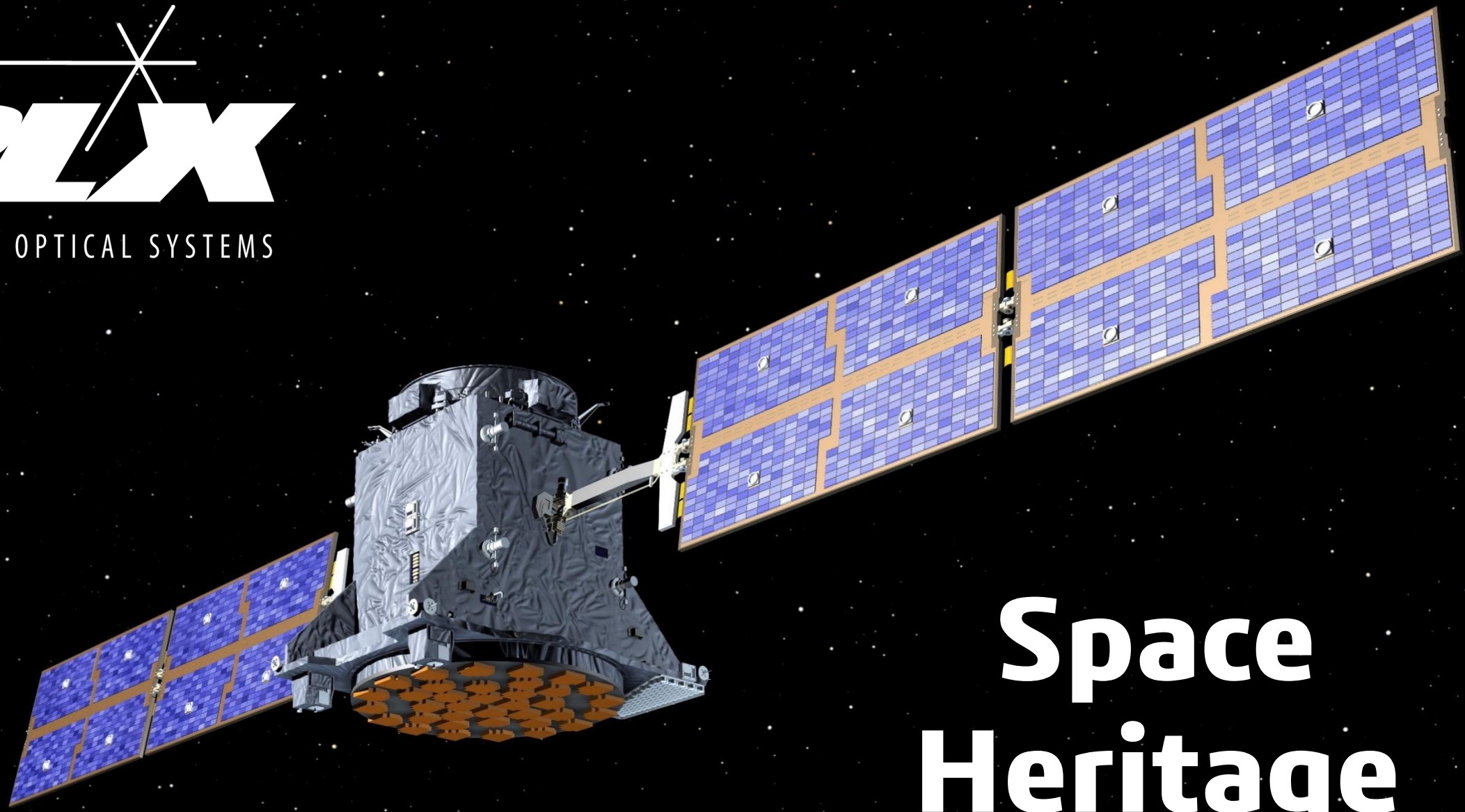
PLX

INNOVATIVE OPTICAL SYSTEMS



Space Heritage

Introduction

PLX Inc. has been fabricating space-qualified assemblies for over 40 years. Our optical technologies are an integral part of some of the world's most notable space missions and experiments.

Throughout the years, we have become accustom to providing high-quality optics that will maintain their integrity and accuracy as well as withstand some of the harshest conditions and environments known.

MILITARY *AEROSPACE* *COMMERCIAL*

Space Clientele

PLX Inc. has been privileged to work alongside some of the leading space agencies and companies all over the world:

Ball Aerospace & Technologies Corp.

ThalesAlenia Space
a Thales / Leonardo company

ROSCOSMOS

JPL
Jet Propulsion Laboratory
California Institute of Technology

NASA

esa

neptec

JAXA

CSA ASC

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Space Participation Timeline

INNOVATIVE OPTICAL SYSTEMS

1975 – NASA's Apollo-Soyuz Mission.

1985 – NASA's Discovery Shuttle Laser Test.

1990 – Ball Aerospace's Relay Mirror Experiment.

1990 – NASA's LACE Experiment.

1997 – NASDA's Retroreflector in Space.

2000 – NASA's Endeavor Shuttle Radar Mission.

2002 – NASA's TES Spectrometer.

2003 – CSA's ACE-FTS Spectrometer.

2003 – ESA's PFS Spectrometer (Mars Express).

2005 – ESA's PFS Spectrometer (Venus Express).

2009 – Keldysh's Space Program.

2015 – NASA's ICE, Cloud/Land Elevation Project.

2016 – ESA's TIRVIM Spectrometer.

2016 – NEPTEC's CAMS Metrology System.

2018 – Ball Aerospace's AMCS Alignment System.

2020 – Laser Utilizing Communication System (LUCAS)

2021 – PLX contracted to work on an interferometer.

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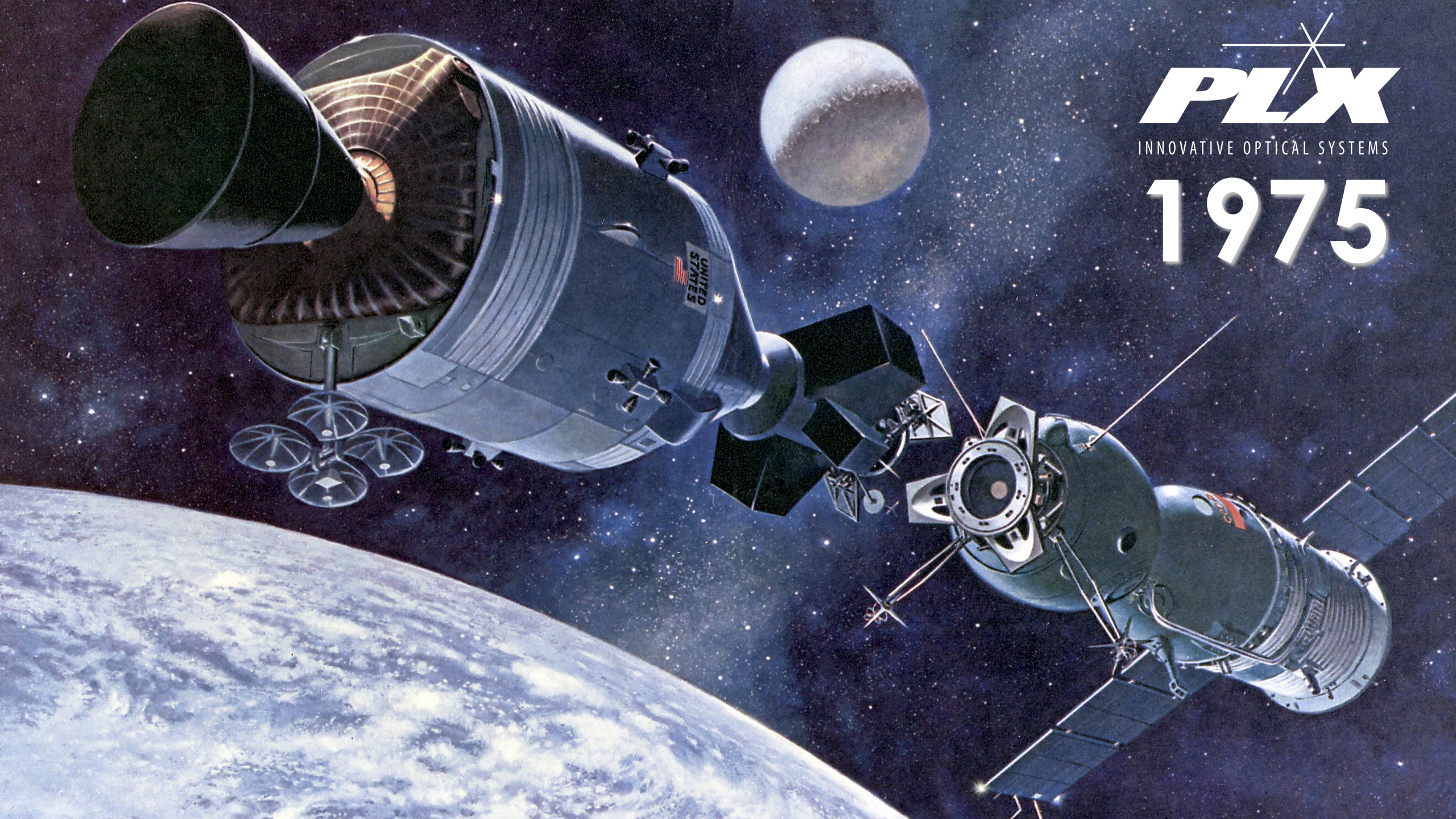
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INNOVATIVE OPTICAL SYSTEMS
1975
UNITED STATES

Apollo-Soyuz Mission (1975)

Mission Status: Completed

Our space heritage dates back to 1975. We provided hollow retroreflectors for the Apollo-Soyuz Space Union between the Americans and Russians. These retroreflectors were used in the docking procedure to align the two spacecraft as well as measure gases in the vehicle environment.

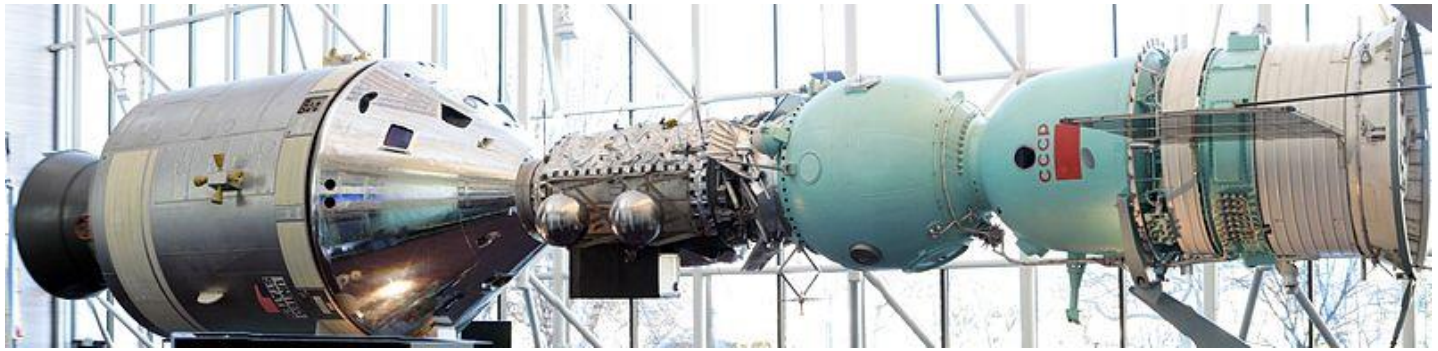

Image courtesy of Wikipedia

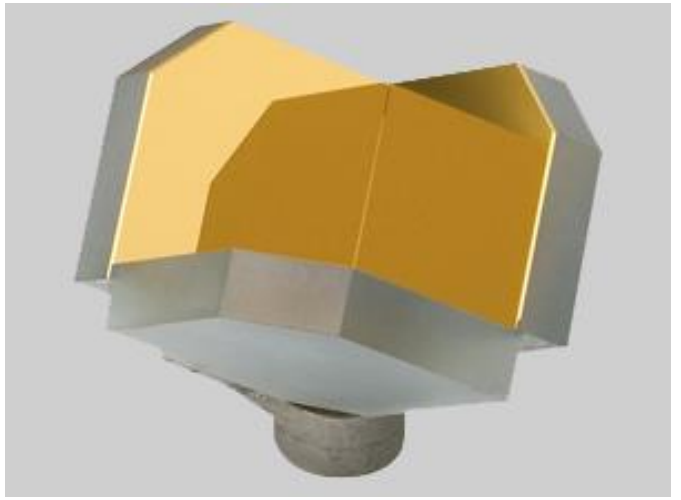

Image courtesy of PLX Inc.

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INNOVATIVE OPTICAL SYSTEMS

1985

NASA Laser Test (1985)

Mission Status: Completed

INNOVATIVE OPTICAL SYSTEMS

In 1985, as part of NASA's Long-Distance Laser Test, PLX Inc. built an 8" [203 mm] diameter retroreflector that was mounted to the space shuttle Discovery. Below is an excerpt from the Washington Post on the success of the test:

The Washington Post

Space Shuttle Succeeds in Laser Test

By Thomas O'Toole June 22, 1985

A beam of laser light fired from a mountaintop in Hawaii bounced off a reflecting mirror on the space shuttle Discovery today as it flew 230 miles overhead at a speed of 17,500 mph.

The event was the first "Star Wars" test between the Air Force on the ground and the National Aeronautics and Space Administration shuttle in orbit. After seeing the test botched two days earlier, the Air Force declared today's attempt a success. But it was not intended to solve any of the most difficult problems of setting up a "Star Wars" defense system. It also was not the first laser tracking test, but it probably was the most media-tracked of the tests in the Strategic Defense Initiative program, as it is formally known.

The "Star Wars" plan envisions knocking down enemy missiles with lasers or other weapons before they reach the United States.

"We demonstrated today that we can track a fast-moving target with a laser on the ground," Meyer said. "Our next step is to perform the same kind of test with rockets fired to an altitude of 360 miles to see if ground-based lasers can stay with them all the way to altitude."

Today's feat was not a technical advance, but one of a series of laser tests in the sky and space. Lasers were first observed from space by American astronauts 20 years ago and have been used by the Pentagon in various applications for the last 15 years. Laser telescopes on the island of Maui, where today's test was conducted, routinely reflect beams off Soviet spy satellites to determine what kinds of optical sensors they carry.

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1990

Relay Mirror Experiment (1990)

Mission Status: Completed

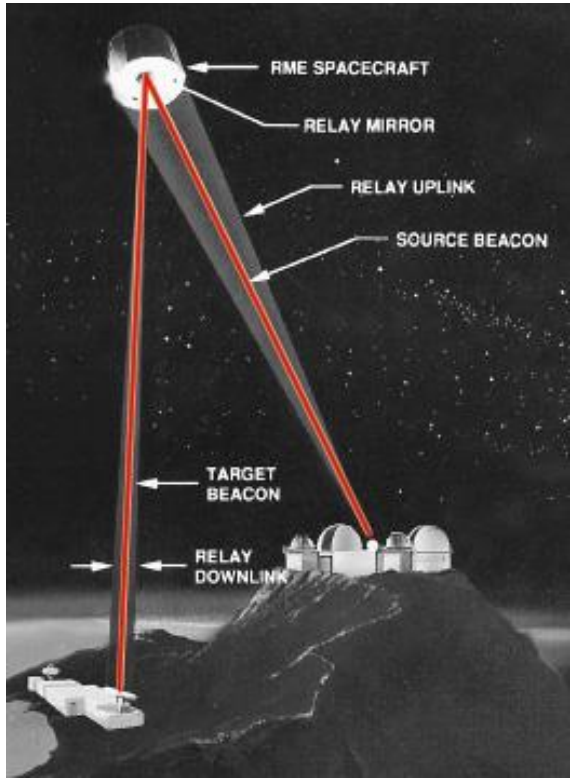

Image courtesy of David Darling

After the success of the Laser Test, PLX Inc. gained significant recognition and was awarded a contract with Ball Aerospace to work on the Relay Mirror Experiment (RME). The experiment directed a 1.064 µm laser beam emitted from one ground site to a mirror orbiting at 450 km altitude, and then to a ground based target.

PLX also contributed to the Low-Power Atmospheric Compensation (LACE) Experiment that was launched as a dual payload with the RME.

Image courtesy of NASA

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1997

Retroreflector in Space (1997)

Mission Status: **Completed**

- The **Retroreflector in Space (RIS)** is one of several instruments aboard NASDA's (now JAXA) Advanced Earth Observing Satellite (ADEOS).
- RIS is a retroreflector for an Earth-Satellite-Earth laser used in long-path absorption experiments of atmospheric trace gases.
- PLX Inc. designed and manufactured a 20" [508 mm] diameter light-weighted retroreflector that achieved an accuracy of one arc second.

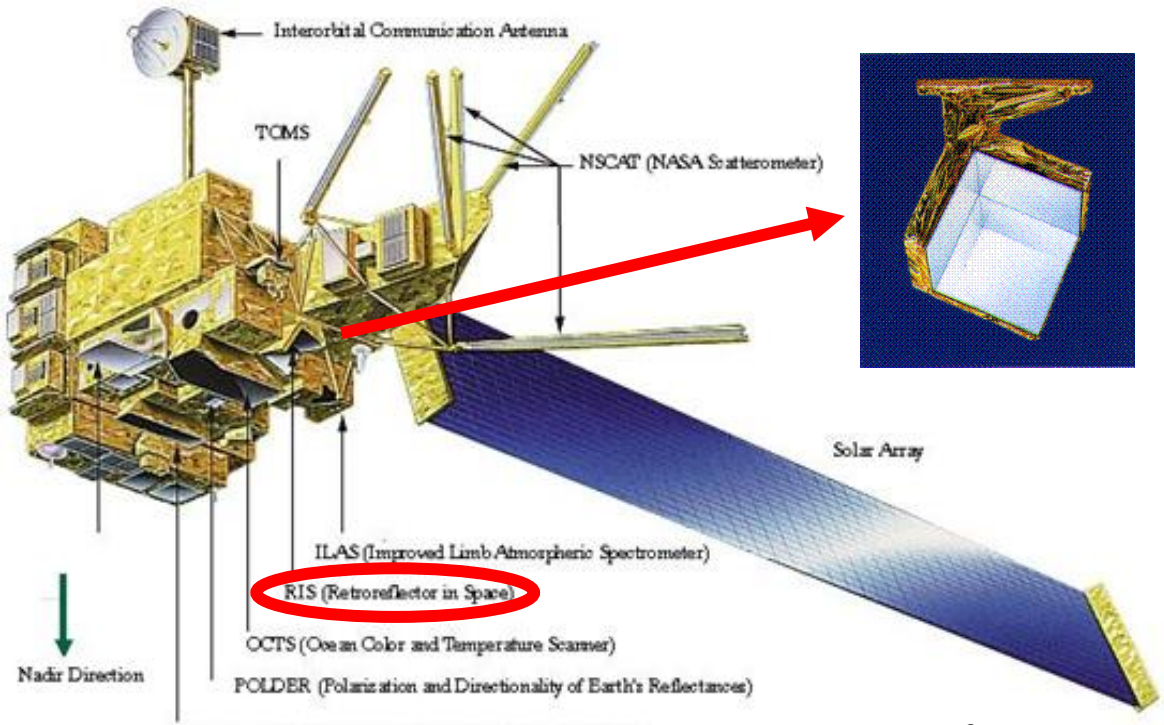


Image courtesy of JAXA

RIS Retroreflector

- To date, this is the largest retroreflector ever sent to space!
- Contained a curved mirror to enhance the far-field pattern seen on earth.

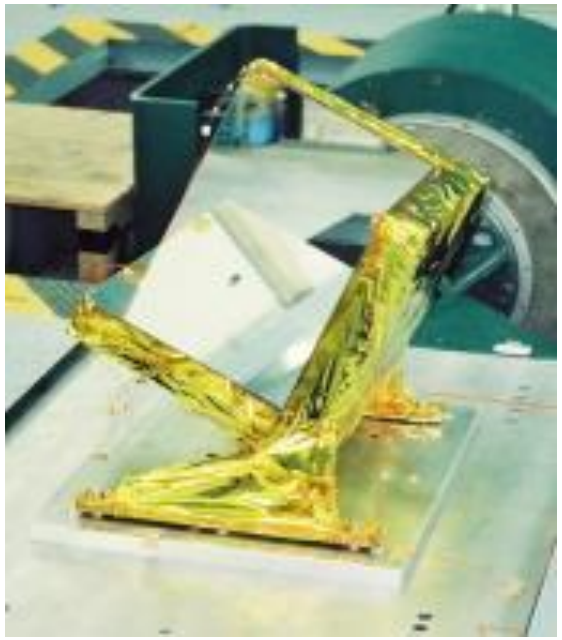


Image courtesy of NIES

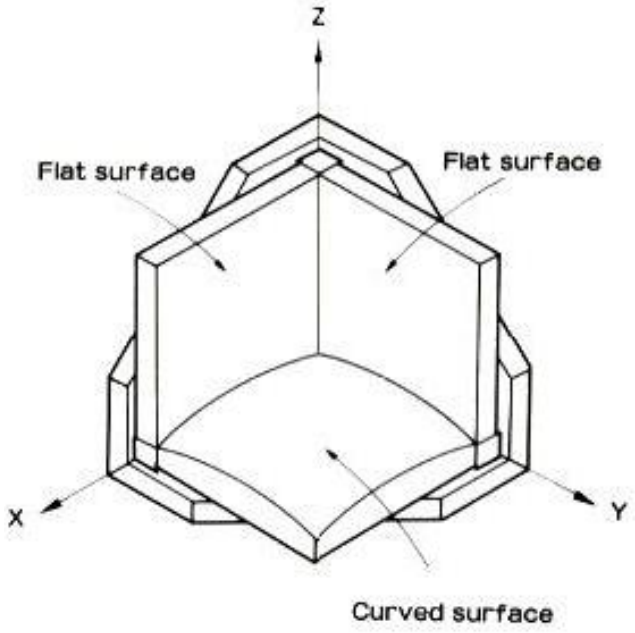


Image courtesy of NASDA

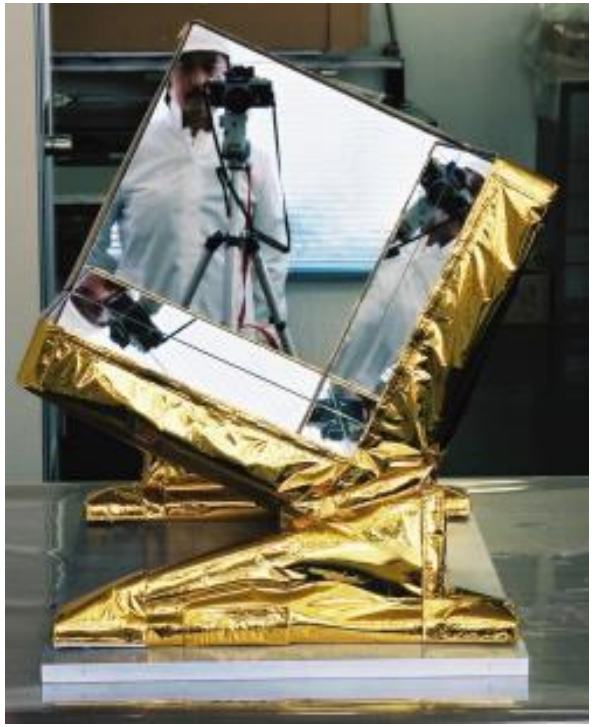
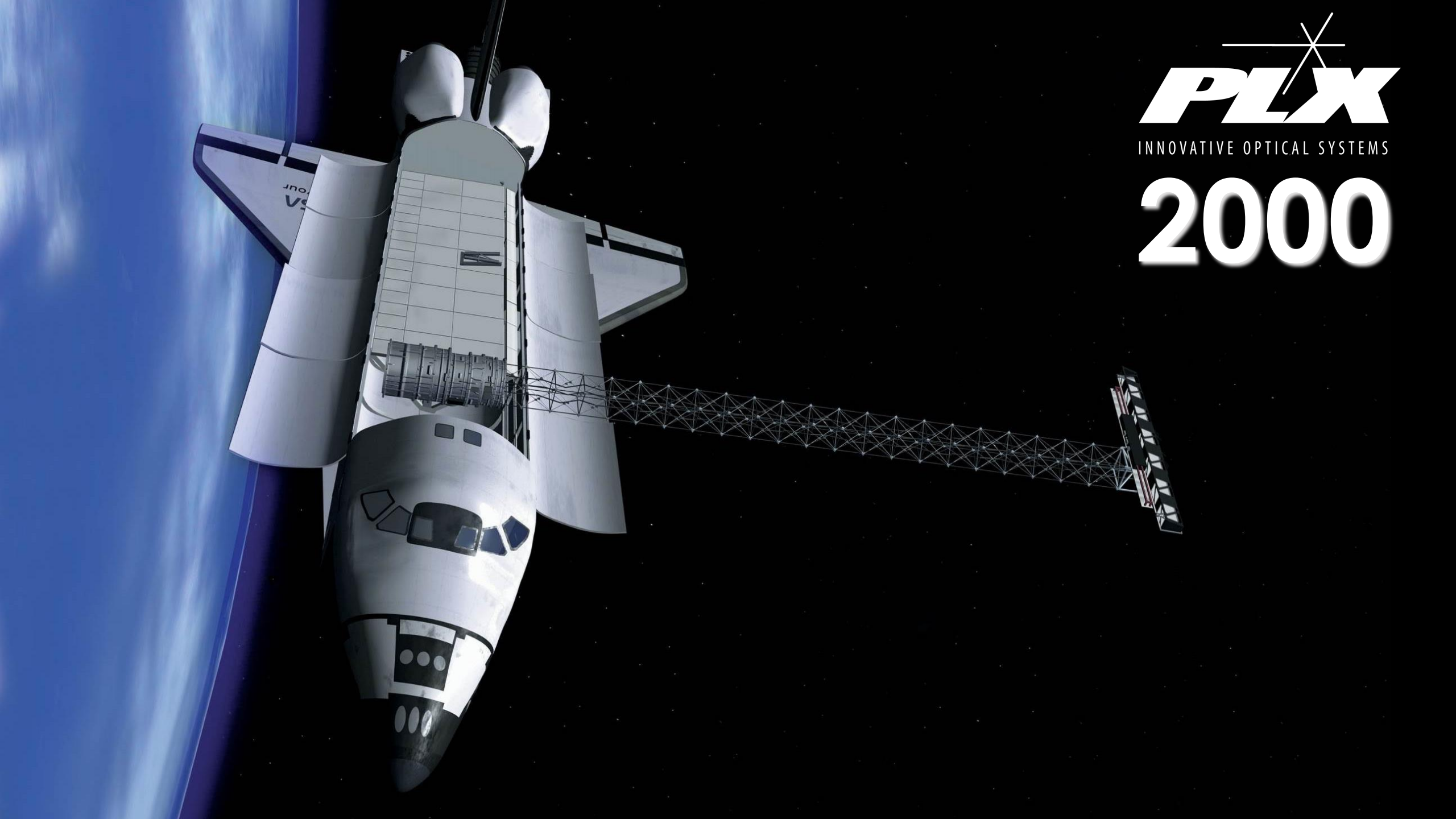


Image courtesy of NIES



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INNOVATIVE OPTICAL SYSTEMS

2000

Endeavor Radar Mission (2000)

Mission Status: Completed

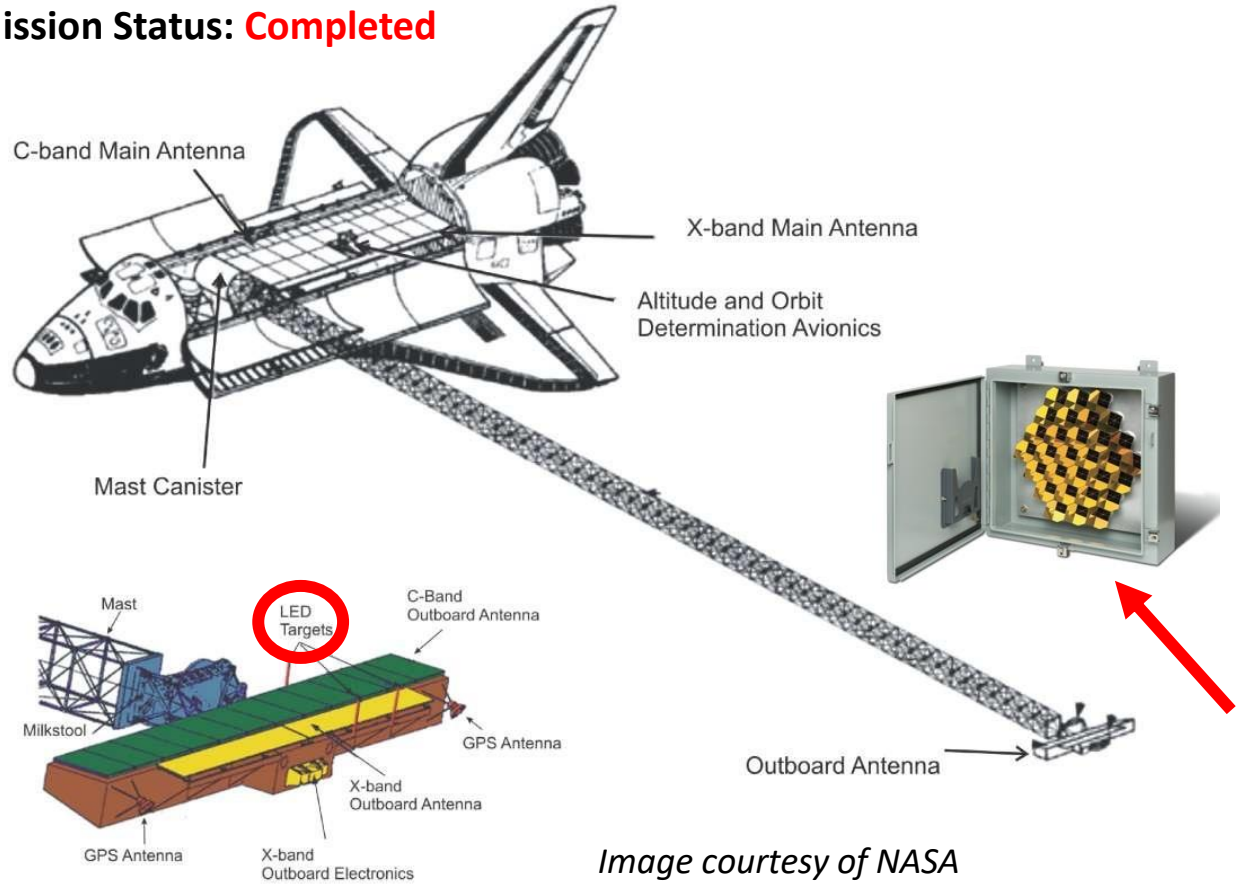
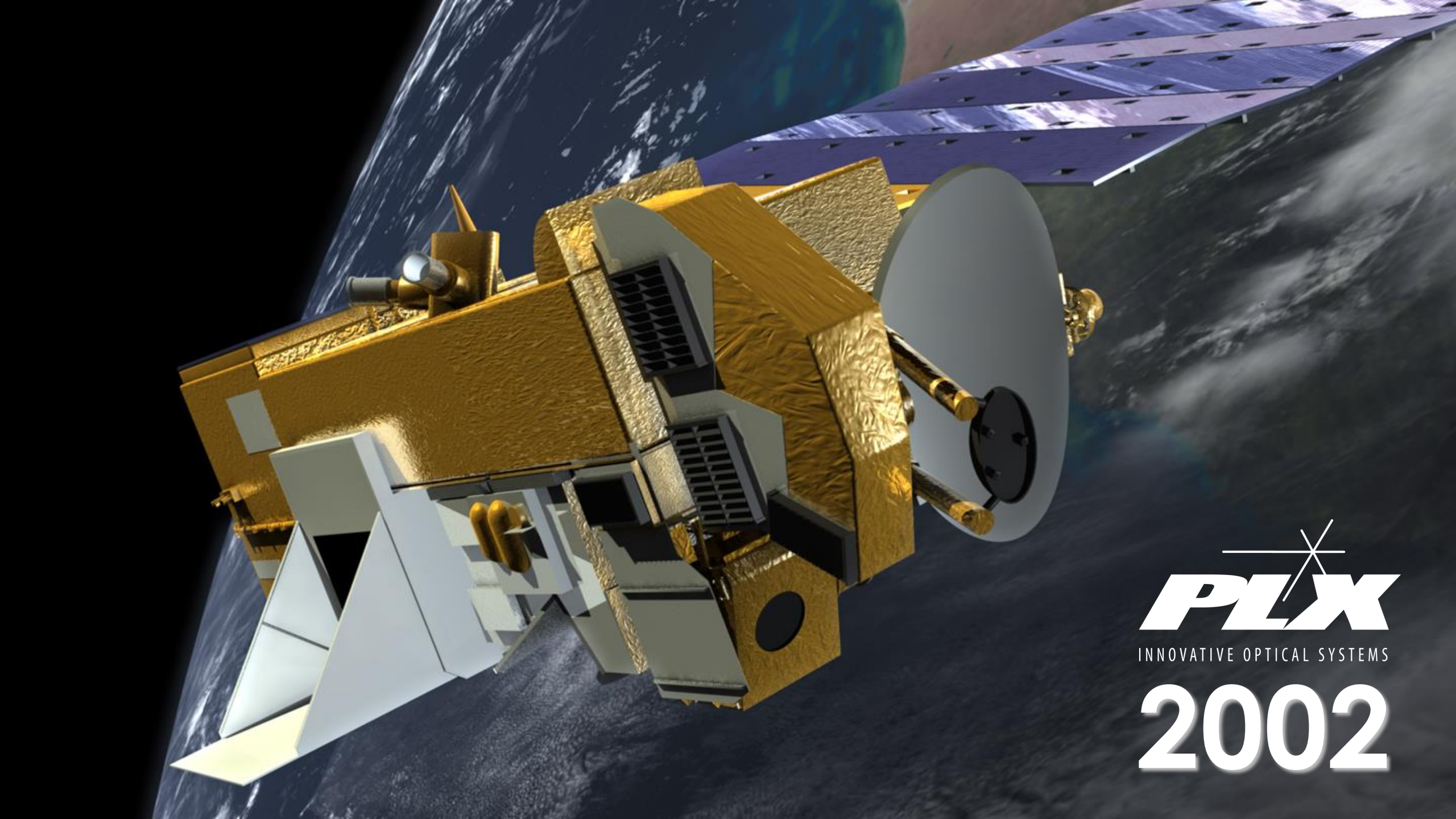


Image courtesy of NASA

- JPL deployed corner reflectors during the mission. These are highly reflective structures that appear as a bright point in the radar image.
- These reflectors deployed with precisely measured coordinates, served as control points in the Shuttle Radar Topography Mission data.
- PLX Inc. designed a Retroreflector Array™ for creating a high-resolution digital topographic database of the Earth.



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INNOVATIVE OPTICAL SYSTEMS

2002

TES Spectrometer (2002)

Mission Status: Active

- The **Tropospheric Emission Spectrometer (TES)** is one of four instruments aboard NASA's Aura Earth Spacecraft (formerly known as EOS-Chem 1.)

- The spectrometer's main operation is to study the chemistry and dynamics of the Earth's troposphere, the lowest level of Earth's atmosphere.

- PLX Inc. provided **high-accuracy** beryllium mirrors and retroreflectors that were instrumental to the success of the spectrometer.

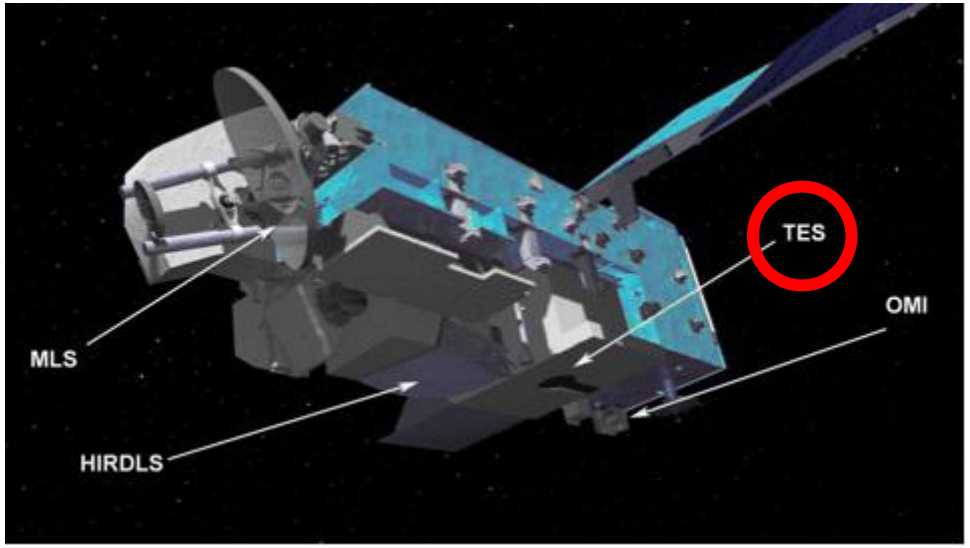

Image courtesy of SPARC

TES Optical Schematic

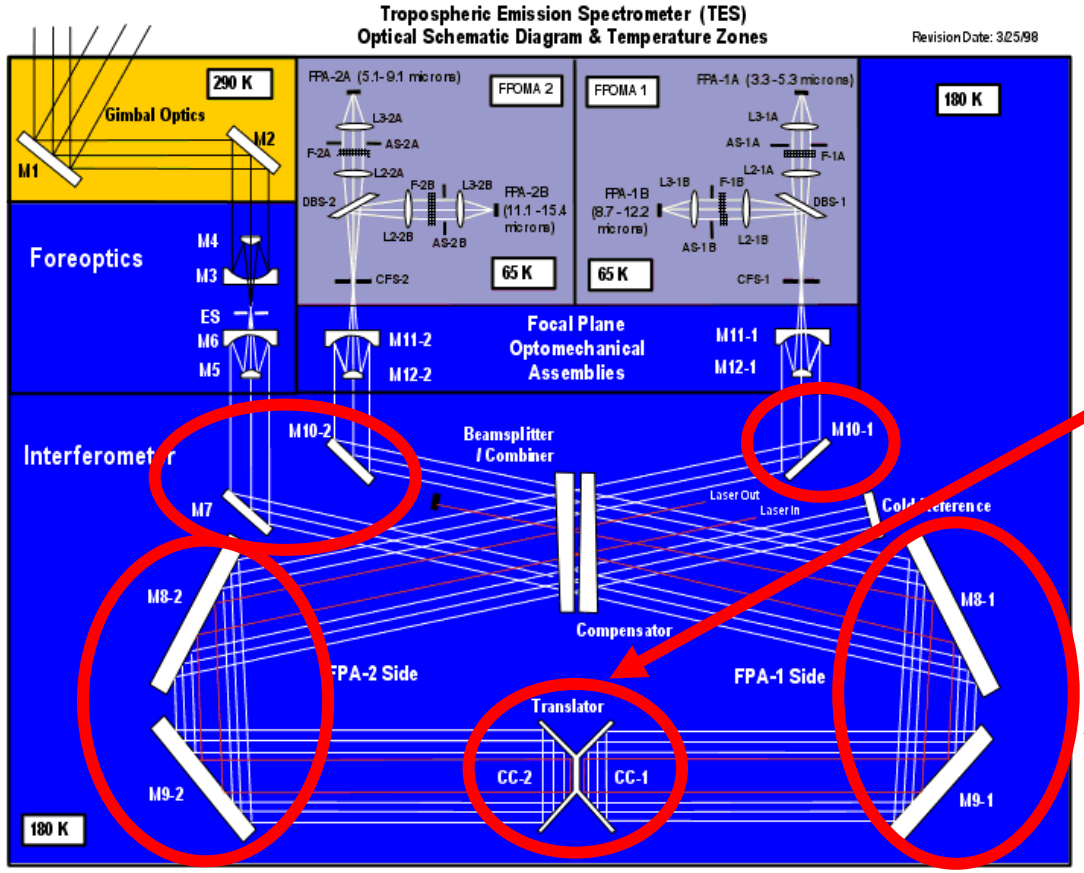

Image courtesy of NASA

- TES is a high-resolution infrared-imaging FTIR spectrometer.
- The change in optical-path difference is achieved by back-to-back corner-cube reflectors (PLX Design) mounted on a translator mechanism.
- PLX Inc. also developed, designed and fabricated beryllium flat mirrors (M7 and M10) and roof mirrors (M8 and M9).

TES Beryllium Retroreflector

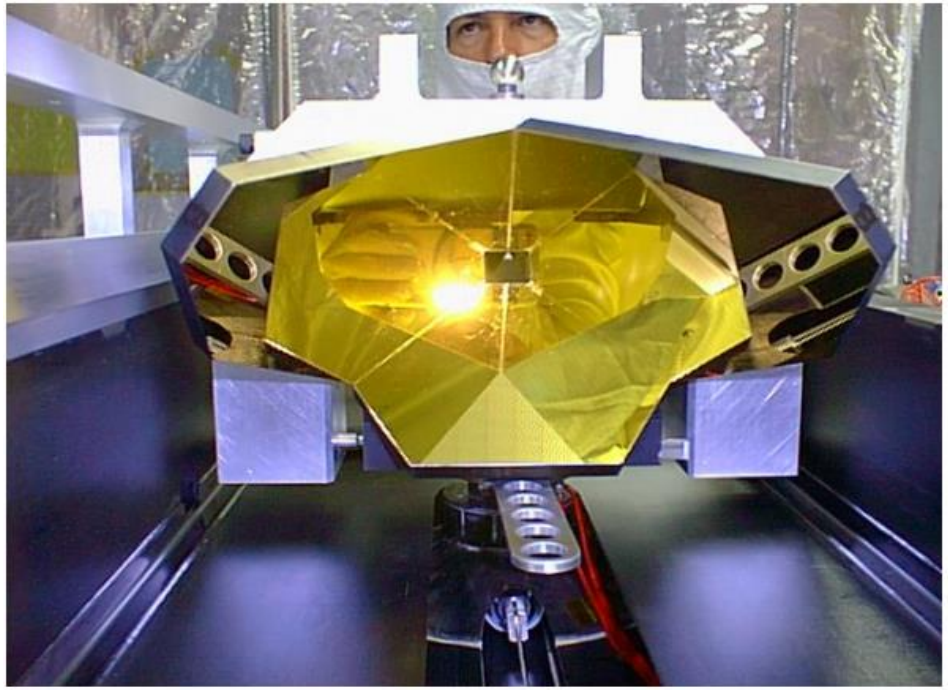

Image courtesy of NASA

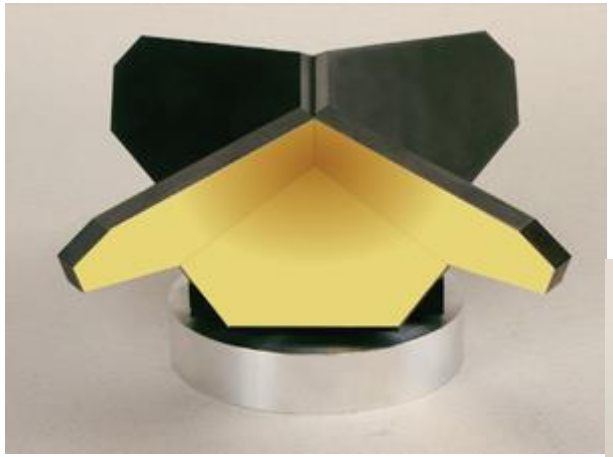

Image courtesy of PLX Inc.

Image courtesy of PLX Inc.

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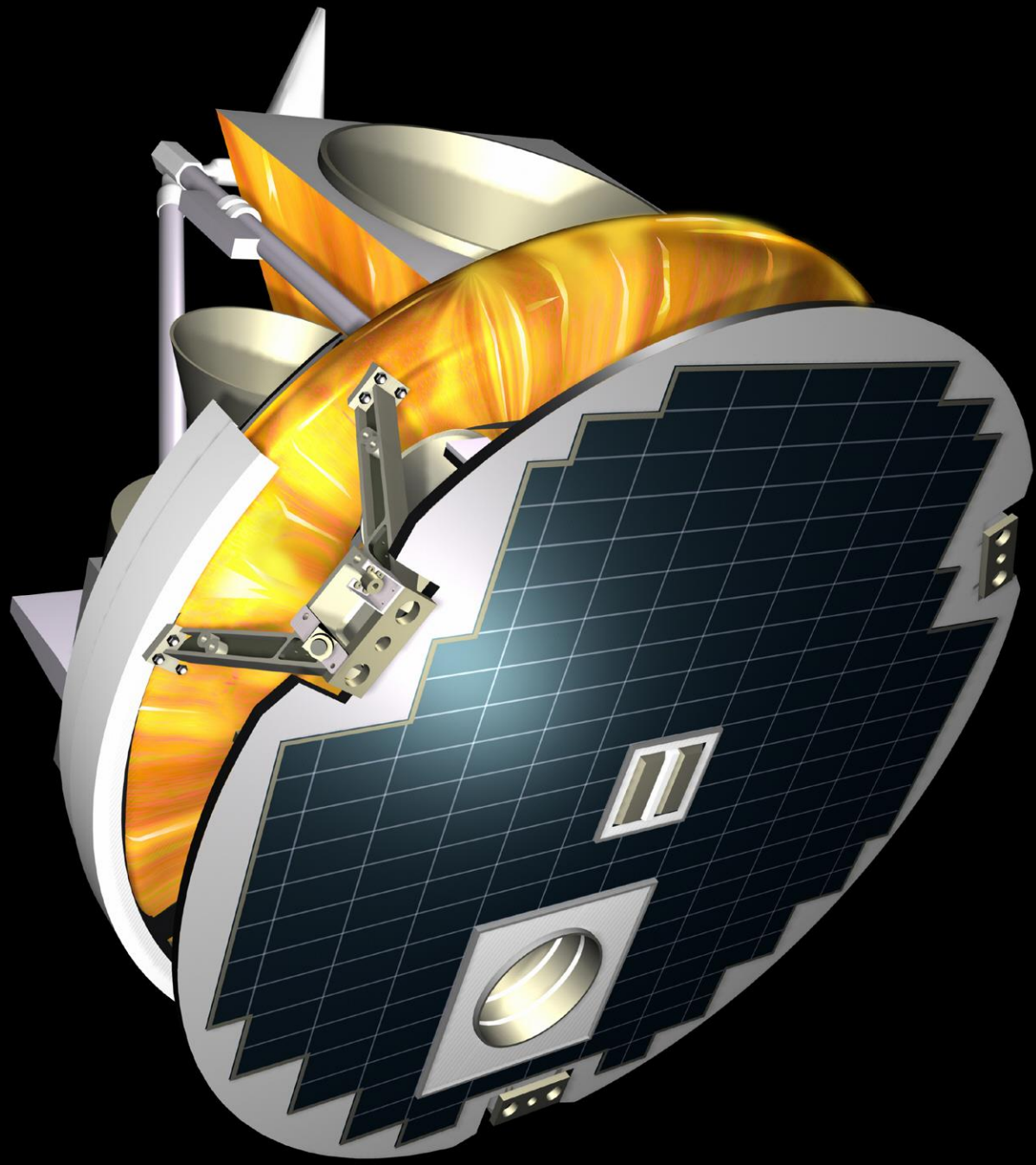
2003



ACE-FTS Spectrometer (2003)

Mission Status: Active

- The **Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS)** is one of several instruments aboard the Canadian Satellite SCISAT.
- The spectrometer's main operation is to measure and understand the chemical processes that control the distribution of ozone in the Earth's atmosphere.
- PLX Inc. specially designed retroreflectors were used to provided modulation which was instrumental to the success of the spectrometer.

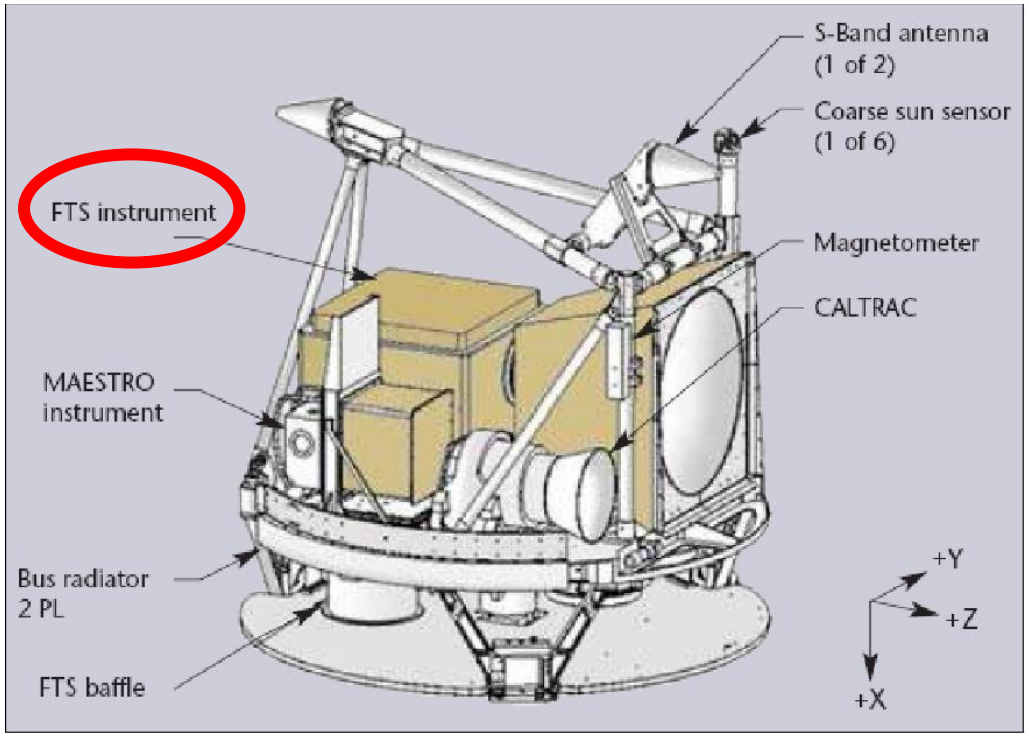
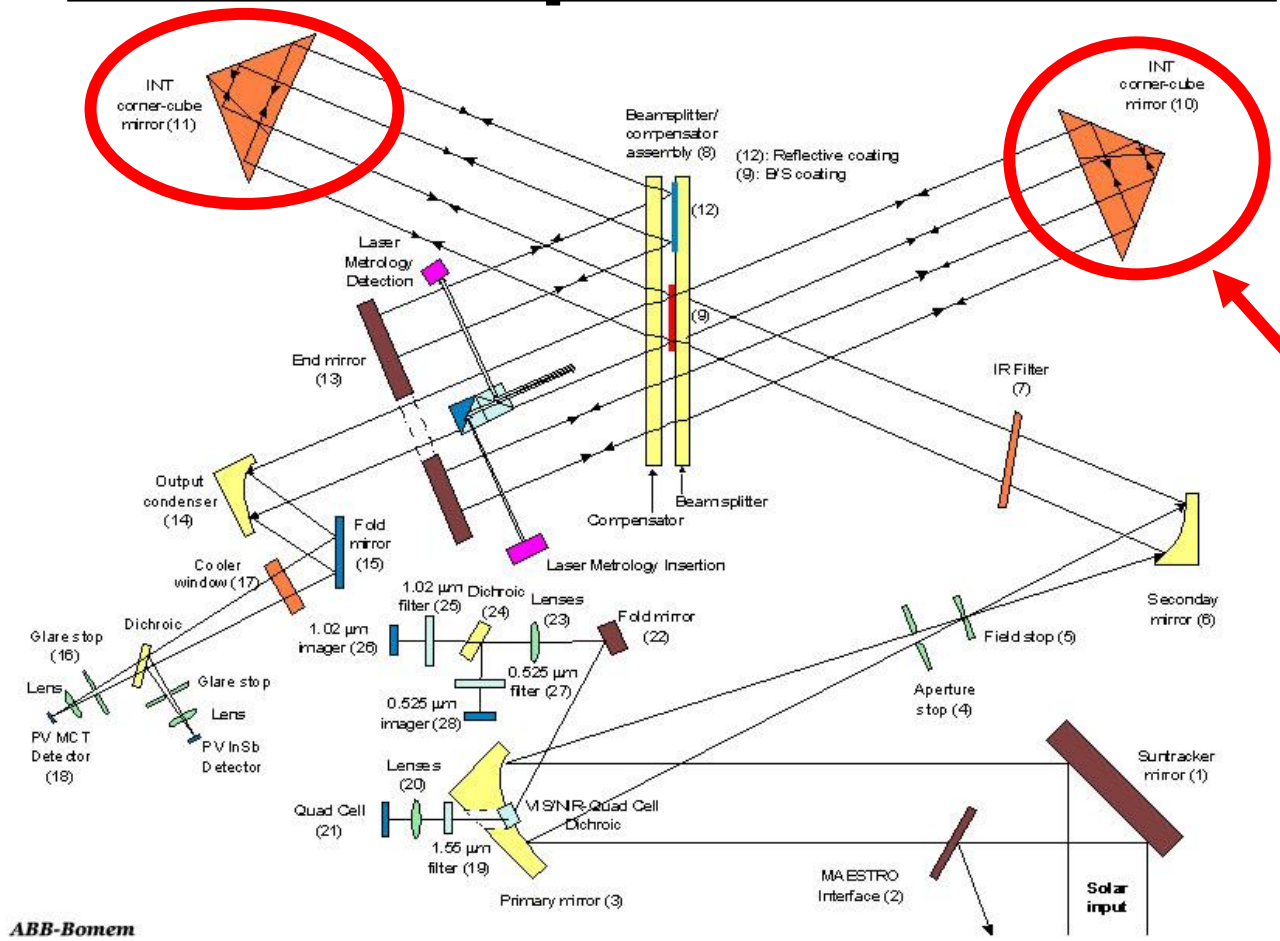


Image courtesy of Bristol Aerospace

ACE-FTS Optical Schematic



- ACE-FTS is a high-resolution infrared-imaging FTIR spectrometer.
- The change in optical-path difference is achieved by two corner-cube reflectors (PLX Design) mounted on a single bracket.

Image courtesy of ABB Bomem

ACE-FTS Instrument

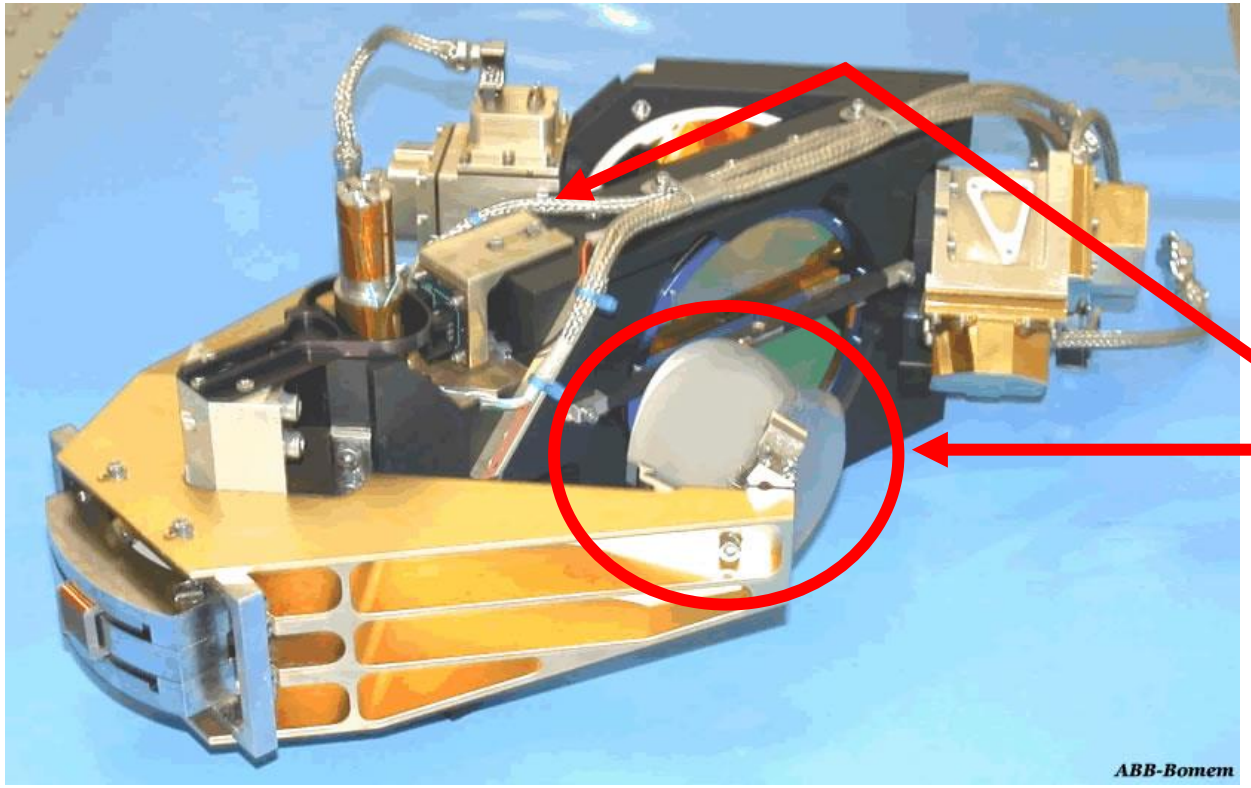


Image courtesy of ABB Bomem

PLX Retroreflectors mounted on a Single Bracket.
Second retroreflector obscured by beam-splitter.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2005

PFS Spectrometer (2005)

Mission Status: Active

- The **Planetary Fourier Spectrometer (PFS)** is one of several instruments aboard the Venus Express Satellite. Another PFS is aboard the Mars Express (launched in 2003).

- The spectrometer's main operation is to study the atmosphere of both Venus and Mars as well as the soil composition on Mars.

- PLX Inc. specially designed retroreflectors were used to provided modulation on rotating interferometers.

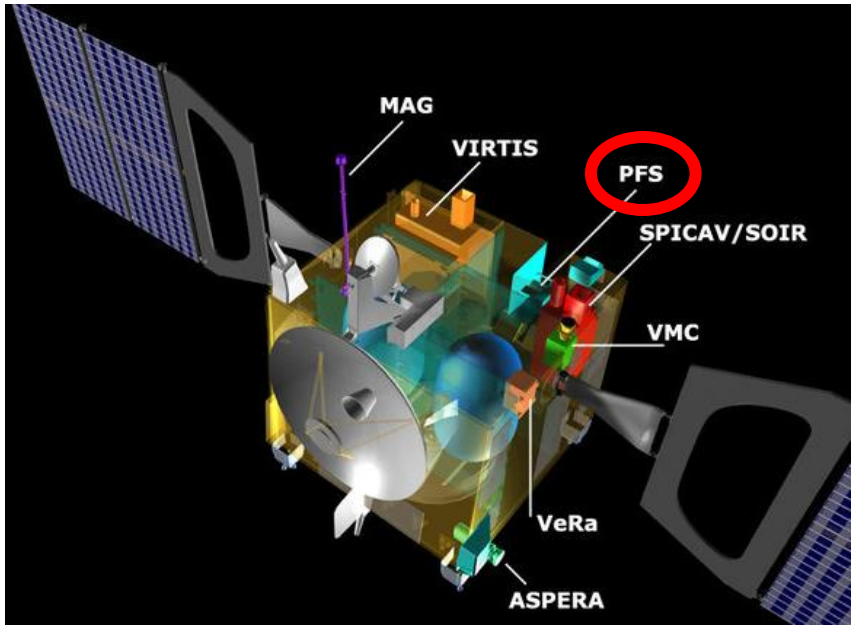

Image courtesy of ESA

PFS Optical Schematic

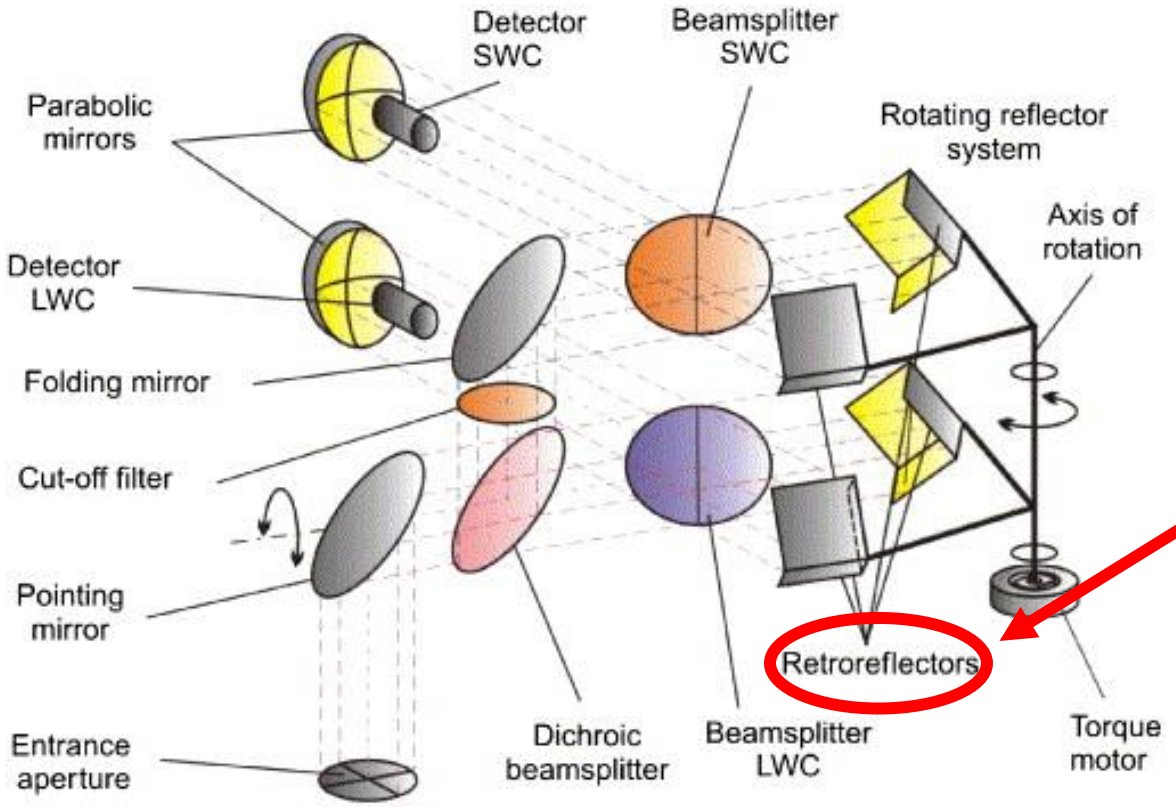

Image courtesy of Science Direct

- PFS is a high-resolution infrared-imaging FTIR spectrometer.
- The change in optical-path difference is achieved by four corner-cube reflectors (PLX Design) mounted on a single rotating bracket.

PFS Instrument

PLX Retroreflector: ○

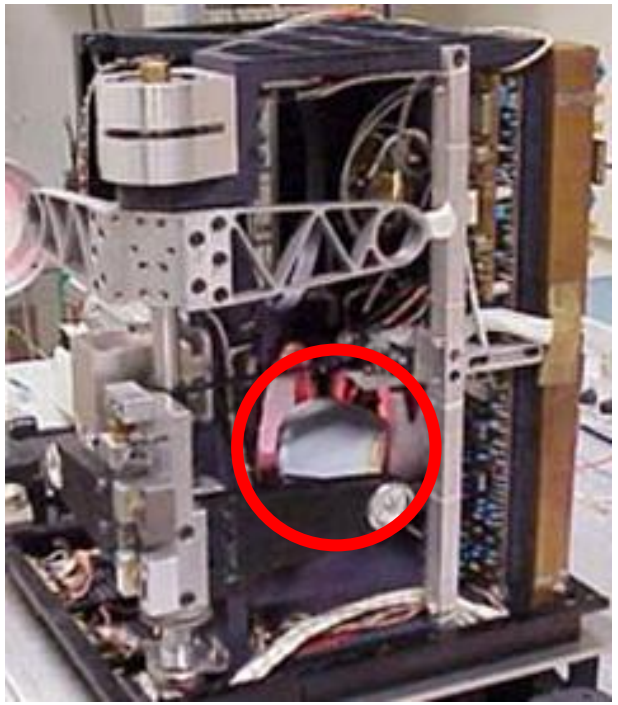

Image courtesy of ESA

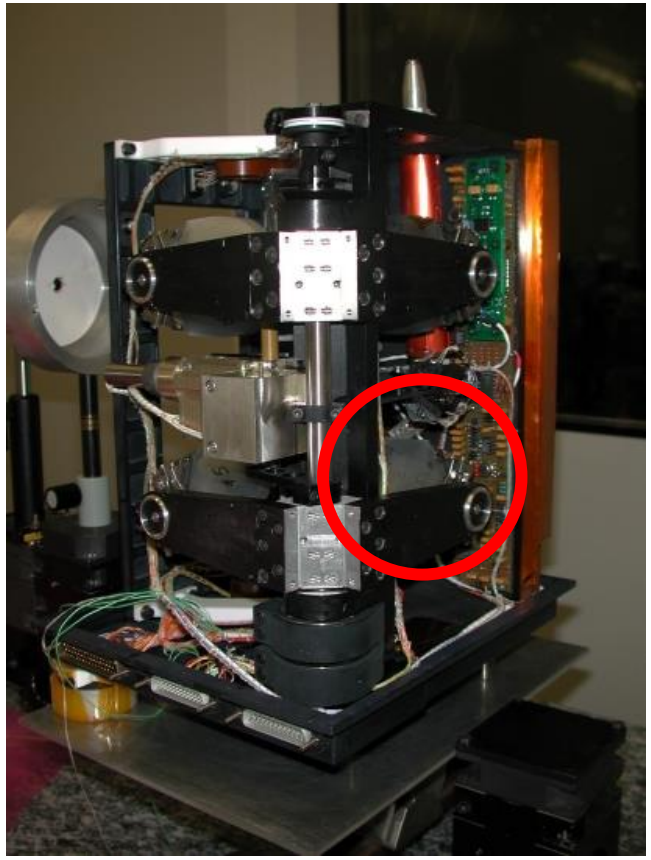

Image courtesy of ESA

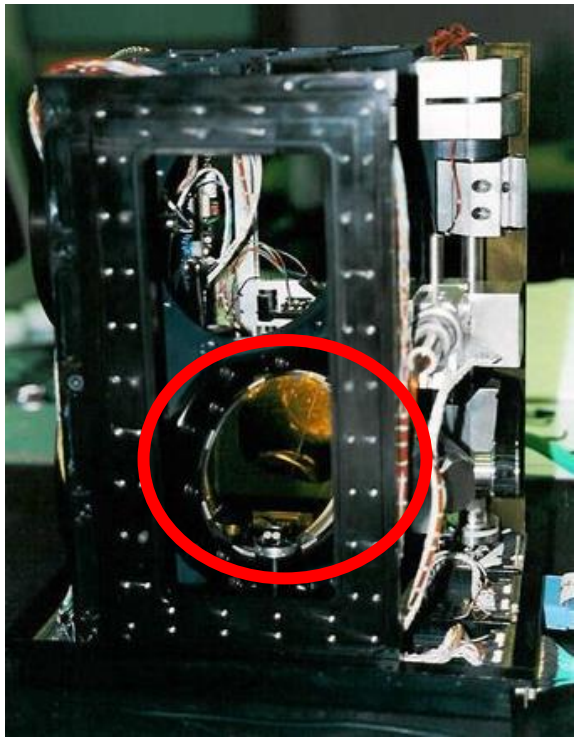

Image courtesy of Piotr Orleanski

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INNOVATIVE OPTICAL SYSTEMS

2009

Keldysh Space Program (2009)

Mission Status: Completed

- PLX Inc. designed hollow retroreflectors for one of the instruments aboard the Meteor-M Satellite.
- The device's main operation is for hydro-meteorological purposes, remote sensing of the surface and atmosphere of the Earth.
- Data from this device is used for obtaining temperature/humidity profiles and trace gases monitoring, as well as for weather forecasting and prediction of climatic changes.
- These specially designed retroreflectors experienced sinusoidal modulation between the range of 10-100 Hz.

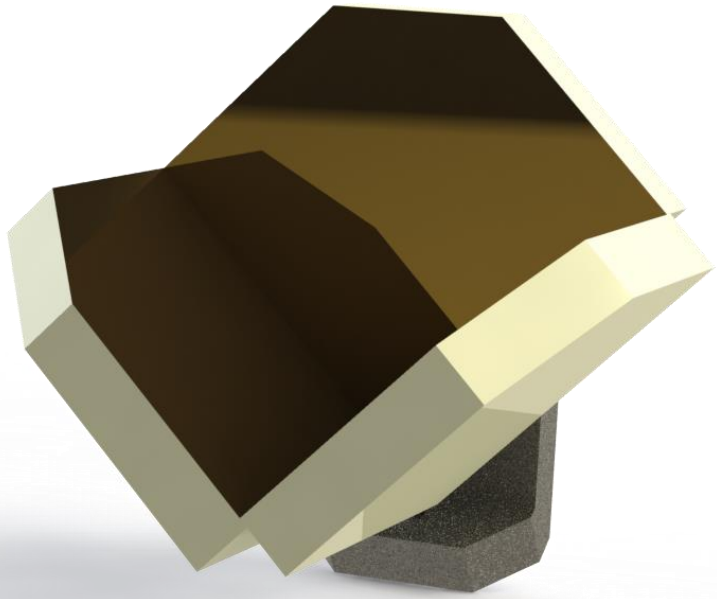

Image courtesy of PLX Inc.

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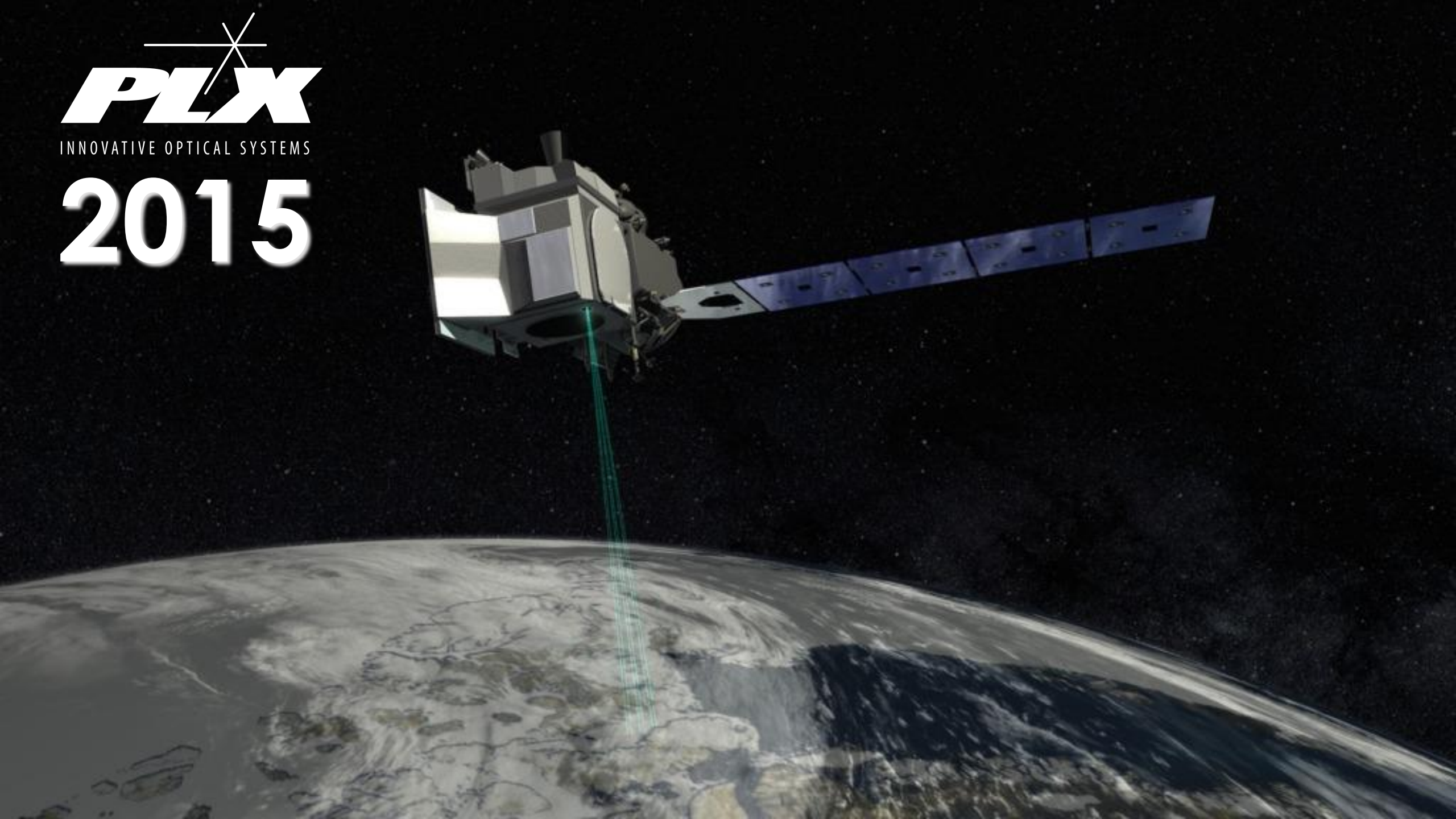
INNOVATIVE OPTICAL SYSTEMS

2015



ICESat-2 Testing (2015)

Mission Status: Completed

PLX supplied NASA a vacuum-compatible Lateral Transfer Hollow Retroreflector (LTHR). This unit was part of the ground support equipment for testing and verifying the Advanced Topographic Laser Altimeter System (ATLAS).

Unit Specifications:

- Clear Aperture: **5” [127 mm].**
- Beam Displacement: **18.5” [470 mm].**
- Overall Accuracy: **1 arc second.**

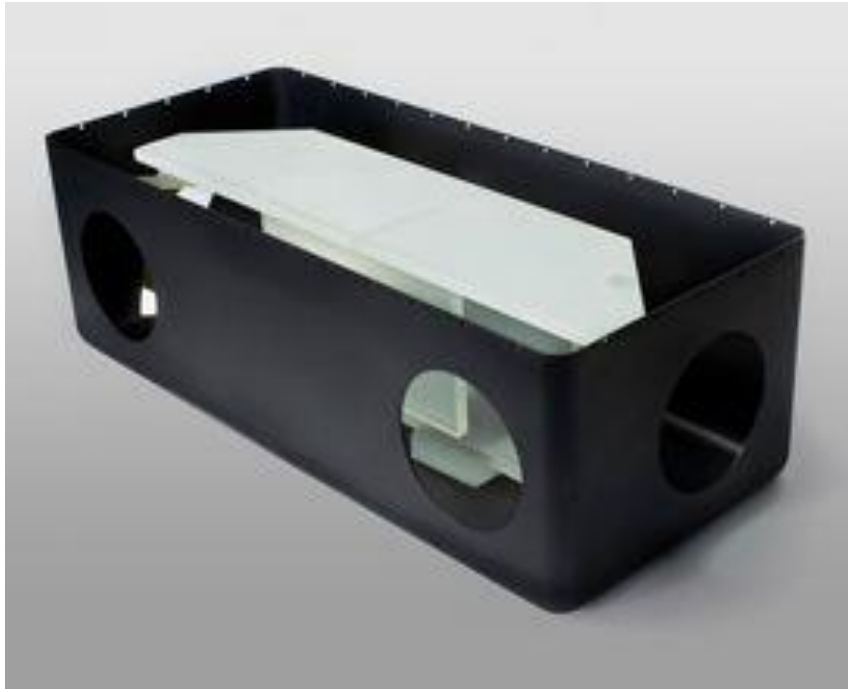


Image courtesy of PLX Inc.

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INNOVATIVE OPTICAL SYSTEMS

2016

TIRVIM Spectrometer (2016)

Mission Status: Active

- The **Thermal Infra-Red V-Shape Interferometer Mounting (TIRVIM) Spectrometer** is one of three spectrometers on the Atmospheric Chemistry Suite (ACS) instrument on board the ExoMars 2016 Trace Gas Orbiter satellite.

- The spectrometer's main operation is to monitor temperature profiles and measure aerosol content during nadir observations.

- PLX Inc. retroreflectors were used for their ability to perform in harsh environments while maintaining exceptional stability and accuracy.

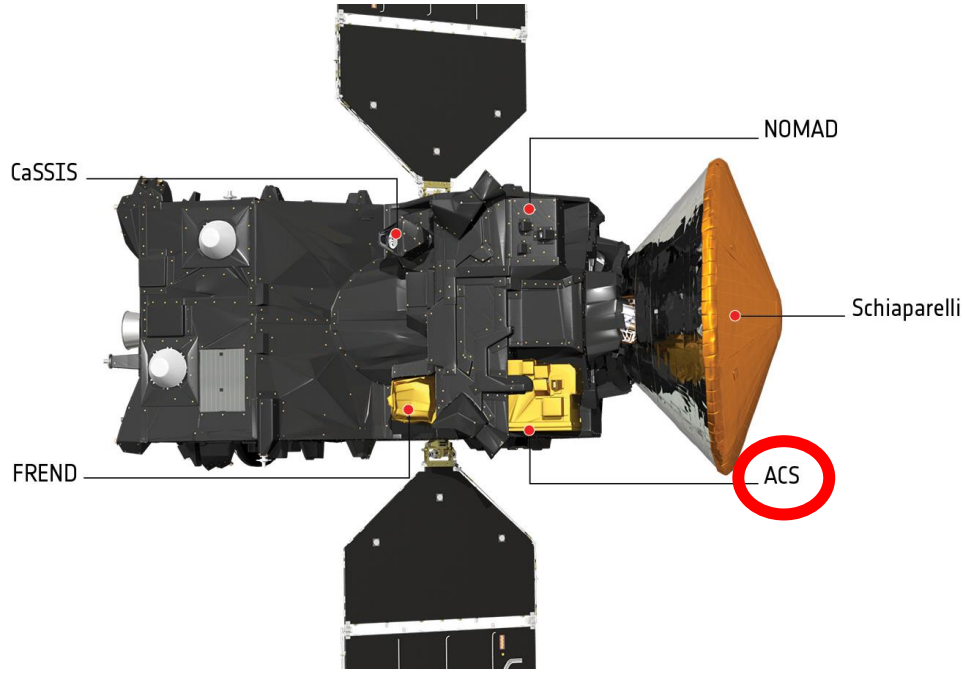


Image courtesy of ESA

TIRVIM Optical Schematic

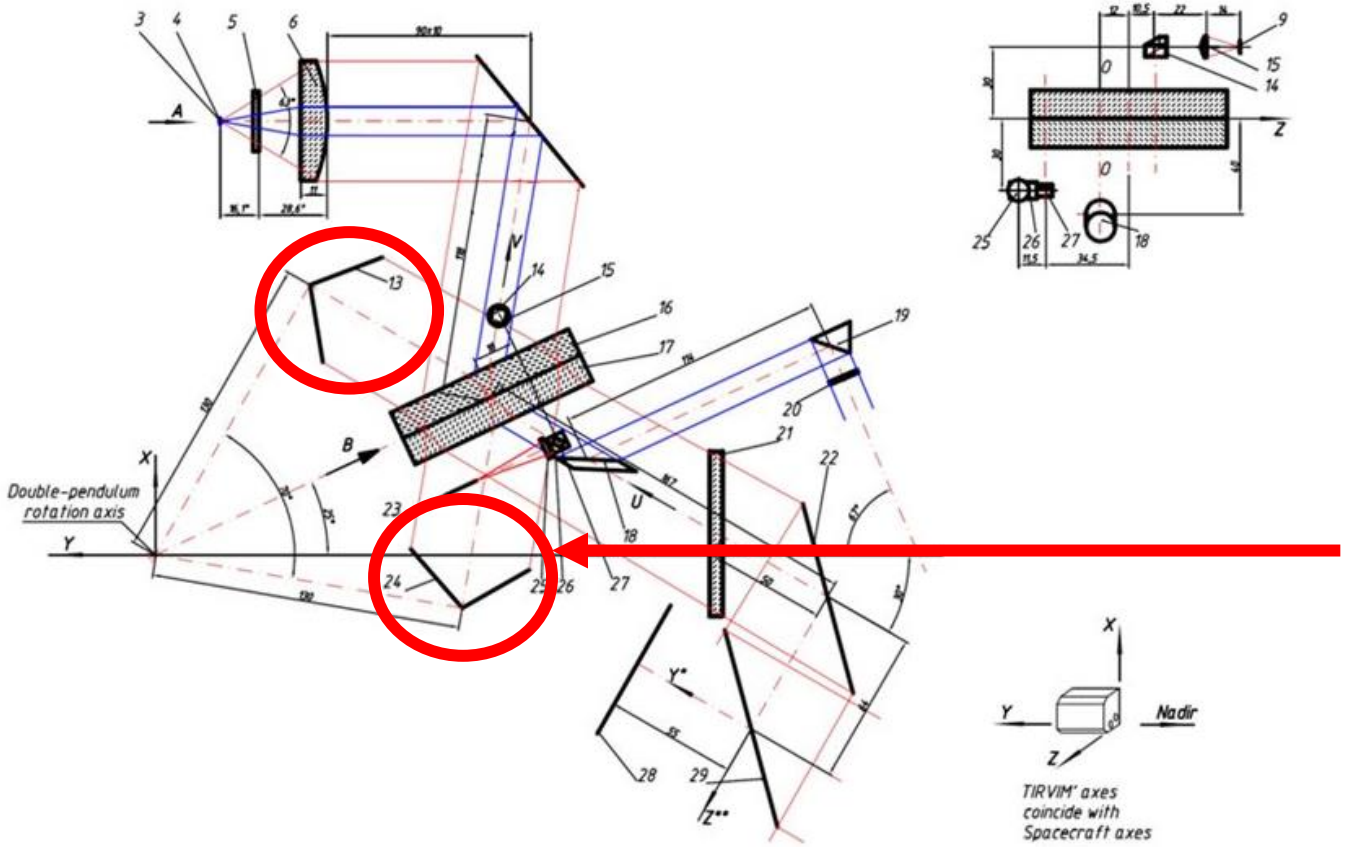
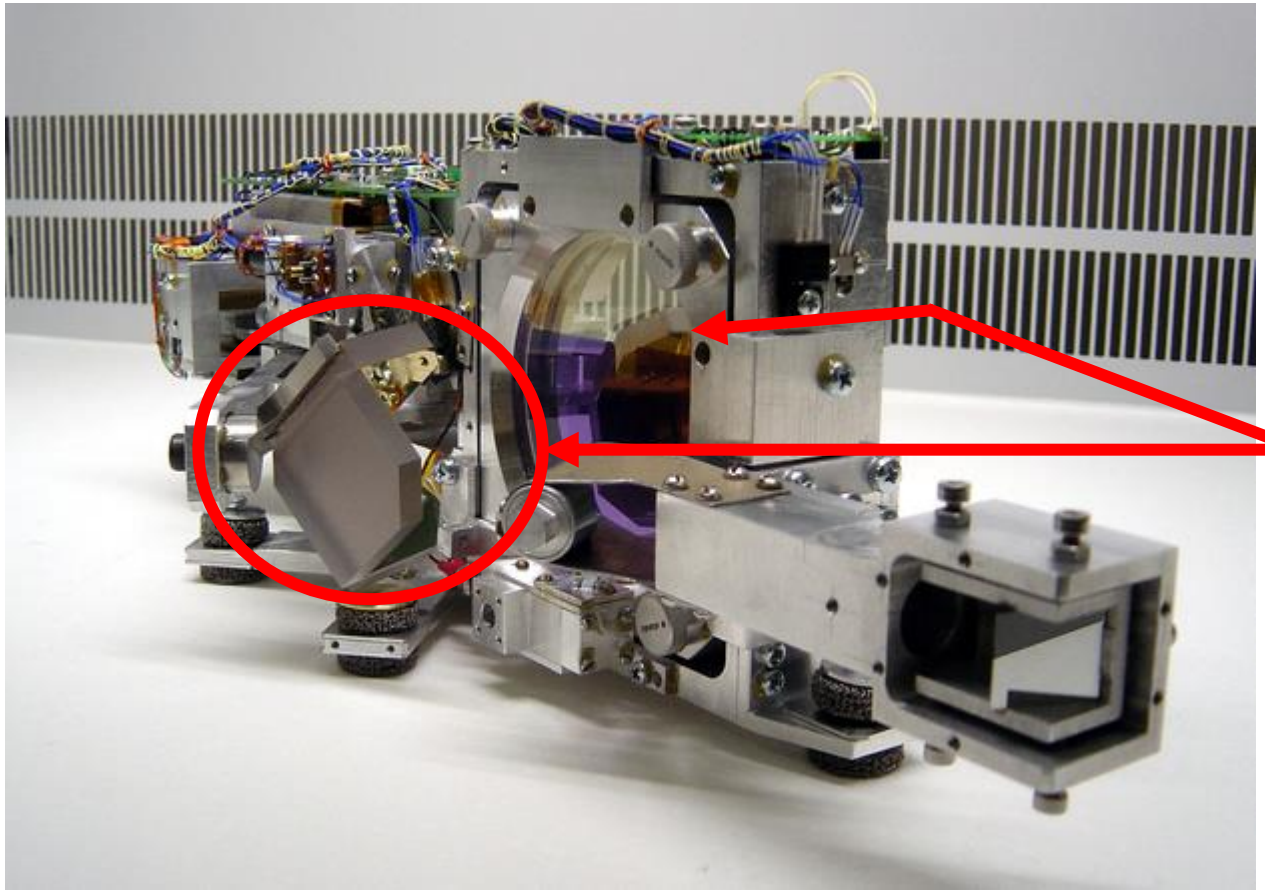


Image courtesy of Cynthia Holmes

- TIRVIM is a high-resolution thermal infrared-imaging FTIR spectrometer.
- The change in optical-path difference is achieved by two corner-cube reflectors (PLX Design) mounted on a single double-pendulum.

TIRVIM Instrument



PLX Retroreflectors
mounted on a Double-Pendulum.
Second retroreflector partially obscured by beam-splitter.

Image courtesy of ESA

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INNOVATIVE OPTICAL SYSTEMS

2016

CAMS Metrology System (2016)

Mission Status: Active

- The **Canadian Astro-H Metrology System (CAMS)** is an alignment system for the Hard X-Ray Telescope aboard the Astro-H observatory satellite.
- CAMS is designed to measure the lateral/rotational displacement in the spacecraft's optical bench relative to the instruments.
- PLX Inc. designed a 1.94" [49 mm] Invar mounted retroreflector with a 0.5 arc second accuracy which was used for alignment monitoring.

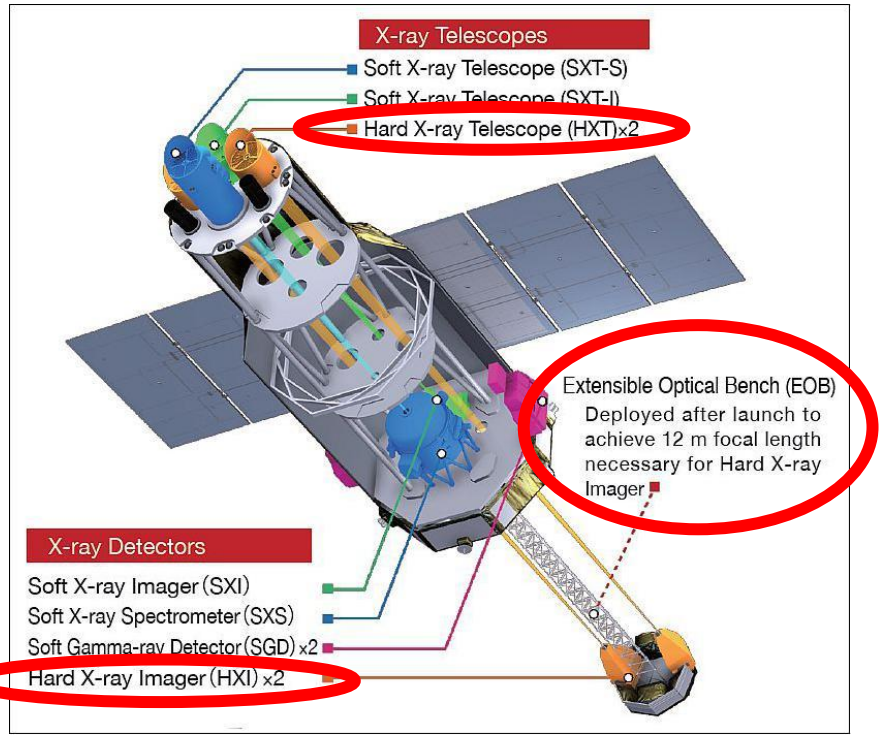

Image courtesy of JAXA

CAMS Optical Schematic

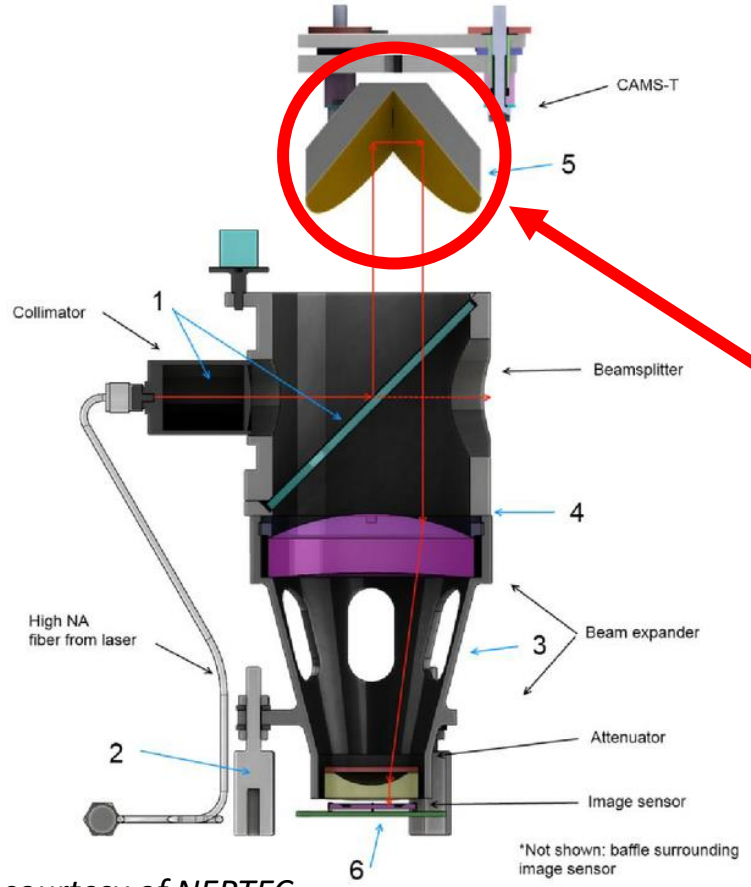

Image courtesy of NEPTEC

PLX Retroreflector used to return the laser beam over 12m back to the CAMS system.

CAMS Retroreflector

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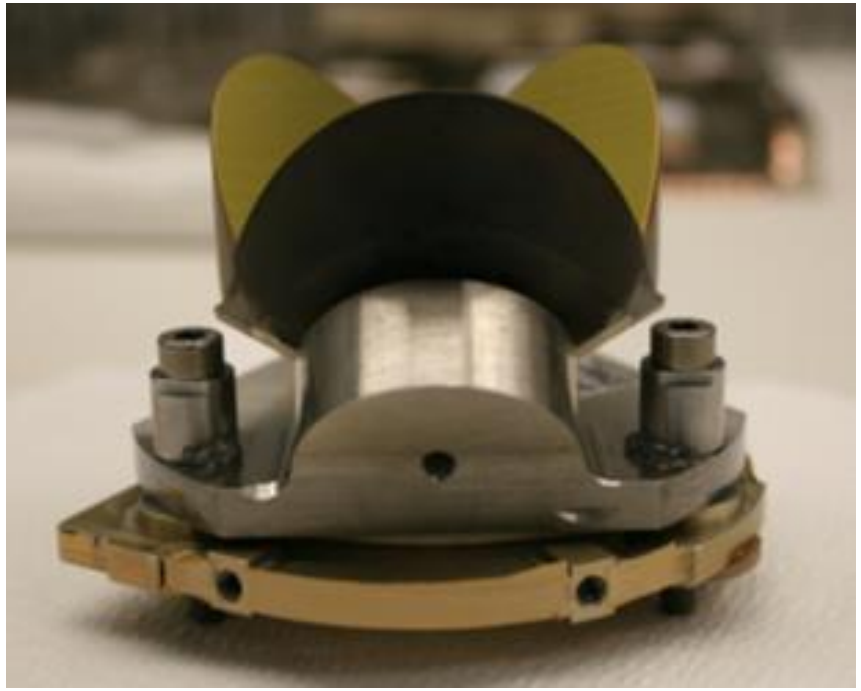

Image courtesy of SPIE

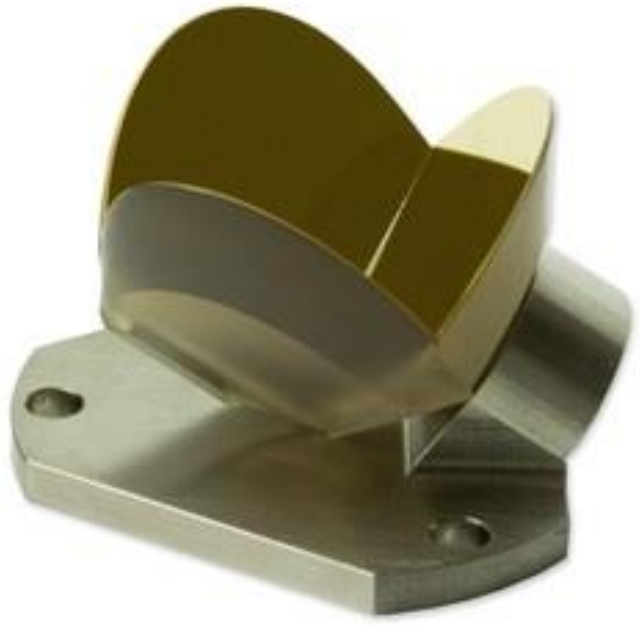

Image courtesy of PLX Inc.

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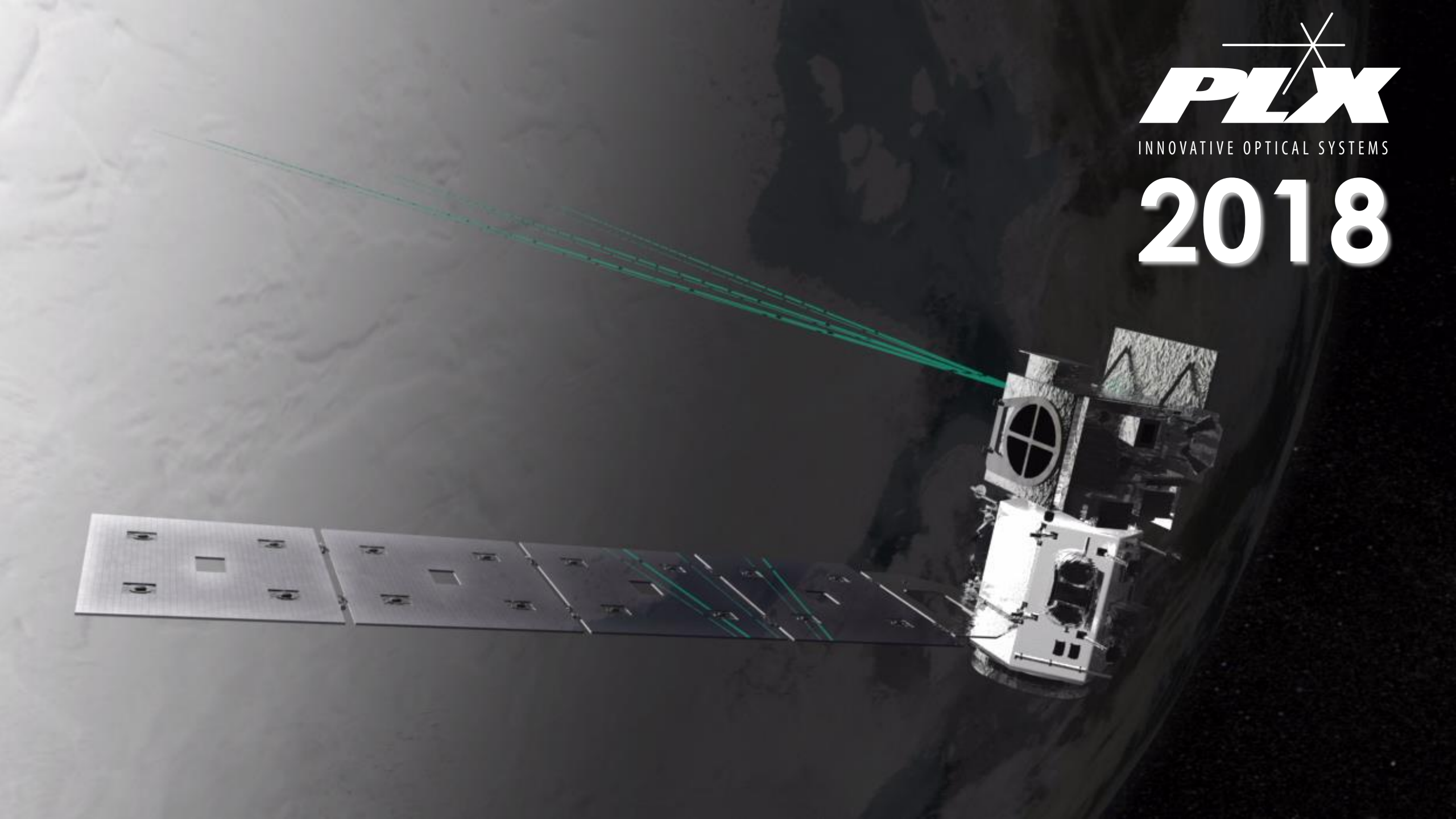

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INNOVATIVE OPTICAL SYSTEMS

2018

AMCS Alignment System (2018)

Mission Status: Active

- The **Alignment Monitoring and Control System (AMCS)** is an alignment instrument for the Advanced Topographic Laser Altimeter System (ATLAS) aboard the ICESat-2 satellite.
- The Ice, Cloud and Land Elevation Satellite-2, or ICESat-2, will measure the height of a changing Earth.
- PLX Inc. designed two Lateral Transfer Hollow Retroreflector (LTHR) that are used to keep the laser and receiving telescope bore-sighted to each other during orbit.

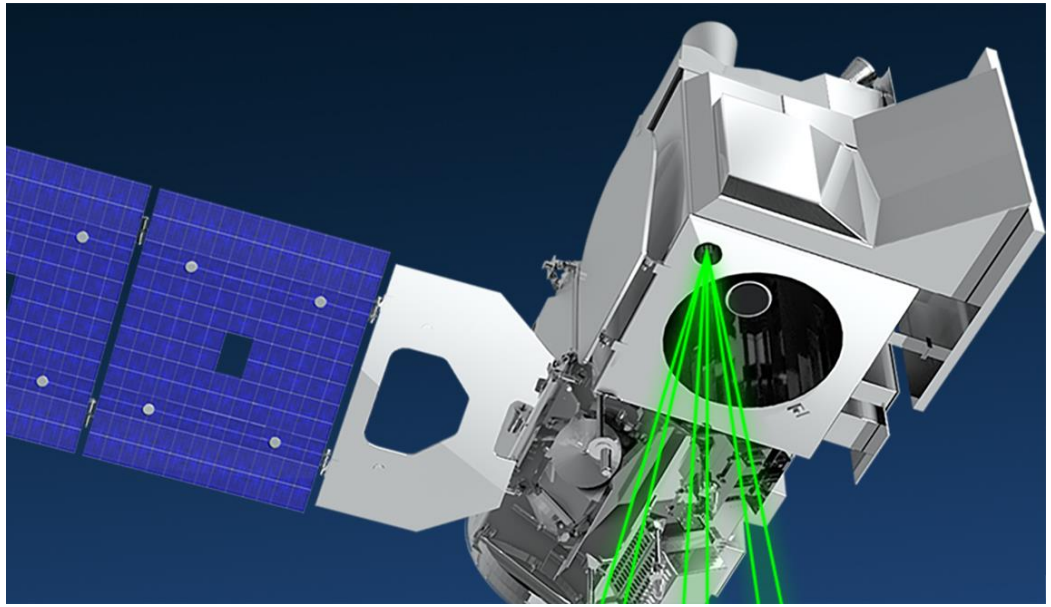

Image courtesy of NASA

AMCS LTHR's for ATLAS System

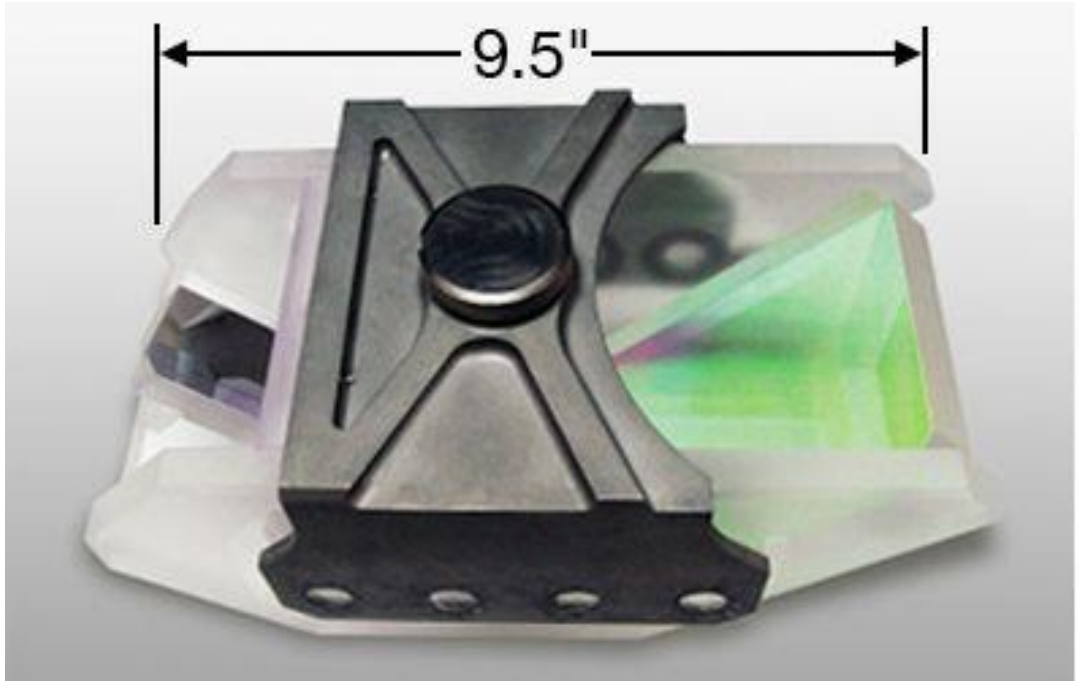

Image courtesy of PLX Inc.

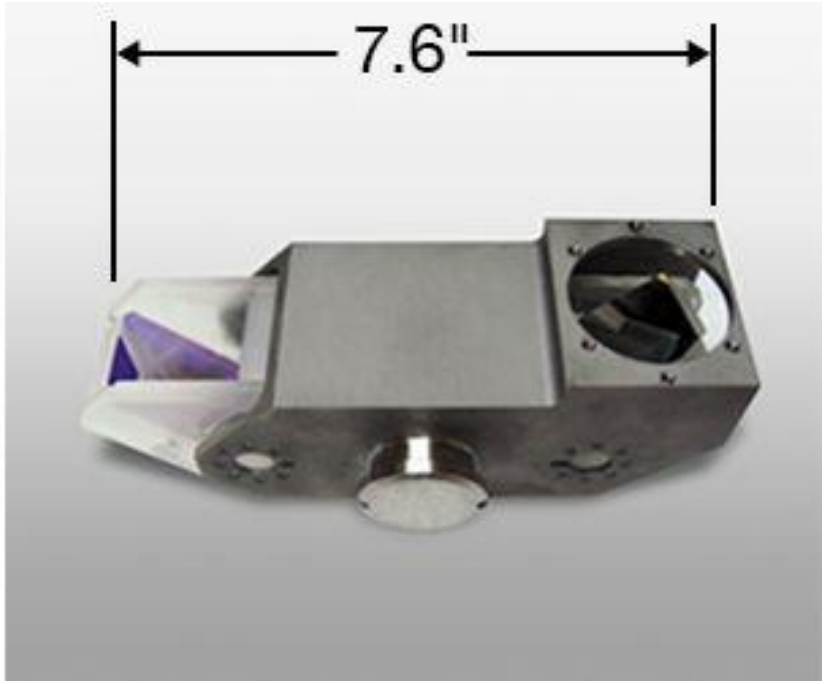

Image courtesy of PLX Inc.

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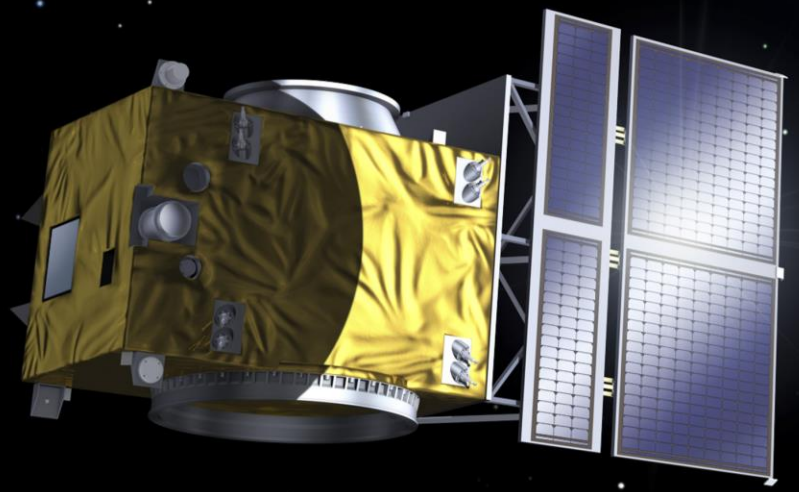

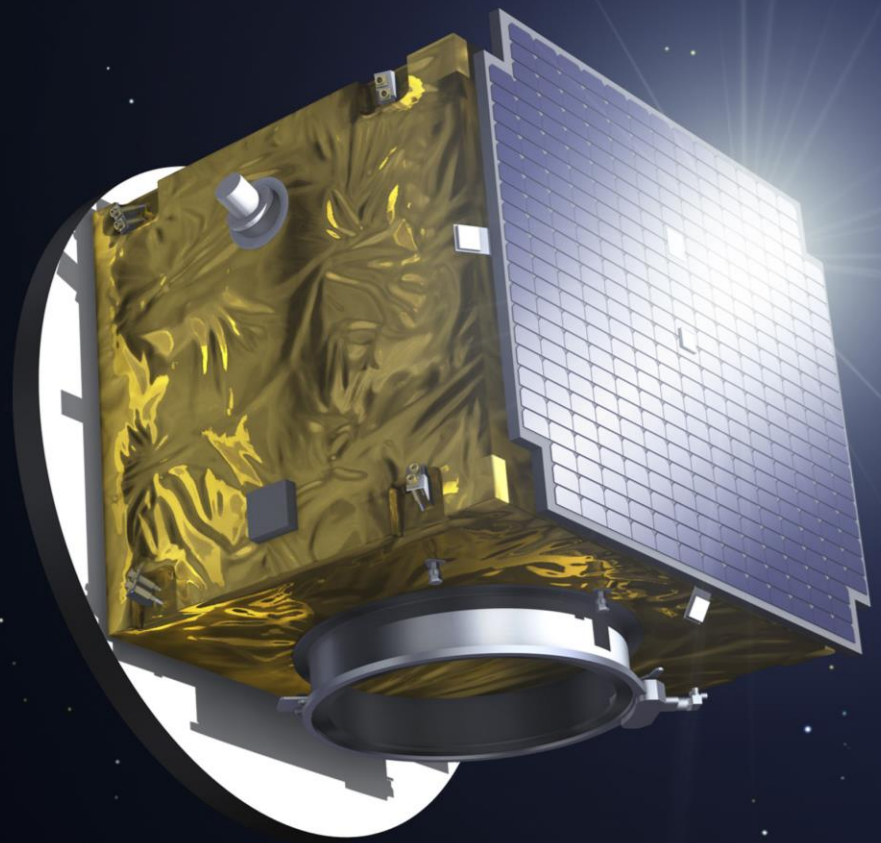

Laser Utilizing Communication System (LUCAS) (2020)

Mission Status: Active

- The **Laser Communication Terminal (LCT)** uses laser light to deliver broadband data transmission in outer space, it has been provided for the LUCAS being coordinated by the Japan Aerospace Exploration Agency (JAXA).
- The LUCAS system developed by JAXA enables data relaying between Earth observation satellites (LEO satellites) and optical data relay satellites (GEO satellites) by optical communication.
- PLX Inc. provided several retroreflectors fabricated from special low thermal expansion materials (Invar and Corning ULE) to maintain the high accuracy during orbit.

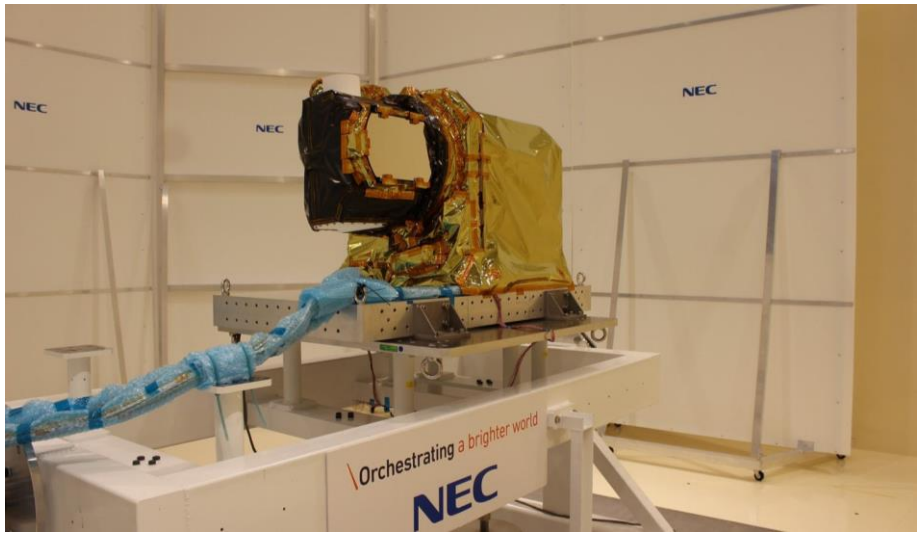

Image courtesy of JAXA

Laser Utilizing Communication System (LUCAS) (2020)

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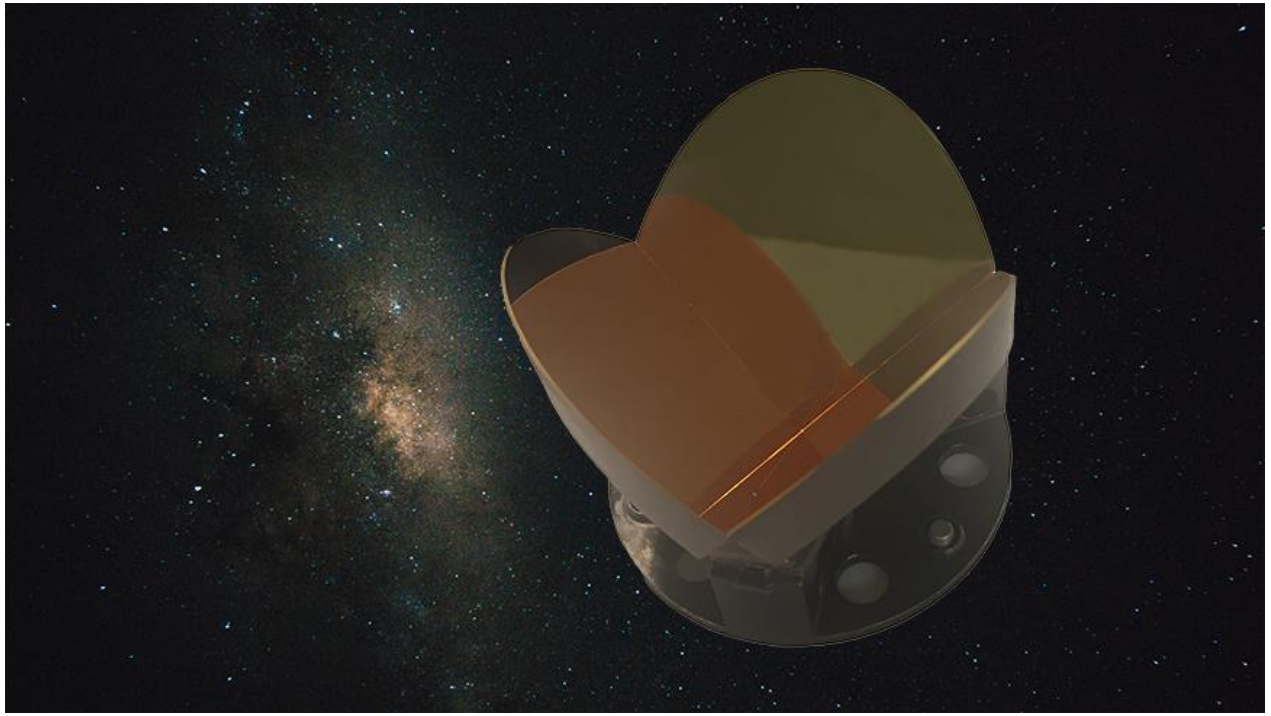
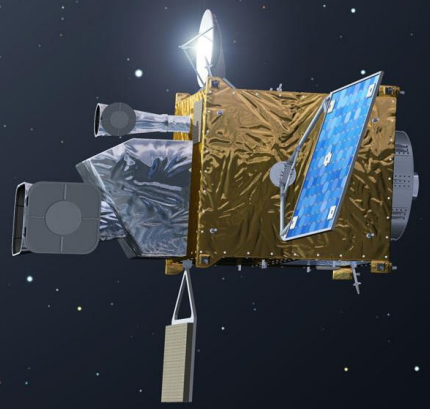
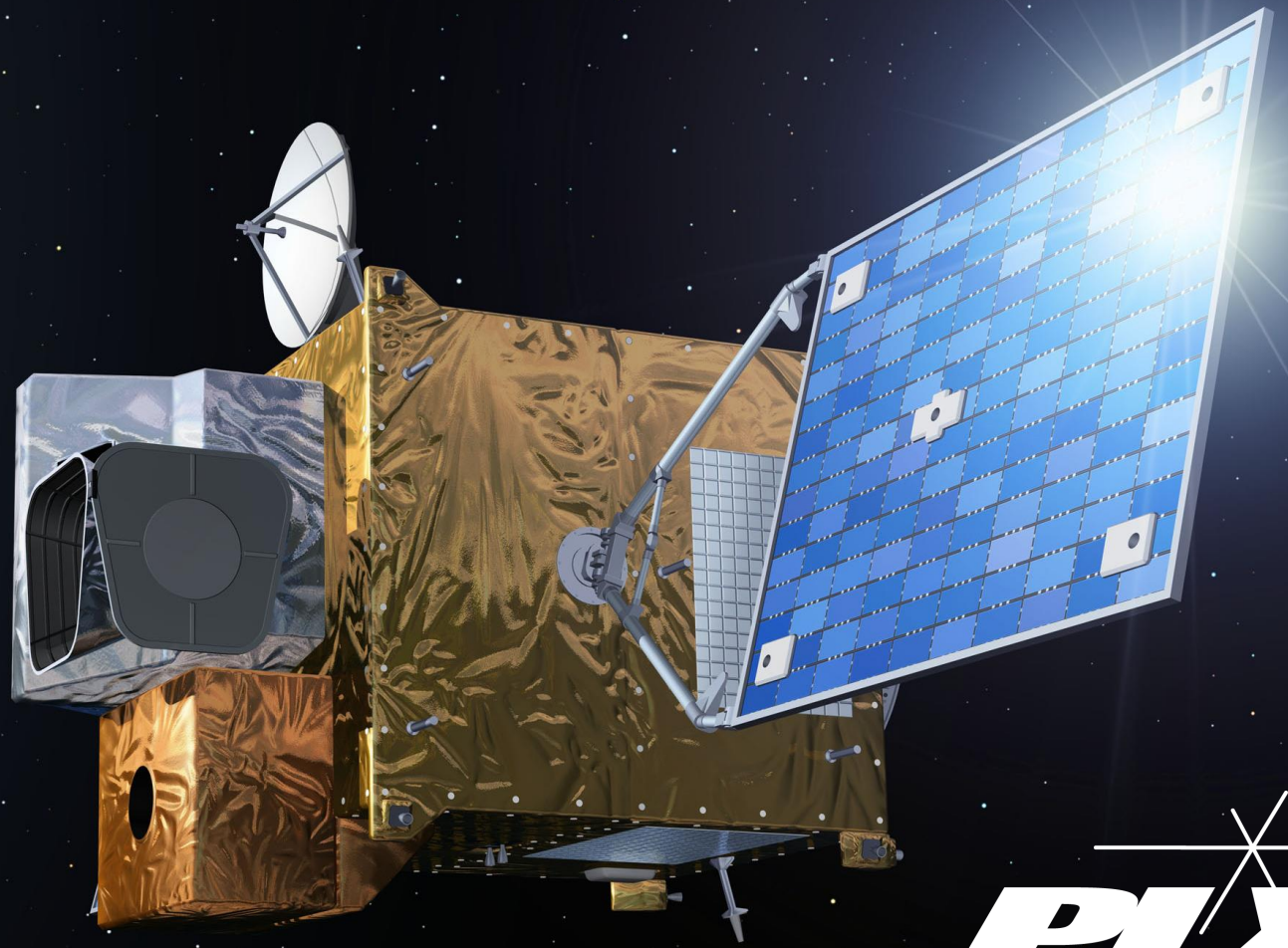


Image courtesy of PLX Inc.

PLX contracted to work on an interferometer.





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As seen from our extensive space heritage, space agencies and companies count on PLX Inc. to meet seemingly impossible optical requirements in critical aerospace applications.

Regardless of your needs, PLX engineers, who are specially trained and experienced in optical, laser and imaging systems, will work closely with you to adapt PLX technology to your requirements. If you're facing an optical challenge, contact PLX today!

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