Development of new low-Earth orbiting Lightning Mapping Capabilities

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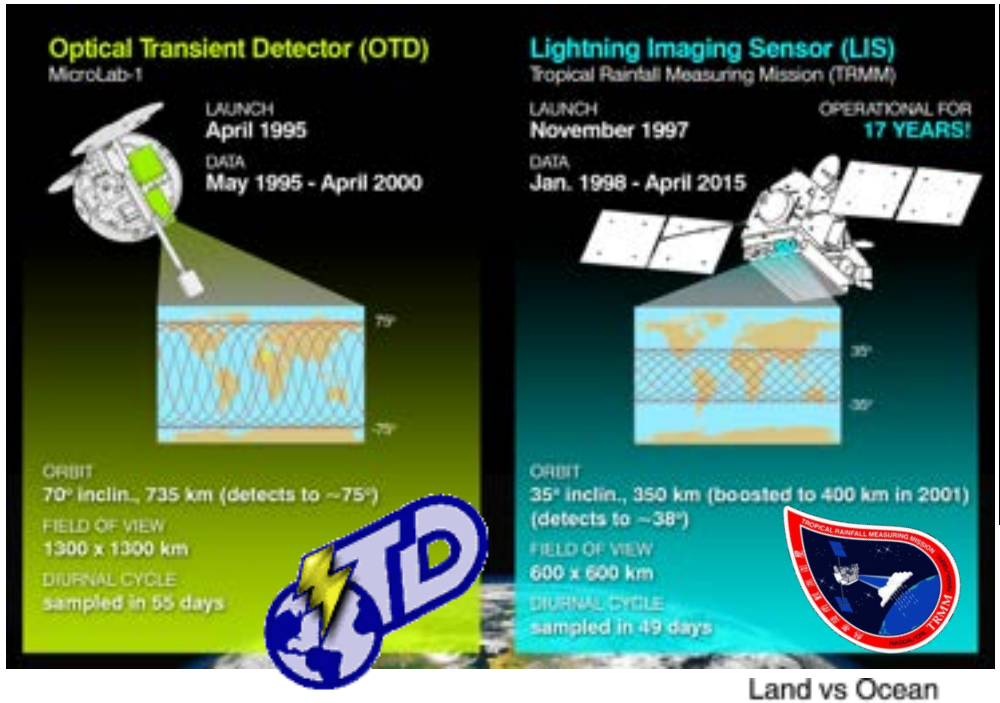
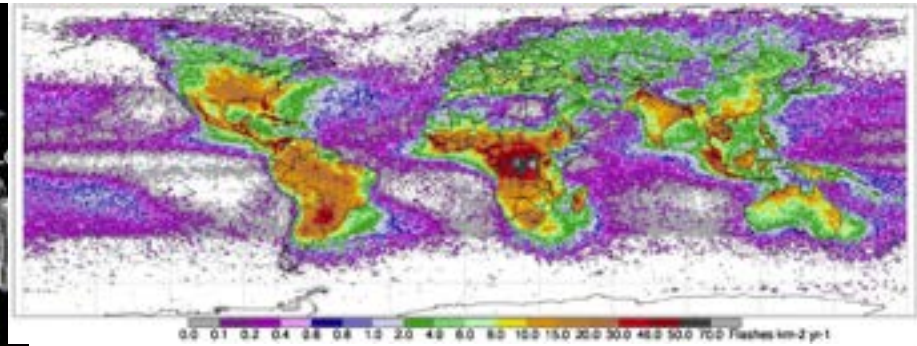
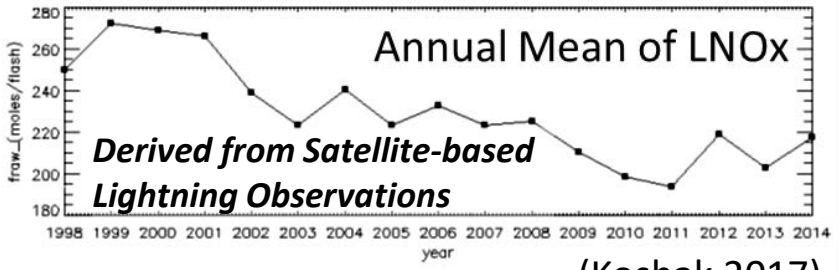
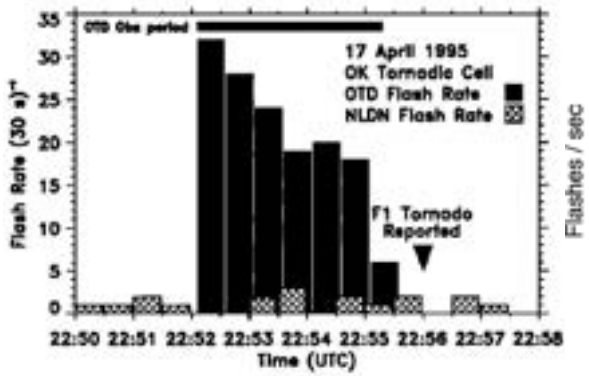
Closing the LIS chapter on global lightning observations from space…



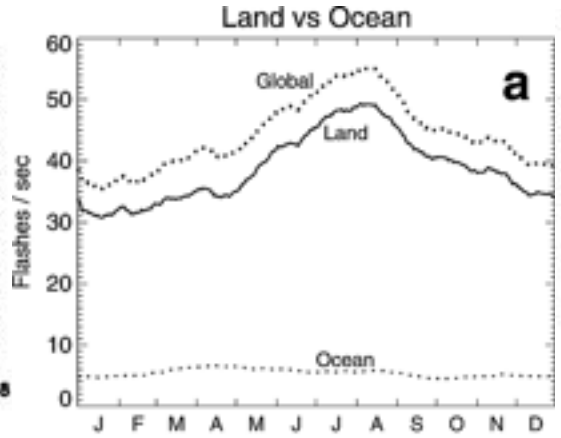




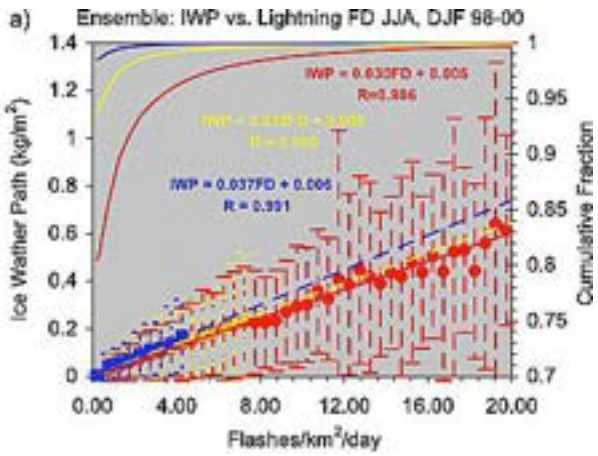
(Koshak 2017)



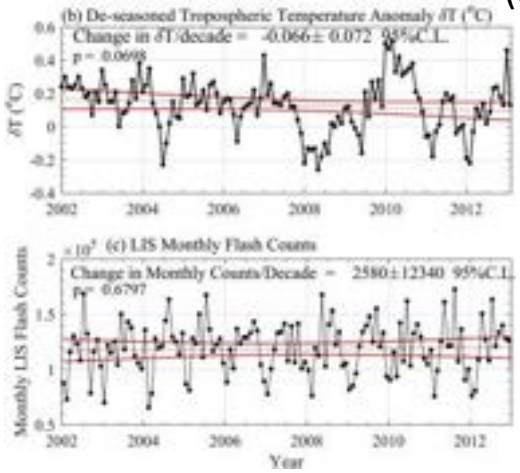
(Buechler et al. 2000)



Month
(Christian et al. 2003)

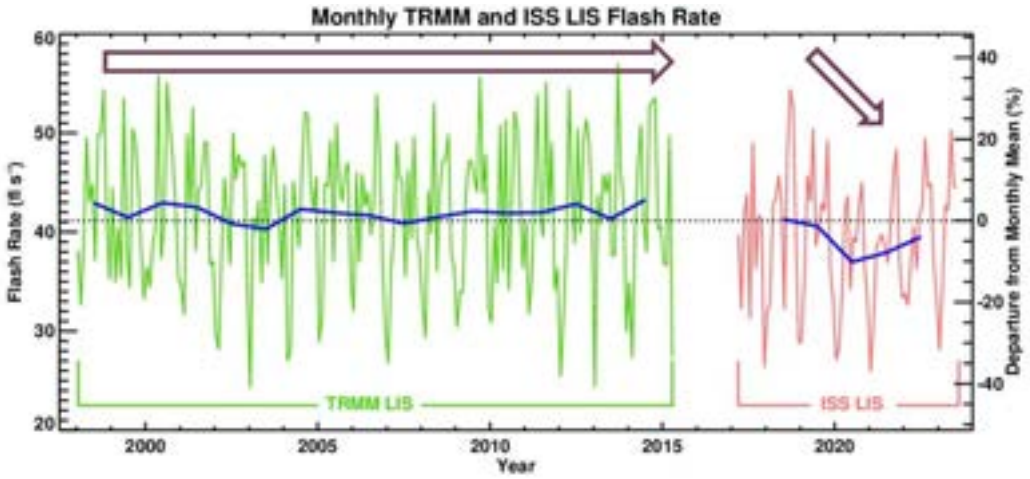


(Petersen et al. 2005)

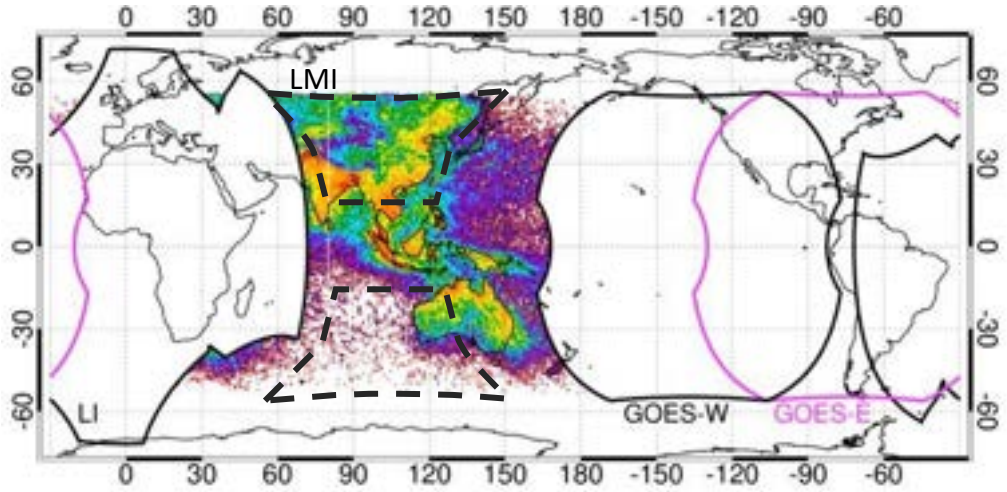


(Williams et al. 2019)

…and drafting a new one to extend and enable novel applications



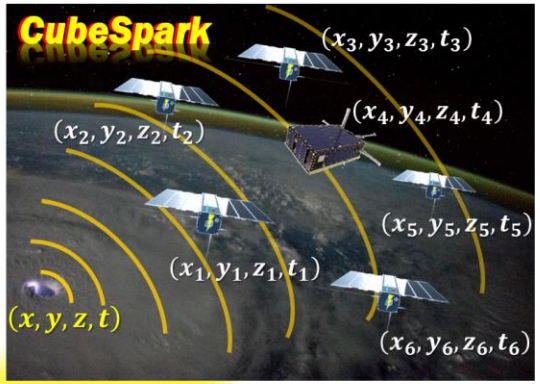
Coverage of GEO lightning mappers (2023)

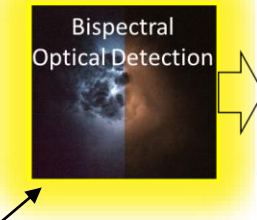


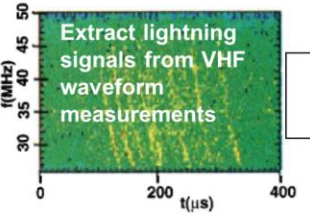
- ❑ Extend the LEO-based climate record
- ❑ Cross-calibrator for GEO lightning mappers
- ❑ *Multispectral* mapping both night *and day*
- ❑ Improve detection of lightning activity in severe storms
- ❑ 3D mapping (proxy for updraft/mass flux, microphysics, LNOx)

Remington et al., 2023: Simulated Feasibility of 3D Lightning Mapping from Space. IEEE Trans. Geosci. Rem. Sens., in review.

Measurement Concept

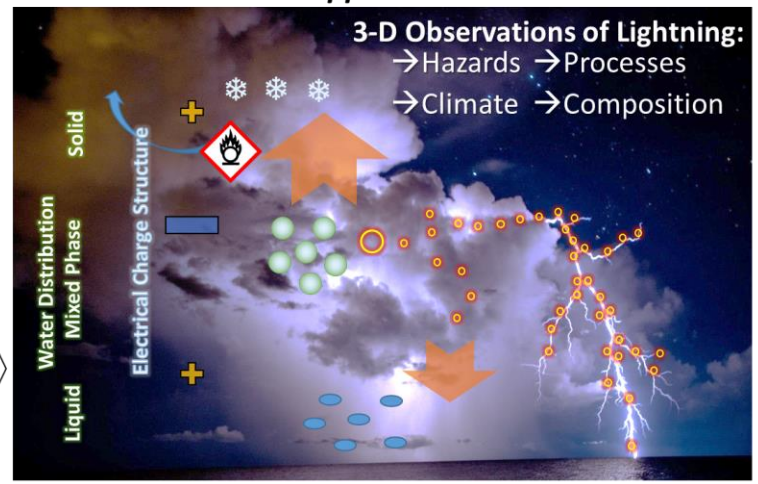






CLIDE

Enabled Science and Applications



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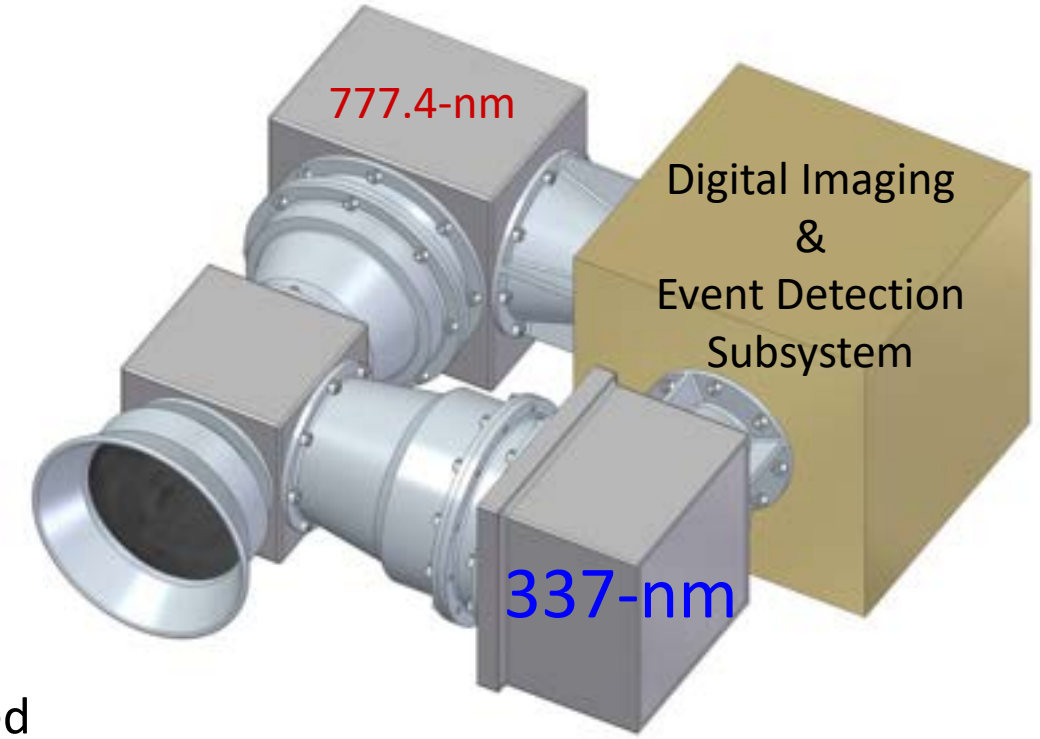
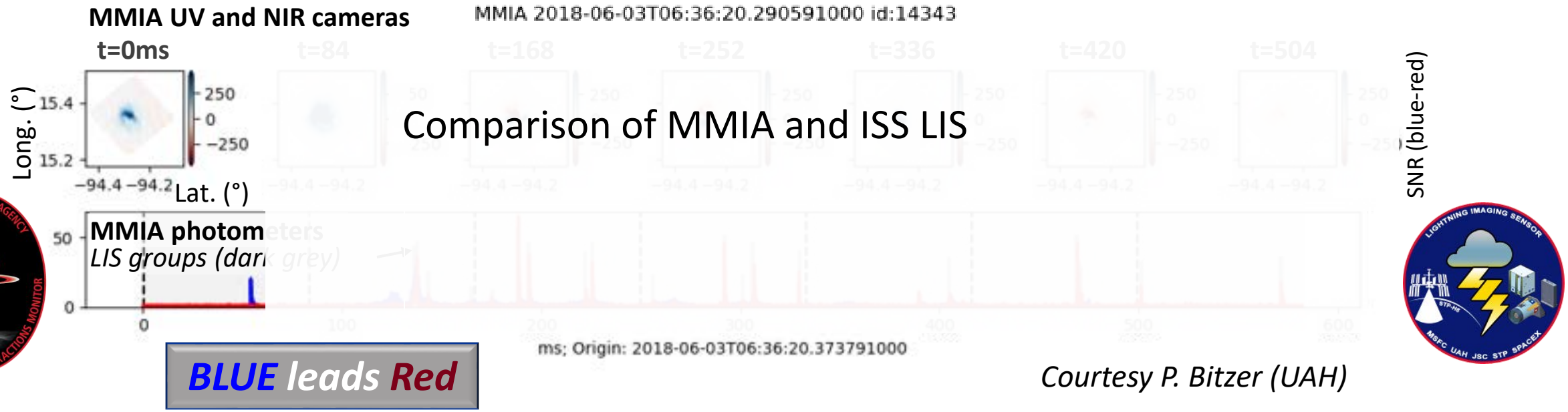
Status of the CubeSat Lightning Imaging and Detection Experiment (CLIDE)

- Objective: Improve the detection of small and optically dim lightning flashes that frequent intense thunderstorms
- Wavelengths:
  - 777.4-nm (OI multiplet—leaders)
  - 337-nm (N_2 SPS—streamers)
- CMOS Image Sensor (CIS):
  - More pixels, faster, digital, lower power
  - Dynamic ROI and pixel binning
  - Enhance QE at 337-nm via backside processing (MBE+AR recipe)
  - Leverage new low noise CIS
- Candidate sensor procured and simulator being developed
- Targeting to resolve 4-km^2 events at 2μJ $m^{-2}sr^{-1}$ (777-nm)
- Being designed for use on small satellite missions
- Current TRL: 3

CLIDE Design Concept



337 nm enables more information extraction from lightning than 777 nm alone



Comparison of MMIA and ISS LIS

BLUE leads Red

Courtesy P. Bitzer (UAH)

- 14% of MMIA blue (337 nm) groups have no corresponding red (777 nm) group
- 10-20% of ISS LIS groups have no corresponding MMIA blue group
- 337 nm emissions result from streamer discharges
  - Likely frequent turbulent regions of a storm
  - Produce LNOx
  - Associated with NBEs

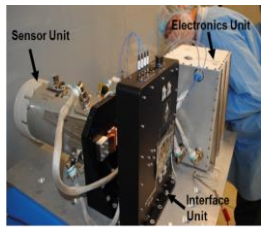
Funded Development activities related to CLIDE and CubeSpark

- Observing System Simulation Experiment (OSSE) for satellite-based lightning (Gatlin/MSFC, Bitzer/UAH)
- CLIDE instrument simulator (Quick/MSFC, Mach/USRA, Podgorny+Corredor/UAH)
- VHF instrument simulator (Behnke/LANL)
- ER-2 data analysis from GOES-R Cal/Val Campaigns (Stough/UAH)
- Community white paper(s) for next Decadal Survey

Comparative Lightning Mapper Technology

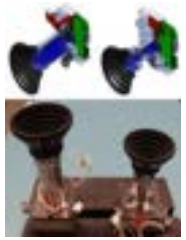
OPTICAL

Optical Transient Detector (NASA MSFC) 1995
- CCD camera @ 777-nm
- 80°x80° FOV
- 1300x1300-km^2 footprint
- 10x10-km^2 nominal resolution
- 500 frames/sec



Lightning Imaging Sensor (NASA MSFC) 1997
- CCD camera @ 777-nm
- 80°x80° FOV
- 550x550-km^2 footprint
- 4x4-km^2 nominal resolution
- 500 frames per second

Geostationary Lighting Mapper (NOAA/NASA) 2016
- CCD camera @ 777-nm
- Full disk FOV (16°)
- 10x10-km^2 nominal resolution
- 500 frames per second



Modular Multispectral Imaging Array (Denmark Tech. Univ./ESA) 2018
- CCD cameras @ 777- & 337-nm
- 80°x80° FOV
- 550x550-km^2 footprint
- 0.4x0.4-km^2 nominal resolution
- 12 frames per second

MTG-I1 Lightning Imager (EUMETSAT) 2022
- 4 CMOS cameras @ 777-nm
- Full disk FOV (16°)
- 5x5-km^2 nominal resolution
- 1000 frames/sec

CLIDE (NASA MSFC) *2027*
- CMOS camera @ 777-& 337-nm
- 60°x60° FOV
- 600x600-km^2 footprint
- ≤2x2-km^2 resolution
- ≥1000 frames per second
- *Small satellite form factor*

OTD

TRMM / LIS

MMIA/ASIM

GOES GLM

ISS / LIS

CLIDE

1995

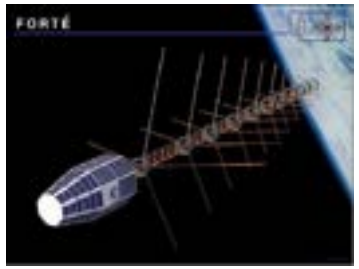
Present

2030

FORTE

CubeSpark

OPTICAL /RF



FORTE (LANL/Sandia/DoE) 1997-2010
- CCD camera @ 777-nm
- 416 frames per second
- 80°x80° FOV
- 1200-km diameter footprint
- 10x10-km^2 resolution
- RF antenna tunable in 20-300 MHz
- Photodiode @ 850-nm

CubeSpark (NASA MSFC/LANL) 2028
- Small satellite constellation
- CMOS cameras @ 777- and 337-nm
- ≥ 1000 frames per second
- RF antenna tuned to VHF
- 2x2-km^2 horizontal resolution
- 1-2 km vertical resolution