National Congress of Space Renaissance Italia **SPAZIO SENZA FRONTIERE: UN MONDO PIÙ GRANDE È POSSIBILE!** Politecnico di Milano, Bovisa – 8-9 May 2014

The Future in Human Exploration

Prof. Rodolfo Monti

Retired Professor, University of Naples "Federico II"

- Before implementing the Space with no limits (i.e. the purpose of this initiative), that the optimistic people are able to see in a far future, one should start doing things in the present and conceive what to do in the near future.
- We should understand that the space progress is linked to Human Exploration
- The space progress is linked to the achievement of impossible missions (like Human Exploration of planets) that opens the road to Space Utilization.

- The invasion of Space in the daily life depends on the TRL of space missions or on their technical feasibility.
 In other words, by the forecasted programs and by the financing of them.
- A Space that is pervasive into the daily life will be based on space vehicles capable to transport humans back and forth to/from space
- Human Exploration does not need any further justification for its missions (anthropological need)
- Human exploration implies a safe return to Earth.

- When selecting a Space program, three aspects should be taken into account: 1. The mission objectives; 2. The technologies; 3. The markets.
- For Human Exploration Program (HEP) the choice of the mission is a very delicate and complex issue.
- Political goals typically prevail and override all the others (see Apollo program). No matter what the mission objectives are, the short term missions should be feasible utilizing the existing technologies.
- Long term missions (not feasible at the moment) have to assume that some breakthrough will take place that could make the mission technologically feasible.

- Due to these uncertainties, one cannot fix a time scale for these missions.
- The Markets are of two kinds: 1. Space Agencies, for scientific exploration (e.g. Moon, Mars, asteroids, according to NASA planning) and 2. Space Tourism. Each of these Markets are characterized by different motivations, utilizers, budget and time scales.
- The Scientific Market is the one that drives the progress in Space by selecting "impossible" missions (as, for instance, Man on the Moon in the sixties) and accomplishes them by developing new technologies.
- The Space Tourism Market, on the contrary, goes wherever one "can" go.

Existing Human Research Programs (HEP) (1/3)

- All the programs being proposed by NASA are:
 1. Return to the Moon; 2. Mars mission; 3. Mission to Asteroid; 4. Asteroid retrieval Mission
- Typically in all productive activities the long-term missions are selected after having chosen the shortterm missions. At the present and for the HEP it is exactly the opposite: only betting on future activities we can identify what to do in short-terms.
- A long debate is going on the return to Moon; this mission "apparently" has been cancelled by NASA, but many people believe that this is not the final decision

Existing Human Research Programs (HEP) (2/3)

- In particular, even though the NASA responsible (Bolden) has recently reiterated that "NASA does not have a Human lunar mission in its portfolio and is not planning for one", Moon mission is still being discussed.
- The funds allocation for Orion Multi-Purpose Crew Vehicle (MPCV) and the Space Launch System (SLS).
- Orion Multi-Purpose Crew Vehicle (MPCV) carries up to four astronauts and is being developed for crewed missions to the Moon, to an Asteroid, to Mars (2020) and to the ISS.
- Space Launch System (SLS) able to lift 70 tons to LEO (in 2020). Two upgrades are foreseen up to 130 tons (beyond 2030).

Existing Human Research Programs (HEP) (3/3)

 But the real competition here is between Mars and Moon. 1. The first mission is very appealing but is too far into the future. 2. The second mission is feasible at the moment but has no appeal (it was already performed about 45 years ago).





Moon

Politecnico di Milano, May 2014

Few comments/considerations to HEP of NASA (1/4)

- When talking of Human Exploration one should be careful about the meaning of the word Exploration.
- It may mean going somewhere for the first time ("been there, done that"), or stay there long time and mine large extensions of the planets.
- Mars mission is probably based on the assumption that problems related to propulsion, energy source and radiation shield would be solved (somewhere and by somebody) providing real breakthroughs in these disciplines and removing the "non return ticket" issue.

- It seems that the two Asteroid missions were proposed to fill the gap between now and the Mars mission. Both these missions lack of an objective and are difficult to realize.
- In particular the "Asteroid retrieval Mission" does not seem to justify the presence of human beings onboard. In fact the mission consists in: 1. Identify a "small" Asteroid; 2. Somehow dock to it by a retrieval spacecraft; 3. Change its orbit and bring it near the Earth (by a solar electric propulsion system); 4. Study the asteroid.

Few comments/considerations to HEP of NASA (3/4)

- Apparently this is pure science fiction! To change the orbit of an Asteroid (small as it can be) by solar electric propulsion may take tens of years!
- With the assumed NASA HEP and for the most likely Space activities one may exclude that Human exploration missions will take place in short terms.
- Apart from the debate on the return to Moon mission, all the other missions included in the HEP need new technologies to be implemented.
- Therefore nobody is able to predict what will be the next HEP mission.

- NASA selected SLS and Orion as the two main elements that would be employed in any Exploration mission. However there are doubts that Orion (as it is being designed) will be the same for Mars, Asteroids and Moon missions (configuration, size, mass).
- In conclusion what can we expect to be next with the NASA planning? Not much, considering that HEP missions i.e. land on Asteroid (2025), putting the vehicle in Mars orbit (2035) and Human landing on Mars (2045) are so far away that anything may happen meanwhile (positive or negative).

Identification of activities in support to HEP (1/3)

- We agree that the things to do meanwhile should refer to the technological support activities for future missions.
- In order to identify the useful activities that may be of interest also in other space activities it is appropriate to consider not only the two or three HEP missions but also the other crewed missions (e.g. Space Station, Tourism).
- Assuming that ambitious and demanding missions will take place (sooner or later) then one should compare all the Space missions performed by humans to find commonalities.

- It is immediately evident that all these missions terminate with the reentry to Earth independent of what is the mission objective.
- Furthermore the last part of the space mission from LEO to ground follows similar flight path that initiate at an altitude of about 120 km (entry interface) and at velocity of 7.8 km/s and decelerate the vehicle down to zero velocity and zero altitude.
- Together with the launch, the reentry is the most risky and uncomfortable phase for the crew.

- The most likely scenario for humans in Space is a large orbiting station with accommodations for Tourists and Astronauts on board of which it is possible to assemble, prepare and assist vehicles going into deep Space or coming back from deep Space.
- A workshop in LEO will help very demanding missions (Moon, Mars, Asteroids) to become real and will avoid very heavy launch masses.
- The scenario of a busy LEO is the first step towards a LEO colonization that will attract people only if they can rely on a safe and comfortable return home.

Alternate Space scenario (1/2)

- Two kinds of scenarios for the HEP missions can be considered.
- 1. NASA scenario:
 - Heavy lift rockets launched from a launch pad on ground
 - Return to ground of the crewed capsule
- 2. Alternate scenario:
 - Space vehicles assembled in LEO and launched from LEO (intermediate step on the way to deep space);
 - Return from deep space to LEO premises (intermediate step on the way back) and return by a re-entry airplane docked to the ISS (from LEO to ground).

Alternate Space scenario (2/2)

- The second (alternate) scenario is the most promising and implies many activities for humans before long journey missions are attempted.
- This alternate scenario assumes that a fully operative, safe and comfortable re-entry vehicle is available in LEO.
- The proposal for the study of a "low risk reentry" vehicle was made at an AIDAA Congress [1] about ten years ago. Since then it has been the subject of studies sponsored by OHB (Germany) and ESA [2,3].
- If this this scenario is chosen then one may expect a beginning of "LEO colonization" to occur that will provide the necessary support to the planned HEP missions.

- For a safer and more comfortable re-entry, a different philosophy is proposed: lift forces can be used to keep a winged vehicle to fly at higher altitudes for longer times.
- Disposing of "large" lift forces ensures the most appropriate re-entry trajectory to limit heat fluxes and decelerations. The striking difference between the proposed vehicle (Phoebus) and the Soyuz (the only re-entry vehicle available) are appreciated on time history plots of altitude and velocity reported in Figure.

The role of the lift forces on the future of the human flight to/from LEO (2/7)



The proposed glider trajectory is also very different from that of Shuttle, that has flown in the conventional mode only at relatively low altitudes.

- Shuttle re-entry, in fact, resembled more Soyuz reentry than the Phoebus re-entry.
- The Shuttle only looked like an airplane, but did not fly like an airplane (at hypersonic speed).
- Let us recall the motivations in favour of a reentering glider compared with a typical reentry capsule representative of the MPCV:
- 1. Thermal Protection System (TPS) localized at the tips of the fuselage/wings/control surfaces, implying that the TPS is light and simple.
- 2. Controllability (pilotability) of the vehicle along the entire flight path.

The role of the lift forces on the future of the human flight to/from LEO (4/7)

- 3. Low pressure forces and decelerations, in particular during the highest heat fluxes.
- 4. Low landing speed (beneficial for use of standard runways and for abort at launch), due to the low wing loading and to the streamlined vehicle shape. Any airport can serve as backup.
- 5. The very large landing footprint due to the long reentry duration. Downrange in the order of 20000 km and crossrange in the order of 2500 km will guarantee a wide choice of landing spots.
- 6. No black-out in the radio-communications to ground and to satellites because a tick plasma sheath around the vehicle is not formed.

The role of the lift forces on the future of the human flight to/from LEO (5/7)

- 7. The streamlined shape of the vehicle and the low angle of attack guarantee an efficient operation of the control surfaces (e.g. vertical tail), that will not be in the aerodynamic shadow.
- 8. No parachute system needed (main+drogue) and no critical retrorocket that must be fired at the last 0.1 s before touching the soil.



- The unique opportunities offered by this vehicle to Human Flight are:
- 1. Low deceleration loads (very important for crew rescue, for deconditioned people and for space tourism)
- 2. Gliding capabilities, implying wide re-entry windows and a big choice of landing sites
- 3. Permanent communications (no blackout during reentry)
- 4. Low landing speeds (helpful in abort occurrences)

- The realization of the reentry airplane may change the future Space scenario that will evolve towards a high traffic LEO.
- Missions to deep Space will stop in LEO at the Space Station, where a number of reentry vehicles are docked and ready to re-enter.
- At the same time, for long journeys, vehicles are available at the ISS, ready to go to deep space.
- The rationale of the choice of the alternate scenario is that no technology breakthrough can change the course of works on the glider plane (that does not rely on energy sources, propulsion and on radiation shielding).

Conclusions

- Human exploration will go on even though at an undefined time scale. Interest of Nations other than USA (e.g. Russia, China, India) ensures that Human Exploration will take place even if with different objectives.
- LEO activities are able to help accomplishing the most demanding missions. These activities are feasible if a "LEO Colonization" is accomplished. LEO Colonization is made possible by the realization of a new (or an upgrade of) ISS, equipped with facilities intended to work on vehicles coming from Earth and going into deep space and on vehicles returning from deep space and reentering the atmosphere.
- A safe return to Earth is a non negotiable prerequisite for all the missions.