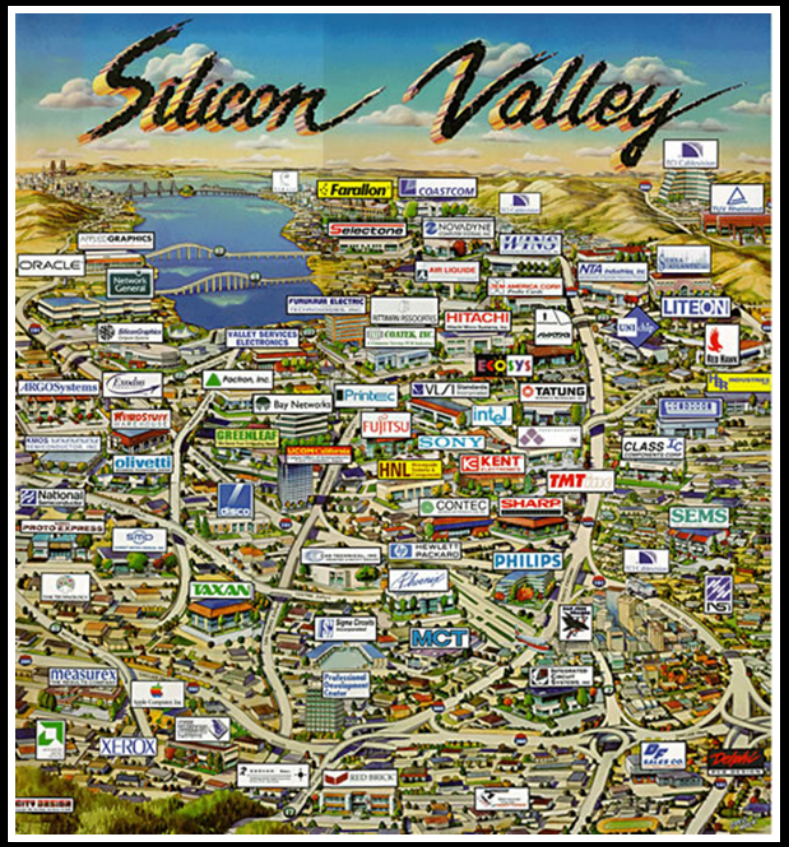
Lunar Commercial Communications Workshop 3:

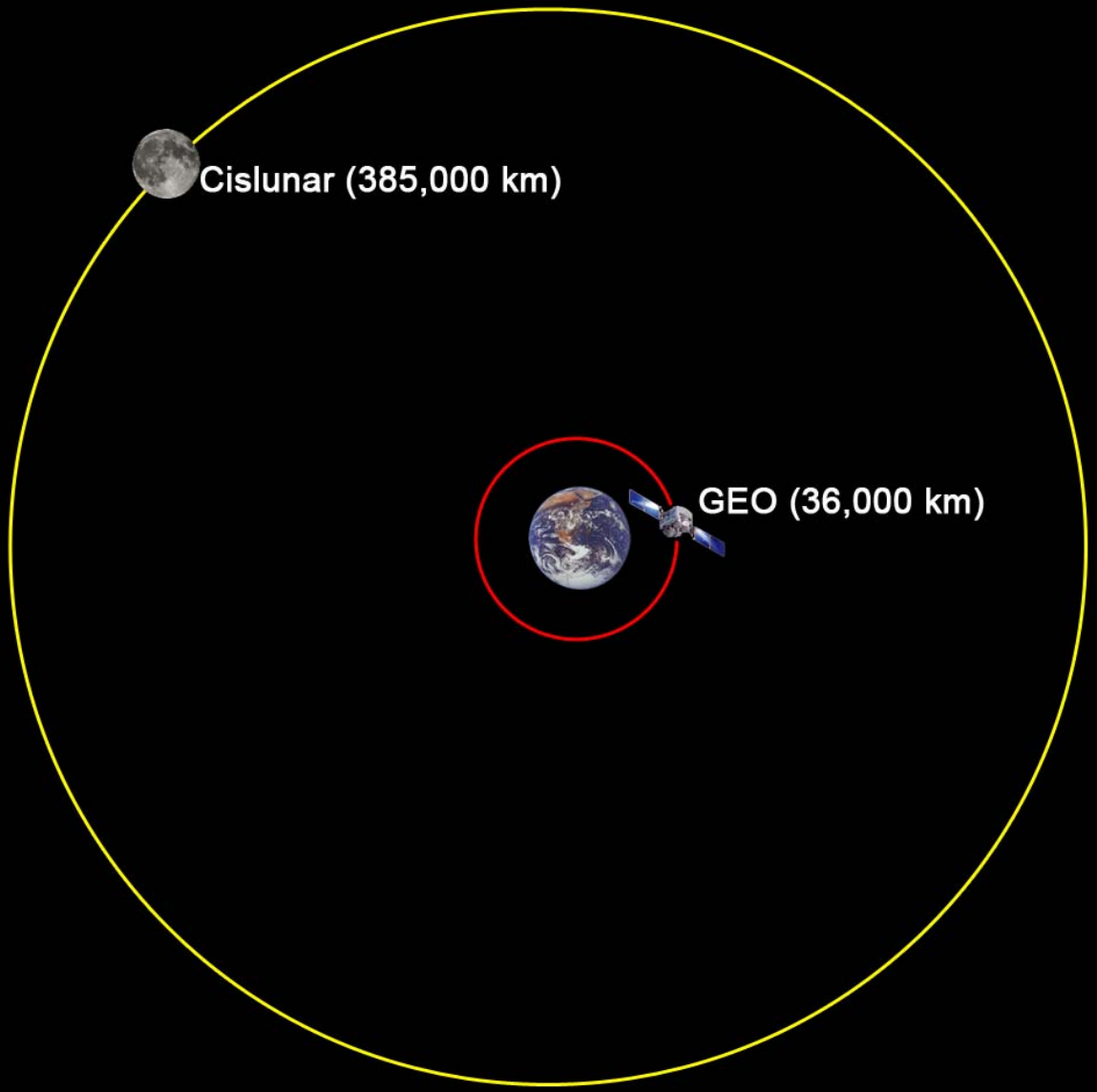
'Catalyzing a Whole New Industry'

Santa Clara CA – 5 September 2008

Steve Durst
Space Age Publishing Company / ILOA
Hawai`i and California, USA

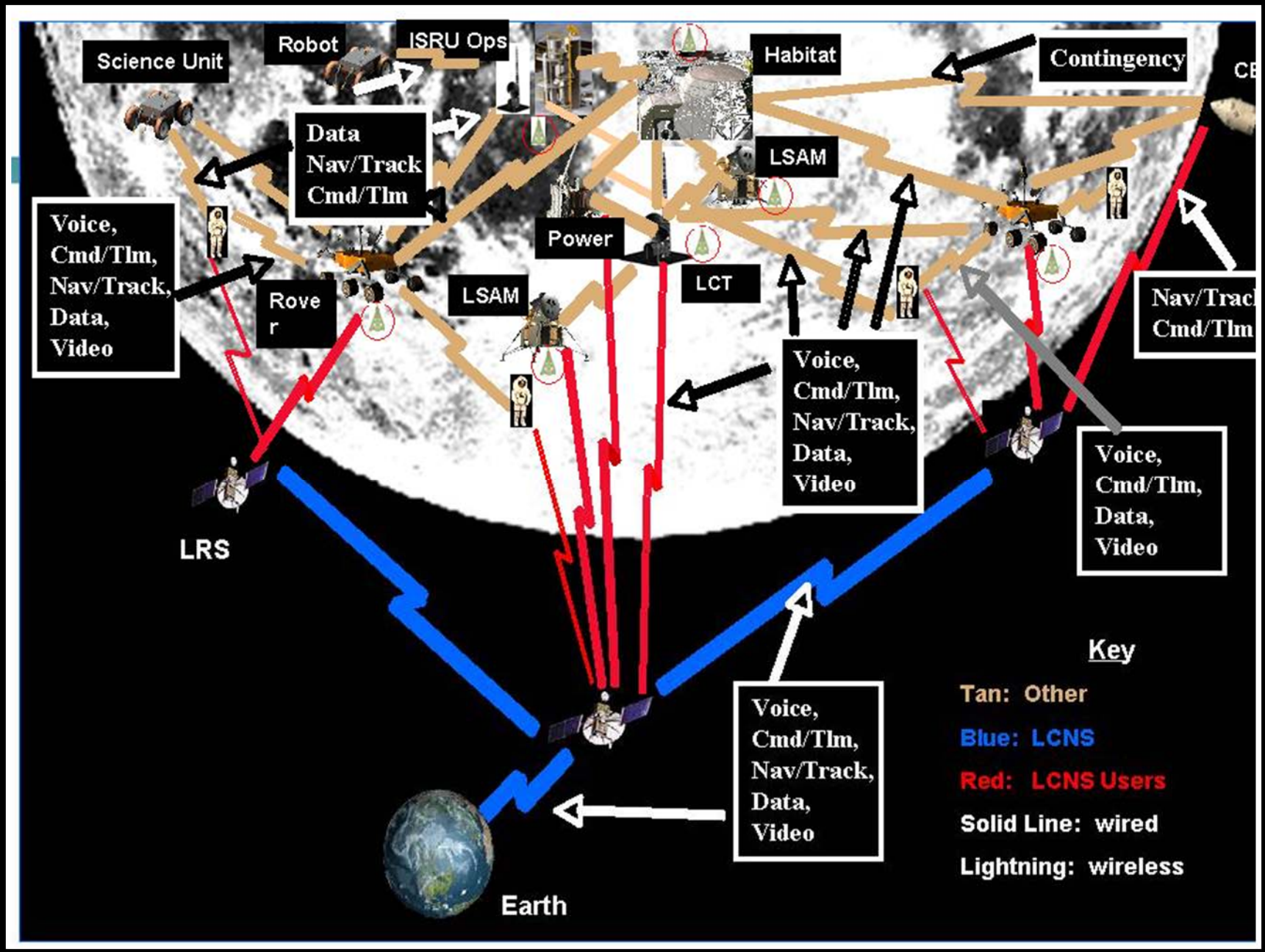


Inter-Global / Cislunar System



Expanding the Sphere of Commercial Communications by more than 1,000 times

Hugh Arif, Cisco Systems – ‘Leveraging Commercial Solutions for Lunar Communications’ (2007)



Services required for Lunar Missions

	IP Telephony	VoiceMail	HDTV	IPTV	Video Conferencing	Multicasting	Storage	Security	Wireless	File Transfer	Data (Sensor, IVHM, Instrument)	Email	Instant Messaging	XML (Web)	Distance Learning
Lunar Surface															
HM	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rover	x		x						x	x	x	x	x	x	
Astronaut	x		x		x				x		x		x	x	
Sensor Networks				x					x		x				
LSAM	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Reactor				x					x	x	x	x		x	x
ISR Plant				x					x		x				x
In-Space															
Astronaut	x	x	x		x				x	x	x	x	x	x	
CEV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
LV									x		x				
LSAM	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HM	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
EDS									x		x				
Com/Nav Relay															
Earth Surface															
DSN	x		x		x					x		x	x	x	x
MCC	x		x		x					x		x	x	x	x

Comm Infrastructure Requirements

Nodal Group	Node to Earth	Current	2010	2020+
Earth Vicinity	LEO Spacecraft (Direct Link)	150 Mbps	>1 Gbps gateway, 1 Gbps D/L	10 Gbps
	GEO Spacecraft (Direct Link)	150 Mbps	>1 Gbps	10 Gbps
	STS	50 Mbps	50 Mbps	50 Mbps
	ISS	48 Mbps	150 Mbps (2005)	300 Mbps
Moon	Earth-Moon L1, L2			0.2 up/1 down Gbps
	Moon			0.2 up/1 down Gbps
Earth-Sun L1, L2	GEO relay and Earth		20 Mbps	>100 Mbps
Mars	Mars Science	100 Kbps	5 Mbps	20 up/100 down Mbps
	Mars Exploration	–	10 Mbps	20 up/100 down Mbps
	Mars Proximity Link	–	–	1-100 Mbps
Outer Planets	Jupiter to Outer Heliosphere	10 Kbps	1 Mbps	>10 Mbps

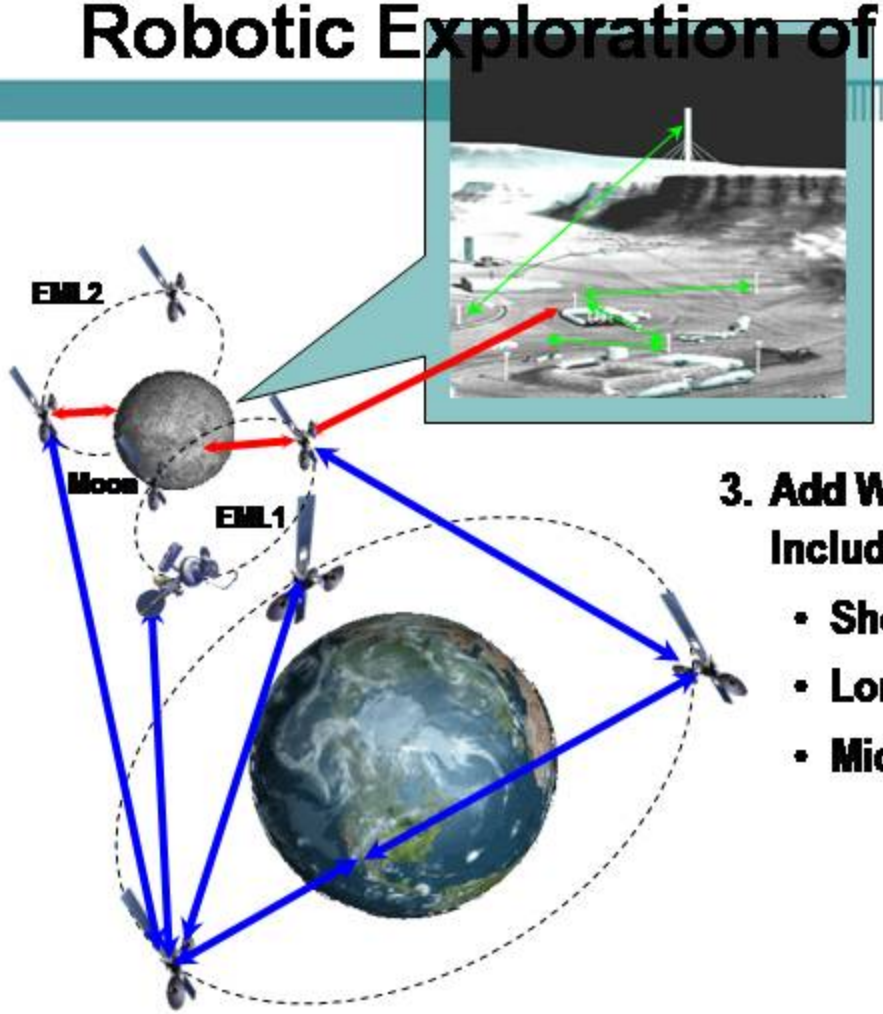
Earth to Moon and Moon Vicinity Communications

Node-to Node Link	Data Rate (Mbps)	Distance	Technology	Service
1) LSMMO relay spacecraft constellation				
Earth ground	>300	384,000 km	Ka-, X-bands	Backbone data services
Earth orbit relay	1,000	384,000 km	Optical	Backbone data services
LSMMO relay spacecraft (crosslink)	1,000	6,500 km	Optical, Ka	Backbone data services
Moon low rate	10	2,700 km	Ka-, X-bands	Emergency, TT&C
Moon science orbiter	100	2,700 km	Ka-, X-bands	Science files
Moon human outpost	1,000	2,700 km	Optical, Ka	Bidirectional voice, HDTV, data
2) Earth-Moon L1 (EML_1) communication relay spacecraft				
Earth ground	>300	323,000 km	Ka-, X-bands	Backbone data services
Earth orbit relay	1,000	323,000 km	Optical	Backbone data services
Earth-Moon L1 Gateway	1,000	10,000 km	Optical, Ka	Access data services
Moon relays, high rate	1,000	61,000 km	Optical, Ka	Backbone data services
Moon low rate	10	61,000 km	Ka-, X-bands	Emergency, TT&C
Moon science orbiter	100	61,000 km	Ka-, X-bands	Science files
Moon human outpost	1,000	61,000 km	Optical, Ka	Bidirectional voice, HDTV, data
3) Earth-Moon L2 (EML_2) communication relay spacecraft				
Earth ground	>300	445,000 km	Ka-, X-bands	Backbone data services
Earth orbit relay	1,000	445,000 km	Optical	Backbone data services
Moon relays, high rate	1,000	61,000 km	Optical, Ka	Backbone data services
Moon low rate	10	61,000 km	Ka-, X-bands	Emergency, TT&C
Moon science orbiter	100	61,000 km	Ka-, X-bands	Science files
Moon human outpost	1,000	61,000 km	Optical, Ka	Bidirectional voice, HDTV, data

Earth to Moon and Moon Vicinity Communications – *cont'd*

Node-to Node Link	Data Rate (Mbps)	Distance	Technology	Service
4) Small Satellite, Low Moon Orbit (SSLMO) relay spacecraft constellation				
SSLMO relay spacecraft (crosslink)	1,000	2,100 km	Ka	Backbone data services
Moon low rate	10	650 km	Ka-, X-bands	Emergency, TT&C
Moon science orbiter	100	650 km	Ka-, X-bands	Science files
Moon human outpost	1,000	650 km	Ka	Bidirectional voice, HDTV, data
5) Small Satellite, Low Moon Orbit (SSLMO) Lunar surface terminal relays				
Earth ground	>300	384,000 km	Ka	Backbone data services
Earth orbit relay	1,000	384,000 km	Optical	Backbone data services
SSLMO relay spacecraft (crosslink)	1,000	650 km	Ka	Backbone data services
6) Human lunar outpost sends and receives voice, video, and data using direct to Earth links				
SSLMO relay	1,000	650 km	Ka	Bidirectional voice, HDTV, data
LSMMO relay	1,000	2,700 km	Optical, Ka	Bidirectional voice, HDTV, data
Earth-Moon L1 relay	1,000	323,110 km	Optical, Ka	Bidirectional, multipoint, voice, video, remote control, science data, emergency
Earth orbit relays	1,000	384,400 km	Optical, Ka	Bidirectional, multipoint, voice, video, remote control, science data, emergency
Earth terminal	200	384,400 km	Ka-, X-bands	Science data, emergency, TT&C
7) Lunar outpost wireless local area network (WLAN)				
Other lunar surface entity at close range	>100	100 m	Ka-, X-, C-bands	Bidirectional, multipoint, voice, video, remote control, data, emergency
Other lunar surface entity at long surface distance	>50	50 km	Ka-, X-, C-bands	Bidirectional, multipoint, voice, video, remote control, data, emergency

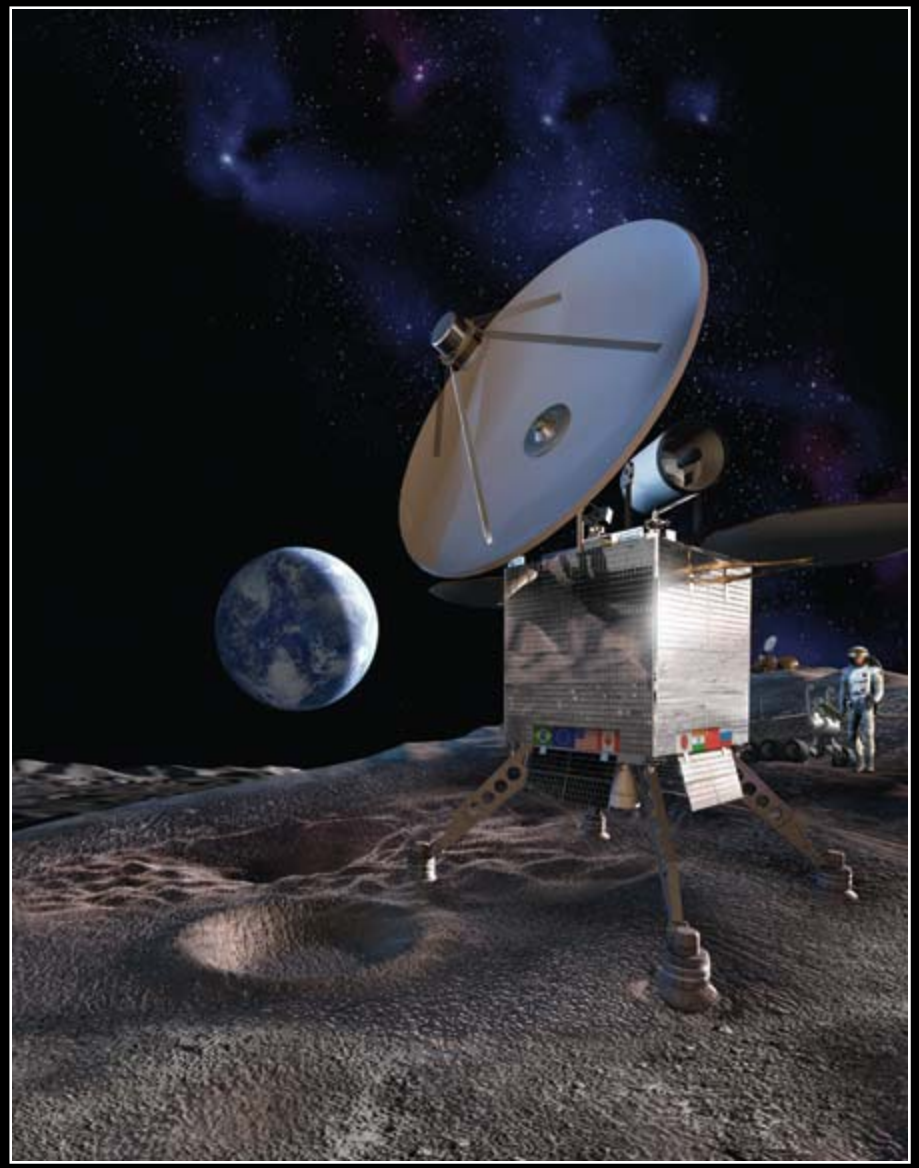
Infrastructure Buildout for Human and Robotic Exploration of the Moon



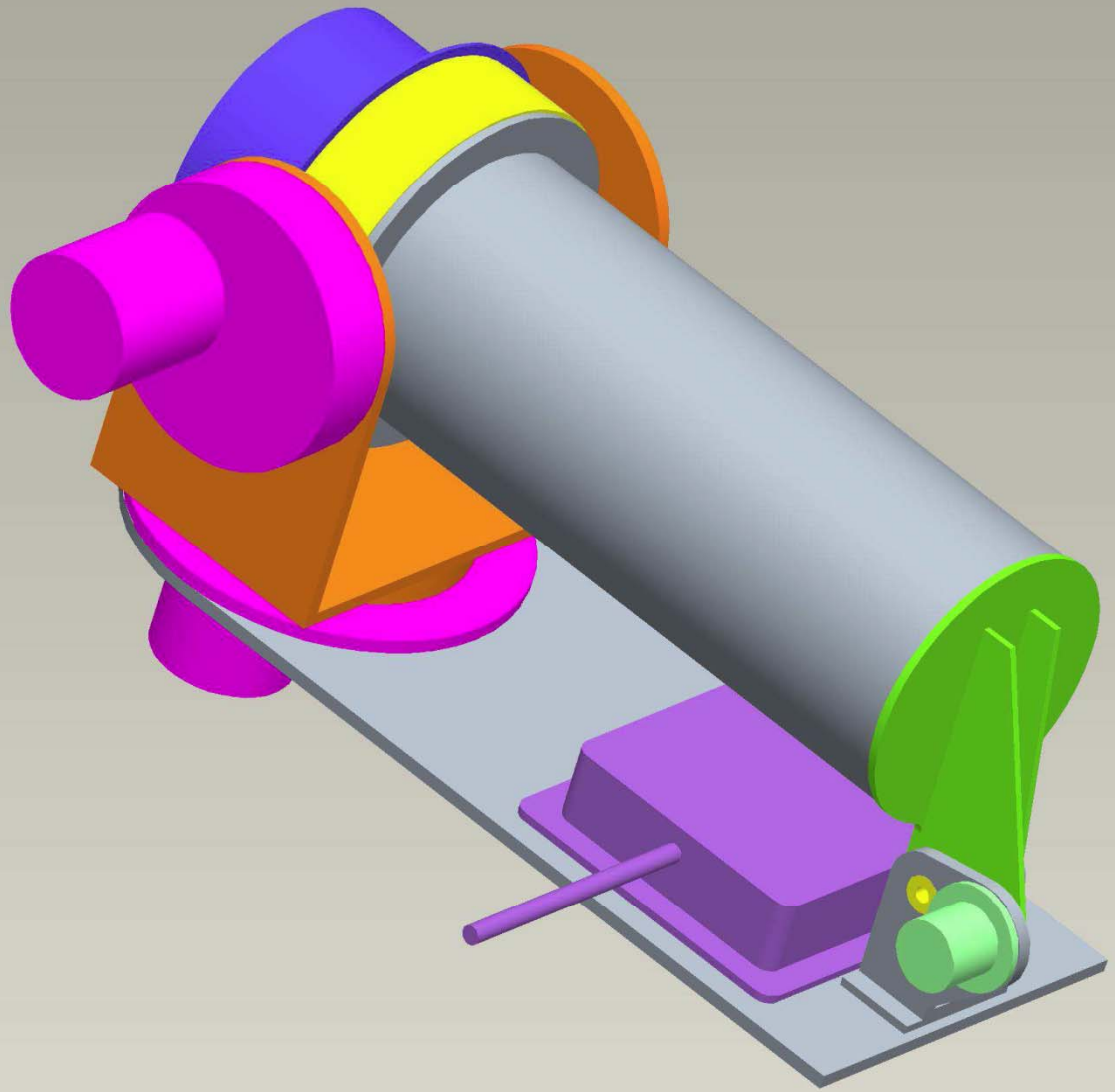
3. **Add Wireless Local Area Network (WLAN). Include:**
   - **Short range WLAN from 1 to 1,000 m**
   - **Long range WLAN from 1 to 50 km**
   - **Microwave links to Lunar relays**

Core/Distribution Nodes
Access Nodes
Planetary WLANs

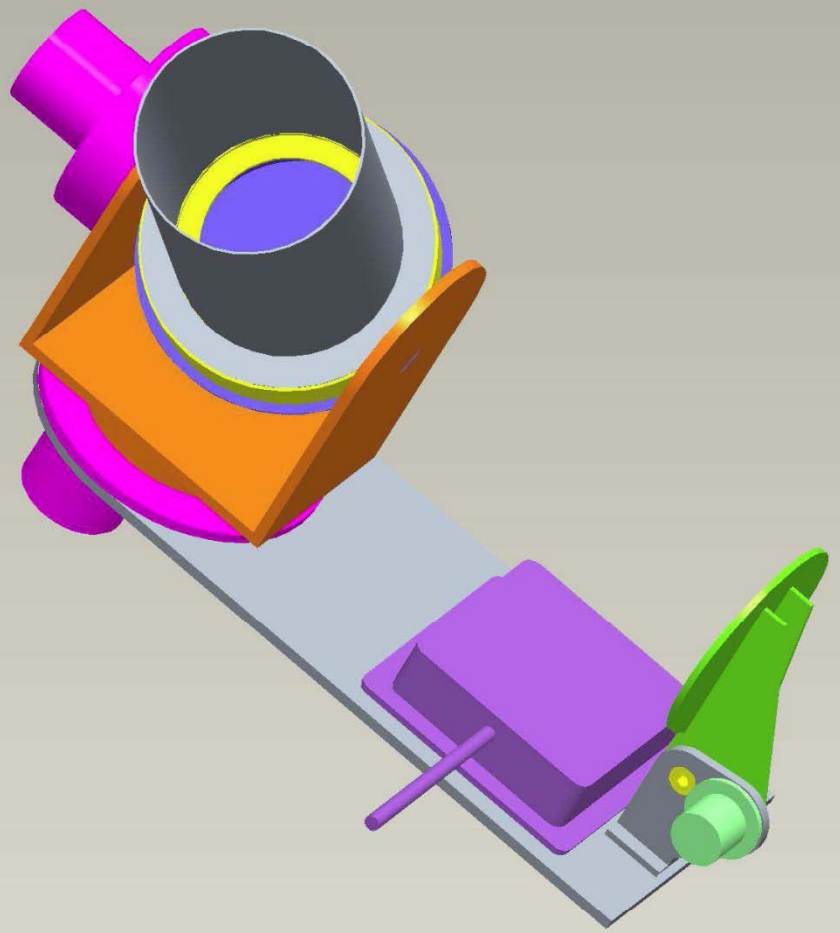
International Lunar Observatory Association – 3 Missions



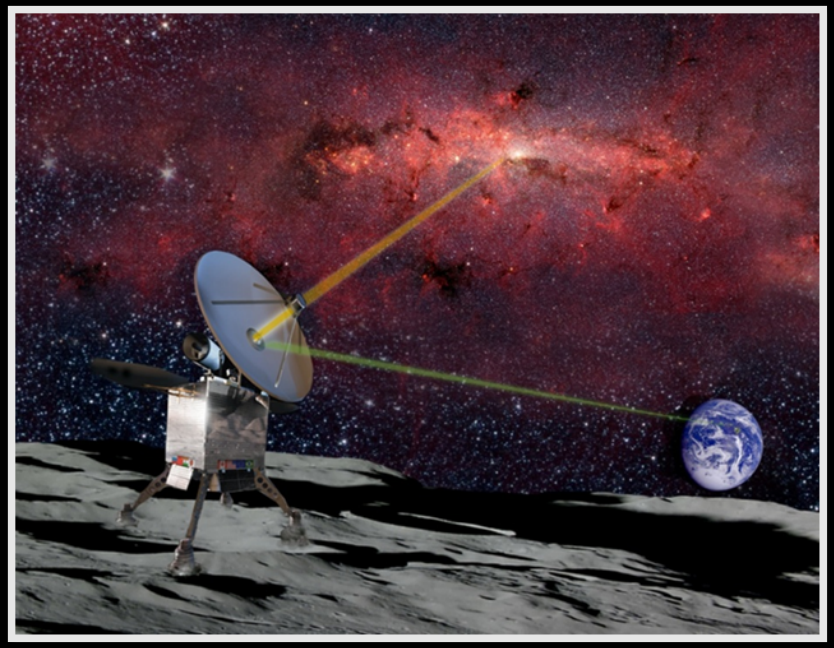
- **ILO-X Precursor Mission** (NET 2010)
- **ILO-1 Polar Mission** (NET 2012)
- **ILO Human Service Mission** (By 2015)



ILO-X Instrument Concept, in Stowed / Launch Configuration; MDA Corporation



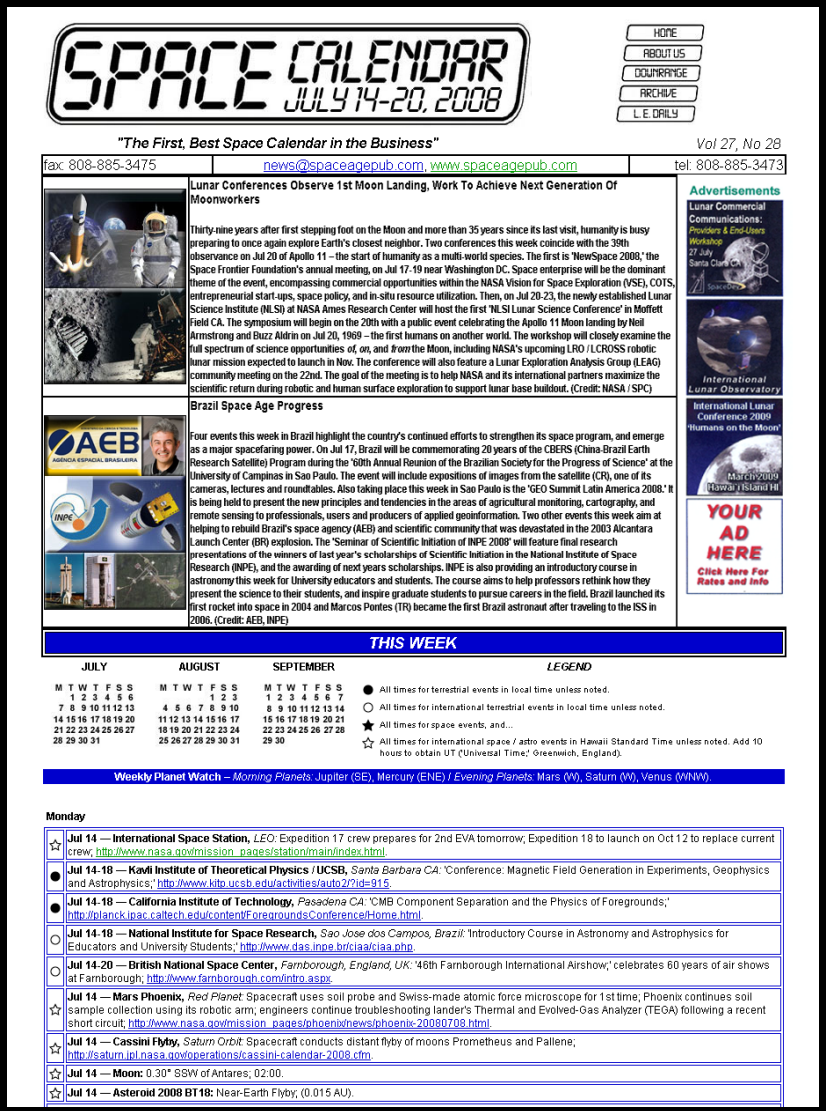
ILO-X Instrument Concept, in Unstowed Configuration; MDA Corporation



ILO Imaging Galaxy Center

Earthrise Photo : 1968 / Apollo 8

'The First, Best Space Calendar in the Business'



SPACE CALENDAR
JULY 14-20, 2008

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Lunar Conferences Observe 1st Moon Landing, Work To Achieve Next Generation Of Moonworkers

Thirty-nine years after first stepping foot on the Moon and more than 35 years since its last visit, humanity is busy preparing to once again explore Earth's closest neighbor. Two conferences this week coincide with the 39th observance on Jul 20 of Apollo 11 – the start of humanity as a multi-world species. The first is 'NewSpace 2008,' the Space Frontier Foundation's annual meeting, on Jul 17-19 near Washington DC. Space enterprise will be the dominant theme of the event, encompassing commercial opportunities within the NASA Vision for Space Exploration (VSE), COTS, entrepreneurial start-ups, space policy, and in-situ resource utilization. Then, on Jul 20-23, the newly established Lunar Science Institute (NLSI) at NASA Ames Research Center will host the first 'NLSI Lunar Science Conference' in Moffett Field CA. The symposium will begin on the 20th with a public event celebrating the Apollo 11 Moon landing by Neil Armstrong and Buzz Aldrin on Jul 20, 1969 – the first humans on another world. The workshop will closely examine the full spectrum of science opportunities *of, on,* and *from* the Moon, including NASA's upcoming LRO / LCROSS robotic lunar mission expected to launch in Nov. The conference will also feature a Lunar Exploration Analysis Group (LEAG) community meeting on the 22nd. The goal of the meeting is to help NASA and its international partners maximize the scientific return during robotic and human surface exploration to support lunar base buildout. (Credit: NASA / SPC)

Brazil Space Age Progress

Four events this week in Brazil highlight the country's continued efforts to strengthen its space program, and emerge as a major spacefaring power. On Jul 17, Brazil will be commemorating 20 years of the CBERS (China-Brazil Earth Research Satellite) Program during the '60th Annual Reunion of the Brazilian Society for the Progress of Science' at the University of Campinas in Sao Paulo. The event will include expositions of images from the satellite (CR), one of its cameras, lectures and roundtables. Also taking place this week in Sao Paulo is the 'GEO Summit Latin America 2008.' It is being held to present the new principles and tendencies in the areas of agricultural monitoring, cartography, and remote sensing to professionals, users and producers of applied geoinformation. Two other events this week aim at helping to rebuild Brazil's space agency (AEB) and scientific community that was devastated in the 2003 Alcantara Launch Center (BR) explosion. The 'Seminar of Scientific Initiation of INPE 2008' will feature final research presentations of the winners of last year's scholarships of Scientific Initiation in the National Institute of Space Research (INPE), and the awarding of next years scholarships. INPE is also providing an introductory course in astronomy this week for University educators and students. The course aims to help professors rethink how they present the science to their students, and inspire graduate students to pursue careers in the field. Brazil launched its first rocket into space in 2004 and Marcos Pontes (TR) became the first Brazil astronaut after traveling to the ISS in 2006. (Credit: AEB, INPE)

THIS WEEK

JULY

M	T	W	T	F	S	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

AUGUST

M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

SEPTEMBER

M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

LEGEND

- ● All times for terrestrial events in local time unless noted.
- ○ All times for international terrestrial events in local time unless noted.
- ★ All times for space events, and...
- ☆ All times for international space / astro events in Hawaii Standard Time unless noted. Add 10 hours to obtain UT ('Universal Time,' Greenwich, England).

Weekly Planet Watch – *Morning Planets:* Jupiter (SE), Mercury (ENE) / *Evening Planets:* Mars (W), Saturn (W), Venus (WNW).

Monday

☆	**Jul 14 — International Space Station,** *LEO:* Expedition 17 crew prepares for 2nd EVA tomorrow; Expedition 18 to launch on Oct 12 to replace current crew; http://www.nasa.gov/mission_pages/station/main/index.html.
●	**Jul 14-18 — Kavli Institute of Theoretical Physics / UCSB,** *Santa Barbara CA:* 'Conference: Magnetic Field Generation in Experiments, Geophysics and Astrophysics;' http://www.kitp.ucsb.edu/activities/auto2?id=915.
●	**Jul 14-18 — California Institute of Technology,** *Pasadena CA:* 'CMB Component Separation and the Physics of Foregrounds;' http://planck.ipac.caltech.edu/content/ForegroundsConference/Home.html.
○	**Jul 14-18 — National Institute for Space Research,** *Sao Jose dos Campos, Brazil:* 'Introductory Course in Astronomy and Astrophysics for Educators and University Students;' http://www.das.inpe.br/ciaa/ciaa.php.
○	**Jul 14-20 — British National Space Center,** *Farnborough, England, UK:* '46th Farnborough International Airshow;' celebrates 60 years of air shows at Farnborough; http://www.farnborough.com/intro.aspx.
☆	**Jul 14 — Mars Phoenix,** *Red Planet:* Spacecraft uses soil probe and Swiss-made atomic force microscope for 1st time; Phoenix continues soil sample collection using its robotic arm; engineers continue troubleshooting lander's Thermal and Evolved-Gas Analyzer (TEGA) following a recent short circuit; http://www.nasa.gov/mission_pages/phoenix/news/phoenix-20080708.html.
☆	**Jul 14 — Cassini Flyby,** *Saturn Orbit:* Spacecraft conducts distant flyby of moons Prometheus and Pallene; http://saturn.jpl.nasa.gov/operations/cassini-calendar-2008.cfm.
☆	**Jul 14 — Moon:** 0.30° SSW of Antares; 02:00.
☆	**Jul 14 — Asteroid 2008 BT18:** Near-Earth Flyby; (0.015 AU).

Lunar Commercial Communications:

The International Lunar Observatory requires communications capacity to transmit astrophysical data to satisfy its primary mission. Bandwidth not utilized for astrophysical data transmission can be made available on a commercial basis.

Commercial Usage of Additional Bandwidth

Pre-sold Bandwidth	Bandwidth Available Upon Emplacement (May be pre-sold when launch date set)		Future Need
Lunar Enterprise Daily This lunar news daily will be transmitted from the Moon. Advertisers will pay a premium rate for transmission of their ads from the lunar surface.	**Internet Search Engine Giants** search engine giants, such as Google and Yahoo, as well as other internet businesses, will be able to purchase bandwidth and use it to provide special services from the lunar surface, which might include local imagery. Interactive games may be developed which actually take place on the Moon.	**Specialty Advertising Opportunities** Large corporations will be able to use a Moon email system to capture the attention and interest of consumers for products which may relate to any of the numerous associations modern culture attributes to Luna.	**In Situ Communications and Monitoring Capabilities for Robotic Project Operators** As the wave of robotic and mining/excavation missions arrive on the lunar surface, they will do so with the knowledge that communications and surface monitoring capabilities in the region of Malapert Mountain and Shackleton Crater will be in place and available for purchase.

ILO Communication Capability

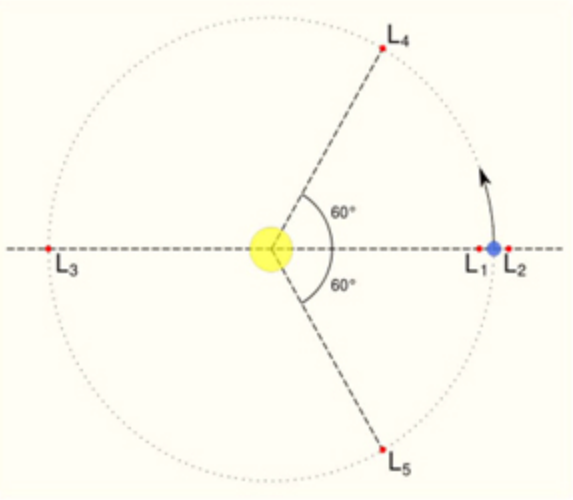
- **Communications Relay Capability**
  - **2 m diameter Communication/Radio Telescope Antenna**
  - **Limited Output Power of 10 Watt RF**
  - **Maximum Data Rate with 34 M Ground Antenna is 3.0 Mbps**

Earth station antenna diameter (meter)	Antenna gain (dB)	Maximum downlink data rate
11	45	300 Kbps
26	52	1.5 Mbps
34	55	3.0 Mbps
70	61	12 Mbps

Parameters:

Frequency: 2200 MHz
Path loss: 211 dB (385,300 Km)
Lunar antenna size: 2.5 meter
Lunar transmitter power: 10 watt
Modulation: BPSK
Forward error correction: None.
Bit error rate: 1.00E-05
Link Margin: 6 dB

Distances to Lagrange Points	
Earth to Moon	384 300 Km
Earth to L4/L5	384 300 Km
Earth to L3	384 700 Km
Earth to L1	326 200 Km
Moon to L1	58 200 Km
Moon to L2	64 700 Km
Moon to L4/L5	384 300 Km
Earth to Center of mass	4700 Km



ALOHA!

For more information about the ILO / ILOA, contact:

Space Age Publishing Company
480 California Ave, #303
Palo Alto, CA 94306
Phone 650-324-3705
Fax 650-324-3716
Email news@spaceagepub.com
Web http://www.spaceagepub.com

ILO Association
65-1230 Mamalahoa Highway, D-20
Kamuela, HI 96743
Phone 808-885-3474
Fax 808-885-3475
Email info@iloa.org
Web http://www.iloa.org

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