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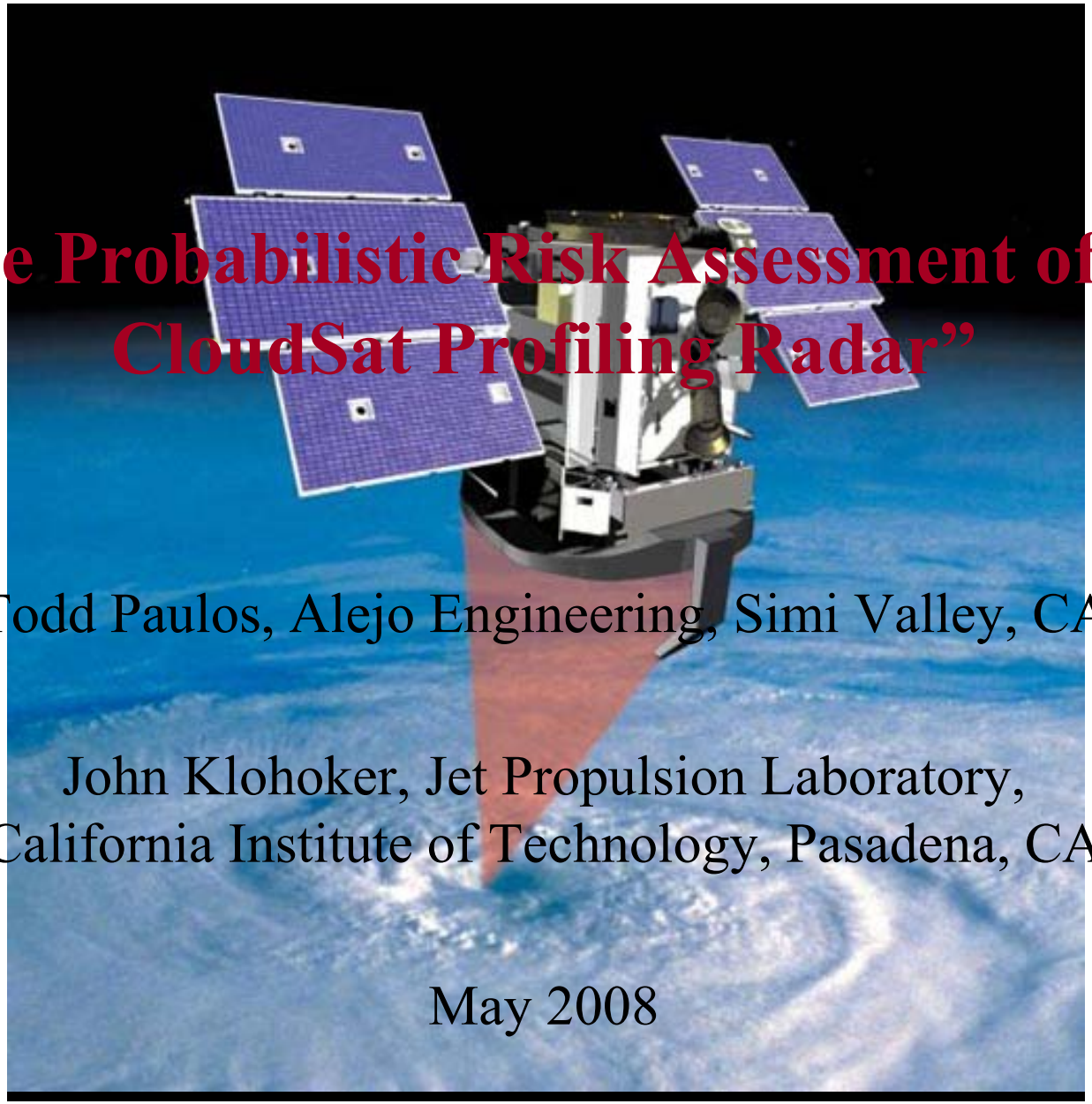

"The Probabilistic Risk Assessment of the CloudSat Profiling Radar"

Todd Paulos, Alejo Engineering, Simi Valley, CA

John Klohoker, Jet Propulsion Laboratory,
California Institute of Technology, Pasadena, CA

May 2008

What is CloudSat?

- Launched on April 28, 2006 with CALIPSO
- Satellite that uses radar to observe clouds and precipitation from space
- Maintains a close formation with Aqua and particularly close formation with CALIPSO
- Utilizes a millimeter wavelength radar that is up to a 1000 times more sensitive than the previous generation of centimeter wavelength radars.

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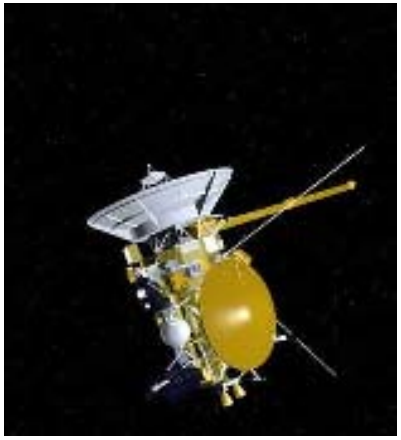
CloudSat Heritage

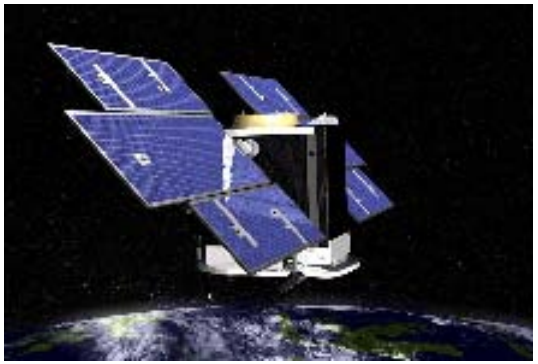
RADAR MISSIONS
SEASAT SAR
SIR-A
SIR-B
SIR-C
SRTM
Cassini
NSCAT
QuickScat
SeaWinds



Cassini, image courtesy of http://jpl.nasa.gov

Ball Aerospace Commercial Platform
(Spacecraft bus)
Quickbird
QuikSCAT
ICESat

QuickSCAT, image courtesy of http://jpl.nasa.gov



CloudSat, image courtesy of http://jpl.nasa.gov

http://www.flickr.com/photos/purpletwinkie/1812431187/

A-TRAIN
Aqua
CloudSat
CALIPSO
PARASOL
Aura

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A-Train

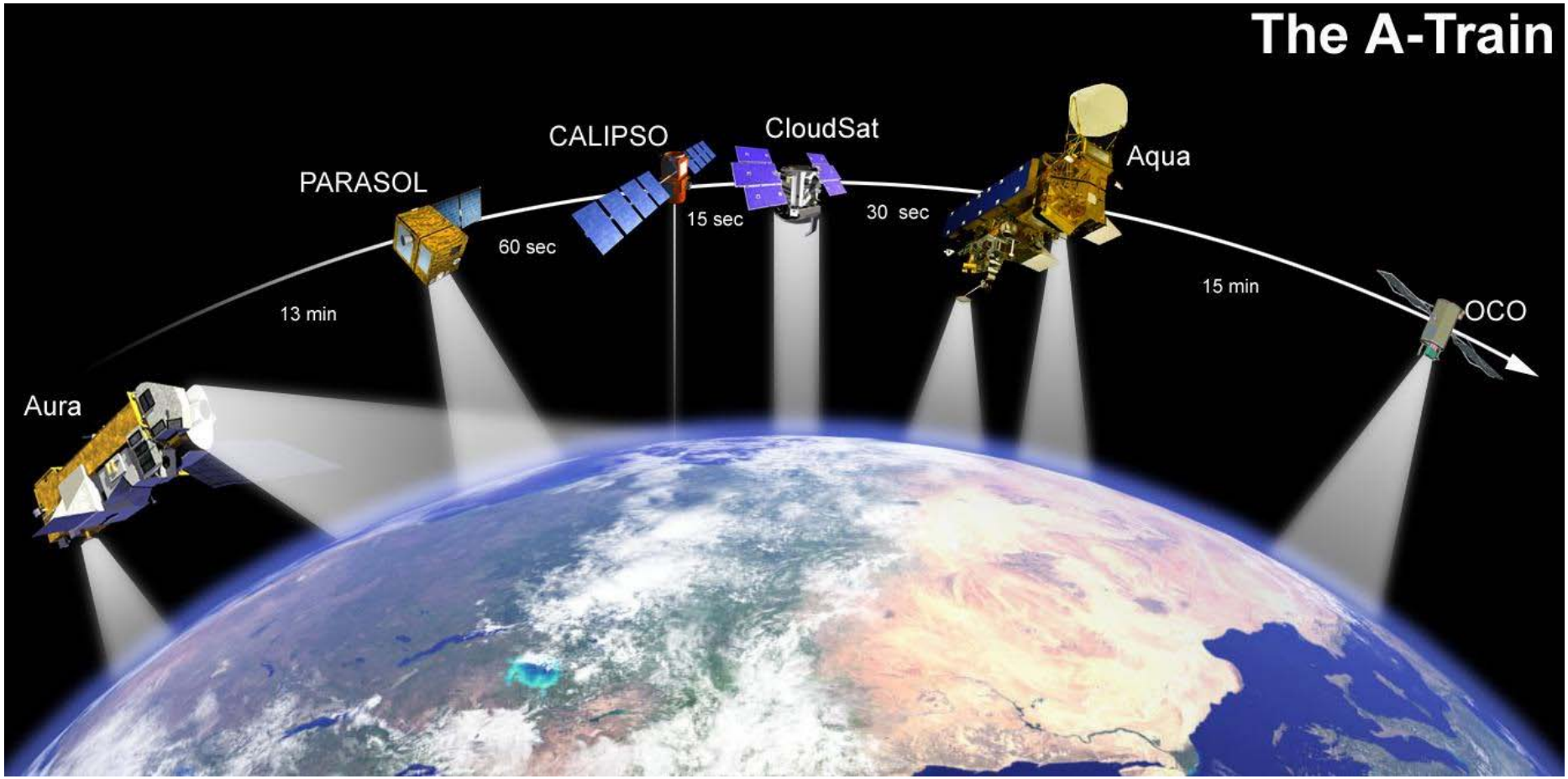

Image from http://jpl.nasa.gov
Artist: Alex McClung

The A-Train

•Aqua carries six state-of-the-art instruments in a near-polar low-Earth orbit. The six instruments are the Atmospheric Infrared Sounder (AIRS), the Advanced Microwave Sounding Unit (AMSU-A), the Humidity Sounder for Brazil (HSB), the Advanced Microwave Scanning Radiometer for EOS (AMSR-E), the Moderate Resolution Imaging Spectroradiometer (MODIS), and Clouds and the Earth's Radiant Energy System (CERES)

•CloudSat carries a millimeter wavelength radar

•CALIPSO carries an active lidar instrument with passive infrared and visible imagers

•PARASOL is carrying a wide-field imaging radiometer/polarimeter called POLDER (Polarization and Directionality of the Earth's Reflectances)

•Aura carries High Resolution Dynamics Limb Sounder (HIRDLS; observes global distributions of temperature and several trace species in the stratosphere and upper troposphere), Microwave Limb Sounder (MLS, uses microwave emission to measure stratospheric temperature and upper tropospheric constitutents), Ozone Monitoring Instrument (OMI) and Tropospheric Emission Spectrometer (TES)

•Orbiting Carbon Observatory (OCO) carries three high resolution grating spectrometers.

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Hurricane Dean Through the Eyes of CloudSat

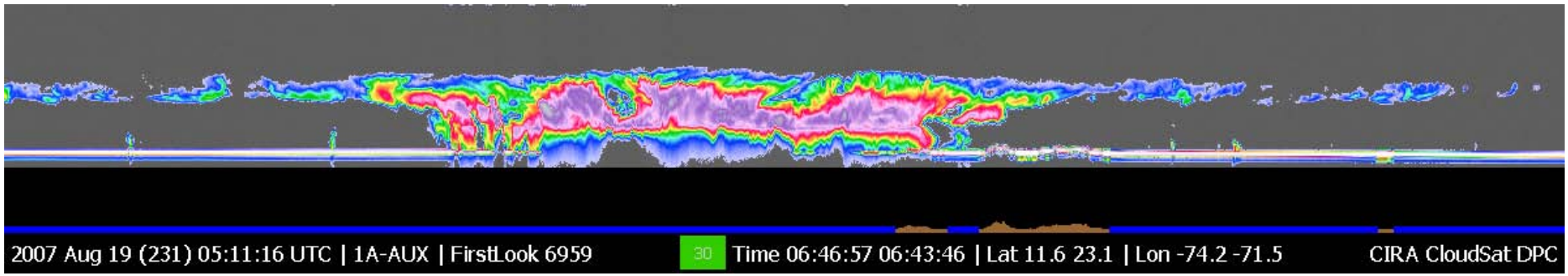

Image from http://jpl.nasa.gov

Picture represents the ground to the top of the atmosphere (~30 km) and 800 km of distance

CloudSat Profiling Radar PRA

- PRA initiated as an afterthought, due to a Request For Action during the Preliminary Design and Implementation Review and Mission Design Review
- CloudSat is mostly single string with selective redundancy; assess the CPR design approach
- PRA performed around the same time as the NASA PRA Procedures was being developed
- PRA uses single event tree approach
    - End States
    - Degraded Mission
- Complete Loss of Mission
- Train another engineer in doing PRA

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CPR PRA ET

Lift Off	Launch	Initialization (M6)	Transmit	Receive	Operations		
LO	LF	DF	CT	CR	OP	#	END-STATE-NAMES
						1	OK
						2	DEG--LEVEL-III
						3	CAT--LEVEL-IV
						4	CAT--LEVEL-IV
						5	CAT--LEVEL-IV
						6	CAT--LEVEL-IV

Results

- Complete Loss of Mission
  - Digital support system (32% of the risk)
  - Power bus (27.5% of the risk)
  - Upconverter (26.5% of the risk), and
  - Receiver (approximately 10% of the risk)
- Design Changes
  - Relay added to provide backup power to drive the M6 mirror switching mechanism
  - Fuse added to protect the power relays to the High Power Amplifier

CloudSat Status

•Prime mission completed on February 27, 2008; CloudSat is now in its extended mission phase.
•There have been several occasions where the CPR has transitioned from Operate Mode to Initialize Mode or Stand-by Mode by the fault protection algorithms on-board the spacecraft. These types of transitions are expected on an occasional basis and do not imply that the vehicle is in trouble, only that hiccups have occurred, such as a single event upset.
•On July 4, 2007 CloudSat performed several propulsion maneuvers to avoid SINAH 1, an Iranian satellite, as it was predicted that they would come to within 100 m of each other. CloudSat performed additional propulsion maneuvers on July 7 to return it to its formation orbit with CALIPSO and continue its science mission.

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Acknowledgement

•The authors would like to thank everyone at the Jet Propulsion Laboratory, NASA, Ball Aerospace and other CloudSat team members who supported this work, and to those of you working in operations who have done a fantastic job on this mission.
•The research described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.