

ICEUM9/ILC2007, Sorrento, October 2007

SESSION 7.4: Power and ISRU (Posters #11 and #13)

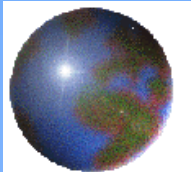
FERTILE Moon – Feasibility of the Extraction of Resources Toolkit for In-Situ Lunar Exploration

**B. Thakore and J. B. Farrow on behalf of S. Podhajsky and
Members of TP-FERTILE Moon, Masters 06**

Full Moon – Storage and Delivery of Oxygen and Hydrogen for Lunar Exploration

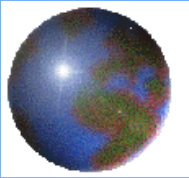
**B. Thakore and J. B. Farrow on behalf of
Members of TP-Full Moon, Masters 2007**

**International Space University (ISU), Strasbourg
farrow@isu.isunet.edu and thakore@isu.isunet.edu**



ISU's Goals and Programs

- ISU celebrates its 20th anniversary this year. The original *credo* describes the Founders' vision of a “peaceful, prosperous and boundless future through the study, exploration and development of Space for the benefit of all humanity”.
- Interdisciplinary, International, Intercultural (3Is)
- Broad coverage of all aspects of space:
 - Space Physics
 - Space Life Sciences
 - Access to Space
 - Space Mission Architecture
 - Satellite Design and Operations
 - Space Applications and Utilisation
 - Economics and Business in Space
 - Project Management and Control
 - Space Policies and Activities
 - Space Law
- Main programs
 - Space Studies Program (SSP) of 9 weeks duration each July/Aug
 - Masters Program of 12 months duration
 - plus Short Courses, Annual Symposia, etc.

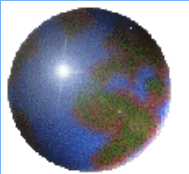


Motivation – Why the Moon?

- Lunar exploration, robotically or by humans, presents enormous interest and challenge to final-year undergrads or Masters students in team projects in aerospace engineering and interdisciplinary space courses.
- Lunar-related topics have been given an added boost by the US ‘Vision’ and through the plans and new developments by other nations.
- These help to motivate students to be a part of tomorrow’s work-force engaged on projects that are or soon will become reality.
- Activities around and on the Moon illustrate very well the many different areas studied in an interdisciplinary space course.
- The subject has been featured regularly in workshops, assignments and team projects at ISU’s Space Studies Program (SSP) and in the Masters courses
- It was also the subject of our last Symposium

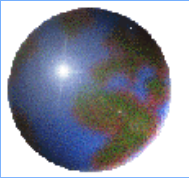
(http://www.isunet.edu/index.php?option=com_docman&task=doc_view&gid=162&Itemid=26)





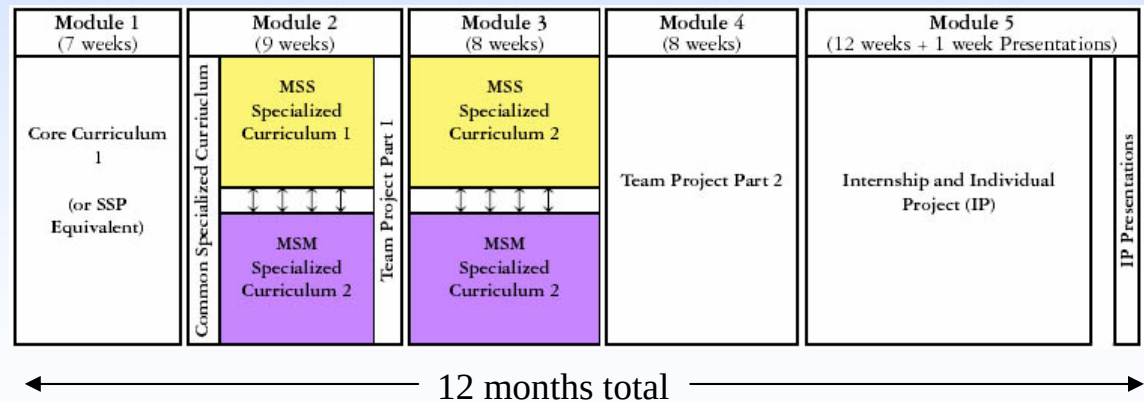
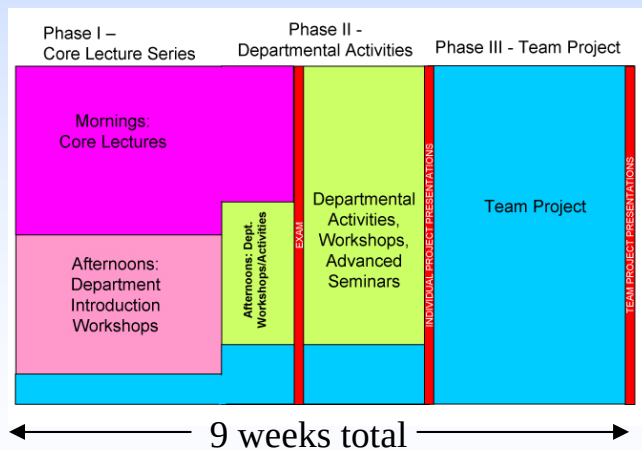
Areas in which 'Exploration' Fits Well

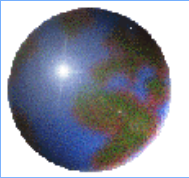
- Lunar exploration is introduced in various ways in ISU's interdisciplinary programs :
 - as a major area of curriculum taught and discussed with experts in the broad framework of the series of lectures
 - through case studies in workshops and short team assignments illustrating and enlivening taught material
 - as the subject for major team projects
 - through personal assignments
 - internships (3 months or more in the year-long Masters)
- In total, exploration-related matters add up to a substantial proportion of the very broad curriculum
- This brief presentation focuses on lunar-related TPs in our Masters program
 - a similar presentation in Session 13B described relevant TPs at our SSPs



Objectives/Duration of ISU Team Projects

- The general objectives of ISU's Team Projects (TPs) are to:
 - put into practice what has been learned in lectures, workshops, etc
 - experience decision-making in a multicultural environment.
 - produce a comprehensive report and overview presentation at the end
 - students are also encouraged to present their work at international conferences
- Typically around 25 – 30 students work together in each project team during:
 - a few weeks in the SSP Program (on the left below)
 - over two months in total in the Masters program (on the right below).

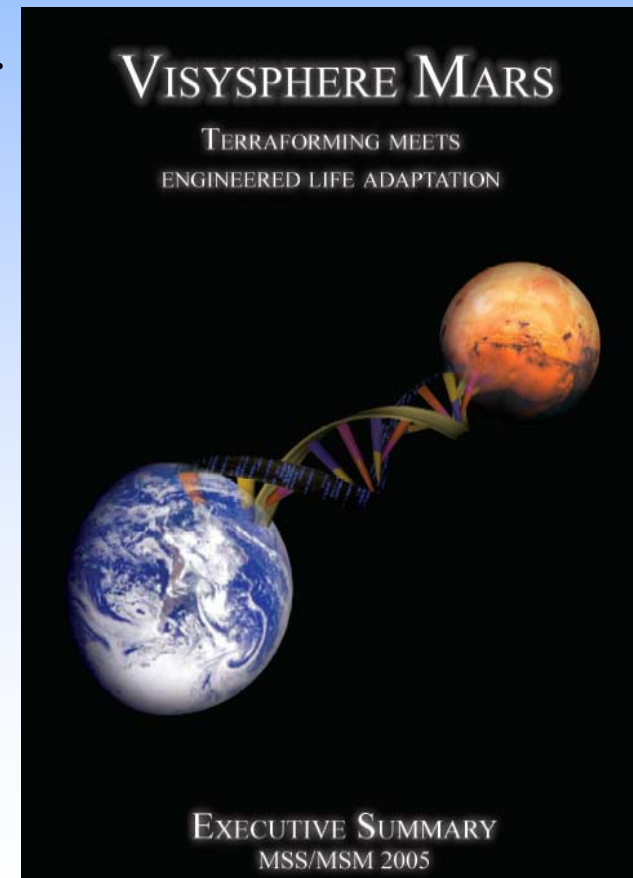


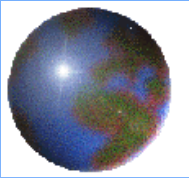


Objectives of Major Team Projects (TP)

- Put into practice what has been learned in lectures, workshops, etc
- Experience decision-making in a multicultural environment.
- Produce a comprehensive report and overview presentation at end

- An example from Masters 04 class (for Mars!)...
 - required good knowledge of Mars environment through literature review, lectures and interactions with experts
 - creativity is a main ‘added ingredient’
 - many questions had to be resolved:
 - the right to transform another planet
 - risks for humans, including radiation
 - need for in-situ resources (ISRU)
 - risks of ‘backwards contamination’.
 - governing structures, legal aspects,...
 - financing such a project, etc...

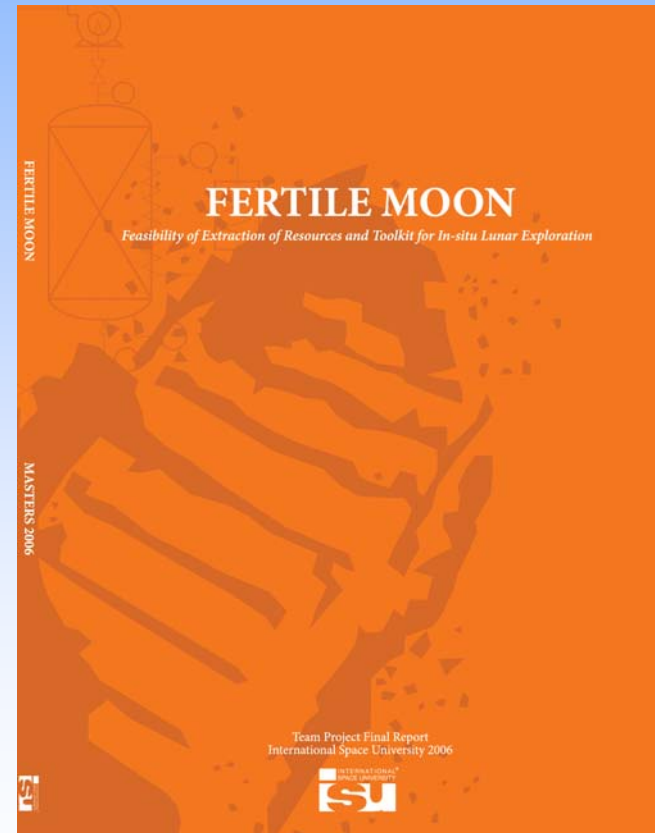


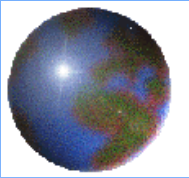


Masters 06 - FERTILE Moon (Poster #11)

FERTILE = Feasibility of Extraction of Resources and Toolkit for In-Situ Lunar Exploration

- Humanity is returning to the Moon, not just returning but creating permanent settlements.
- This endeavor will require numerous new strategies in order to succeed - especially ISRU.
- The potential savings are unknown since the concept remains in the early stages of development.
- This report introduces and describes the FERTILE Moon Model, a decision-making tool to judge whether ISRU is beneficial in terms of engineering, cost, etc compared to re-supply of vital resources from the Earth.

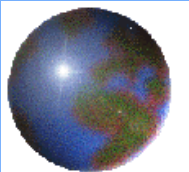




Masters 07 – Full Moon (Poster #13)

Full Moon: Storage and Delivery of Oxygen and Hydrogen for Lunar Exploration

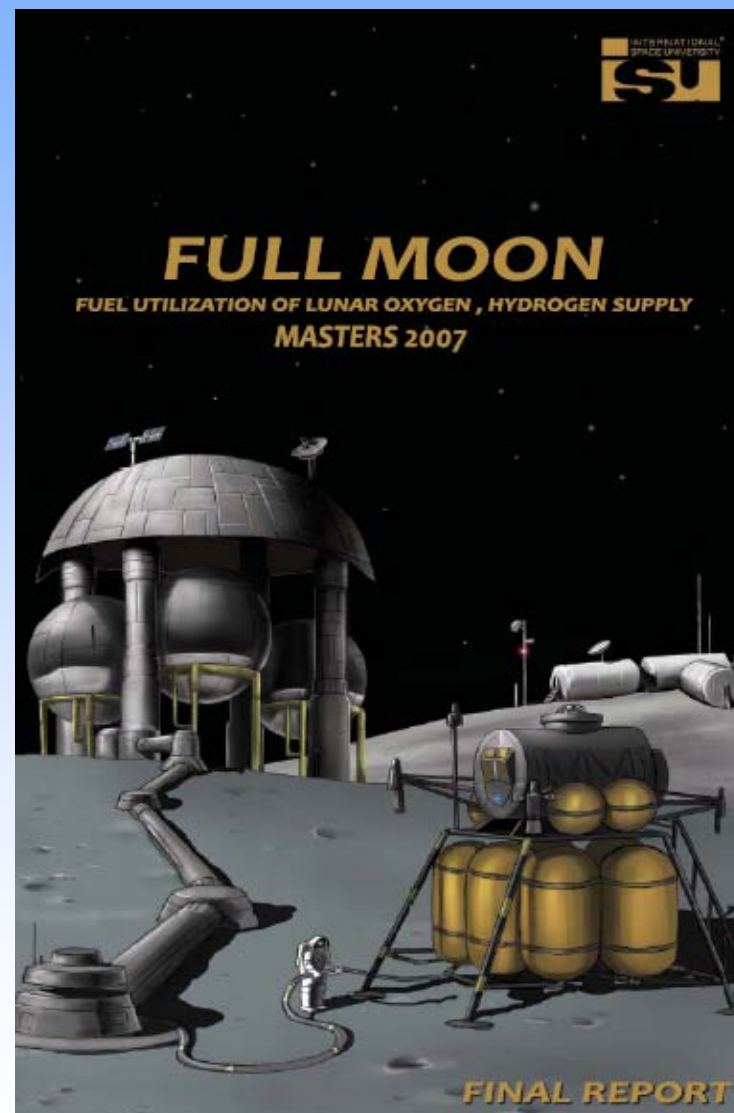
- The key question driving lunar exploration is no longer “How do we get there?” but “How do we stay there?”.
- Oxygen and hydrogen are essential as propellants for transportation and as elements for life support systems.
- While extraction and production methods are well-researched and the use of these products well-known, it is still not clear how oxygen and hydrogen can be made accessible to the user easily and cost-effectively.

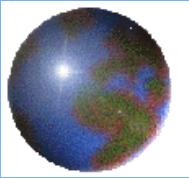


Full Moon, Cont.

- This study addressed these gaps by developing the concept of a 'lunar gas station,' beginning with an analysis of markets, customers and drivers for such a concept.
- This was followed by a technical assessment of possible storage and delivery options.
- System selection was then carried out based on those options to best meet the users' needs.
- The report is online at:

http://www.isunet.edu/index.php?option=com_content&task=blogcategory§ionid=21&id=109&Itemid=251

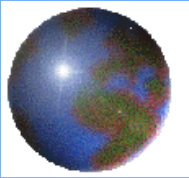




Thoughts Concerning Lunar-Related TPs

- + ‘Lunar Exploration’ themes are inherently interdisciplinary but also offer opportunities for more focused investigations for individual work or in teams
- + Lunar missions are academically demanding and need a good appreciation of celestial mechanics, propulsion, communications, etc if realistic concepts are to be developed
- Lunar missions tend to be relatively complex and costly so an excessive emphasis is not necessarily the best basis for a career
- It’s increasingly difficult to come up with fresh ideas

- We welcome the opportunity to share our experiences with others
- Further descriptions of ISU TPs are included in Session13B (YLE) where specific reference is made to posters devoted to:
 - Luna Gaia (Poster 240, SSP 06)
 - Phoenix Lunar Archive (Poster 12, SSP 07)



Masters 08 Program – Polar Lunar Base

- This week our current Masters students are taking their first steps in this year's team projects, one of which is entitled 'Polar Lunar Base'.
- We welcome the opportunity to share information with other ICEUM9 conference participants on recent or proposed student team projects elsewhere that have addressed this issue.
- We also request advice from experts at this conference on which focused areas could most usefully be addressed in terms of filling any known gaps in plans for future concept design and operation.
- If you have relevant information or advice that you would be willing to share with the team please contact their Faculty Advisor, Dr Vasilis Zerbos (zervos@isu.isunet.edu)