



Robotic astronomy on the Moon

▲ Shackleton Crater.

Landing on the Moon has become the goal of many public and private space-faring companies recently. One such company is the International Lunar Observatory Association which has plans to test and prove the concept of conducting robotic astronomy from the Moon, starting very soon.

Permanent human expansion to the Moon is our next great advance and with it would see the start of humans becoming an interglobal, Multi-World Species.

Supporting this vision is the International Lunar Observatory Association (ILOA).

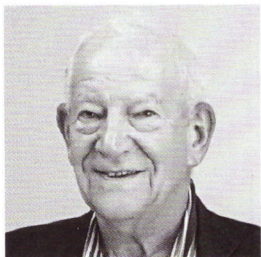
Based in Hawai'i, the ILOA was established in 2007 as a non-profit organisation to help realise the goals of the ILO - to advance human knowledge of the cosmos through observation from our Moon, and to participate in constructing a lunar base at the Moon's south pole. The Moon's south pole is an exciting destination, not least due to its close proximity but it also offers a prime frontier to a whole new world, one that could be benefited by international, public and private partnerships alike.

The first step in realising these ambitious plans is to place a small observatory on the south pole of the Moon comprising of both a combined radio astronomy/communications payload and an optical telescope in order to conduct astrophysical studies from our nearest celestial neighbour.

This bold endeavour is the association's flagship ILO-1 mission, which is currently being developed through work of ILOA prime contractors Moon Express Inc and Canadensys Aerospace Corp.

Moon Express is working on the critical landing and hazard avoidance technologies necessary to land safely on the Moon, while Canadensys Aerospace Corps is developing the Lunar Optics Program for ILOA. It is intended to deliver a flight-ready low-cost optical payload for the ILO-1 mission, ruggedised for the lunar south pole environment.

Canadensys completed the Lunar Electronics Program for ILOA in October 2017. This Lunar



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The ILO-1 will be landed on a 'peak of eternal light' at the lunar south pole by a Moon Express robotic explorer system

Optics Program, which also involved the Canadian Space Agency, complements the previous development of robust electronics components for the mission, and develops further technology required to enable the observatory to survive and operate under the harsh temperature, radiation and vacuum environment it will encounter during its long-term lunar south pole mission.

The ILO-1 will be landed on a 'peak of eternal light' at the lunar south pole by a Moon Express robotic explorer system. These peaks were first realised by the pioneering German lunar mapper Johann Heinrich von Mädler, but later romanticised by the French astronomer and author Camille Flammarion in 1879, who called these always-sunlit places "pics de lumière éternelle". These whimsical sounding features are actually defined as, 'points on the surface of an astronomical body that are nearly always bathed in sunlight'.

While the more precise technical term might not sound as starry-eyed, they are an important geological feature nonetheless, especially when it comes to the Moon. Why might this be so? Many of the planets in our solar system have axial tilts - Uranus for example has a spin axis tilted by a staggering 98 degrees, meaning it essentially spins on its side.

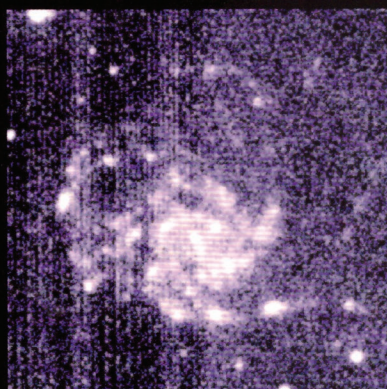
The Earth's axis on the other hand is inclined 23.5 degrees relative to our orbital plane - the plane of Earth's orbit around the Sun - meaning that some parts of the surface are preferentially warmed at certain times of the year (i.e. we have seasons). The mean inclination of the lunar orbit to the ecliptic plane on the other hand is 5.1 degrees, meaning that on the Moon, the Sun is always near or just below the horizon as seen from its poles and it never rises above the rims of some deep polar craters.

Having a direct line of sight to Shackleton Crater will be advantageous to the mission because it is another location of great interest to the lunar, science and space settlement communities due to nearly continuous sunlight at its peaks, and shadows in the crater. It is very likely another area where exploration and build-out will occur, as it could contain higher than average amounts of hydrogen, and water ice. Moon Express will therefore utilise this opportunity to explore the Moon's south pole for mineral resources and water.

Building on the past

ILO-1 evolution builds upon years of research including studies contracted with Space Dev (now Sierra Nevada Corp) and Odyssey Moon. Odyssey Moon was the first team to register for

Astronomy From The Moon



Chang'e-3 Lander Lunar Ultraviolet Telescope
2 December 2014

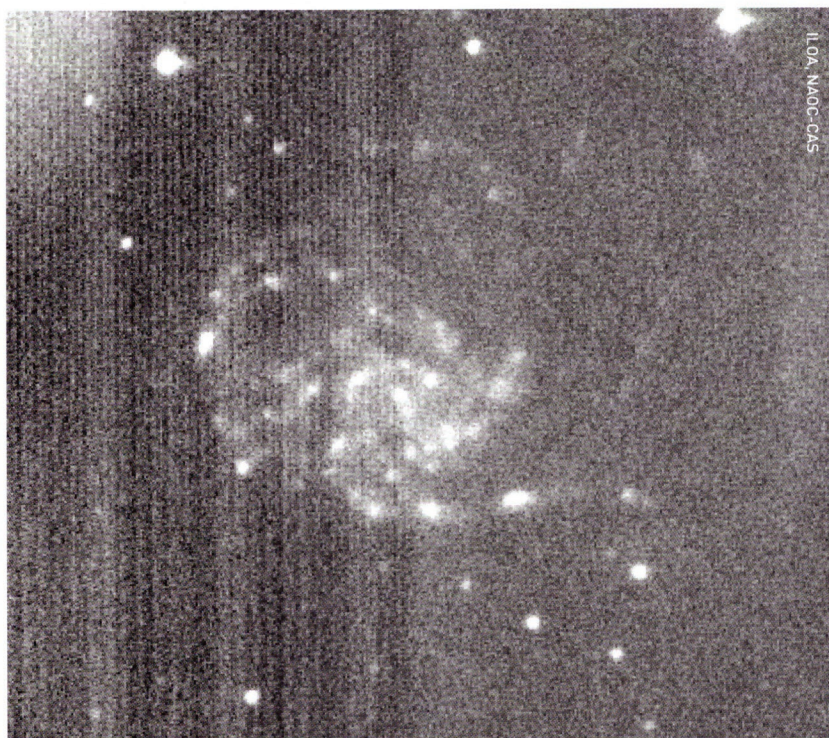


Pinwheel Galaxy M101

Visible / Control
Digitized Sky Survey / Aladin Virtual Observatory



ILOA/NAOC-CAS/Aladin Sky Atlas

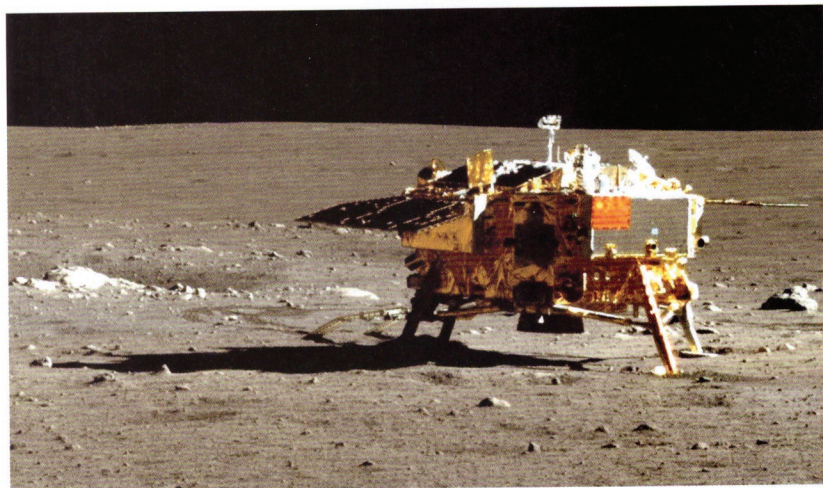


ILOA/NAOC-CAS

the Google Lunar X Prize, a competition that in the end, no team won. However, a concessionary US\$1 million in funds was recently awarded to the SpaceIL team behind the Israeli Beresheet spacecraft for their near successful attempt at landing on the lunar surface.

Similarly, ILOA is persistent in its pursuit of a lunar goal and as such the association has funded several technology development efforts and a series of studies supporting robotic and human-tended lunar surface observatories.

▲ Astronomy from the Moon - the Pinwheel Galaxy M101 from the Chang'e-3 lander's UV telescope (left) compared to a visible control image.



▲ China's Chang'e-3 on the lunar surface.

The ILOA's ambitions are also widespread and encompassing as evidenced by participating in numerous technology development efforts. For example, the ILOA has signed memorandums of understanding (MOU) with Canada-France-Hawaii Telescope (CFHT), a Multinational MoU with Southeast Asia Principal Operating Partners in four countries to date (Indonesia, Singapore, Thailand, Malaysia), the Chinese National Space Administration (CNSA) and also with the National Astronomical Observatories of the Chinese Academy of Sciences (NAOC-CAS), the latter of which occurred in September 2012. This formal agreement allowed ILOA scientists to conduct galaxy observations with the UV telescope aboard the 2013 Chang'e-3 lunar lander. This resulted in the first successful observation of a spiral galaxy known as M101, that took place from the lunar surface on 2 December 2014. ILOA is looking ahead to further successful collaborations with the Chang'e 4, 5, 6 missions.

Future plans

Amongst the many endeavours planned for the ILO-1 astrophysical observatory and research station,

one of its tasks is to capture the first image of the Milky Way galaxy centre from the surface of the Moon. It is also planned to observe the Stars, Earth in various wavelengths, local lunar environment and conduct a wide-range of Moon-to-Earth and Moon-to-Space communications. Not only that, but Space Age Publishing Company (SPC), ILOA's commercial affiliate, intends to broadcast its Space Calendar weekly and Lunar Enterprise Daily via ILO-1.

Once collected and processed, data from the ILO-1 will be made available for the public, especially schools, and through its wide-ranging network of Galaxy Forum participants. With nearly 90 Galaxy Forums to date, the programme continues to pursue its two principal priorities: to advance Galaxy 21st Century education in every class, and to develop Principal Operating Partnerships (PoP) to support ILOA missions by helping fund final spacecraft/payload development and launch costs. ILOA is working to establish regional and international PoPs, and each will consist of a single agency, organisation, institution or individual (or combined thereof) which forms an administrative committee to direct local node of collaboration for the project.

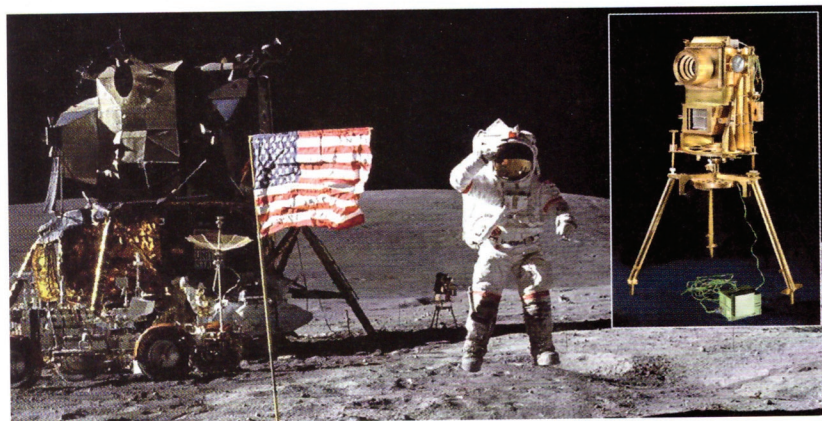
Before ILO-1 heads to the Moon, a precursor mission named ILO-X is in the pipeline to be delivered to the lunar equatorial region. This instrument will be a multi-functional lunar imaging system designed and built by Canadensys Aerospace Corp. It will be an ultra-miniaturised (<1 kg) form factor, approximately 10 x 5 x 5 cm with a design that makes it extensible to multi-camera installations. ILOA has submitted a proposal to the recent NASA Lunar Surface Instrument and Technology Payloads programme for its potential flight via commercial landers as part of Moon Surface NET 2020. ILO-X would also present the opportunity to flight test potential ILO-1 technologies.

First steps in the solar system

The Moon in recent times has become a very desirable target of interest for many countries around the world, with ambitions ranging from rovers roaming the surface looking for minerals to crewed bases and a lunar gateway platform in a nearby orbit.

The Chinese human Moon mission studies and discussions continue to increase as the CNSA robotic lunar programme enters its third phase with the upcoming lunar sample return of Chang'e-5. India may startle the space community with 2019 lunar landing firsts from ISRO South Pole Chandrayaan-2. The ESA Moon Village, International Space Exploration Coordinating

▼ John Young with a UV camera on the Moon. This brings challenges of its own, such as how to keep a lunar observatory or rover warm enough when temperatures can dip to minus 173 Celsius when the Sun goes down.

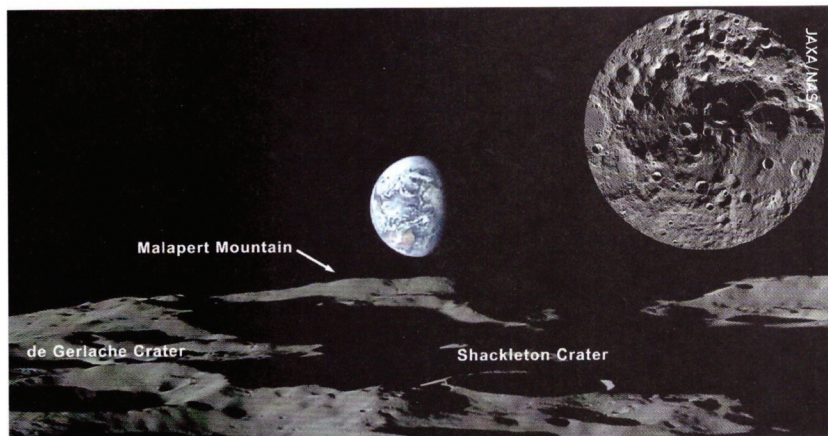




Group and International Lunar Decade all have human lunar considerations, as do national lunar programmes of the USA, Canada, Russia, Europe, Japan, Korea, as well as the International MoonBase Alliance and ILOA in Hawaii. Contributing another vital dimension, independent commercial enterprises such as Blue Origin, Bigelow Aerospace, SpaceX, Japan Manned Space Systems Corporation, Astrobotic, Moon Express, and Canadensys all should be capable of some form of human Moon activities in the next decade.

The ILOA is no exception. Once firmly planted on the lunar surface, servicing and technical upgrades required for the ILO-1 mission will necessitate an ILOA Human Service Mission (HSM). This HSM is an anticipated participant in the developing coalition of Human Moon enterprises and organisations. ILOA successfully contracted and completed two Human Service Mission technical studies with SpaceDev Inc and participated in a Human Lunar Lander multi-party technical design project with Golden Spike Company from 2011-2014. ILOA aims to fund its Human Service Mission to its future observatory through independent marketing and fundraising.

ILOA, SPC and Galaxy Forum are also raising awareness and advocating for the pioneering possibilities for the 'First Women on the Moon' via its Human Service Mission. First Women on the Moon is a 21st century mission to advance diversity and equality in astronautics, facilitate



large-scale international collaborations and inspire next generation, cross-cutting ideas, technologies, research and science for all people - with the belief that this could be as significant as the first man on the Moon. It also helps fulfil the Apollo 11 pledge 'In Peace for All'. ILOA and SPC have produced more than 20 First Woman on the Moon articles for public use through Space Calendar and Lunar Enterprise Daily, as well as a 'Women in Space and Women on the Moon' poster featuring the 63 women who have been to space so far.

ILOA has also sponsored the 'First Women on the Moon' Essay Contest in late 2018, collaborating with astronaut Soyeon Yi, and a second contest will be held in 2019 in cooperation with the Moon Village Association, and possibly others this year. The First Women on the Moon may soon become a reality as USA is planning the Artemis programme to land the first woman, and man, at the Moon south pole by 2024. Artemis, the name of Apollo's twin sister, could advance the celestial aspirations of the Apollo missions - now in their 50th year."

As the first word in the organisation's name indicates, the International Lunar Observatory Association has worked since its founding to connect people from many nations/continents for the primary goal of building a Multi-World Civilisation starting with the Moon, and a clear strategy to start with the major spacefaring powers. With a belief that sustained, long-term survival of humanity depends on global/interglobal cooperation, ILOA has made it its goals to see an all-inclusive human return to the Moon for good. ■

About the author

Steve Durst is Director of the International Lunar Observatory Association, based in Hawaii, USA, and its ILOA Galaxy Forum programme. He has also been Editor and Publisher at Space Age Publishing Company since 1976. He received a BA (1965) in European History and an MA (1966) in American History from Stanford University in California, and is self-taught in Asia/China history and culture.

▲ Left: Graphic depicting ILO-1 astronomy from the Moon. Above: the lunar south pole.

Having a direct line of sight to Shackleton will be advantageous to the mission because it is another location of great interest to the lunar, science and space settlement communities