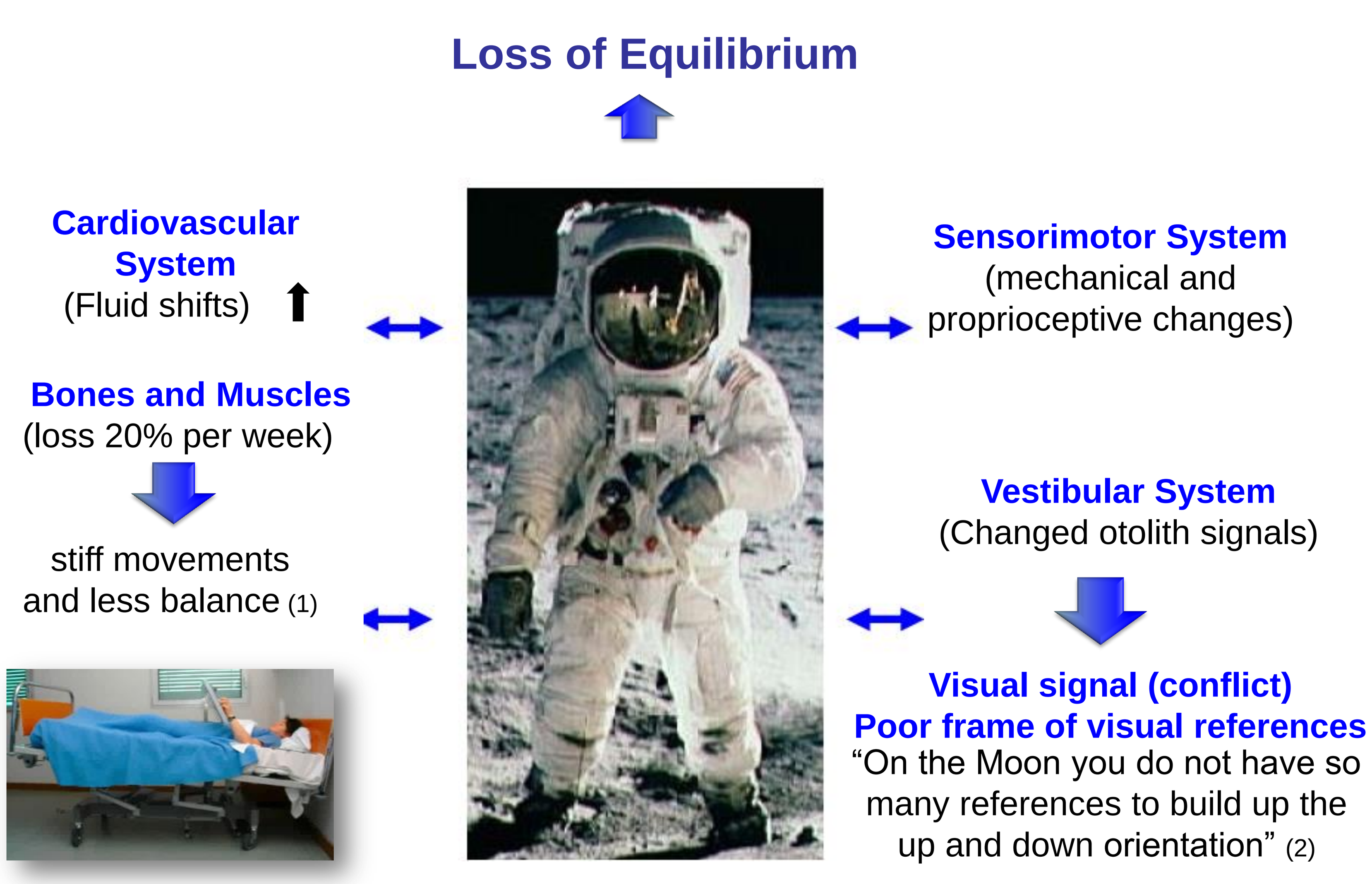

Fig. 2. Balance on the Moon. (Image elaboration: Schlacht)
Image reference: Prof. Jörn Rittweger courtesy communication (1), Workshop EAC 15.2.2016 (2). *(Clément, 2005) Effects of Micrograyity on the Human Organism; From D. Manzey (2009). Seminar Raumfahrtpsychologies. Microgravitation 3; TU-Berlin.*

3. Methods: **INCLINED TREADMILL.** The Walking on the Moon experiment proposed to NASA and ESA bed-rest study, will address the walking pattern and balance by measuring the biomechanical variables of the gait that impact an astronaut's balance during Moon and Mars missions.
To simulate the same conditions of a Moon/Mars mission, we need: partial gravity achieved with a vertical treadmill, deconditioning achieved with bedrest, and artificial gravity (AG) as physiological countermeasures. Subjects who will undergo three different conditions will be compared (parallel-group design): sixty days of -6° head down tilt bedrest only (Control group), 60-day head down tilt with continuous AG, and with intermittent AG. The data collected will be kinematographic and biomechanical data during walking and running in simulated hypogravity with a vertical treadmill. On this instruments, the subjects will be suspended by a belt system to simulate Lunar and Martian hypogravity. An accelerometer will measure speed, step extent, direction of movement, variation of altitude, typology of walk, and balance. The recording of video data will support the research of the line of sight to derive the vestibular plane direction. The data will be collected three times: at the baseline, a few days after 60d of bedrest, and after recovery. Finally with a debriefing the all crew together will discuss problem and solution, this will produce qualitative data for the improvement of walk pattern and balance.

4. Methods of comparison: MOON BUOYANCY & MOON PARABOLIC FLIGHT. Another methodology that will be analysed consists of the utilization of the swimming pool of the ESA's Neutral Buoyancy Facility at the European Astronaut Centre. By using underwater a combination of distributed mechanical loads on different parts of a subject's body, a realistic reduced gravity effect can be obtained to simulate and analyse Moon and Mars walking pattern. Finally Moon and Mars gravity can be olso simulated for around 20 sec each parabola with a parabolic flight.

5. Conclusion: This research will address balance and deconditioning, for the first time getting much closer to the real conditions that will affect astronauts during Moon and Mars missions.

Authors. Dr. Schlacht, experiment principal investigator, human factors field expert and coordinator of extreme-design research group; Prof. Rittweger, head of the Space Physiology division of the DLR and manager of the vertical treadmill; Prof. Foing, director of the ILEWG and scientific reviewer of the project; Prof. Daumer (& team), scientific director of the Human Motion Institute and coordinator of the data collection and analysis of the accelerometer, and Prof. Masali (& team), 50 years of field specialization in space anthropometry, video data analysis of the walking patterns and vestibular visual guidance.

References: *[1] NASA (2004). Vestibular System in Space.* www.nasa.gov/audience/forstudents/9-12/features/F_Human_Vestibular_System_in_Space.html; *[2] Kanas N., Manzey, D. (2008). Space Psychology and Psychiatry. Springer; [3] Clément (2005) Effects of Microgravity on the Human Organism, Springer; [4] Rittweger, J. (2016). Communication* (Analogue Study workshop, ESA-EAC 15.2.2016)

EUROPEAN LUNAR SYMPOSIUM AMSTERDAM THE NETHERLANDS & MOON VILLAGE WORKSHOP esa SERVI 2016 18-20 MAY ESA ESTEC Noordwijk