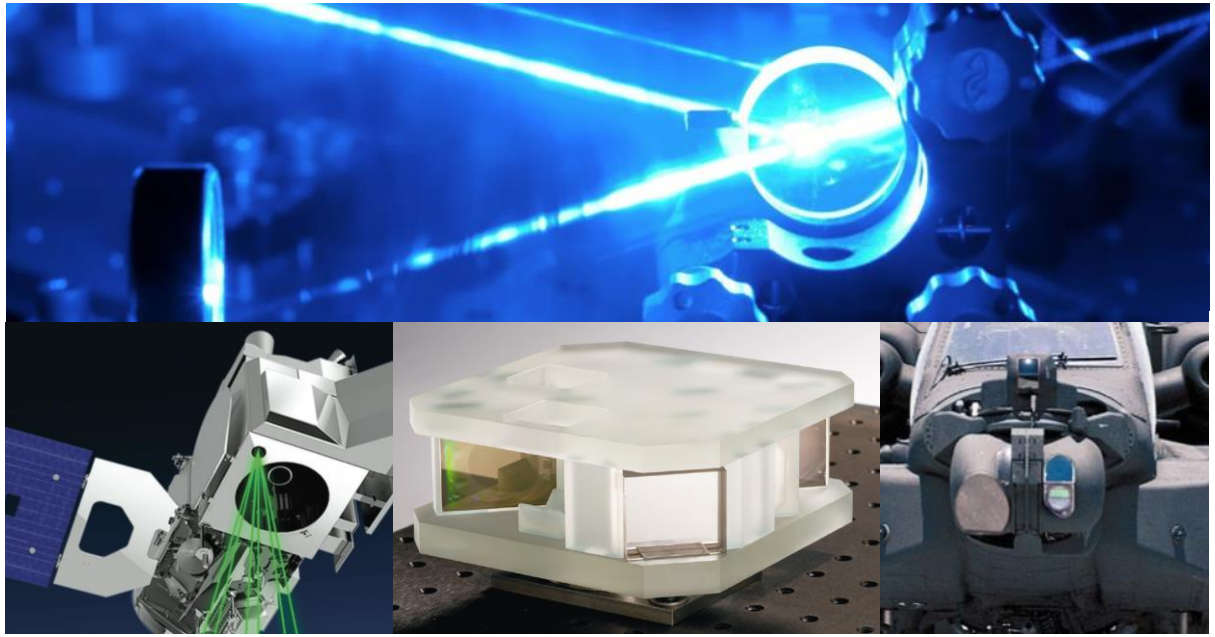
EPIC
European Photonics Industry Consortium

PLX
INNOVATIVE OPTICAL SYSTEMS

Transforming Space Optics By Integrating Innovative Monolithic Optical Systems.

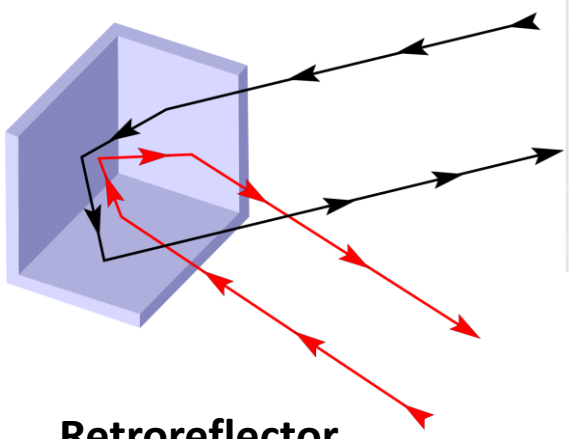


Itai Vishnia CEO, PLX Inc.
40 W. Jefryn Blvd. Deer Park, NY 11729, USA

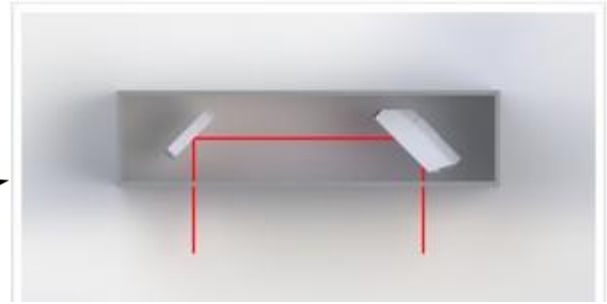
PLX
INNOVATIVE OPTICAL SYSTEMS

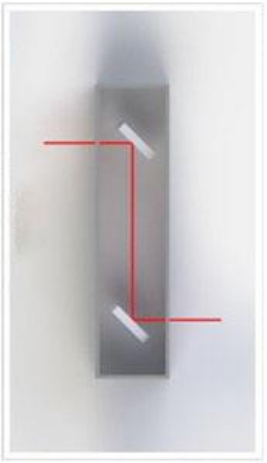
What We Do: High precision Light Manipulation

- Sub-arcsecond Beam Delivery
- Targeting & Boresighting
- Beam Folding & Steering
- Lasers Systems
- Interferometry Systems

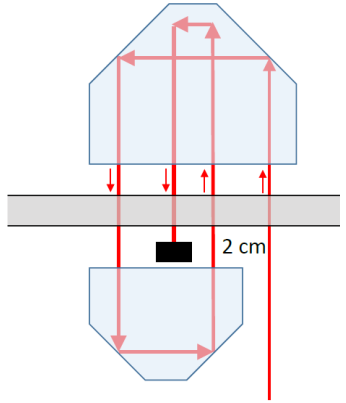


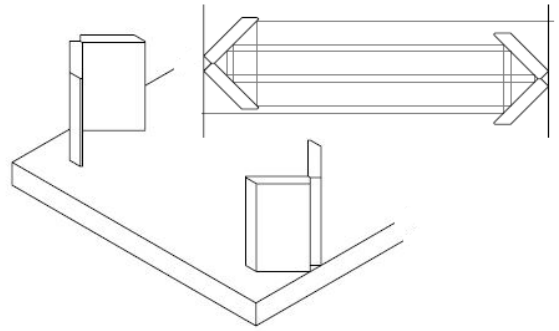
Retroreflector





Lateral Transfer Hollow Retroreflector & Periscope (LTHR & LTHP)





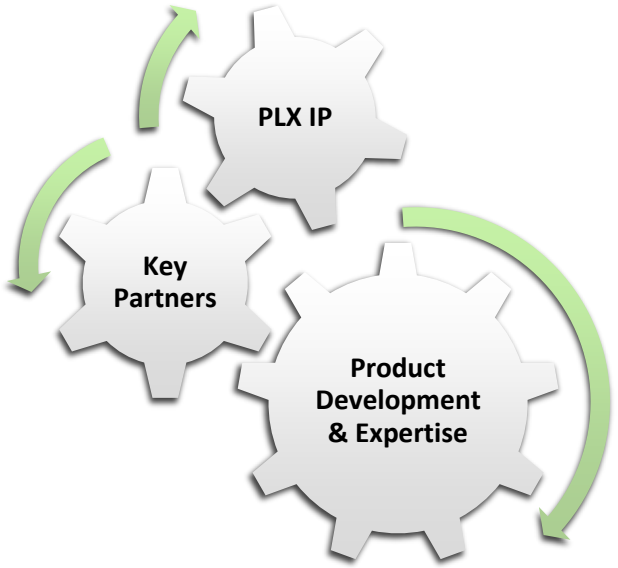
OEM Applications: Atomic Clock & Delay Sys.

INNOVATIVE OPTICAL SYSTEMS

PLX Business Model

OEM Solutions Provider

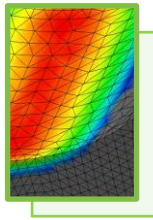
- System Integration
- Subsystem Integration
- Optical Assemblies



Business Development

Engineering Design

- Expert design engineers utilizing PLX 65-years of innovative patented technology

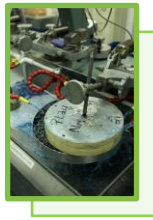


Analysis & Testing

- FEA Analysis of Performance
- Environmental Testing: Thermal, Vibration, Shock

Fabrication Shop

- Glass Fabrication & Grinding



Precision Optical Shop

- Polishing optics with better than λ/20 flatness.

Assembly Labs

- State-of-the-art precision stations for with Zygo interferometers.

QC/QA

- Performance & Environmental Testing, Zeiss CMM.
- Registered ISO 9001:2015

Coating Capabilities

- Metallic coatings, Anti-Reflective(AR) coatings, and dielectric mirror coatings for all types of optics.

Clean Room

- Class 100 Clean Room

PLX
INNOVATIVE OPTICAL SYSTEMS

Just the starting point of parameters…

PLX has delivered assemblies meeting the following performance under the harshest levels of vibration and shock, such as rocket launces, helicopter flight and battlefield conditions.

Beam Deviation	Wavelength Range
as low as 0.20 arc seconds	From UV to IR

Clear Aperture	Beam Offset
Retroreflectors: Ø 2 mm to Ø 500 mm LTHR/LTHP: Ø 6 mm to Ø 130 mm	LTHP/LTHR: 2 mm to 1800 mm

Environmental Conditions	
Shock: 250G	Sinusoidal Vibration/Acceleration: 60G
Random Vibration: 20 to 2000 Hz, 47Grms	Temperature Range: -100°C to + 100°C
Altitude: From 1km below the Earth's surface to over 200km above it	

PLX
INNOVATIVE OPTICAL SYSTEMS

Space Participation Timeline

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.

2021 – Future Project for an interferometer.

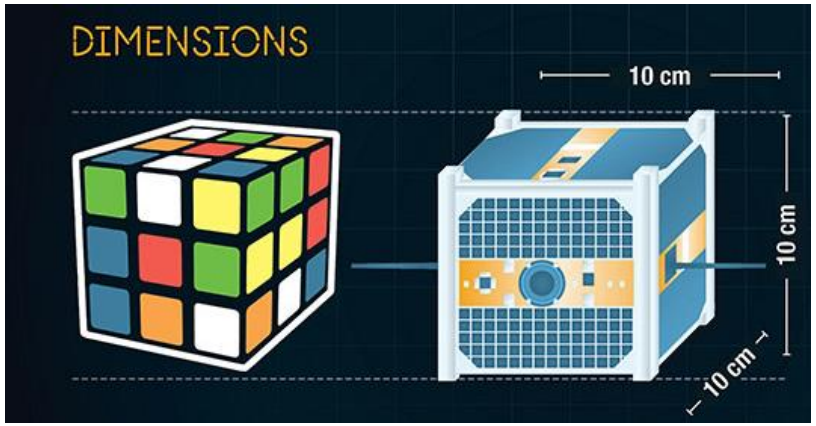
NASA esa Ball Aerospace & Technologies Corp. JAXA ФГУП «Центр Келдыша» ROSCOSMOS

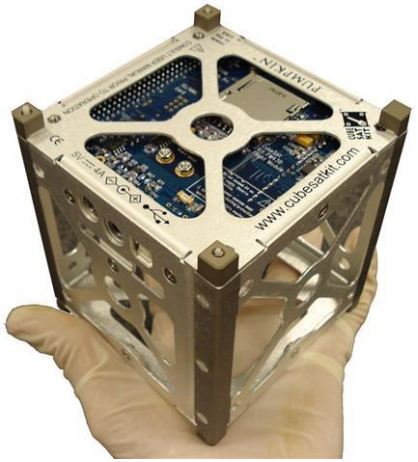
JPL Jet Propulsion Laboratory ThalesAlenia Space a Thales / Leonardo company CSA ASC AIRBUS MDA APOLLO/СОЮЗ

INNOVATIVE OPTICAL SYSTEMS

EPIC: What We Can Provide and What We Need?

Besides large satellite projects, PLX products can especially be an asset to the CubeSat community.





What do we need:

- We are pushing the limits
- Lightweight materials
- Extreme light weight technology

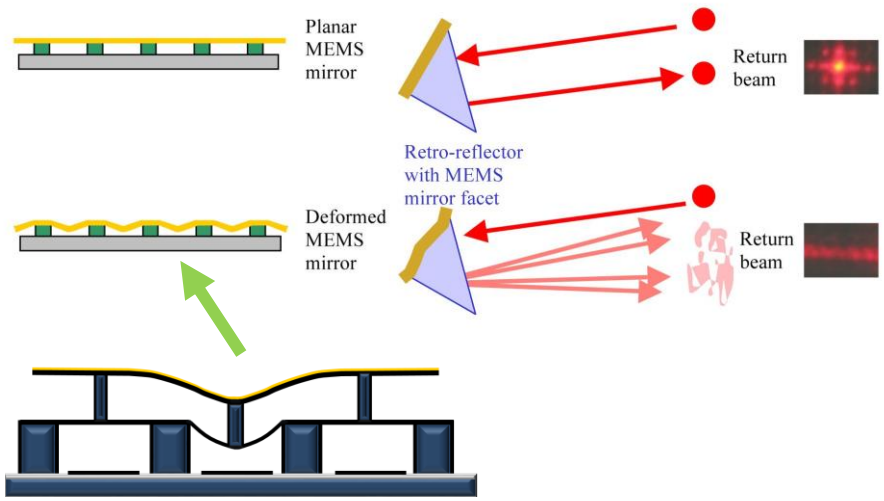
PLX can integrate many optical components into a single monolithic assembly, saving space and weight. This integration also increases reliability, reducing risk.

For simple applications, PLX can supply standard products (COTS), reducing cost and lead time, while maintaining high quality and stability.

PLX
INNOVATIVE OPTICAL SYSTEMS

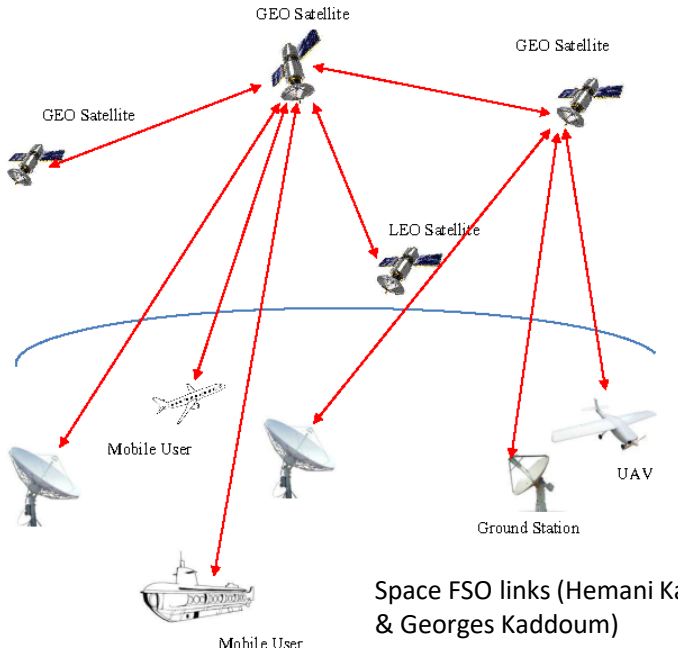
Free-Space Optical Communication (FSO)

- PLX's development of a custom MEMS Retroreflector in conjunction with MEMS partners.
- The Modulating Retroreflector (MRR) system has been demonstrated to provide continuous asymmetric free space optical communication at data rates up to 200 Kbps using a binary modulation scheme.



Deformable/MEMS mirror

MMR with PLX Retroreflector



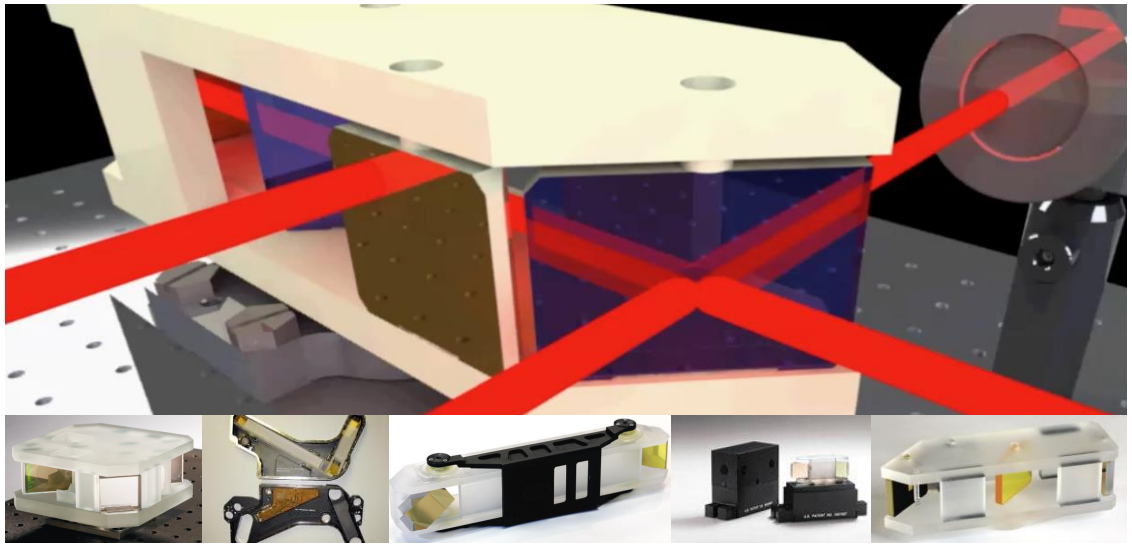
Space FSO links (Hemani Kaushal & Georges Kaddoum)

- **Ground-to-satellite (satellite-to-ground) links**
- **inter-satellite links**
- **deep space links**

PLX
INNOVATIVE OPTICAL SYSTEMS

INTRODUCING M.O.S.T™

Monolithic Optical Structure Technology

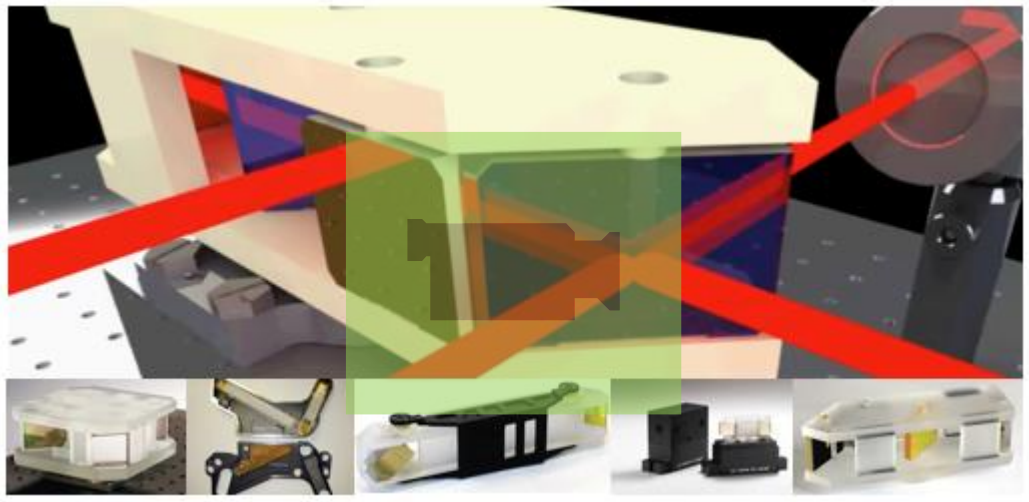


INNOVATIVE OPTICAL SYSTEMS

INTRODUCING M.O.S.T™

Monolithic Optical Structure Technology

YouTube Video:
https://youtu.be/qn5sMYv9KHU

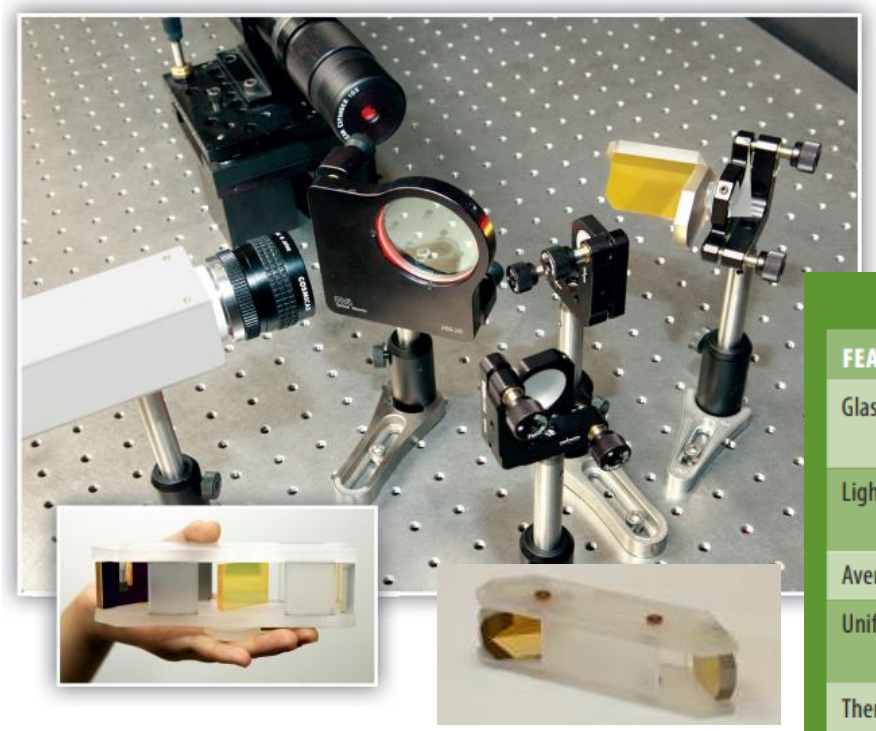


PLX
INNOVATIVE OPTICAL SYSTEMS

M.O.S.T.™ Monolithic Optical Structure Technology

Advantages with M.O.S.T Technology

- Combines all of the elements of a complex optical setup into single rugged monolithic unit.
- Superb optical stability, unsurpassed shock and vibration resistance.
- Sub-arc second accuracy between optical elements.
- Permanently aligned so you will never need to adjust it and also lasts indefinitely.



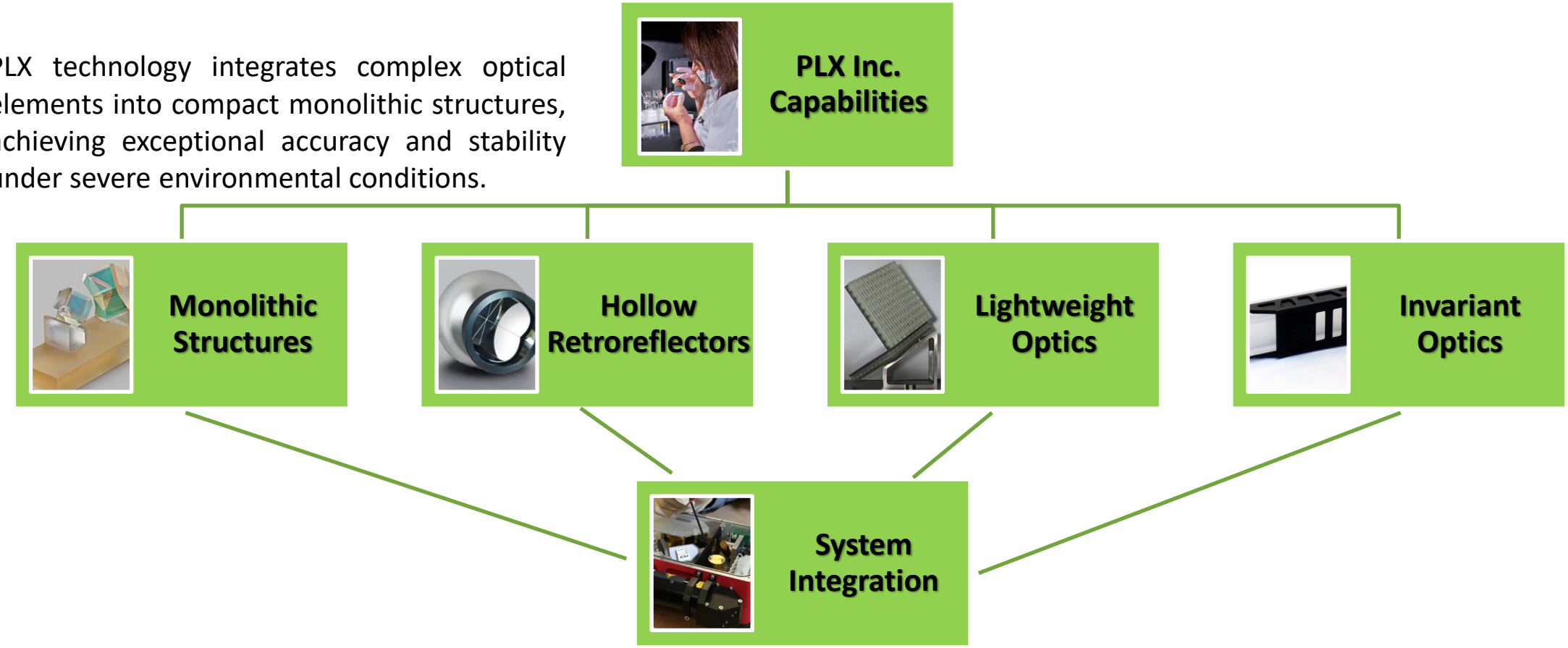
M.O.S.T. PROPERTIES

FEATURES	SPECIFICATIONS
Glass Types Used	Typically fused Silica (SiO2), low-expansion Borosilicate, ULE 7971, BK7 and ceramics
Lightweight Structure	Average glass density is 2.2 g/cm^3 (lighter than Aluminum)
Average Specific Stiffness	3.3x10^4 N m/g (higher than Aluminum)
Uniform CTE	Coefficient of Thermal Expansion using fused Silica is 0.55 ppm/° K
Thermal Dependency	≥ 0.15% per degree
Oscillation Capability	≥1 KHz dependent upon the design and requirements

INNOVATIVE OPTICAL SYSTEMS

Getting the M.O.S.T.™ out of optical systems.

PLX technology integrates complex optical elements into compact monolithic structures, achieving exceptional accuracy and stability under severe environmental conditions.



PLX
INNOVATIVE OPTICAL SYSTEMS

Aerospace System Integration

Case Study 1

PLX INNOVATIVE OPTICAL SYSTEMS

TES Spectrometer (2004)

Mission Status: Completed

- 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.

Mission: A main goal of the TES mission is to monitor ozone in the lowest layers of the atmosphere directly from space.

TES mission duration: 2004 ~ 2018

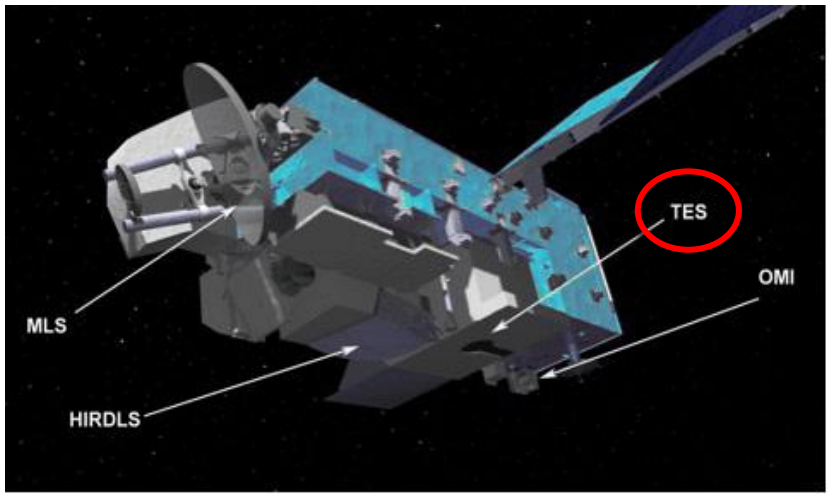


Image courtesy of SPARC

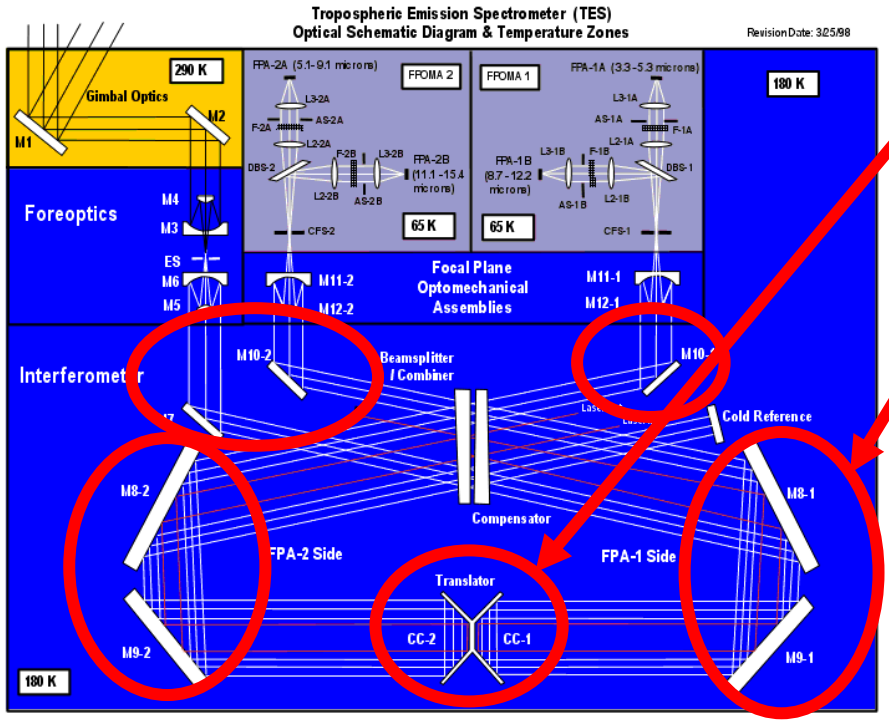
Case Study 1

PLX
INNOVATIVE OPTICAL SYSTEMS

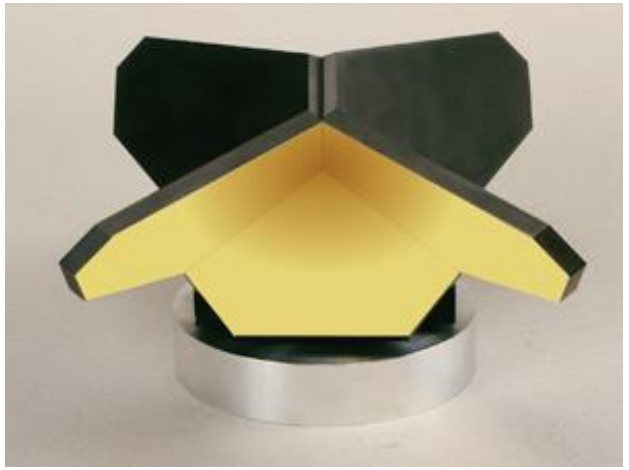
NASA JPL Jet Propulsion Laboratory

TES Spectrometer (2004)

Mission Status: Completed



- 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).



Beryllium Retroreflector by PLX

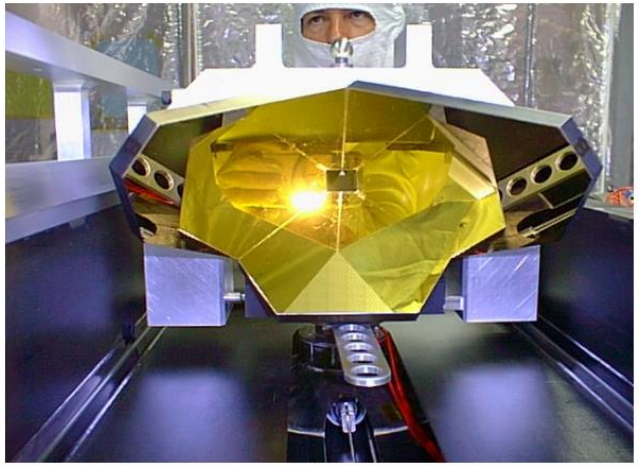


Image courtesy of NASA

Case Study 2

PLX
INNOVATIVE OPTICAL SYSTEMS

esa

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.

Mission: A main goal is to studying methane (CH_4) and other trace gases in the Martian Atmosphere that could be the evidence for possible biological activity.

Mission duration: Planned: **7 years**
Elapsed: **4 years, 1 months**

Image courtesy of ESA

Case Study 2

PLX
INNOVATIVE OPTICAL SYSTEMS

esa

TIRVIM Spectrometer (2016)

Mission Status: Active

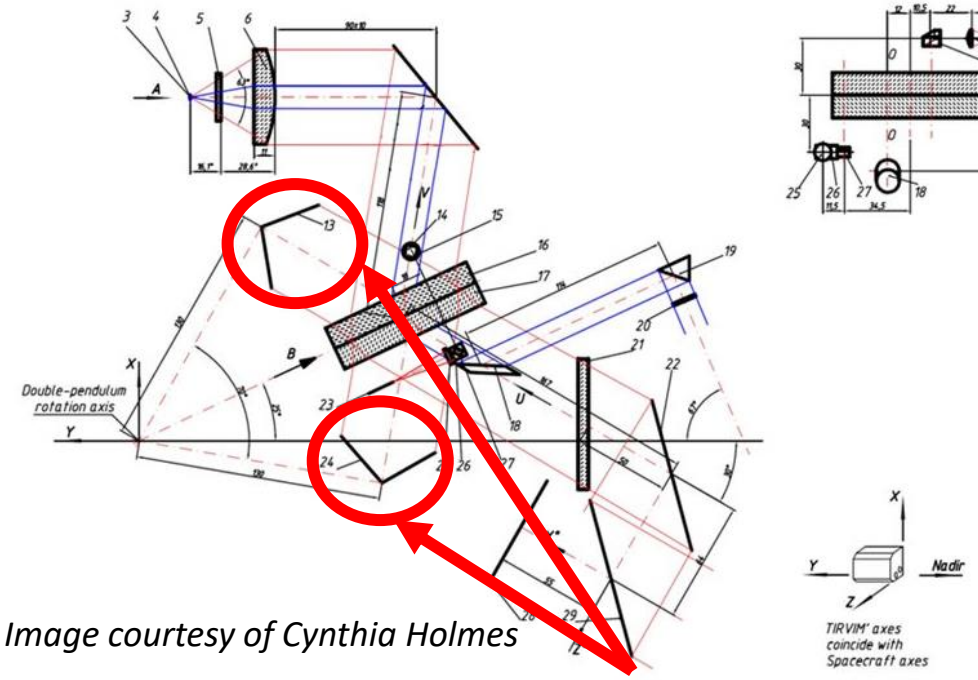


Image courtesy of Cynthia Holmes

The change in optical-path difference is achieved by two corner-cube reflectors (PLX Design) mounted on a single double- pendulum.

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

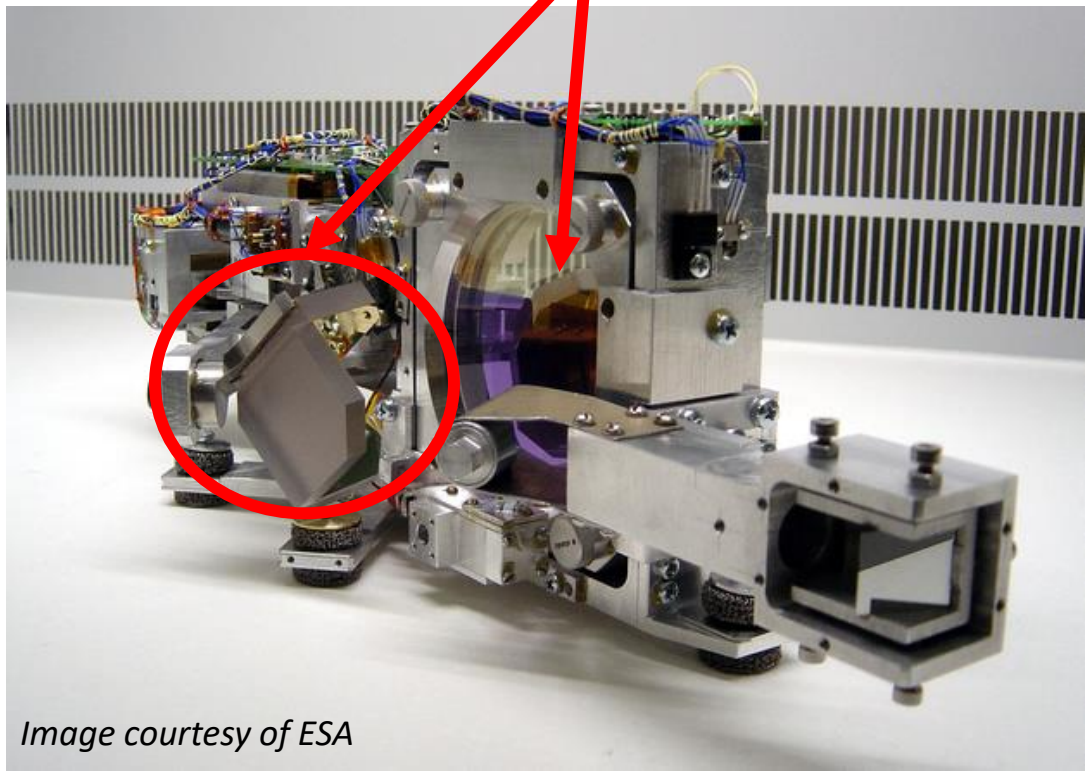


Image courtesy of ESA

Case Study 3

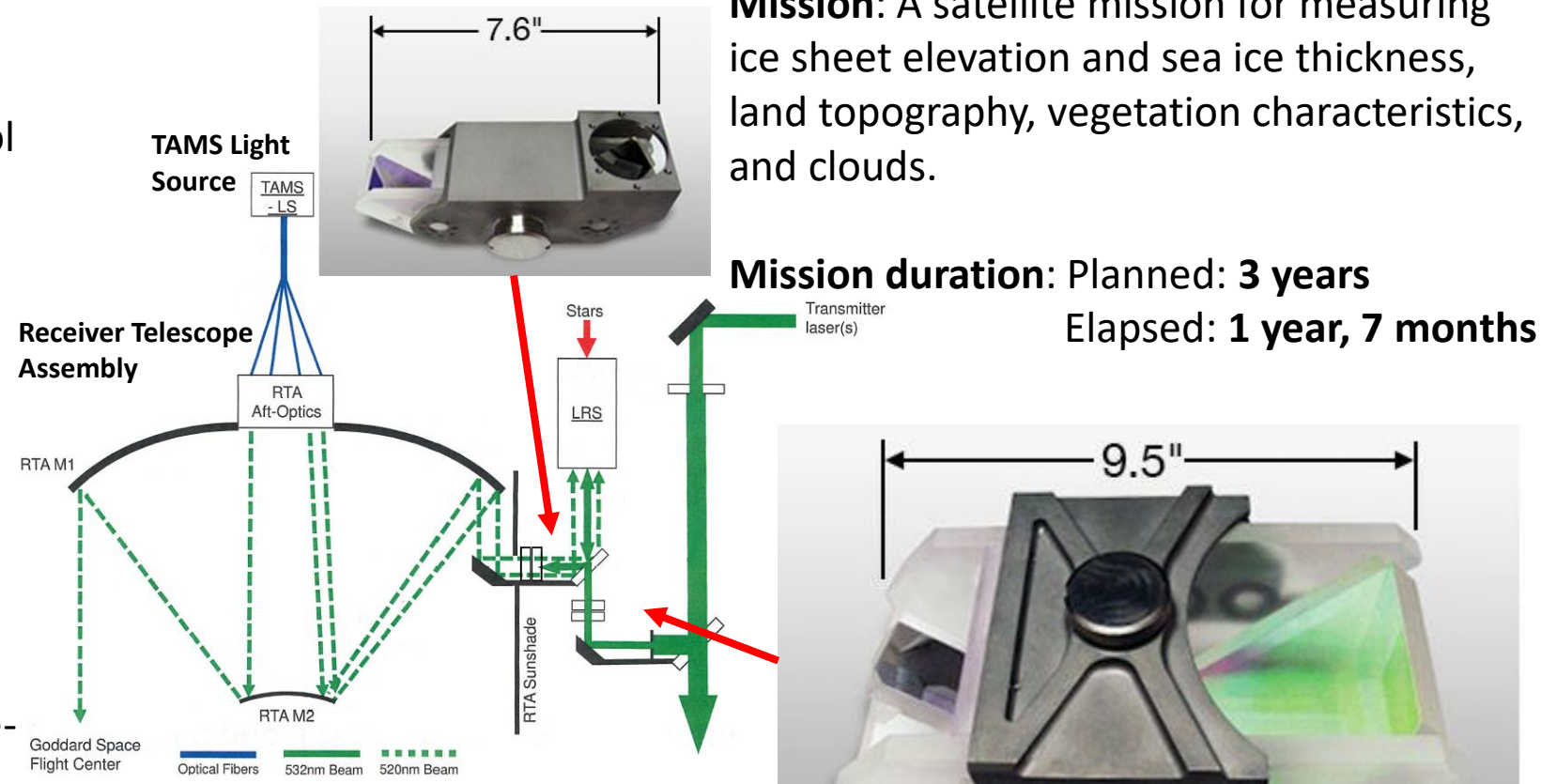
PLX INNOVATIVE OPTICAL SYSTEMS

Ball Aerospace & Technologies Corp.

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**.
- PLX developed two Lateral Transfer Retroreflectors in conjunction with Ball Aerospace Technologies.
- The retroreflectors are used to keep the laser and receiving telescope bore-sighted to each other during orbit.



TAMS: Telescope Alignment Monitoring System
LRS: Laser Reference System

Mission: A satellite mission for measuring ice sheet elevation and sea ice thickness, land topography, vegetation characteristics, and clouds.

Mission duration: Planned: **3 years**
Elapsed: **1 year, 7 months**

PLX
INNOVATIVE OPTICAL SYSTEMS

An infinite amount of applications