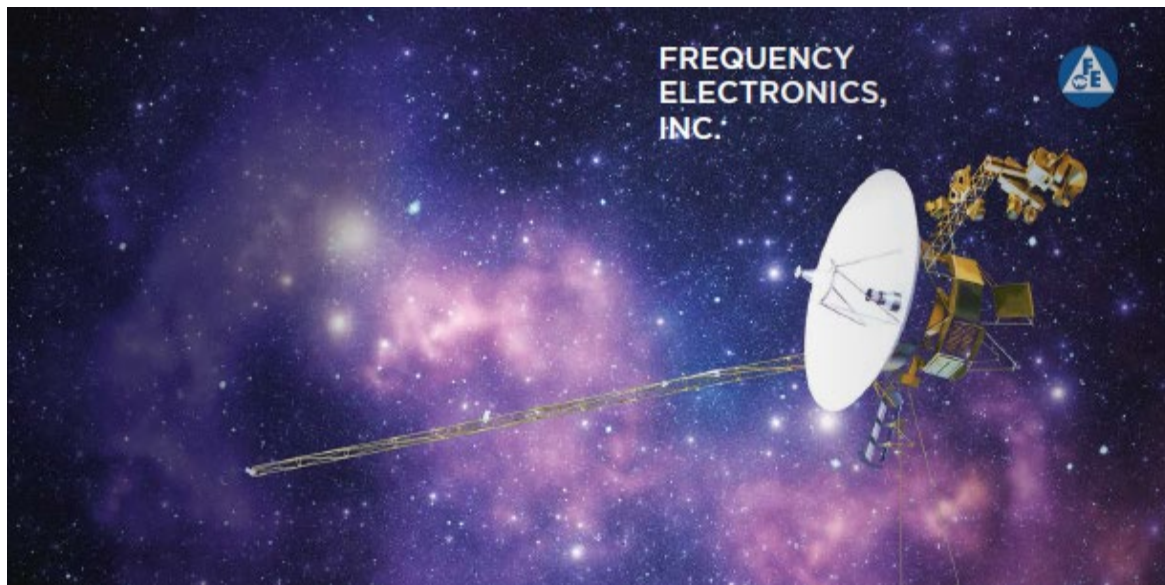




FREQUENCY ELECTRONICS, INC.



Needham Conference

January 15, 2025



A Snapshot of Frequency Electronics, Inc. (FEI)

Corporate Headquarters

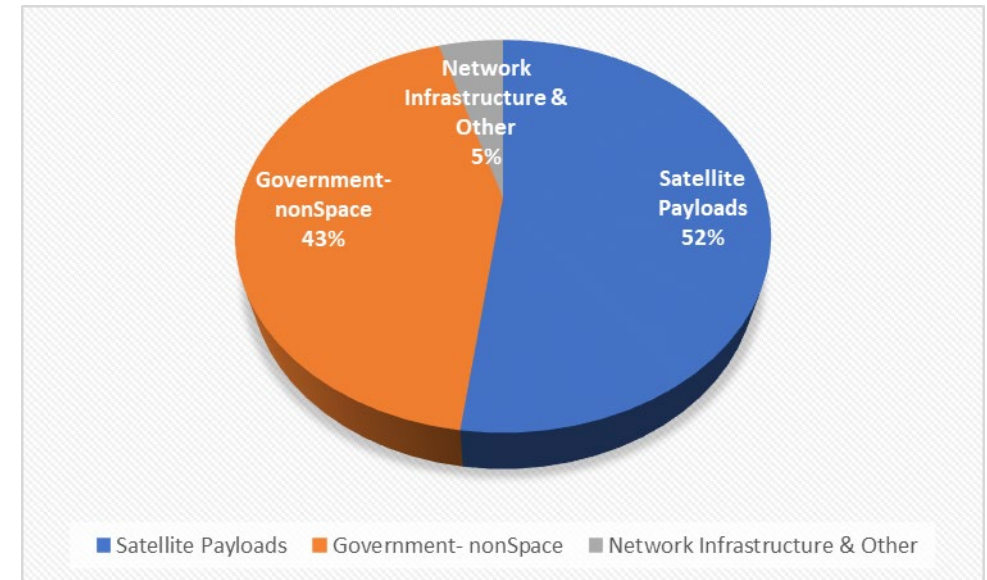
- Founded 1961
- Mitchel Field, New York
- ~ 220 Employees
- 100,000 sqft: Laboratory, Engineering and Production Space
- AS 9100C : 2009-01 Registered
- NASDAQ: Stock Symbol FEIM

Subsidiaries

- FEI-Zyfer - GPS/SAASM/Secure Communications
- FEI-ELCOM Tech – Electronic Warfare

FEI corporate LTM

- Revenue \$60.2 M
- Operating Profit \$ 7.0 M



FEI designs, develops and manufactures products used in satellites and terrestrial markets



Corporate Overview

Business Overview

- World leader in quartz and rubidium high-precision time and frequency (“T&F”) technology, and related quantum sensors
- Proven track record with a 55-year legacy in space (satellite payloads)
 - *Transforming laboratory demonstrations into practical products*
 - Deep technical expertise, especially in quantum physics
- Products in mission-critical systems (DOD, Space, Communication)
 - Excellence
 - Execution
- Robust research and development program
 - Next generation advanced optical atomic clocks
 - Photonic microwave sources
 - Clock ensembling
 - Quantum sensors

Applications

Secure Communications

Precision Strike

Radar

Secure Command and Control

GPS Denied Environments
Anti-Jamming, Anti-Spoofing

Precision T&F Products Which Incorporate
GPS Receivers

Distribution of Precision Time and Frequency

Electronic Warfare
Intelligence

Surveillance &
Reconnaissance

Quantum Sensors

FEI is poised to accelerate growth, providing new quantum sensor based products



The importance of time

- Precise knowledge of time is an enabler
 - Atomic clocks on satellites made GPS navigation possible
 - Wireless, secure communication depends in many ways on precise synchronization
- Neural networks of synchronized sensors, utilizing artificial intelligence make possible a variety of previously impossible applications

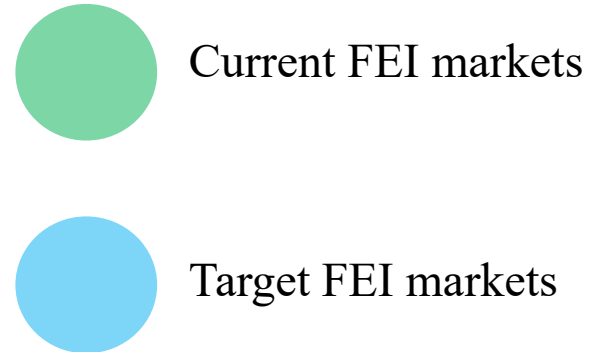
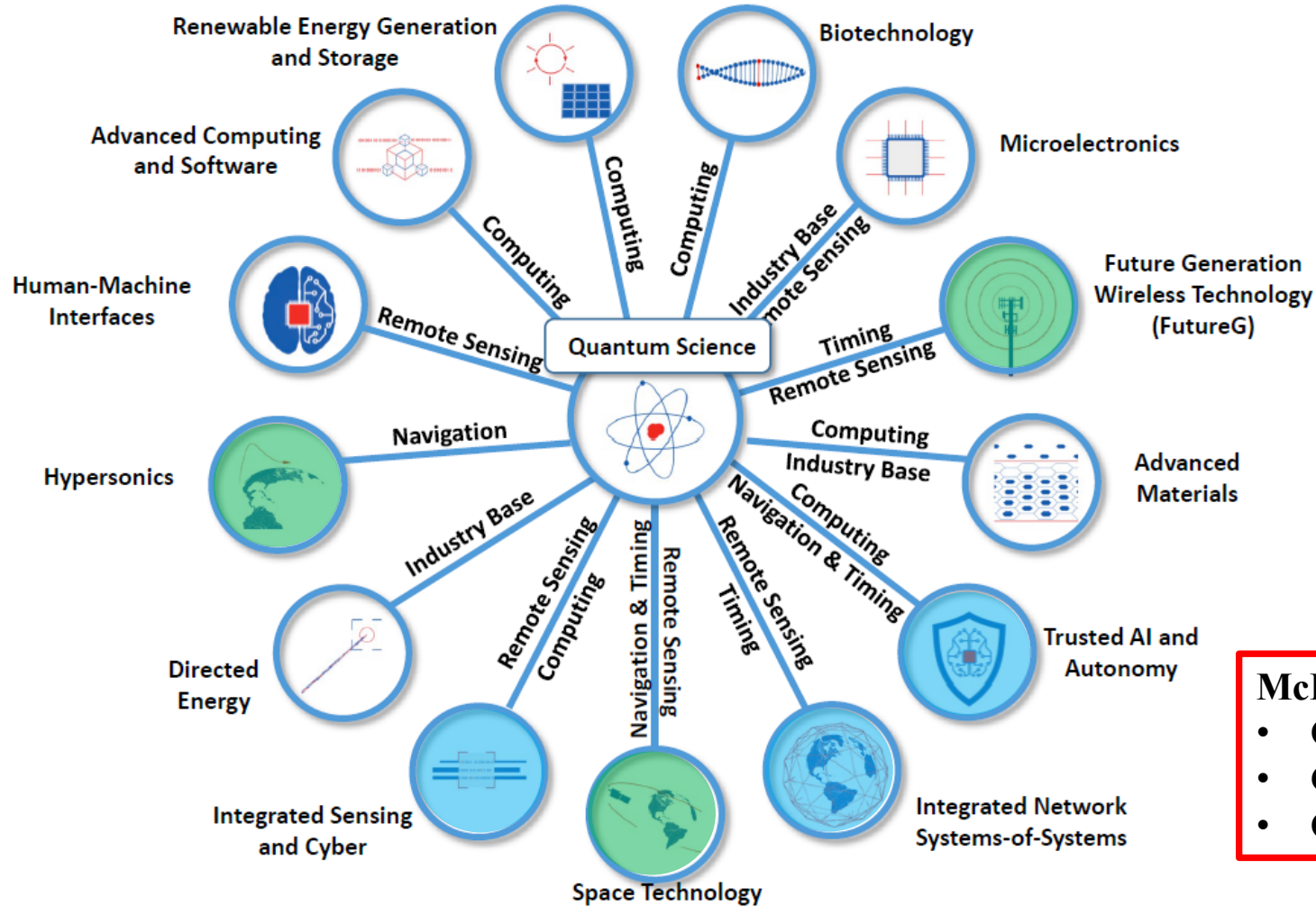
- Stock trades thousandth of sec (millisec)
- Air traffic control ten thousandth of sec (100 microsec)
- Wireless communication 0.1 millionth of sec (100 nanosec)
- Navigation billionth of sec = 1 foot (1 nanosec)
- Sensor fusion 0.1 billionth of sec (0.1 nanosec)

- Global atomic clock market: \$300 M - \$450 M per year (Mitre Corporation estimate, 2022)

FEI's proven products, and expertise in precision time are critical elements for new quantum sensors



Quantum Technology



McKinsey:

- Quantum sensors, 2025: \$750M - \$1M
- Growth: 10-15%/year
- Quantum overall: > \$10B

FEI Total Addressable Market is more than \$10 B



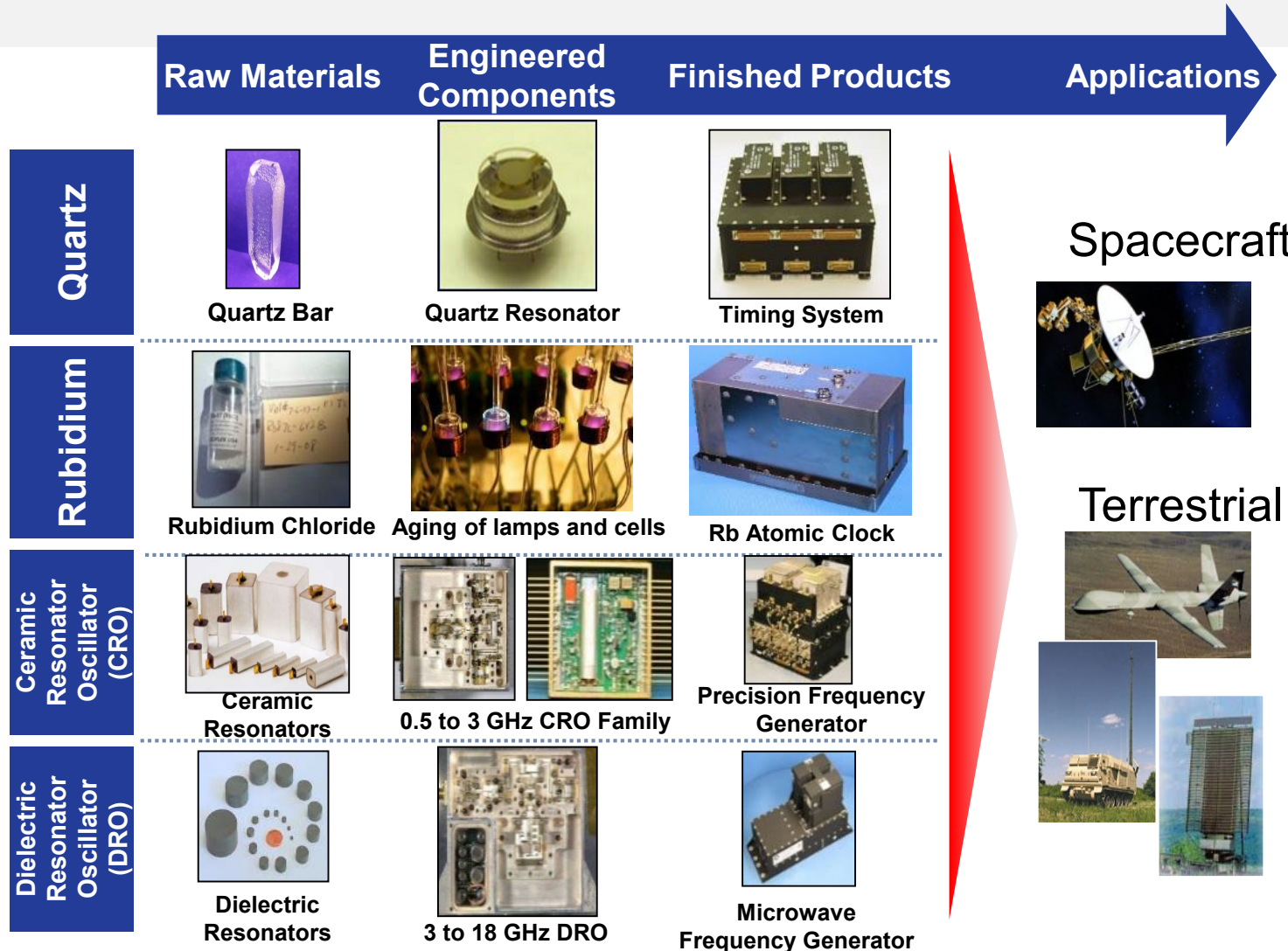
Consolidated Financials, FY2022 – Present

		(millions, unless otherwise indicated)			
		FY22	FY23	FY24	LTM
Revenue		\$ 48.3	\$ 40.8	\$ 55.3	\$ 60.2
Cost of Sales		\$ 39.7	\$ 32.9	\$ 36.7	\$ 36.5
Gross Margin		\$ 8.6	\$ 7.8	\$ 18.6	\$ 23.7
Gross Margin %		17.8%	19.2%	33.6%	46.3%
SG&A		\$ 11.7	\$ 9.4	\$ 10.2	\$ 11.6
R&D		\$ 5.0	\$ 3.1	\$ 3.4	\$ 5.1
Operating Profit/(Loss)		\$ (8.0)	\$ (4.7)	\$ 5.0	\$ 7.0
Backlog		\$ 39.5	\$ 55.8	\$ 77.7	\$ 81.4

- FEI is debt free
- FY23Q3 FEI paid a \$1 special dividend of approx. \$9.4M
- FY25Q1 FEI paid a \$1 special dividend of approx. \$9.6M



Fully Vertically Integrated Business Model

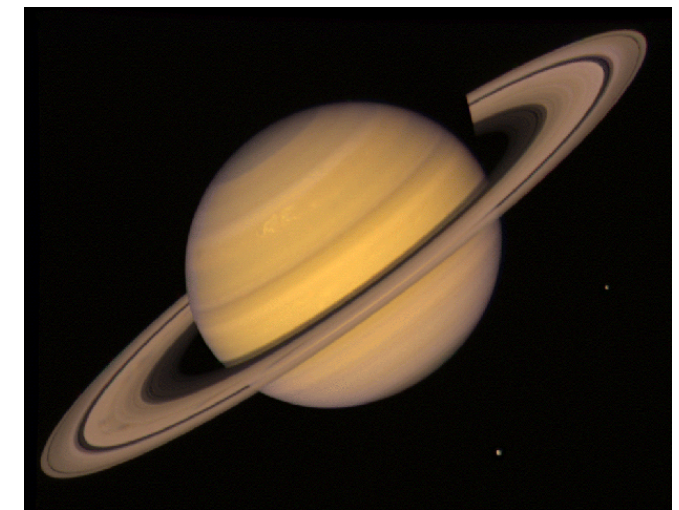
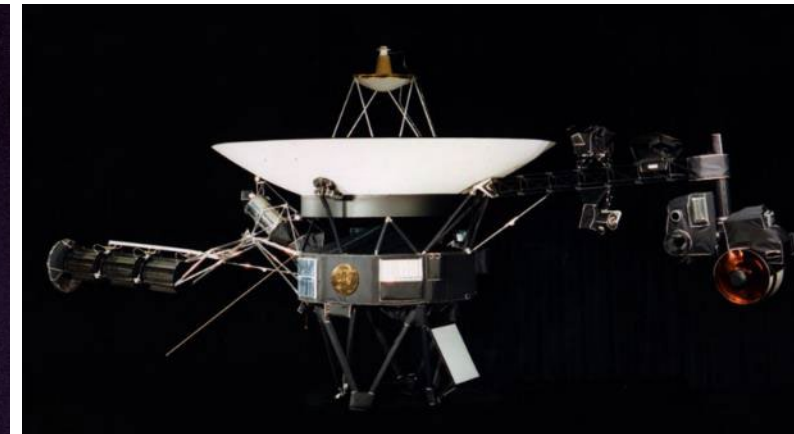
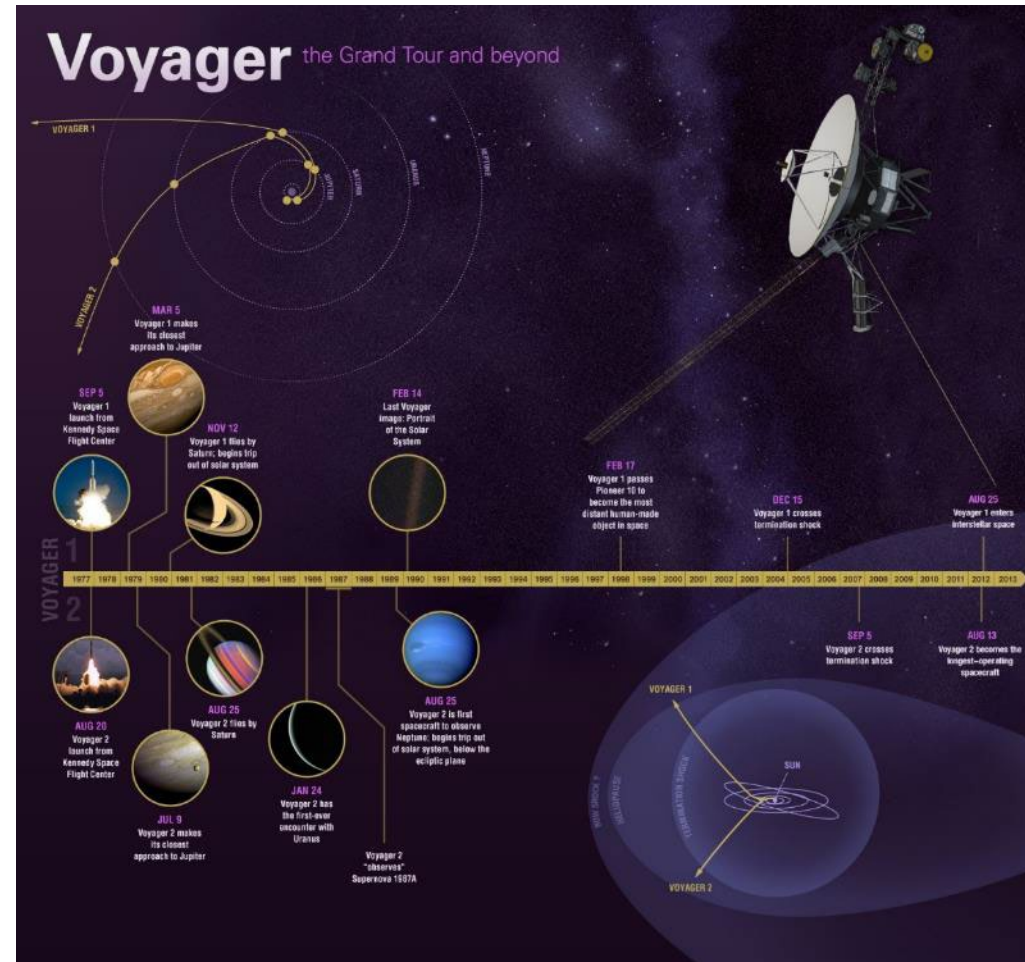


In-house engineering and manufacturing to control performance, quality and production



Voyager Space Exploration 1977

- Provided quartz oscillators for Voyager 1 and 2 satellites
- Launched in 1977, Voyager 1 and 2 intended for 7-year mission
- Voyager 1 Quartz Oscillator Clock operated for 34 years!
- Voyager 2 Quartz Oscillator Clock continues to function (47+ years)!!



FEI's oscillators have kept precise time and frequency for 47+ years
Longest operating clocks in space



Position, Navigation, and Timing (PNT) Systems

Systems incorporating advanced atomic clocks and oscillators - 2003

- FEI's Zyfer subsidiary provides advanced systems integrating state of the art GPS receivers with advanced frequency and time sources, and other sensors
- Smart systems which utilize data from multiple sensors
 - Detect interference
 - Incorporate learning to operate successfully in GPS denied environments





Iridium-Next Low Earth Orbit Satellite Constellation

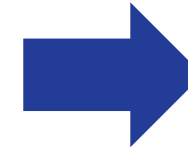
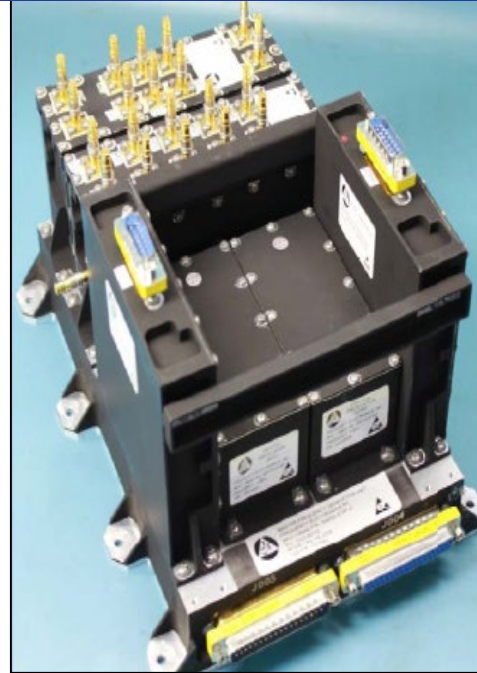
2013

L-Band Frequency Converter Assembly



- Sixteen high dynamic range half-duplex L-Band frequency converters
- Quantities:
 - 162 Flight Units
 - Qty. 2592 converter slices
 - 324 EPC assemblies

Master Frequency Generation Unit



- Provides ultra stable reference frequency and local oscillator signals
 - Dual 10 MHz ultra-stable reference oscillators
 - 10 LO outputs at L-Band
- Quantities: 81 Flight Units

Automated Testing

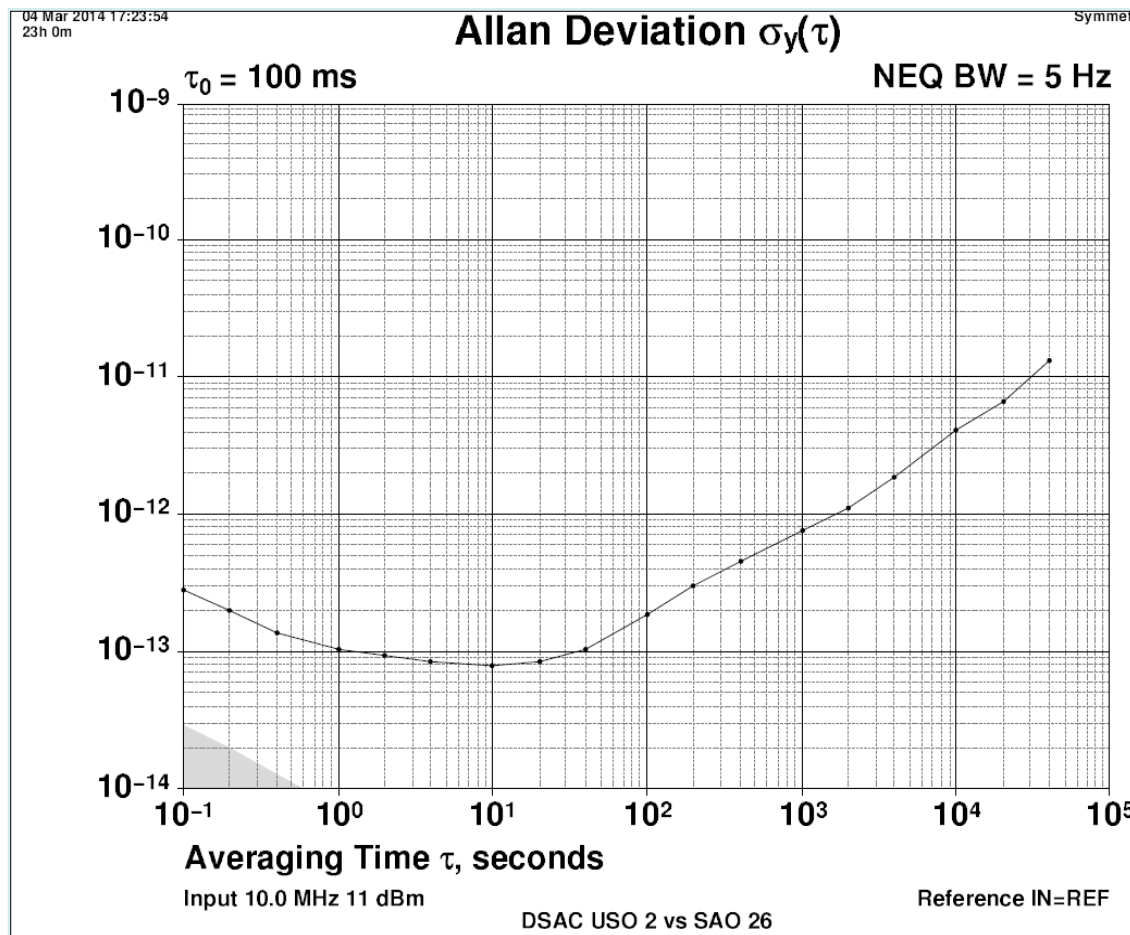


High production capacity for space-qualified hardware – 4000+ subassemblies delivered



Deep Space Atomic Clock (DSAC) 2014

- Provided for deep Space NASA mission
- Local oscillator used for Stored Ion Frequency Standard
- Two oscillators delivered to NASA January 2014
- DSAC completed its on-orbit demonstration mission successfully in 2021

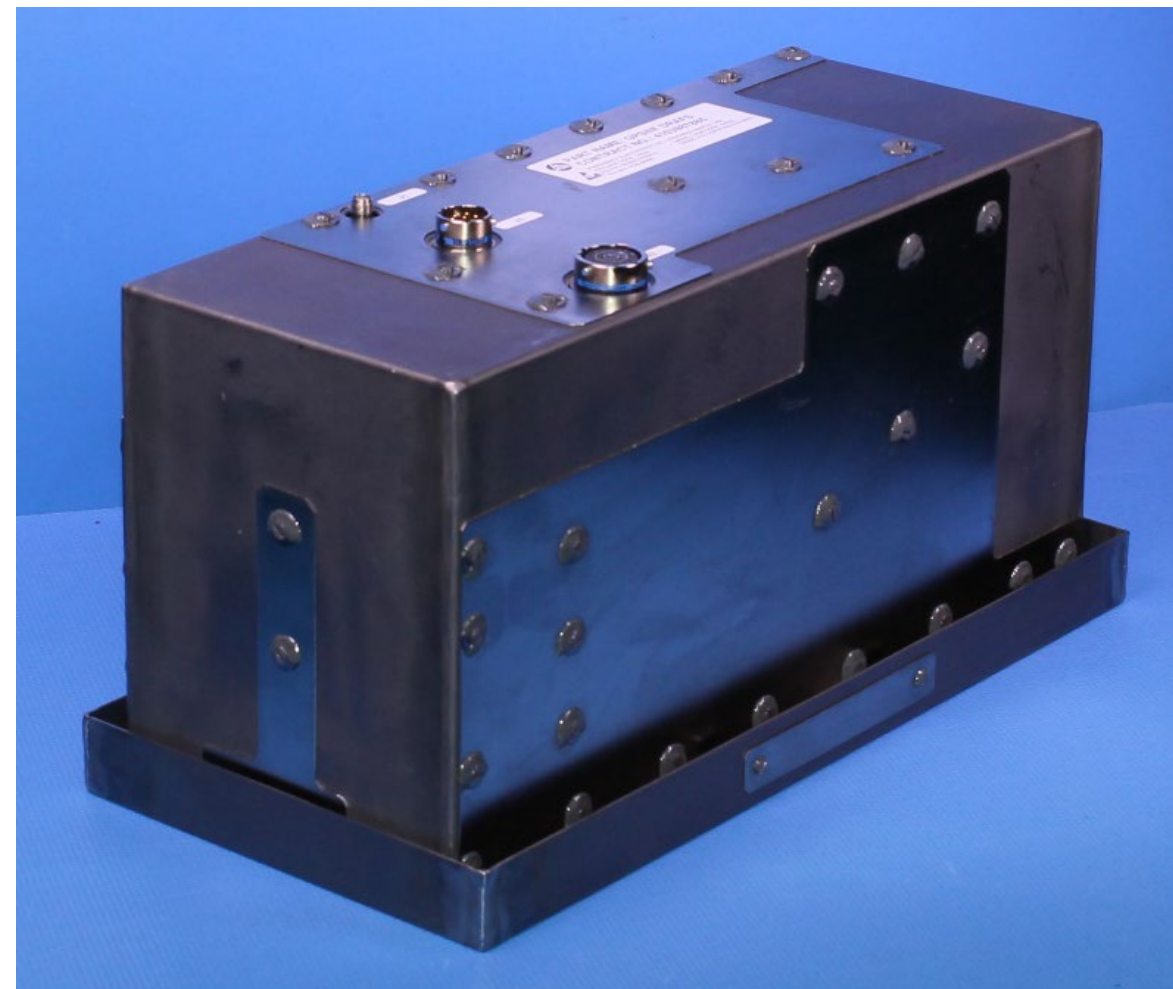


State of the art short term frequency stability



Digital Rubidium Atomic Frequency Standard (DRAFS) 2015

- Developed space qualified DRAFS
- Compliance with GPS III space segment RAFS requirements
 - Successful completion of GPS-III CDR in 2015
 - Successful completion of GPS-IIIF CDR in 2019
 - Flight qualification complete
 - Demonstration scheduled on GPS III space vehicle
- Leverages space experience and on-going in-house Rb cell and precision quartz manufacturing capabilities
- Digital control loop
 - Eliminates most component sensitivities
 - Space qualified FPGA – portable firmware design, immune to part obsolescence
- Currently being used on non-US satellite navigation systems



State of the art for precision timing in space



Voltage Controlled Crystal Oscillator (VCXO) 2020

- VCXO development and flight unit production under contract with L3Harris for GPS IIF
- The VCXO is used within the GPS IIF MDU on the Navigation payload:
 - The VCXO provides the basic frequency reference for the navigation satellite
 - It provides an accurate and stable frequency which is used in the generation of clock, timing and RF signals
 - The output frequency is varied in response to a digital frequency control signal from the TKS
- CDR successfully completed in July 2020
- Flight qualification complete



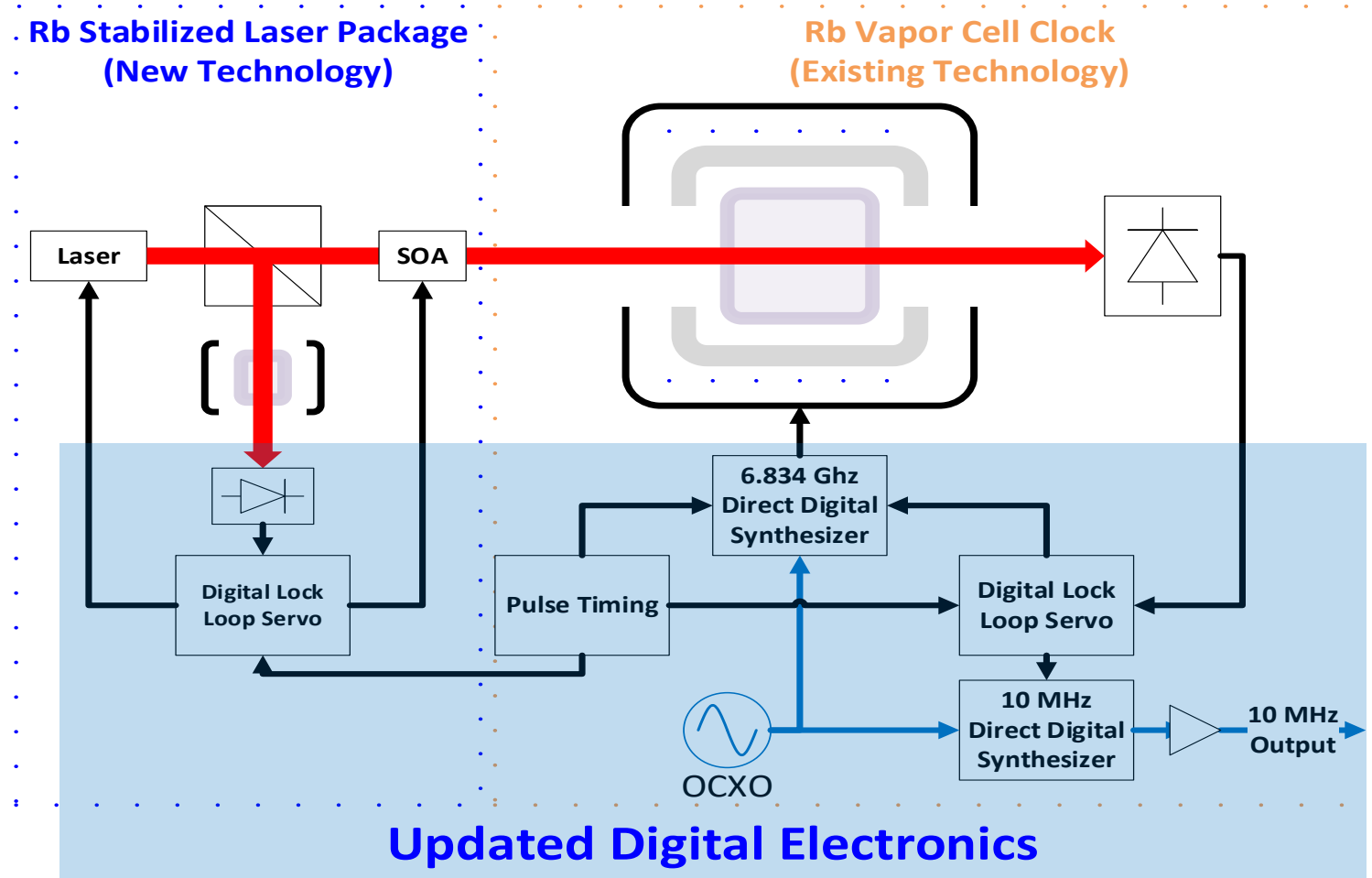
Deliveries in process for GPS IIF satellites



POP Rubidium Vapor Atomic Clock

Current Development: production 2026

- Pulsed Optically Pumped (POP) Rubidium vapor atomic clock
- Rb lamp replaced with **single** laser light source and filter cell removed
- Remaining physics elements are proven legacy technology
- 10X improvement in stability predicted:
 - $\sigma_y(\tau) = 3E-14/\sqrt{\tau}$
 - drift < 1E-14/day
- Small size, weight and power target size: 3U VPX, 2 slots



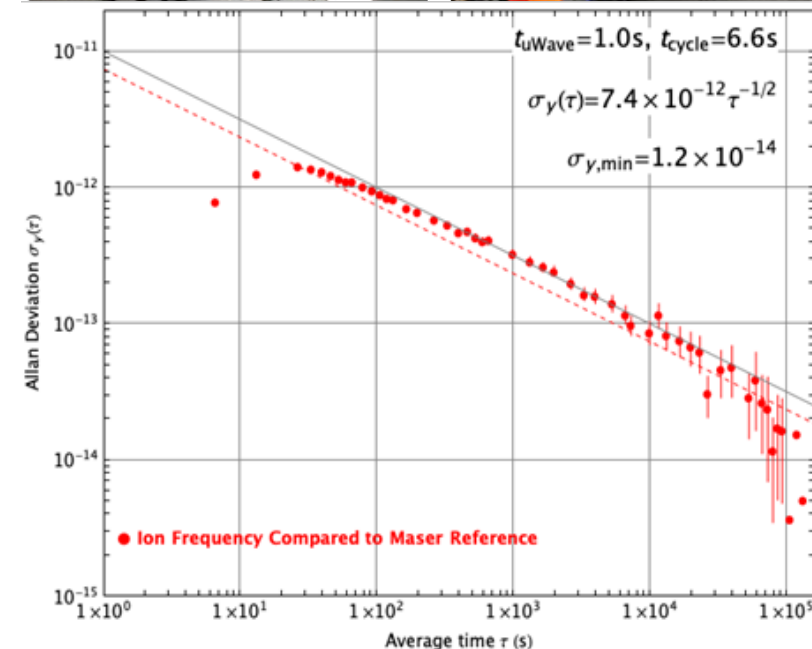
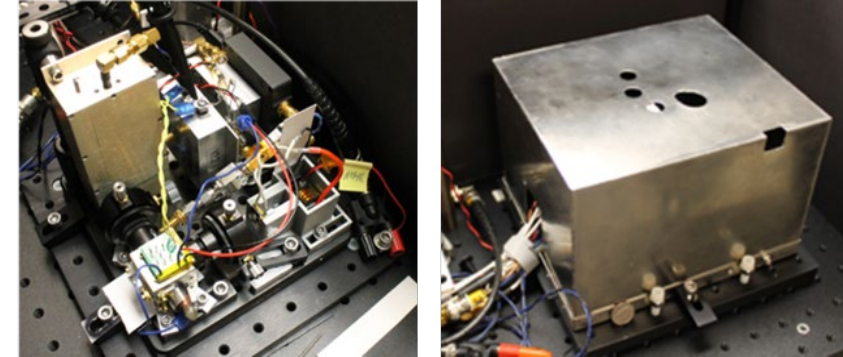
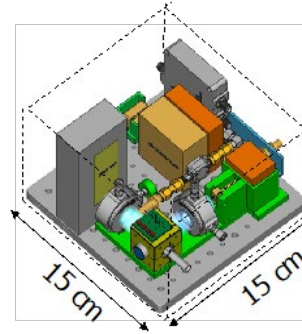
POP Clock: Better long-term stability, vapor cell clock simplicity



Mercury Ion Atomic Clock

Current Development: production 2027

- FEI is working with JPL to bring their Mercury Ion clock technology from the laboratory to production to production
 - Advanced clock technology
 - Enhanced long term stability from electromagnetically trapped ions
 - Compact, environmentally robust packaging
 - FEI's role is to make the clock manufacturable



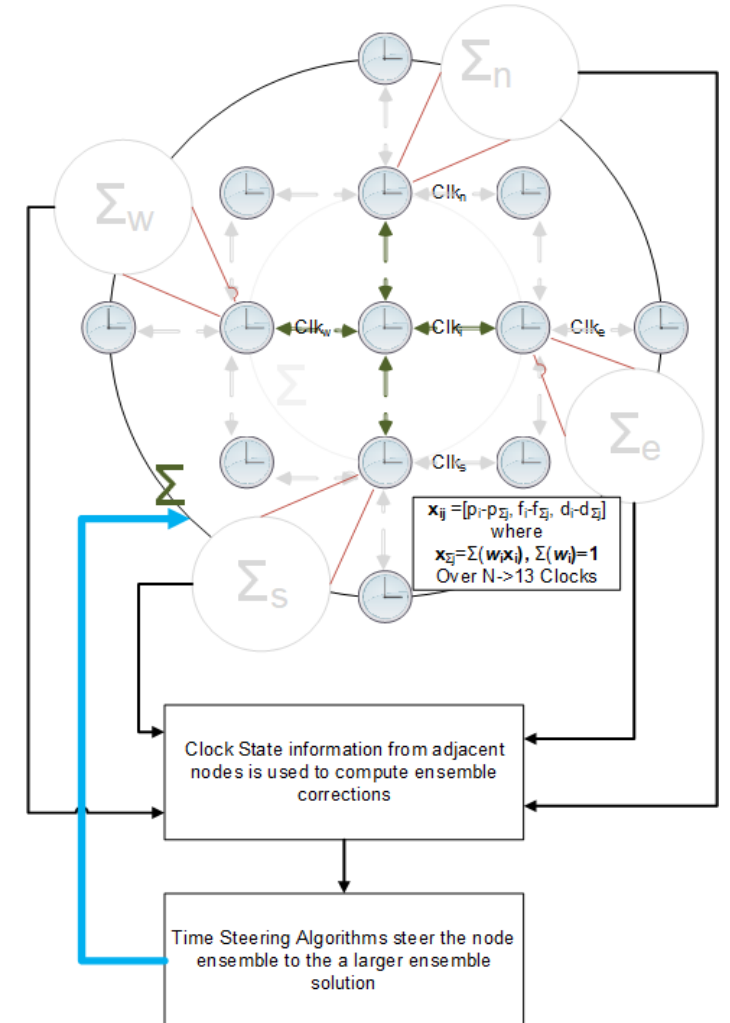
Hg+ Ion Clock: Better long-term stability than vapor cell clock



Leveraging FEI's Technical Capabilities

The future

- FEI's existing technical capabilities, and proven ability to develop esoteric laboratory science demonstrations into reliable products is our key value proposition
- NV diamond magnetometers
- Rydberg Sensors
- Clock ensembling
- Advanced optical atomic clocks
- Photonic Oscillators
- Quantum computing



FEI is collaborating with NIST, MIT – LL, JPL, and others to transform their laboratory demonstrations into products



FEI Targeted Sensor Technologies

Remote Static Field Quantum Sensors: 2028 and beyond

Magnetometer

Anomaly Detection

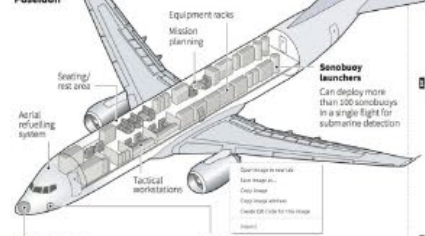


NeuroImage, V 149, #1, p404 (2017)

U.S. surveillance aircraft

Boeing's P-8 Poseidon is an anti-submarine and anti-surface warfare aircraft, featuring advanced sensor and display technologies.

The P-8 Poseidon



Multi-mode radar
Picks up other aircraft and surface ships. Can provide accurate information under all weather conditions (day and night).

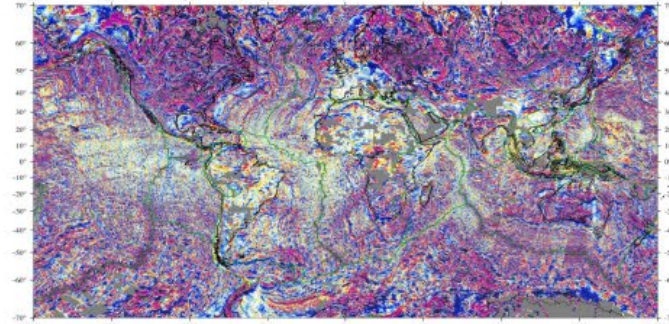
Sources: Boeing, Northrop Grumman Corporation, Birm Sensorbuoy Des'gn. © GEOSIS, 11/1/2014



Magnetic Anomaly Detector (MAD)
How it works
MAD uses a magnetometer to monitor the Earth's magnetic field under the sea.
Large metal objects, such as submarines, create variances in the magnetic field.
MAD detects such variances, revealing the location of submarines.

Navigation

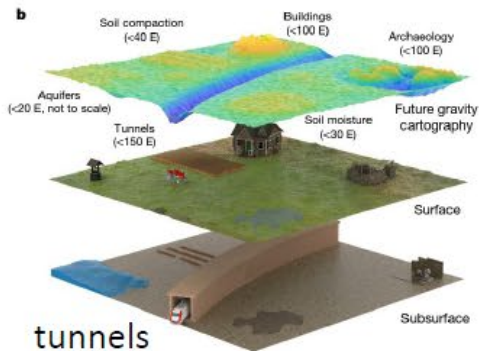
Magnetic navigation



<https://ngdc.noaa.gov/geomag/emag2.html>

Gravimeter

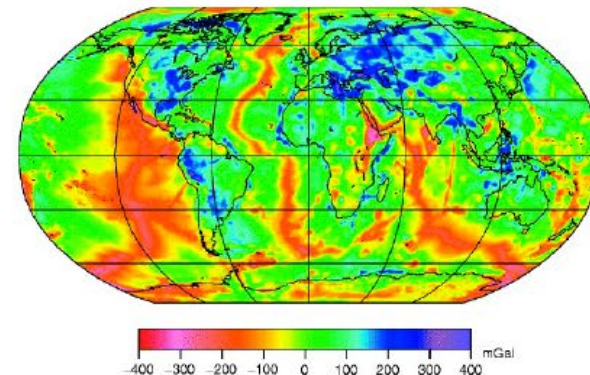
Gravity



tunnels

Stray, Ben, et al. *Nature* (2022)

Gravity aided navigation



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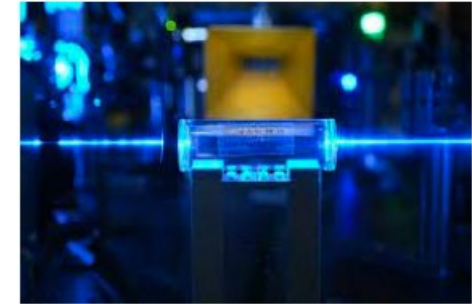


FEI Targeted Sensor Technologies

Electromagnetic Field Quantum Sensors: 2028 and beyond

- Very compact receiving antennas
 - Size of conventional antennas is determined by the signal wavelength – very large for low frequencies
 - Rydberg atom based antenna size is independent of the signal wavelength
 - Ideal for modern phased array antennas
- Rydberg sensors utilize the same building blocks as FEI's Rubidium (Rb) atomic clocks
 - Rb atoms
 - Vapor cells
 - Laser optical sources
 - Photo detectors

Rydberg Atom RF receiver



<https://phys.org/news/2020-03-scientists-quantum-sensor-entire-radio.html>



Anderson et. al. IEEE Transactions on Antennas and Propagation 69(2021)

- FEI is a 64-year-old company, with a proven track record
 - strong and improving margins and cash generation
 - no debt
 - a capital allocation policy balancing R&D and returns in cash to shareholders
- FEI currently provides precision time and frequency products for demanding applications
 - Aerospace
 - Defense
 - Commercial space
- FEI has demonstrated an ability to productize sophisticated scientific demonstrations
- The demand for these products (FEI's existing products, as well as those that so far exist only in advanced laboratories) is growing



FEI Contacts

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