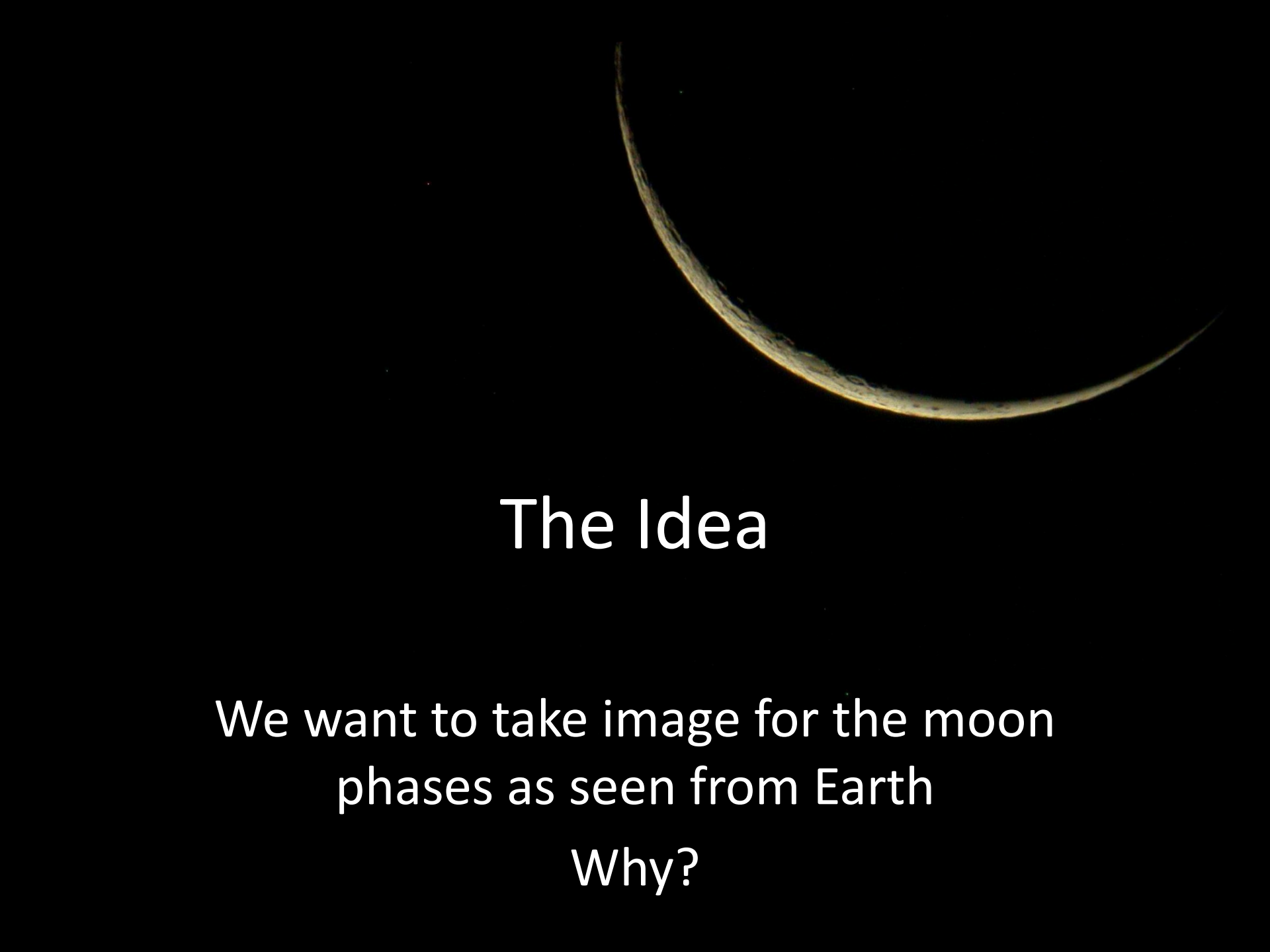
OTSUKIMI
Moon-sighting Satellite

Kyushu Institute of Technology

3rd Mission Idea Contest

UNISEC Global



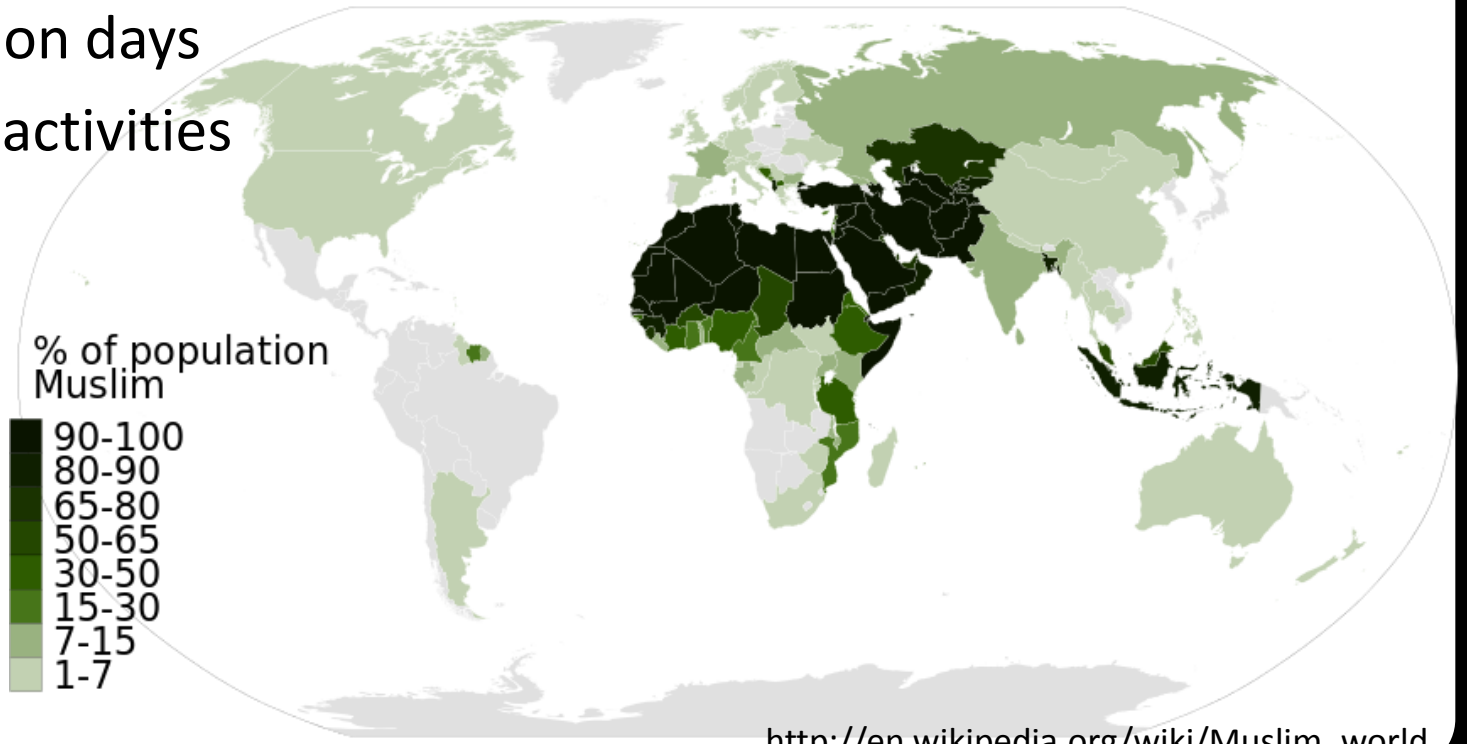
The Idea

We want to take image for the moon phases as seen from Earth

Why?

Introduction

- 1.6 billion ,23.4% of world's population
- Muslims Countries depend on "Lunar Calendar"
  - Religious rituals
  - Celebration days
  - Cultural activities

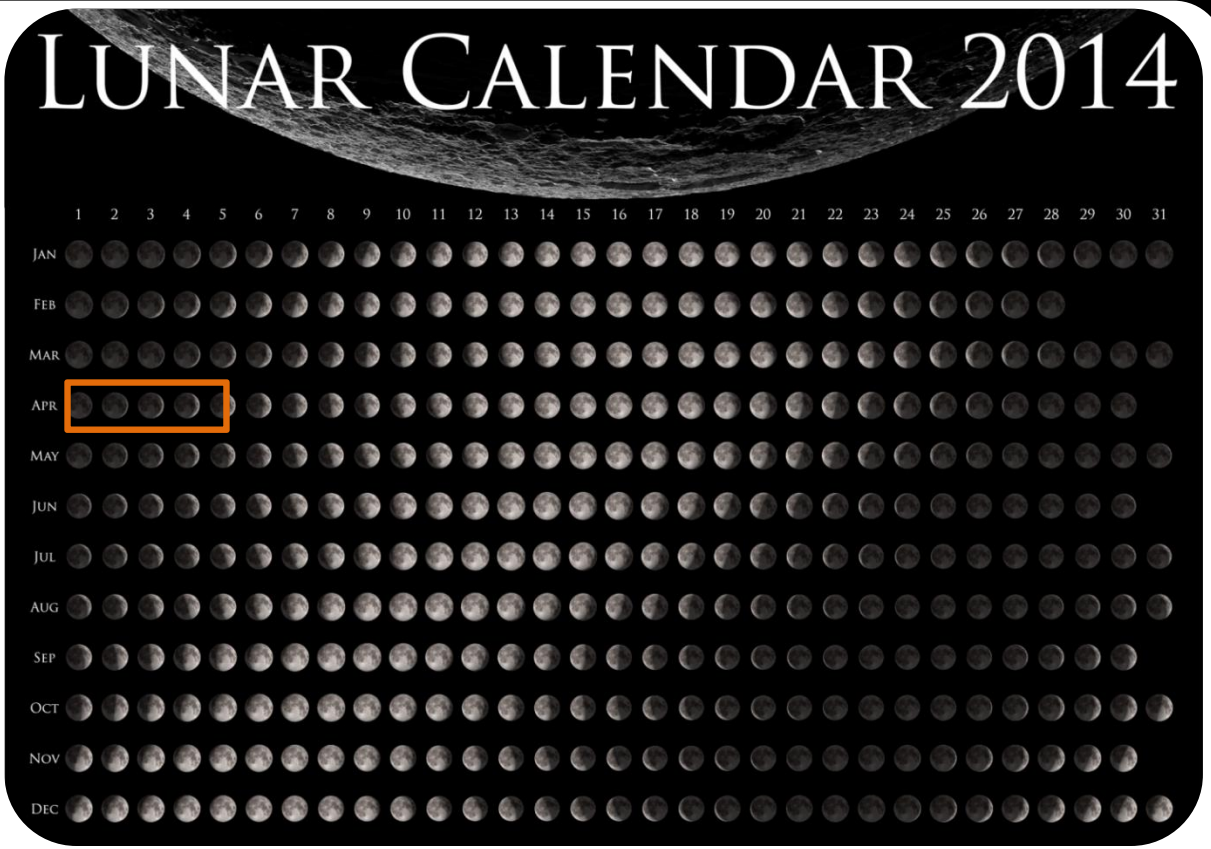


http://en.wikipedia.org/wiki/Muslim_world

Introduction
The Lunar Calendar

Lunar year:

- 12 months
- First day is when the crescent is born.
- Julian year is 11 days more.

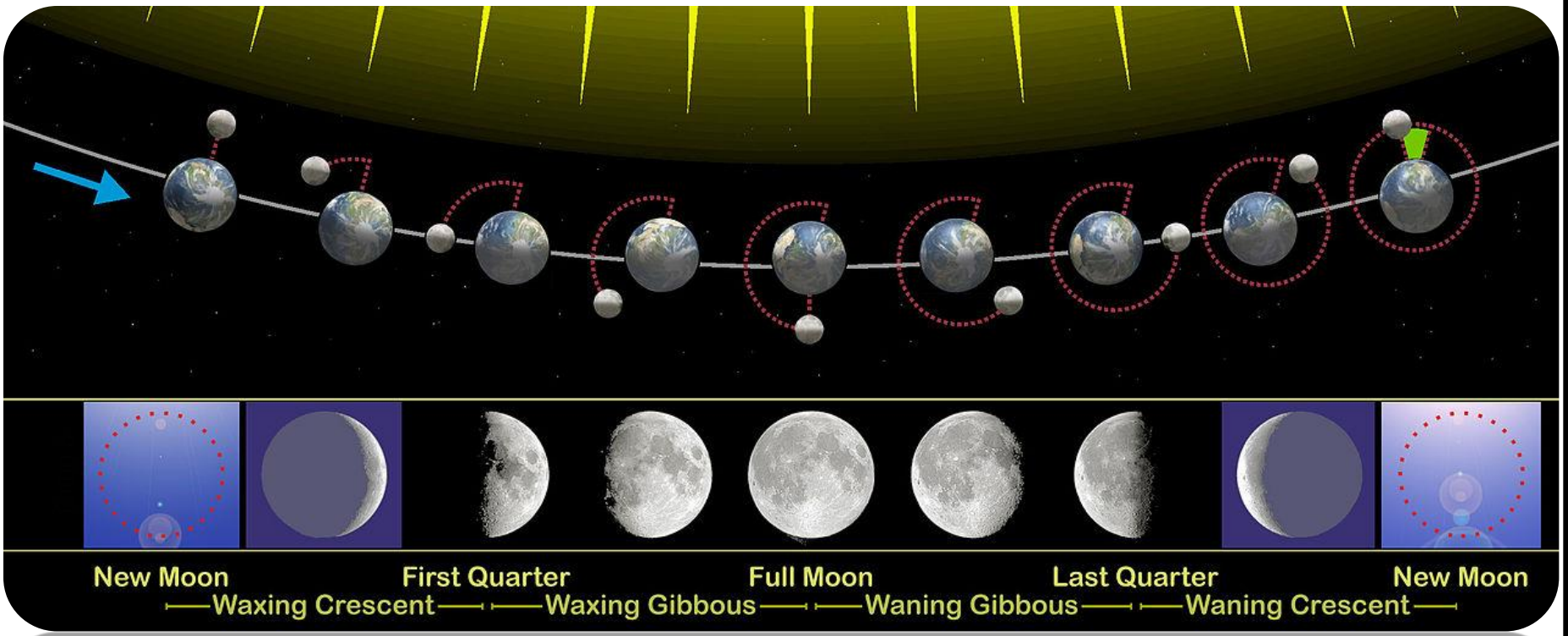


Introduction
The Lunar month

- It takes 29.5 days per month

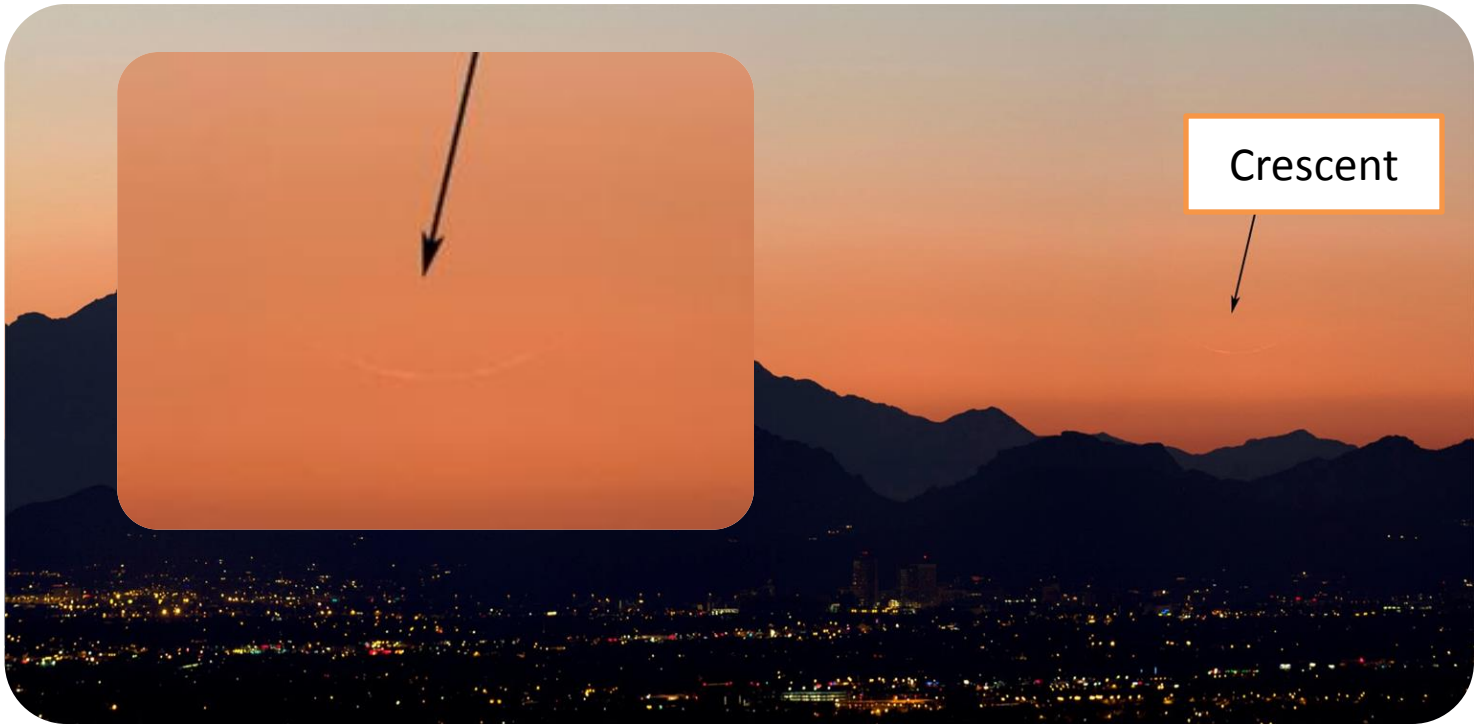
When can we see the crescent?

- The critical time to sight 1st day crescent



When we can see the crescent?

- Looking towards the west sky before sunset on the 29th day
- Only for few minutes.
- Fortunately this is a clear sky, crescent is visible.

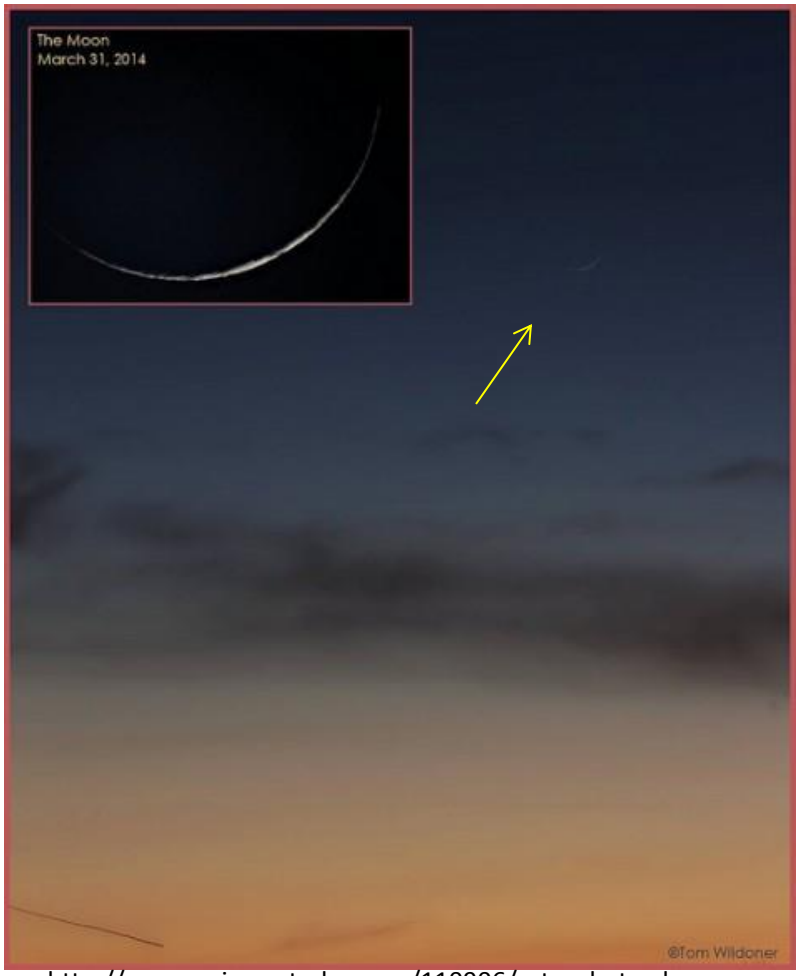


http://theketelsens.blogspot.jp/2014/01/chasing-skinny-crescents.html

The problem

- Air pollution has become a problem.
- Light refraction at the horizon
- Bad weather
- Short vision time

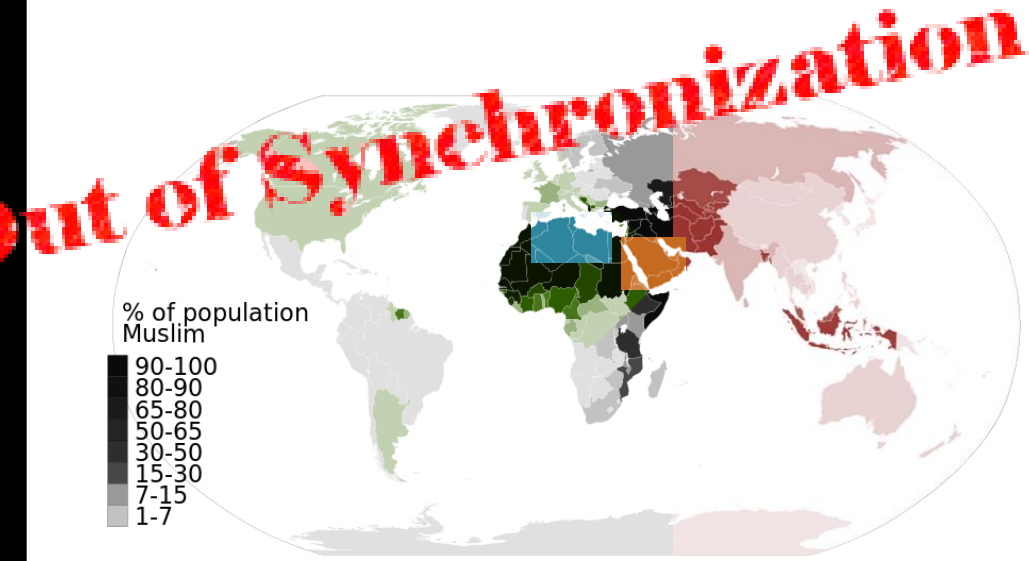
→ we can not see the crescent



http://www.universetoday.com/110906/astrophotos-heres-what-a-super-thin-crescent-moon-looks-like/

Why it is important for Muslims?

- Muslims rituals, celebrations and festivals depends on Lunar calendar.
- **<u>The problem is</u>** : The Non-unified start of the Lunar Month in these countries



Muslims sighting for the crescent

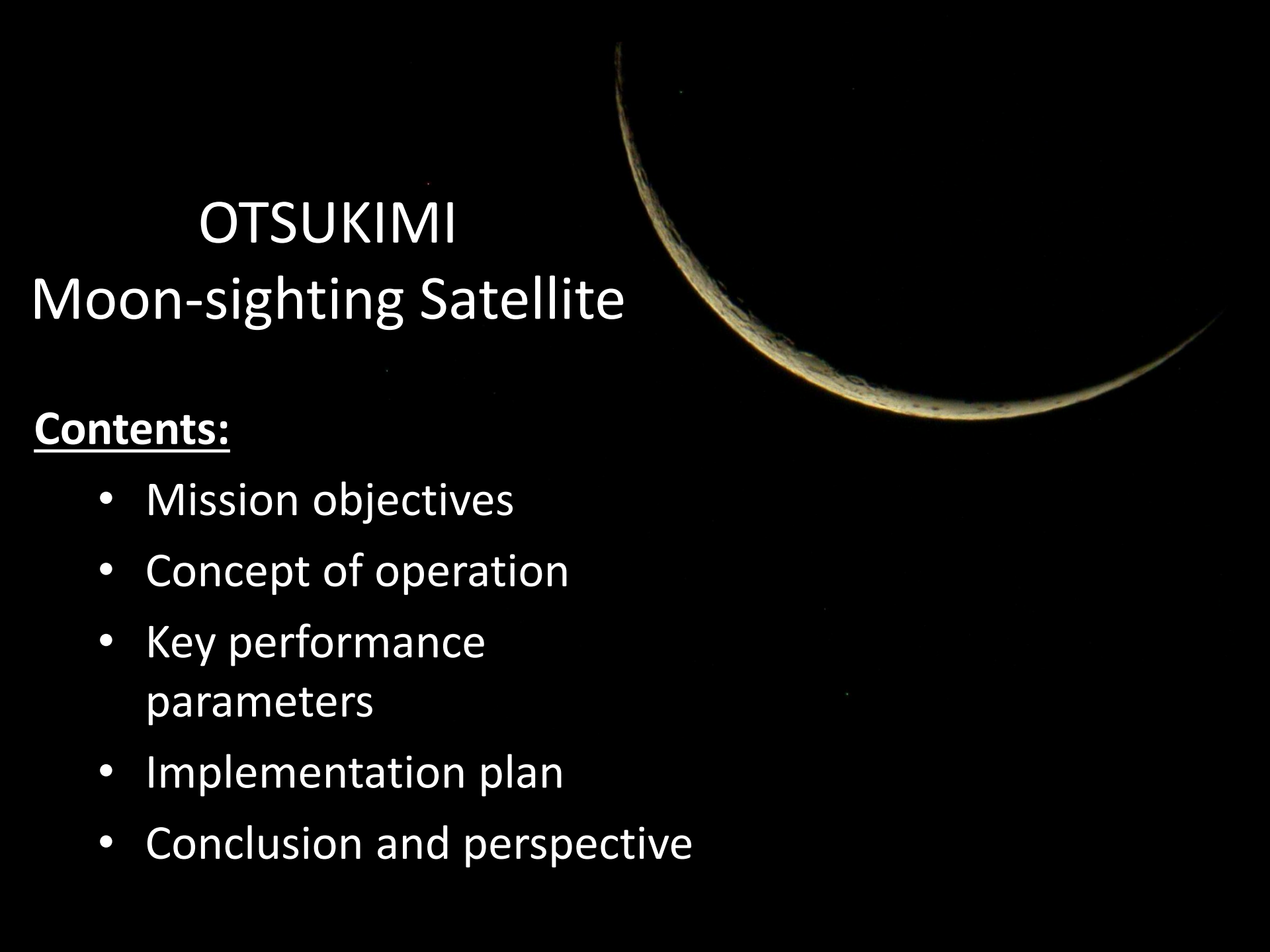
- Calculation-based methods are used to confirm the crescent sighting.

Conditions to be fulfilled:

- **Conjunction** has occurred before sunset.
- The possibility of sighting with bare eye or a telescope in any place of a region that is sharing the same night time.

Astronomers added :

- The Moon sets after sunset where there is possibility of sighting.
- Angle between the crescent and the horizon at sunset is at least 5°.
- Distance between Sun and the Moon is at least 8°.



OTSUKIMI
Moon-sighting Satellite

Contents:

- Mission objectives
- Concept of operation
- Key performance parameters
- Implementation plan
- Conclusion and perspective

Mission Objectives

Mission statement:

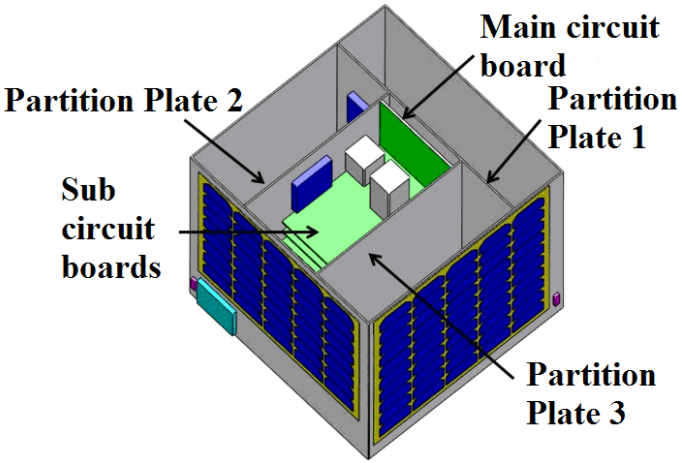
To capture images of the lunar phase at sunset and distribute the data to users within approximately 2 hours.

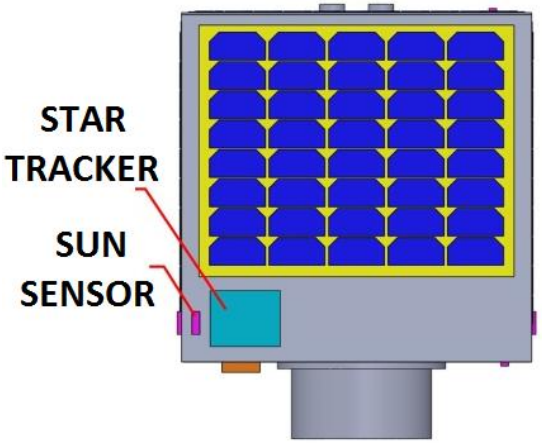
Secondary missions:

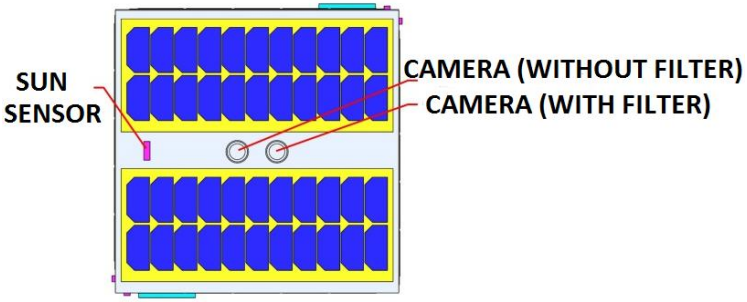
- Observing the moon all the time (eclipse , etc.)
- Satellite ground station operated from several countries.
- Online database.
- Developing countries involved embracing space technology in solving their developmental challenges
- Encourage universities to develop nano-satellites projects, which will be based on successful missions in other countries (e.g. Japan).

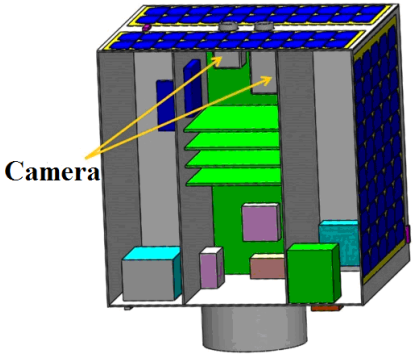
Overview

- Overview of the satellite stru
  - Mass: 30 kg
  - Size: 50 x 50 x 50 cm





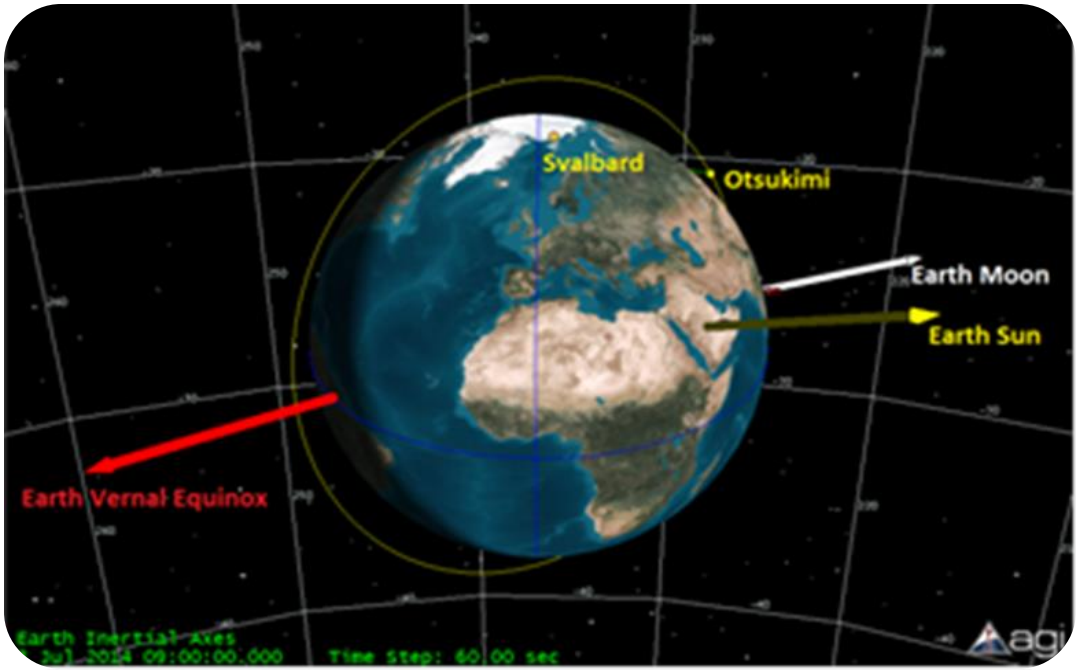




Concept of Operations

SPACE SEGMENT

- Orbit: Circular dawn-dusk sun-synchronous orbit
  - Altitude: 1000 km
  - Inclination: 99.5°
- 3-axis Attitude Determination and Control System (ADCS)
- special filtered lens



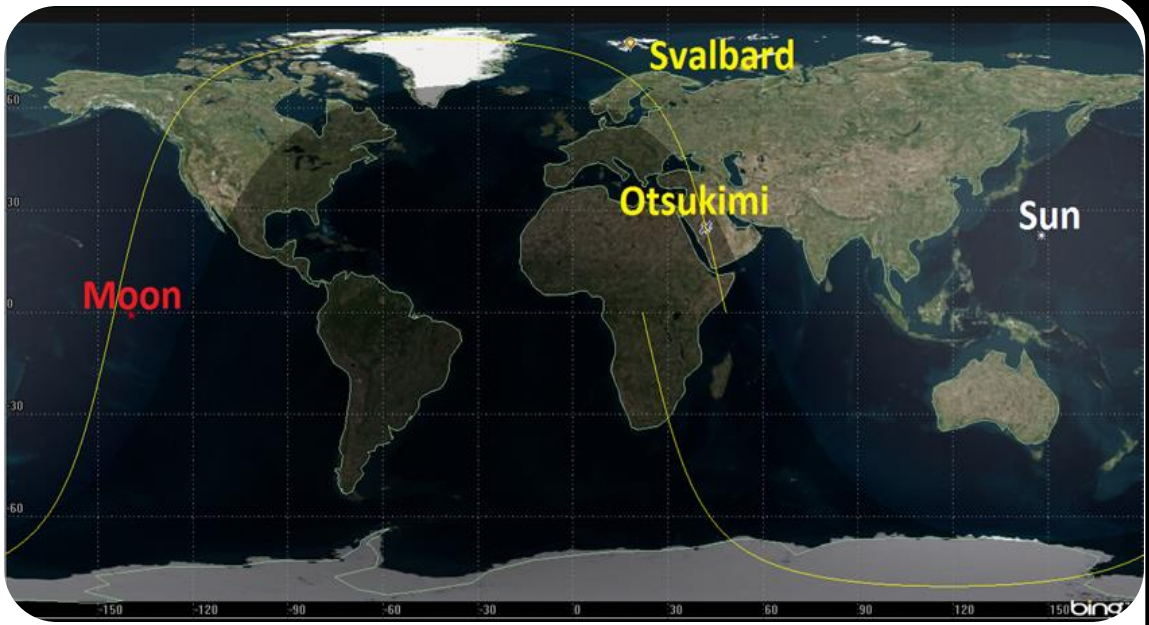
Concept of Operations

GROUND SEGMENT

- downlink the images in each orbital period;
- multiple passes at sunset over the Middle East
- a near-North Pole ground station- Svalbard Satellite Station
- Fast outreach to public
- Visibility ~10 min
- Downlink ~20 images per pass.

LAUNCH

- H2A rocket



MODES OF OPERATION

- Normal Mode: satellite regularly tracks and acquires images of the Moon;
- Multi-images Mode: at the beginning (emerging) of the New Moon

Key Performance Parameters

Key Parameter	Design Requirement	Subsystem Requirement
3 Mega pixels Image	Payload shall be a reasonable CAM	Use of: • QXGA type CAM • 1/2 or 1/3 Image Sensor • 200 to 300 mm Focal length
Constantly Tracking the Moon	ADCS shall provide 3-Axis Stabilization Control	Use of : • Star Tracker • Reaction Wheels • Magnetorquers
Download the Mission Data directly upon Request	COM shall provide High data rate downlink	Use of: • UHF/VHF for Telemetry and commanding • S-Band for Mission Data Download

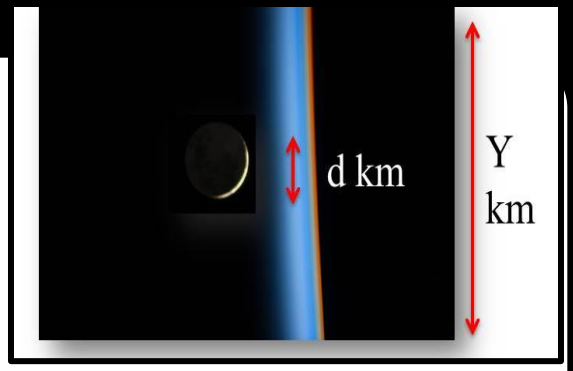
Key Performance Parameters CAM

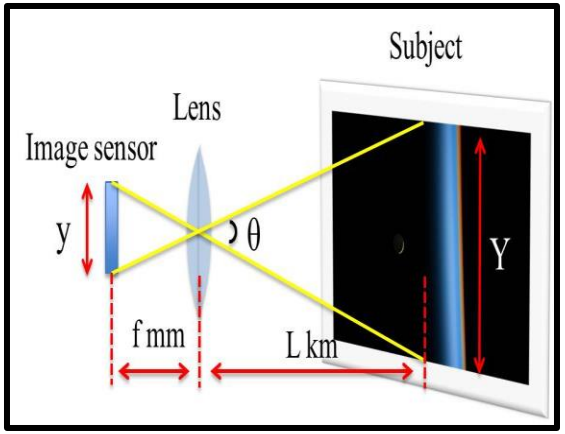
$$\theta = 2\,tan^{-1}\frac{Y}{2L}$$

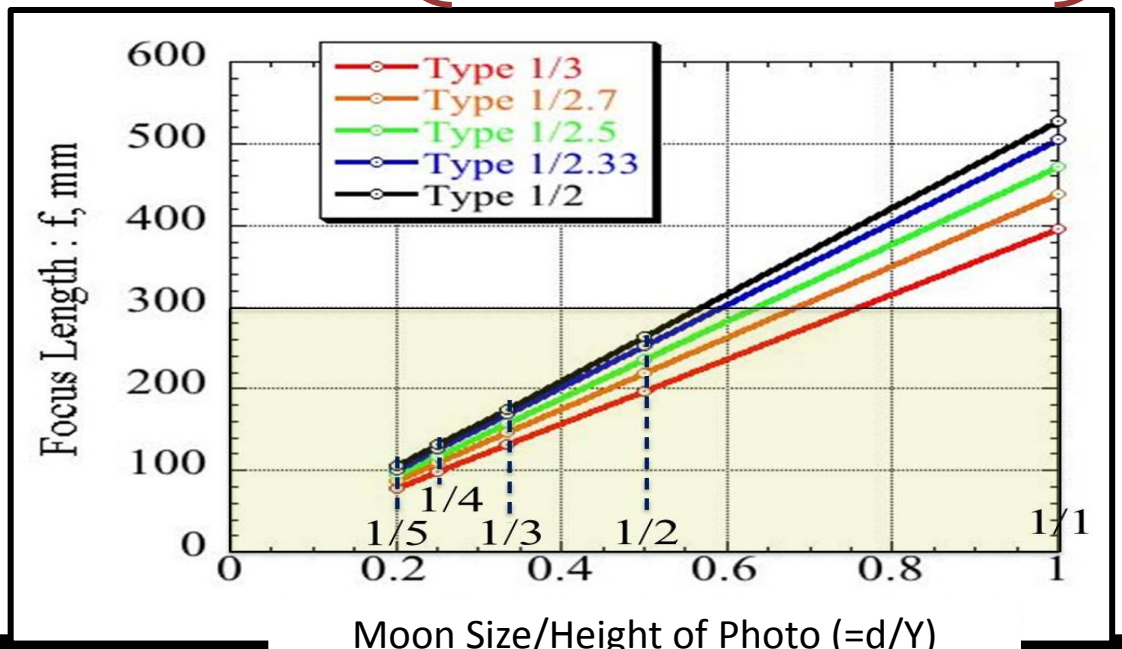
$$f = y \times \frac{L}{Y}$$

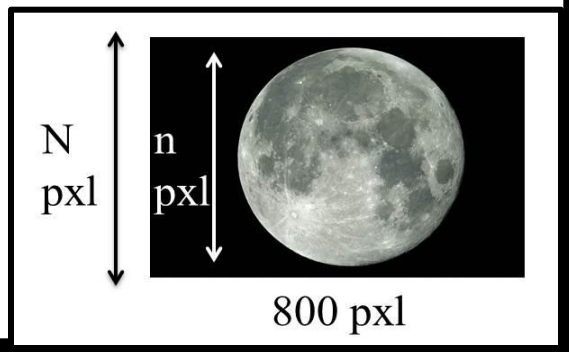
$$Y = k\,.\,d$$

Y : Vertical length of photo [km]
y : Vertical length of image sensor [mm]
L : Distance to the subject [km]
f : Focal length [mm]
θ : Angle of view [deg]
K : Magnification Factor









Key Performance Parameters
ADCS

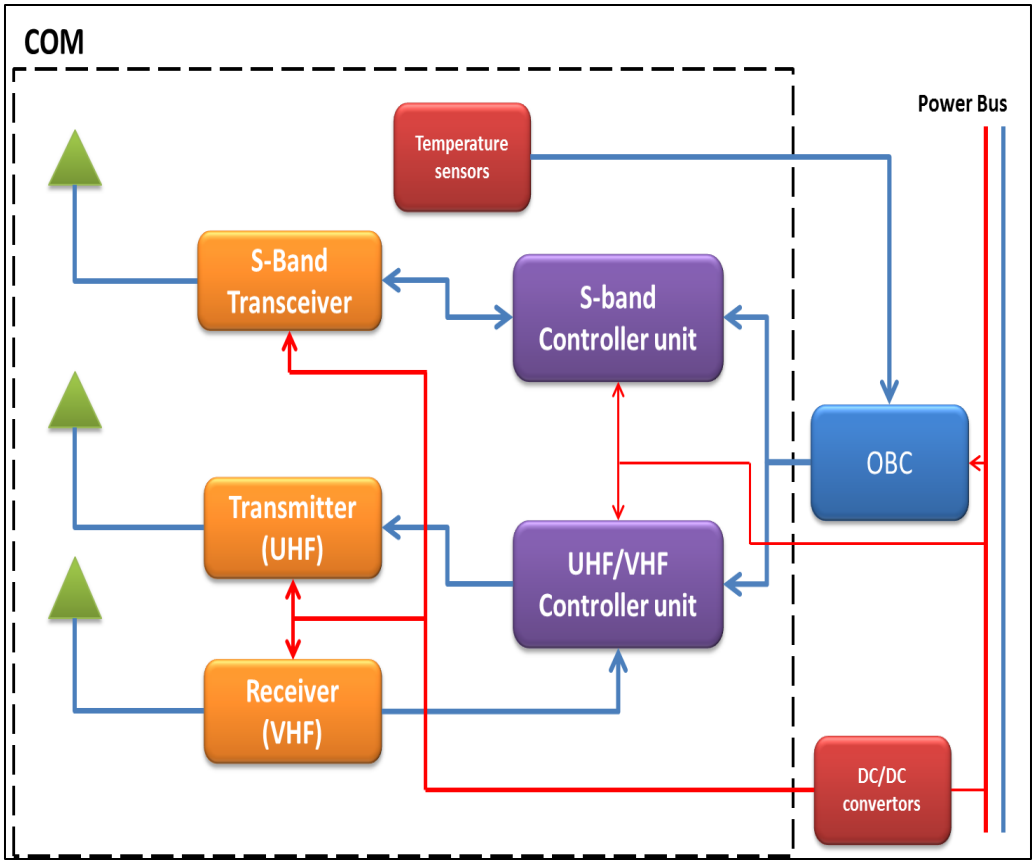
Mode of Operation	Description
POWER Mode (Default)	Pointing The Satellite towards the SUN
MISSION Mode	Pointing the CAM towards The Moon

Required Component	Quantity	Specifications
Gyroscope	1	3 axis gyroscope (in inertial measurement unit)
GPS receiver	1	-
GPS active patch antenna	1	-
Sun sensor	6	FOV: 114°, Accuracy: <0.5°
Star tracker	2	Accuracy : 18 arcsec (x,y axis) 122 arcsec (z axis)
Reaction wheel	4	Momentum Storage: 7.6 mNms @ 1000 rpm Maximum Torque: 0.625 mNm
Magnetorquer	3	3 axis , actuation level 0.24 Am^2 max
80960 MC processor	2	25 MIPS at 25 MHz

Key Performance Parameters COM

Functions	Band / Freq.	Data Rate
Transmit Beacon and Telemetry	UHF / 534Hz	9600 bps
Downlink Mission Data	S / 2400MHz	2 Mbps
Uplink Commands	VHF / 145 MHz	1200 bps

Link Budget	S-band	UHF
Carrier-to-Noise Ratio (dB)	94.3	70.07
C/N required (dB)	77.10	56.82
Margin (dB)	17.20	13.25



Expected product

- An image of crescent from space (New moon).
- Photographed from ISS.

http://en.wikipedia.org/wiki/Lunar_phase

Implementation Plan

- **Product:**
  - Moon-sighting satellite.
- **Service:**
  - Ground station.
  - Database of Moon images.
  - Increasing outer space knowledge.
  - Community need (Lunar Calendar)
- Life time: 2 years min. (COTS)
- Total cost: < $6.5M USD ($4 launch).
- Responsible organization: Kyutech and interested parties.

Implementation Plan

Major Project Phases

Phase	Major Task	Duration	Major Milestone	Outcomes
Pre-A (Advanced Studies)	Concept exploration	1.5 months	Mission Concept Review (MCR)	Mission statement of work and objectives
A (Preliminary Analysis)	Mission Analysis	3 months	Mission Definition Review (MDR)	Conceptual Design report
B (Definition)	Detailed system and components definition	6 months	Preliminary Design Review (PDR)	Preliminary Design report and preliminary design documents
C (Design)	Prototypes' implementation and testing	6 months	Critical Design Review (CDR)	Prototypes and test reports
D (Development)	Production of flight model	6 months	Operational Readiness Review (ORR)	Flight model and full design documents
Pre-E (Launching)	Launch preparation	3 months	Launch Readiness Review	Launch permission
E (Operation)	Day-to-day space segment operation and mission End-of-Life procedures	2 years (minimum)	Decommissioning Review (DR)	Daily log and lessons learned
F (Post-Operation)	Maintaining online database of all Otsukimi observations	As needed	Establish public database	Online database for the scientific community

Conclusions and Perspectives

- **Our mission provides:**
  - Opportunities for space science and satellites technology for developing countries.
  - First space mission dedicated to Moon observation serving cultural purposes (Lunar Calendar for Muslim communities).
  - Solving regional problems by international efforts.
  - The mission provides an online database of high-resolution Moon images for all who are interested in Moon observation.

Conclusions and Perspectives

- **Expected partners and investors:**
  - This satellite can carry more missions related and proposed by the involved countries
    - National Authority for Remote Sensing and Space Sciences (Egypt) (NARSS);
    - Space Research Institute of Saudi Arabia (KAC ST-SRI);
    - UAE Space Agency;
    - Algerian Space Agency (ASAL);
    - Tunisian Space Agency;
    - Etc.

Otsukimi Satellite