The History of Lunar Exploration

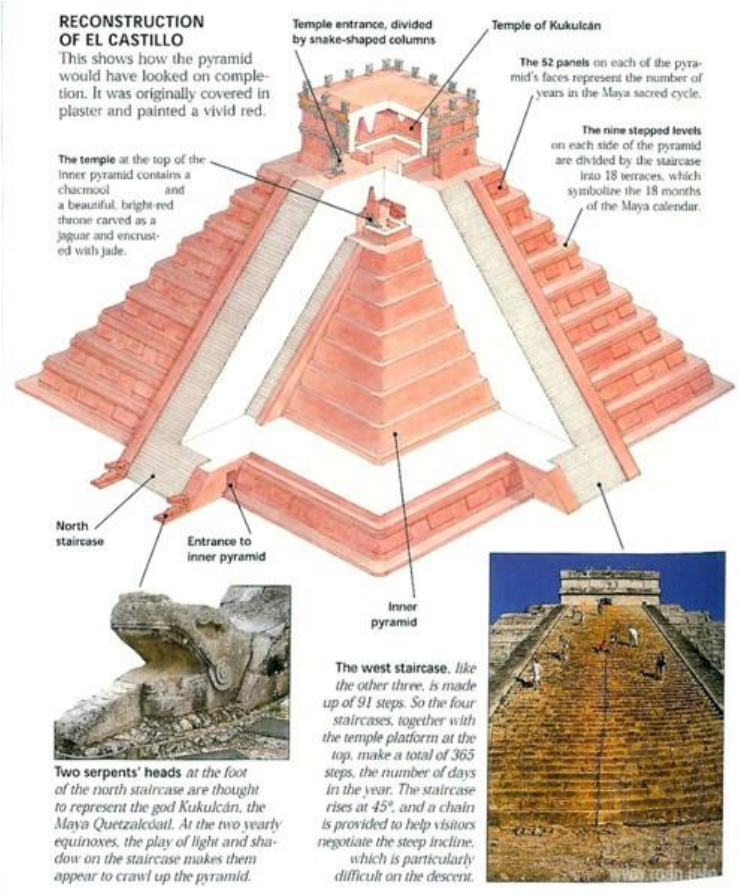
Jackie V, Bella W, Aleana P

Space Observations- Early History

Temple of Kukulkan

Mesoamerican monument located in Chichen Itza for the winter and summer equinox that pays respect to the serpent god that descends upon earth once every december and june

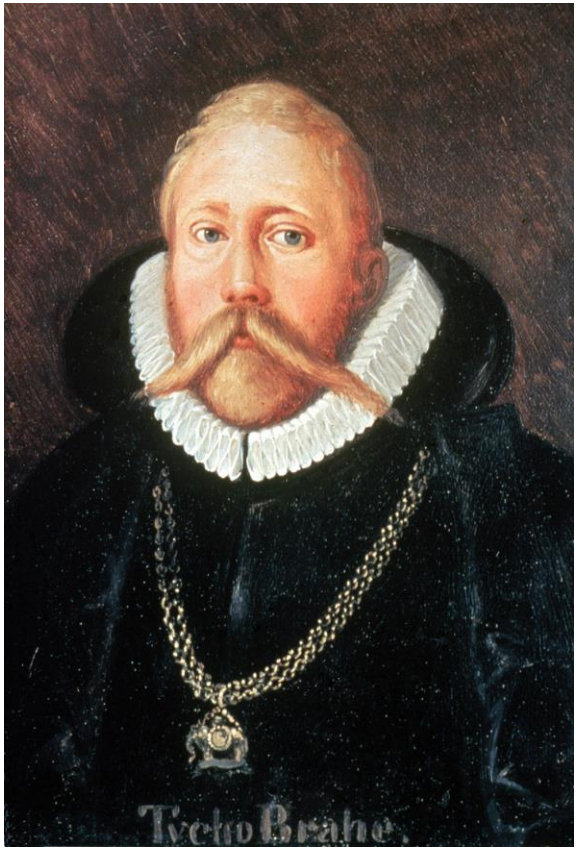
The location of the pyramid aligns at the intersection between four cenotes (natural pits/sinkholes): the Sacred Cenote, Xtoloc, Kanjuyum, and Holtún. This alignment supports the position of El Castillo as an *axis mundi* (Earth Axis- the celestial pole). The western and eastern sides of the temple are angled to the zenith sunset and nadir sunrise, which may correspond with other calendar events such as start of the traditional planting and harvesting seasons and the summer solstice.



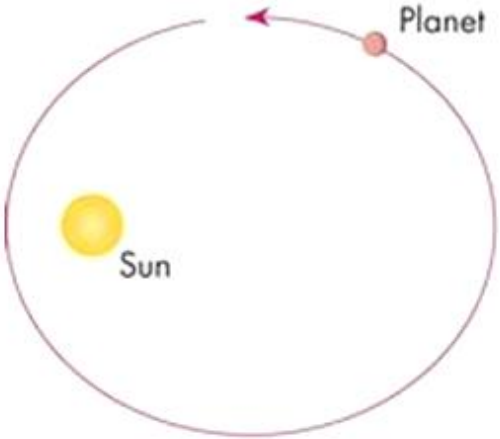
Galileo’s Telescope

- Built crude refracting telescope with about 20 x's magnification (1609){- not the first telescope invented!}.
- First to use telescope to see into the skies and witness Venus’s phases
- First to observe sun spots
- First to observe the craters of the moon
  - Refutation of the “perfect” world
  - 4 Galilean moons: Io, Europa, Ganymede, and Callisto

Tycho Brahe and Johannes Kepler

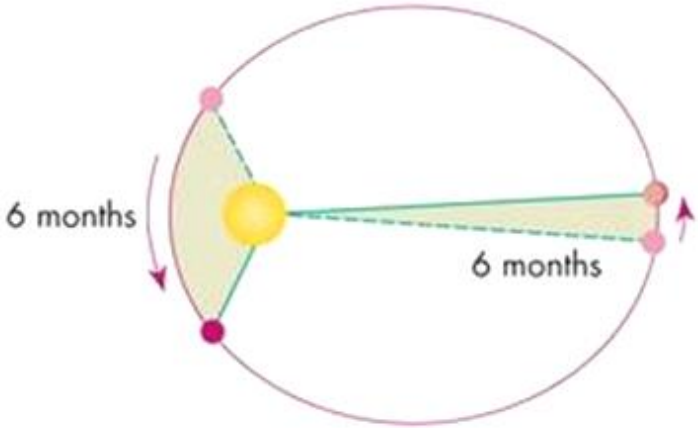


Kepler's 3 Laws of Planetary Motion



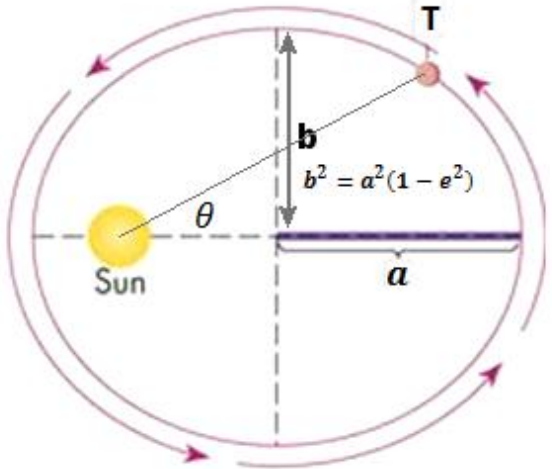
(1)

The orbits are ellipses



(2)

Equal areas in equal time



(3)

$T^2 \propto a^3$

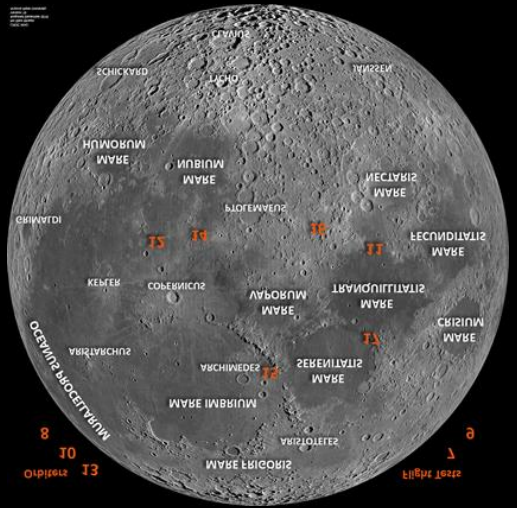
T = time to complete orbit

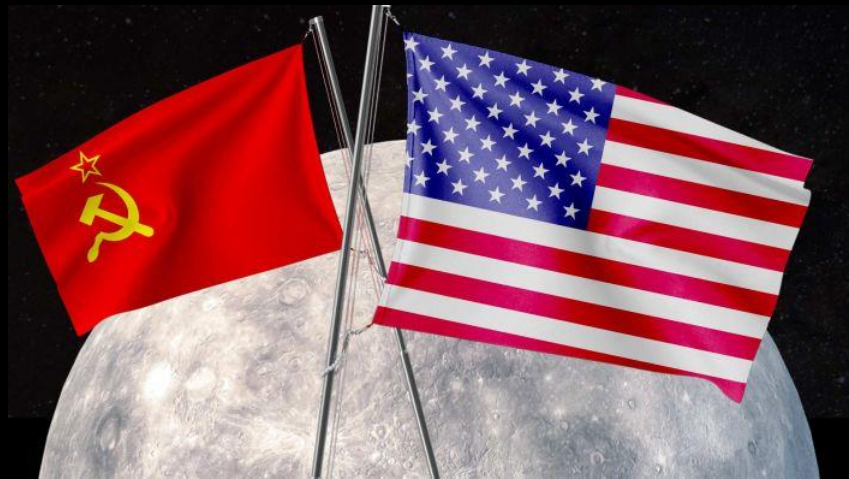
a = semi-major axis

USA

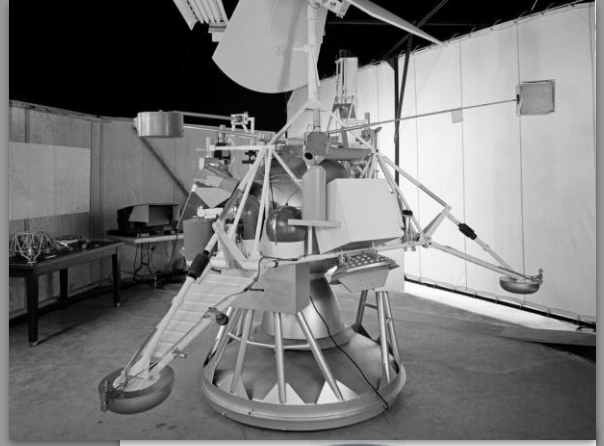
Historical Context:

- On October 1, 1958 the National Aeronautics and Space Administration began operation with about 8,000 employees and an annual budget of around $100 million
- The space race, along with the nuclear arms race, was a huge part of the Cold War
- In response to Russia’s Vostok 1, and the first human in space in 1961, President John F. Kennedy committed the US to sending a man to the moon within the decade





Important Missions/Programs



Rangers Program: 1961-1965

- Probes were designed to obtain up-close photographs of the lunar surface
- 9 probes were launched, 3 were successful

Surveyor Program: 1966-1968

- 5 total missions
- Collected and analyzed physical properties of the surface

Lunar Orbiter Program: 1966-1967

- 5 missions
- Purpose was to map lunar surface before Apollo landings
- ALL missions were successful & 99% of the Moon's surface was photographed

Apollo Program: 1963-1972

- First humans to explore the Moon
- 6 of the missions accomplished goal of getting man on the Moon
- Apollo 11: July 20, 1969, first Moon landing with astronauts Neil Armstrong, Buzz Aldrin,& Michael Collins
- Apollo 17: December 1972, final Apollo mission

Important Missions/Programs

Clementine (1994) and Lunar Prospector (1998):

- Clementine was launched to study the moon and test the spacecraft components during extended exposure
- Both orbiters mapped the lunar surface and found evidence of water ice at lunar poles

Lunar Reconnaissance Orbiter (LRO): 2009

- Primary goal was to make a 3D map of the lunar surface
- The LRO is currently in extended mission phase and continues to orbit

Lunar Crater Observation & Sensing Satellite (LCROSS): 2009

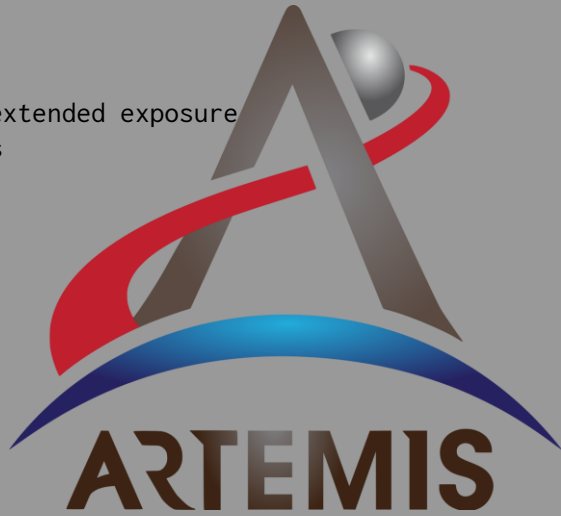
- Launched with the Lunar Reconnaissance Orbiter (LRO)
- Both orbiters found evidence suggesting that lunar soil in shadowy craters is rich in useful materials as well as confirmed the existence of water ice

Artemis Mission: 2010-Present

- Twin robotic probes that are currently orbiting the Moon and providing data on solar wind

GRAIL Mission: 2011

- Twin spacecraft (Ebb & Flow) flew in tandem around the Moon to map variations in the lunar gravitational field



ESCAPE VELOCITY

Russia

Historical Context:

-Theories of space exploration were already substantial in Soviet Russia even before World War I, thanks to Konstantin Tsiolkovsky

-In 1955, 10 years after the end of World War II, and little after the beginning of the Cold War, the USSR Rocket and Space Program was formed

-Due to the private and primarily classified military nature of the Soviet Space Program, announcements of outcomes of missions were delayed until success was certain, and failures were sometimes kept secret

-After the fall of the Soviet Union, Roscosmos (the current space program) was established

Important Missions/Programs

Sputnik Program: late 1950's-1960

- Supposed to demonstrate the viability of artificial satellites
- had 5 missions in total, including:
  - Sputnik 1: October 1957, the first artificial satellite to enter orbit, marked the beginning of the space race
  - Sputnik 2: November 1957, first animal in space
  - Sputnik 5: August 1960, first flight to return living creatures unharmed

Vostok Program: 1960-1963

- Aimed to send man into space for the first time
- Vostok 1: April 1961, Yuri Gagarin is first human in space
- Vostok 6: June 1963, Valentina Tereshkova, first woman in space

Voskhod Program: Following the Vostok's success

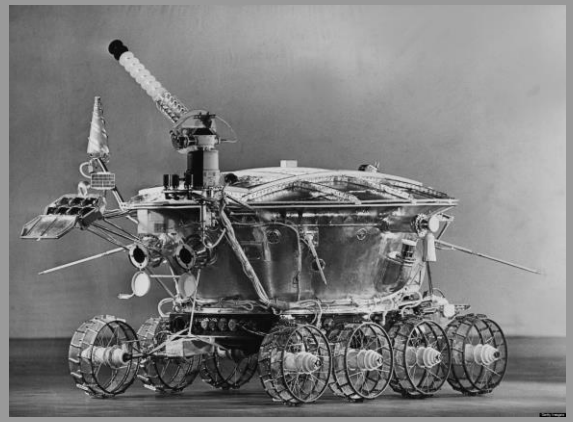
- Second Soviet human spaceflight project
- Only 2 manned flights
- Vokshod 1: October 1964, First multi-person crew
- Vokshod 2: March 1965, first spacewalk by Alexey Leonov

Soyuz Program: Started in early 60's however did not perform a launch until 1966

- Attempt to get humans on the moon
- Colonel Vladimir Komarov tragically dies after the spacecraft's main parachute failed to open

Important Missions/Programs

Before trying again with the Soyuz program, the USSR did a series of unmanned launches using Soyuz capsules, as a part of the Zond Program



- Zond 5: September 1968, first living creatures to fly past the moon

Luna Program: 1959-1976

- Designed to collect information about the Moon and it's environment
- Included: fly-bys, lunar orbiting, & soft-landing missions
- Luna 1: January 1959, First fly-by of the moon
- Luna 2: September 1959, first spacecraft to impact lunar surface
- Luna 3: October 1959, first pictures of lunar farside
- Luna 17: November 1970, delivered Lunokhod 1 rover to the moon's surface

After the United States "won" the space race with the Apollo 11 mission,the Soyuz program continued, but changed focus to developing the Salyut space stations, and eventually the famous MIR space station, which was launched in 1986, finished assembling in orbit in 1996, and stayed in orbit until 2001

Then, in 1998, Roscosmos along with 4 other space agencies (NASA, JAXA, ESA, & CSA) launched the International Space Station

(SOURCES: NASA, EN.ROSCOSMOS.RU, THOUGHT.CO, NATIONAL ARCHIVES)

China

HISTORICAL CONTEXT/POLITICS:

-China began involvement in space and lunar exploration in the late 1950’s and partnered intelligence with Russia, then the Soviet Union, to win against the United States in the cold war which was centered in the production of nuclear weapons and a successful mission to the moon.

-in the 1960’s, China became independent in its missions and their then ruler Mao Zedong would hault scientific exploration in favor of cultural development to aid his ruling.

-The China National Space Administration (CNSA) was established in 1988 with much public outcry as money would be better spent in more immediate public aid

Missions/Programs

Government funded Missions:Chang'e 3, 5T1, Chang'e 2, Chang'e 1 (No Chang'e mission has been manned so far`

- All current Chang'e missions have only orbited the moon
- Initial launch in October 2007 (although launch was planned for April of the same year)
- Each of the Chang'e launches were only three years apart (2007, 2010, 2013)
- There are plans for Chang'e 5-8 (Sample return, Sample Return, Survey Mission, and Technology Test missions respectively)
- Chang'e 5 plans to launch in late 2020

Private Organization Program Launches: Shenzhou Program

The Shenzhou Program is a private organization authorized for human spaceflight by the CNSA in 1992.
Prior to the commencement of the program, there were 4 unmanned test flights launched in 1999, 2001, and two launches in 2002.

- Phase 1: 2 unmanned spaceflight launches
    - work first began in 1968 for a projected launch in 1973. Work finished early and launched in 1970 successfully. The crewed flight was cancelled that same year because of lack of funds and political/public interest

-Phase 2: Fly-by's
- launched in 2007
- successfully docked other operations in orbit

-Phase 3: 2010 / 2015 20 ton shuttle space station (crewed, fly-by)

Shenzhou 4:

- Launched December 29, 2002.
- Equipped for manned flight but instead carried 2 dummy astronauts to test life support systems

Shenzhou 5: Yang Liwei sent to space in October of 2003 (Did not land and further attempts were underfunded as the public questioned if money was being well spent)

Notable- Shenzhou 7: 1st Chinese spacewalk. Shenzhou 10: 1st Chinese woman in space

By 2018 China had 33 successful satellite launches
(SOURCES: CNN, TIME, CHINESE SPACE PROGRAM, THOUGHT.CO)

True Capitalization:

2016 Start-Up in Beijing for i-Space, currently 3 successful missions

2018: 5 successful launches of commercial satellites

Goal: demonstrate the technological capabilities of China and create lunar/space tourism. (SOURCE: THE GUARDIAN)

Interesting facts:

- As of 2011, US Congress OSTP and NASA have not had joint science activity deals with any Chinese space exploration agency
- The first rudimentary rockets were built in China for war in 900 AD against Mongol invaders (Kei-keng Battle 1232)
- Private space exploring organizations challenge the extent of ITAR rules/regulations
- Chang’e is the name for the Chinese goddess of the moon

India

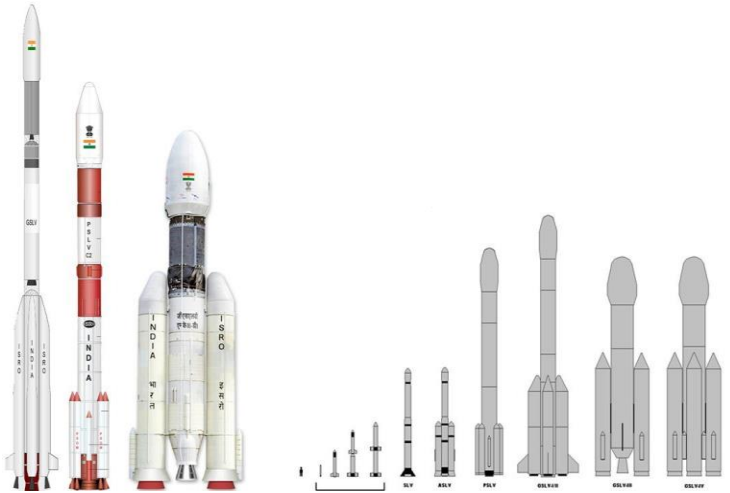
POLITICAL/HISTORICAL CONTEXT:

India’s prime minister Atal Bihari Vajpayee (1998-2004)

- Political Party Affiliation: Indian Peoples Party (BJP, right-winged party)
- Associated with the current leading political party in India
- Created and funded the Indian Space Research Organization (ISRO) in 1969
- Main objective: provide scientists with chemical mapping of the lunar surface

ISRO Objectives:

- Chemical mapping of the permanently shadowed regions of the lunars north and south poles
- Find water-ice
- Identify the chemical in the peaks of lunar craters
- X-ray spectrum observation coverage of most of the lunar surface
- Provide insight to moon's origin and evolution



Missions/Launches

Chandrayaan 1:

-Oct. 2008 Chandrayaan lunar probe successfully launched

- Communication suddenly lost in August 2009 and calculated to be supposed to have crash-landed on moon in 2012
- As of 2016, other probes have shown that Chandrayaan 1 is still in Lunar orbit and has yet to land

Earth Orbit Burns:

- Burns 1-5 Oct.-Nov. 2008 reached a maximum height of 380,000 KM

Lunar Orbit Insertions:

- Insertions 1-4 orbited between 08 Nov. 2008 - 12 Nov. 2008 reached a maximum height of 7,500 KM*
- *Sensor failure on maximum height of Lunar Orbit Inserter 4

Mangalyaan Probe

- Launched 2014
- India became the 1st Asian nation to reach Mars
- Reached mars with half of NASA's budget

Gaganyaan

- Planned manned launch in 2022

Japan

Japan has launched three rover missions, of which two were successful, and eleven sample return flights were attempted with three successes.

The Pittsburgh-based company Astrobotic plans to send its robotic Peregrine lander to the lunar surface in July 2021. This mission is sponsored by NASA's Commercial Lunar Payload Services (CLPS) program.

Peregrine will also carry the United Kingdom's first-ever moon rover built by London-based company Spacebit as well as Japan's first lunar rover, a tiny, wheeled robot named Yaoki, which was developed by Tokyo-based company Dymon.

JAPAN'S SUCCESSFUL LUNAR MISSIONS

1. **1990- ISAS (institute of space and astronautical science)**

   HITEN (Muses-A) was designed for a flyby and was placed into selenocentric orbit

2. **1992- ISAS & NASA**

   Geotail- series of flybys to reach earth-sun lagrangian point

3. **2007- JAXA**

   SELENE(Kaguya), Okina(RSAT), and Ouna(VRAD) were all orbiters

   Kaguya impacted the moon, and RSAT and VRAD were deployed from Kaguya

Japan cont...

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Japan - other milestone missions

Date	Event of space exploration	Mission Name
12 February 1997	First orbital radio observatory	HALCA
20 November 1998	First multinational space station, largest man-made object built in space to date (Russia, USA, ESA, Japan, Canada)	International Space Station
19 November 2005	First asteroid ascent (25143 Itokawa) First interplanetary escape without undercarriage cutoff	Hayabusa
13 June 2010	First sample return from asteroid (25143 Itokawa)	Hayabusa
10 August 2015	First food grown in space eaten (lettuce). (USA, Japan)	International Space Station
21 September 2018	First operational rover on asteroid (162173 Ryugu)	Hayabusa 2

JAXA- Japan Aerospace Exploration Agency

Future of lunar exploration for Japan

-The Japanese government plans to join NASA in its Artemis program of lunar exploration. Japan is the second major spacefaring nation to announce their intent to collaborate on the Artemis program.They want to join to gain diplomacy and security, international competitiveness, commercial opportunities and support for later missions to Mars.

-Future endeavors: In 2022 JAXA plans to send “SLIM” and “DESTINY+”

-SLIM would be used for pinpoint landing and roving, while DESTINY+ would be a lunar flyby toward an asteroid

ISRAEL

In 1982, the Israel Space Agency was created, which is responsible for coordinating the space program of Israel.

The Israel Network for Lunar Science and Exploration (INLSE) program was established by the Israeli Space Agency part of an international effort to study the moon and the solar system.

In January 2010 a joint declaration by NASA and Israel Space Agency was signed making Israel a member of the NASA Center for Moon Research and promote cooperation between the two agencies.

Israel

Satellite programs:

- Ofeq - Series of reconnaissance satellites. The first of these was launched from the Palmachim site on September 19, 1988.
- Amos - Series of communications satellites
- Eros - Series of observation satellites
- Techsat - Researching satellite launched by the Technion
- TechSAR - a SAR-based observation satellite.

The Israel Space Agency operates the spaceport located in Palmachim Air Force Base.

Due to Israel's geographic location and hostile relations with surrounding countries, launches take over the Mediterranean Sea to avoid flying over hostile territories. This is also to prevent possible debris from falling above populated areas. This limitation imposes lifting capabilities struggles.

Recent ISA launches include:

- June 11, 2007 - Ofeq 7 satellite
- June 22, 2010 - Ofeq 9 satellite
- April 10, 2014 - Ofeq 10 satellite
- September 13, 2016 - Ofeq 11 satellite

ISRAEL'S MISSIONS

-The 2019 Beresheet was a lander from SpaceIL was the first privately funded lunar lander mission that crashed into the lunar surface after main engine fail during descent from lunar orbit phase.

Though the spacecraft crashed, **Israel** became the seventh country to make lunar orbit and the fourth country, after the Soviet Union, the United States, and China to attempt a soft landing on the **Moon**. Two days after the failed attempt to soft land on the **Moon**, SpaceIL announced plans for a second attempt, Beresheet 2.

Ilan Ramon (1954 – 2003)

Israel's first astronaut. He was an Israeli fighter pilot, and was selected among six other astronauts for Colombia's STS-107 mission.

The seven astronauts died during a re-entry accident above Texas on Feb. 01, 2003.

Ramon was 48 years old- the oldest crew member of the mission.