Laser-Assisted Rain Control Constellation

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INTRODUCTION

Hydrological disasters and droughts affect millions of lives and cause great economic damages every year. The increase in occurrence and magnitude of such disasters are worrying especially for developing countries where the recovery process can be long and costly. Many existing water management efforts such as dams and waterways can only be useful only when the water is already there, whereas the most straightforward measure is to control the rainfall over a specific area at a precise moment. We propose a novel method to induce and thus control rainfall by combining powerful laser technology with satellite technology. The requirements of our satellite system are:

- Induce rainfall over the area affected by drought.
- Induce rainfall from rain clouds over the oceans or low-impact areas in order to prevent heavy rain from falling in flood-prone areas.
- Gather near real-time meteorological data over in order to improve the operation's accuracy and efficiency.

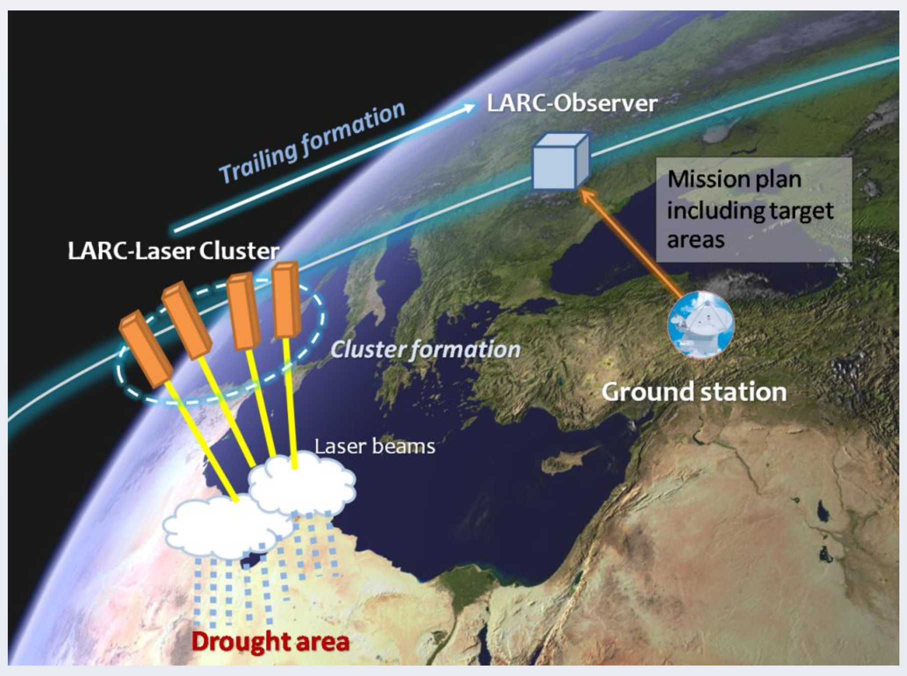

Figure 1. Illustration of a LARC cluster

CONCEPT OF OPERATION

The basic concept of operation revolves around the following key concepts:

- **Emergency and need assessment**

  On-ground mission planning uses two sources of data:
  - Meteorological data from weather satellites and climate models
  - Current emergency events and urgent needs submitted by national disaster prevention organizations.

- **Mission's feasibility study and planning**

  Since the mission plan is computed based on meteorological prediction, the target cloud may disappear, dislocate or increase in volume by the time the mission is due. Therefore, near real time information about the target area's situation will help the satellite to confirm or cancel the plan. An onboard infrared spectrometer in the observer satellite (LARC-Observer) will capture the image of cloud localization over the target area and analyze the level of cloud coverage. If the target is still in place, it will refine the location of the target cloud and send laser firing commands to the laser-emitting satellites (LARC-Beamers).

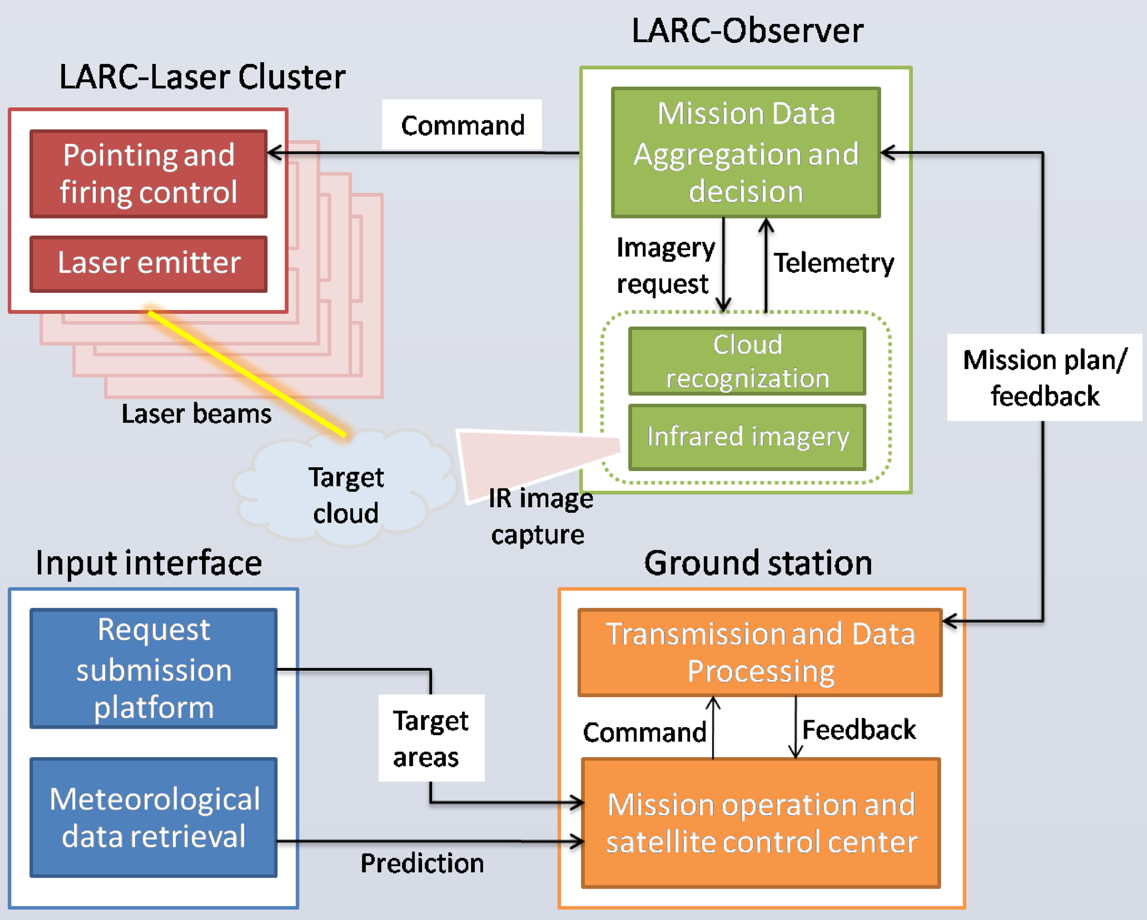

Figure 2. System architecture of one LARC cluster

- **Inter-satellite commanding and satellite to ground communication**

  The two types of satellites in the same cluster exchange location and orientation information and laser firing commands. With the ground, the observer satellite receives mission plan and response with feedbacks after the mission.

SPACE SEGMENT, ORBIT AND CONSTELLATION

Parameter	Value	Arguments for decision
Beamers/cluster	4	Reduce power requirement per Beamer with multiple Beamers
Number of clusters	6	Increase revisit rate (35) and the chance to make the rain fall while the target cloud has not dissipated
Altitude	250 km	Trade-off between orbit perturbations and laser power needed
Inclination	35'	Near equatorial coverage over tropical area where rain-related disasters are frequent
Distance (Observer, Group of Beamers)	3500 km	Provide enough processing time for LARC-observer before the Beamers reach over the target and still maintain visibility

Table 1 Key parameters and their criteria

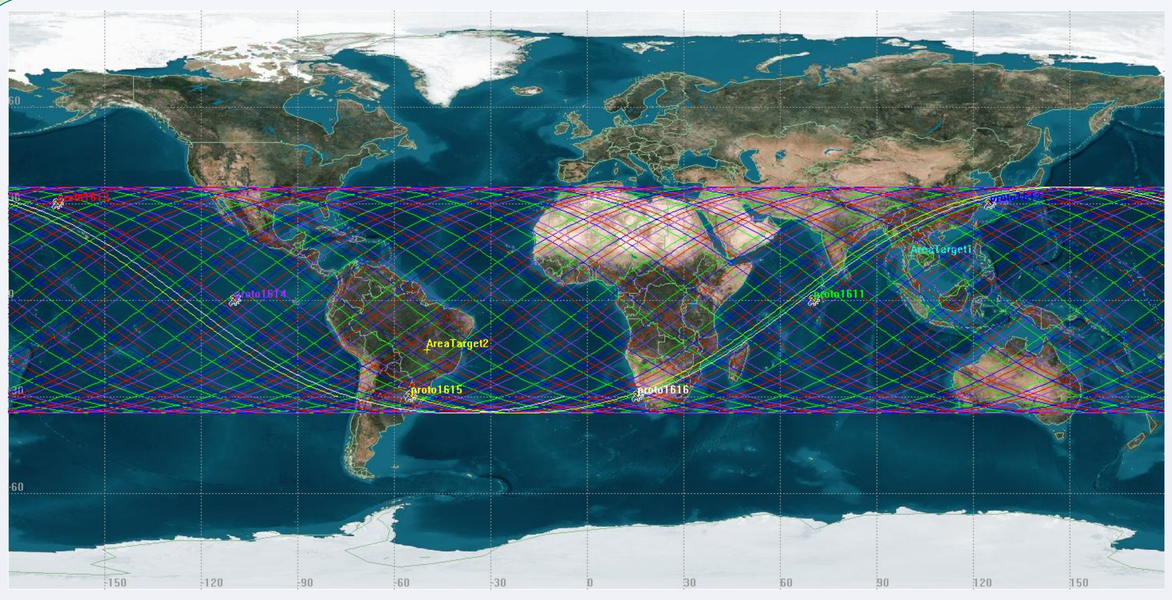

Figure 3 One-day ground track of the six clusters of the LARC-CON in their near equatorial orbit

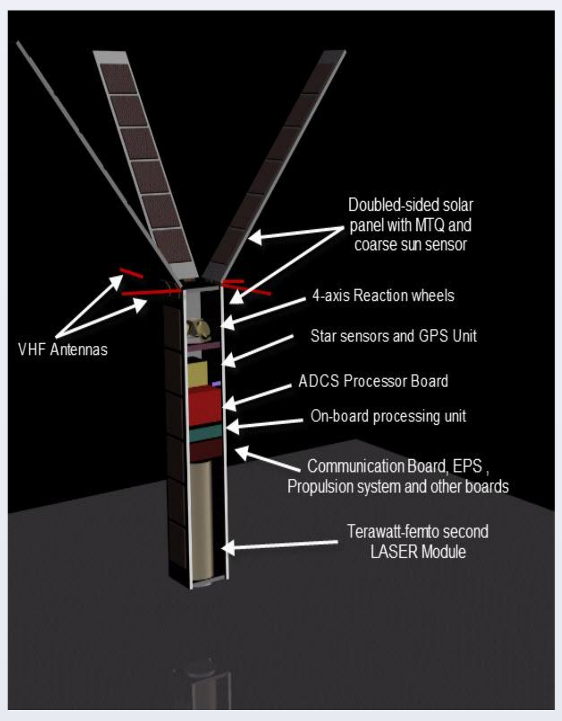

Figure 4 CAD drawing of a LARC-Beamer

About the Teramobile mobile laser system

The Teramobile mobile femtosecond-Terawatt laser system is the fruit of the collaboration between CNRS (France) and DFG (Germany). It yields 5 terawatts and 100 fs (10^{-13} s) pulses, with 350 mJ pulse energy at 10 Hz repetition rate and is contained in a standard freight container. In 2011, a group of Swiss researchers succeeded in creating nitric acid particles in atmospheric air with laser emission from the Teramobile system. These particles in turn cause water droplets to form. This mission idea sprung from there: why could not we use laser technology to make rain? The most challenging issue is: how to rescale the size and the power requirement of such system to fit in a small satellite?

LARC-Beamer and LARC-Observer

All the components on board both the LARC-beamer and the LARC-Observer are COTS barring the Laser System and the AIT can be done in Thailand. The miniaturization of Teramobile femtosecond-Terawatt laser is the most challenging aspect in turning this mission idea into reality.

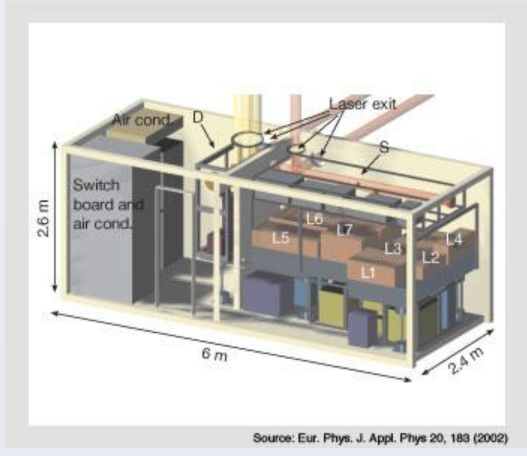

Figure 5 Teramobile mobile fs-TW laser system

DEVELOPMENT ASPECTS

Possible players : GISTDA and foreign space agencies, Thailand's natural resource management agencies, aerospace engineering students and researchers from Thailand and abroad

Cost and budget : The most important costs come from launching, developing the laser payload and renewing Beamers (since their lifetime is short). The constellation of 6 clusters would cost 18.27 M$ which represents less than 0.05% of the economy damage of the Thailand 2011 flood. Budget can come from Strategic Committee for Reconstruction and Future Development (SCRFD) and Strategic Committee for Water Resources Management (SCWRM) in Thailand and from other countries willing to participate and benefit from the LARC-CON.

Costing ($K)	Observer	Beamer
Design cost	80	120
Bus procurement	100	80
Payload Procurement	150	180
AIT (inc MGSE, EGSE)	50	30
Launch	200	200
Disposal costs	5	5
Total	585	615
Margin	50	75
Per cluster	3045 ± 350	
Ground segment	250	
Operation (per year)	125	

Table 2 Estimated cost for one cluster

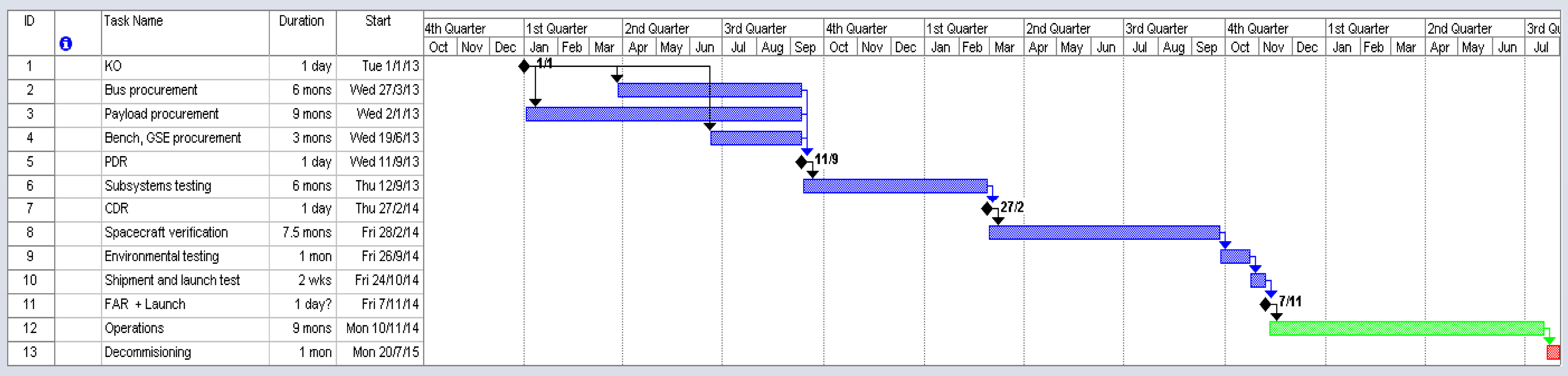

Figure 6 Provisional GANTT diagram for the project

Risk assessment: immaturity of the laser-assisted rain control technology, inability to procure adequate off-the-shelf power distribution module for the laser emitter payload, exceed anticipated project cost due to unexpectedly high renewal rate of Beamers, damage or interference caused by the laser to some aircraft systems, the system might be used as outer space weapon.

CONCLUSIONS

In the upcoming years, the effort on preventing and counteracting natural disasters must be heightened, should mankind desires to survive. Combining laser with satellite, we might finally be able to induce rainfall at wish, thus, keep droughts and floods at bay. However, the laser-assisted rain control technique is still largely theoretical and the power requirement is enormous. Many aspects of the idea need to be re-dimensioned to fit with the current limit of satellite technology in order to conceive a feasible satellite system. Also, the efficiency of such rain controlling technique should be compared with the one initiated from the ground.

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