Global partnership between countries & agencies
ILEWG International Lunar Exploration Working Group

- Sponsored and members appointed by agencies, with support by experts
- To develop an International Strategy for the Exploration of the Moon
- Forum and mechanism for communication and co-ordination
- To implement international co-operation and report to COSPAR

- Website: http://sci.esa.int/ilewg
ILEWG Community events

- ILEWG Int’l Conferences on Exploration & Utilisation of the Moon
  ICEUM
  Beatenberg 94, Kyoto 96, Moscow 98, ESTEC 2000, Hawaii Nov 2003,
  Udaipur Nov 04, Toronto Sept 05, Beijing Jul 2006, Sorrento Oct 07,
  ICEUM10/LEAG/SRR Port Canaveral 27-31 Oct 08

- COSPAR: Washington 92, Hamburg 94, Nagoya 98, Warsaw 00,
  Houston 02, Paris 04, Beijing 06, Montreal 08, Bremen 10

- IAF/IAA: Houston 02, Bremen 03, Vancouver 04, Fukuoka 05, Valencia
  06, Hyderabad 07, Glasgow 08, Daejong 09

- EGS/EGU lunar sessions: Hamburg 95, Vienna 97, Nice 98, The Hague
  99, Nice 00 – 04, Vienna 05-06-07-08-09

- Website: http://sci.esa.int/ilewg
- Publications: 9 ICEUM proceedings + 7 books (Adv. Space Res.)
- Outreach: 18000 Google quotes
ILEWG Executive Bureau

- ILEWG President (2006-2008): Prof Wu Ji
- Executive Director: Prof Bernard Foing (Past-President 1998-2000)
- Past-President (2004-2006) Prof Narendra Bhandari
- Vice-President (2006-2008) Dr Simonetta di Pippo
- Vice-President (2006-2008) Dr Michael Wargo
- Past Presidents: H. Mizutani, E. Galimov, M. Duke, C. Pieters
- Founding agencies (1994): ASA, ASI, BNSC, CNES, DARA, ESA, ISAS, NASA, NASDA, RSA

• **Science of, on and from the Moon -> Scientific Knowledge**
  Pursue scientific activities that address fundamental questions about the history of Earth, the solar system and the universe - and about our place in them.

• **Technologies and Resource Utilisation -> New Technologies**
  Test technologies, systems, flight operations and exploration techniques to reduce the risks and prepare future missions to Moon, Mars and beyond.

• **Human Aspects, and Lunar Bases -> Human Civilization**
  Extend human presence to the Moon to enable eventual settlement.

• **Collaborative Roadmap & Moon-Mars Synergies -> Global Partnerships**
  Challenging, shared and peaceful activity that unites nations

• **Social, Economical Commercial, Societal Aspects -> Economic Expansion**
  Expand Earth’s economic sphere, and conduct activities with benefits to home

• **Education Public Outreach & Young Lunar Explorers -> Public Engagement**
  To engage the public and youth students, and help develop the high-tech workforce required to address the challenges of tomorrow.
Science: What processes shape Earth-like rocky planets?

Moon laboratory for Comparative planetology
Geophysics & Geochemistry

cratering, Impacts, volcanism, tectonics, erosion, volatiles

Hadley rille near Apollo 15 site (SMART-1)

Fresh Glushko crater (SMART-1)

Cassini crater Impacts and lava (SMART-1)

Prospector H map
Science of Moon: Formation and evolution of rocky planets

Origin of the Moon: geochemistry
Evolution of Earth/Moon system
Impact craters and bombardment history in the inner solar system
South Pole Aitken Basin
Large impact basins

SMART-1 X-ray Element fluorescence
SMART-1 Infrared mineral spectroscopy
Expanding life beyond Earth

- Bacteria and extremes of life: Survival, replication, mutation and evolution
- Extraterrestrial botanics: Growing plants on the Moon (tulips, mustard Arabidopsis, Tagetes Petula, ...)
- Animals: physiology and ethology on another planet
- Closed Ecological Life Support Systems
- Greenhouses, Local Food Production
- Living off the land
- Support to human exploration
- Permanent human presence
- Biospheres on the Moon
- Planetary and environment protection issues
- Protection of Earth life (Noah’s ark, DNA bank)
ILEWG Technology Task Group: What can be tested on the Moon?

- New technology and system level engineering demonstration
  - Remote sensing miniaturised instruments
  - Surface geophysical and geochemistry package
  - Instrument deployment and robotic arm
  - Close mobility, nano-rover, sampling, drilling
  - Regional mobility: rover, navigation

- Robotic laboratory
  - Mecha-electronics-sensors
  - Tele control, Telepresence, Virtual reality
  - Autonomy, Navigation,
  - Artificially intelligent robots
ILEWG Technology Task Group: What can be tested on the Moon?

• **In-Situ Utilisation of lunar resources**
  – Regolith, Oxygen, glasses, metals utilisation
  – Long term: He 3 extraction

• **Establishment of permanent lunar infrastructure**
  – Life sciences laboratories & Life support systems
  – Large astronomical facilities (VLF, interferometers)

• **Environmental protection aspects with humans**

• **Planetary protection validation for Mars**
Travelling, Living, Working, Settling: Elements for Human Moon/Mars Exploration

- Advanced Launch /access to space
- Orbital Infrastructure
- Crew Exploration Vehicle
- Transport/ communication
- Habitable Descent / Ascent Vehicle
- Surface Power Generation
- In-Situ Fuel Production
- Robotic outposts and rovers
- Habitation Modules
- Workshop
- Scientific Laboratories
- Greenhouse / Agriculture Module
- Medical Centre
- Pressurized Rover
- Advanced EVA Suit
- Life Support Systems
ICEUM/ILEWG: global village and international network

- **Udaipur 2004**: The participants endorse the ILEWG stepwise approach, starting with joint science analysis from ongoing precursor missions (Smart-1, Lunar-A, Selene, Chang’E, Chandrayaan-1, Lunar Reconnaissance Orbiter, Moonrise), continuing with lunar landers cooperating into an international **lunar robotic village before 2014**, evolving technologies for man-tended missions and preparing the ground for an effective, affordable human lunar exploration and **permanent presence by 2024**.

- **Toronto 2005**: We advocate **robotic engineering precursors** for geophysical characterization, life sciences, in-situ resource utilization and the deployment of infrastructures in preparation for human-tended operations.

- **Beijing 2006**: Recognizing the importance of the **geophysical studies of the interior of the Moon** for understanding its formation and evolution, the necessity for a better monitoring of all natural hazards (radiation, meteorites impacts and shallow moonquakes) on the surface, and the series of landers planned by agencies in the period 2010-2015 as an unique opportunity for setting up a **geophysical network on the Moon**, we recommend the creation of an international scientific working group for definition of a common standard for future Moon network instruments, in a way comparable to Earth seismology and magnetism networks.

- **Sorrento 2007**: We need now to exchange information and coordinate the studies of national lunar missions that could lead to **complementary elements of a global robotic village**
Lunar science and exploration missions

- Data analysis & Interpretation
- Science and Technology Lessons Learned
- Preparation for human lunar missions

**International collaborations**

2003  SMART-1 mission and exploitation
2007  JAXA Selene  Kaguya (science exchange)
2007  Chinese Chang’e 1  (ground station)
2008  ISRO  Chandrayaan-1  (ESA SIR2, C1XS, SARA; NASA M3, miniS.)
2009  LRO & LCROSS  (planning, impact, outreach)
2011- Orbiters  (GRAIL+LADEE, LEO, ESMO, BW, ASI)
2011- Landers, Rovers & Robotic village  (GLXP, Chang’e2, Selene2, India, Lunaglob, UK Moon Lite)
2013-2016  International Lunar Network, ESA Moon-NEXT
2017- ESA Logistics lander, **Sample return:** Chang’e 3, Selene3
2019-  Human missions
Sorrento lunar declaration (sci.esa.int/ilewg)

- 9th ILEWG Conference on Exploration and Utilisation of the Moon (ICEUM9)
- >250 participants, time STS120 launch & docking
- SMART-1, Kaguya, launch of Chang'E 1
- Preparation Chandrayaan-1, LRO/LCROSS
- Space Agencies Exploration Coordination Group to benefit from ILEWG
- Integration and analysis of data and results from historical and new missions
- Cooperation at all levels (agency, mission, instrument, science, subsystem, ops)
- Outstanding lunar science questions remaining
- ICEUM unique gatherings, moving to a workshop mode
- More emphasis on the human aspects
- Lunar data dissemination via modern free web-based
- Establish an informal ILEWG Lunar Surface Operations Working Group
- Support Young Lunar Explorers and student lunar projects
- Initiate discussion (political and legal) on exploration and the use of the Moon
- Lunar Odyssey: engage the public (and youth) in science and technology
- Science analysis of current precursor robotic missions, to the global robotic village, and the preparation of international human settlements on the Moon.
Other ILEWG related events:

- 14-18 Jul. 08 COSPAR B0.1 Moon session, Montreal
- 15-18 Sep. Moon and beyond III, DGLR, Bremen
- 22-26 Sep. Europlanet Conference, Munster
- 29 Sep-3 Oct IAC Space Exploration Symposium, Glasgow
- 27-31 Oct 10th ILEWG conference on Exploration and Utilisation of the Moon
  – Port Canaveral Florida, ILEWG/NASA LEAG/Space Resources Roundtable
- 20-24 April 09 European Geoscience Union, Vienna
- 13-18 Sep. 09 Europlanet Conference, Potsdam
- 12-16 Oct 2009 IAC Space Exploration Symposium, Korea
- 2009 11th ILEWG CEUM
- May 2010 IAF Global Lunar Conference, Beijing
- COSPAR2010 Moon science and exploration symposium, incl. session on International Lunar Base (COSPAR B, F, PEX, ILEWG), Bremen
### ILEWG ROAD MAP TO THE MOON VILLAGE, MARS AND BEYOND

*(Europe, robotic, life sciences/Manned)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Chang’E 1 orbiter II</td>
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<tr>
<td>2011</td>
<td>GRAIL+LADEE, Phobos Grunt</td>
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<tr>
<td>2012</td>
<td>LEO, Chang’e 2, Moon-LITE, Selene-2, Chandrayaan2 lander</td>
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<tr>
<td>2013</td>
<td>IL Network, Maggia, ESMO, ExoMars, Mars Scout</td>
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<tr>
<td>2014</td>
<td>Intl Lunar Robotic Global Village Scouts?</td>
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<tr>
<td>2015</td>
<td>CEV Crew Exploration Vehicle, ACTS</td>
</tr>
<tr>
<td>2016</td>
<td>ILN, Moon-NEXT point land, life sciences, biology lab Mars-NEXT</td>
</tr>
<tr>
<td>2018</td>
<td>ESA Logistics lander demo, Chang’E 3 sample return Astrobiology Field Lab?</td>
</tr>
</tbody>
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### International Lunar Exploration Base and Mars Exploration

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2019</td>
<td>Chinese mission to the Moon?</td>
</tr>
<tr>
<td>2020</td>
<td>ESA Logistics lander, US human on Moon</td>
</tr>
<tr>
<td>2021</td>
<td>Early Earth Sample Return?, European, Indian, Japanese on the Moon? Lab, Infrastructures, energy, ISRU, greenhouse</td>
</tr>
<tr>
<td>2022</td>
<td>EMCRV Crew Return Vehicle? Mars Sample Return</td>
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<tr>
<td>2023</td>
<td>Long Term Lunar Base &gt;2030 Humans to NEO/Phobos</td>
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