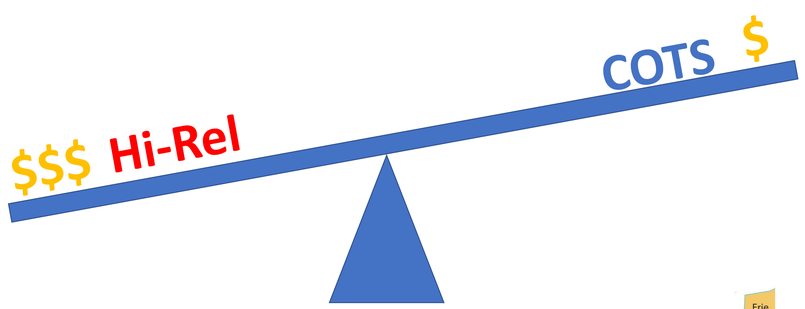
LEO Market Assessment for Crystal Oscillators

What is the Balance Point Between Commercial Off The Shelf (COTS) and High-Reliability Space Oscillators for Low Earth Orbit Applications?



L-Series Low Earth Orbit Oscillators

- Designed and Constructed from Best performing Product Lines
- Commercial or Military Components
- Radiation Tolerant for Various LEO Mission Profiles
- Analysis and Documentation Compromise Between COTS and S-Level
- All Oscillator Families Passed Qualification Testing for Total Ionized Dose (TID) and Single Event Latch-up (SEL) as a Completed, Functioning Oscillator
- Designed, Assembled and Tested in Two Locations:
  - US Companies: Mount Holly Springs, PA, USA
  - European Companies: Neckarbischofsheim, Germany

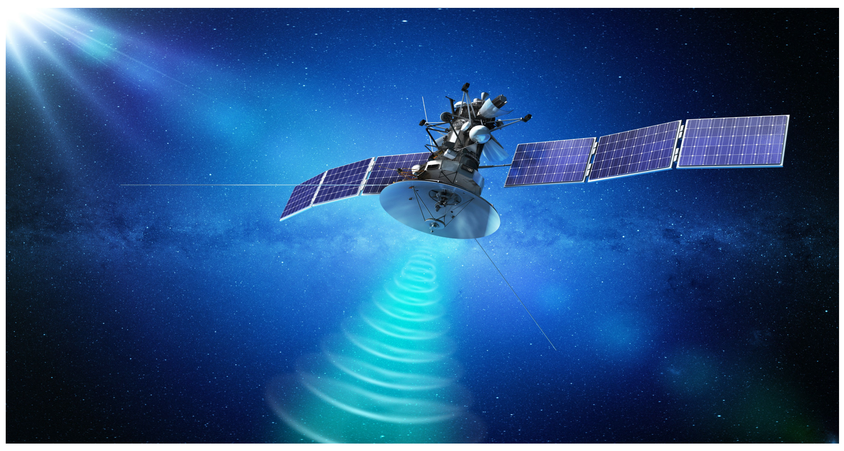
L-Series Requirements

Radiation:
- Total Ionized Dose (TID): 50krad
- Single Event Latch-up (SEL): 42 MeV-cm2/mg

Reliability:
- Commercial to Military Assembly and Screening

Rating:
- Commercial or Military Grade Components

Ruggedization:
- Designed and Constructed to Survive Launch and Mission Profile
- 4-point Mount Crystals Except for XO
- Swept Quartz to Minimize TID Effects



Assessment of Requirements for Mission Profiles				
	Cube Satellites	Commercial LEO Constellations	Exo Atmospheric Weapons	Launch Vehicles - Rockets
Orbit	Low Earth	Low Earth	Exo Atmospheric Ballistic Trajectories	None
Life Span	3 to 12 Months	5 to 10 Years	Unpowered 10 years	Unpowered 5 years
Total Ionized Dose	None	50 krad	None	<1 krad
Single Event Latch-up	None	40MeV-cm2/mg	60 MeV-cm2/mg	60 Mev-cm^2/mg
Prompt Dose	None	None	Yes	Yes
Shock and Vibration	Survive Launch	Survive Launch	Survive Launch and Mission Profile	Survive Launch
Temp Range	-40°C to 85°C	-40°C to 85°C	-55°C to 125°C	-40°C to 85°C
Screening Level	Unscreened	Class B- Screening + Aging + PIND	Class B Screening + Group A + PIND + XRAY	Class B Screening + PIND + XRAY
Component Grade	COTS	COTS	Military	COTS
Quartz	Unswept	Unswept	Swept	Unswept
Crystal Mount	2-point	3-point Minimum 2-point Mount 5 x7 or Smaller	4-point	3-point Minimum 2-point Mount 5 x7 or Smaller
g-Sensitivity	No	No	Yes	Yes
Recommended Design and Construction	Ruggedized	Ruggedized	Ruggedized	Ruggedized

Additional Options for Reliability Confidence

Optional: Worst Case Circuit Analysis to Account for Thermal and Datasheet Electrical Variations

Optional: Final Electrical Test Data Packet for Traceability

Optional: MTBF Analysis and Report Tailored to Environment and Temperature

High Reliability vs COTS Compromise

The need for economically priced oscillators for low earth orbit applications presents a compromising position for all those making a living in the high reliability world. The comfortable, although exhausting, position of ensuring every electrical and mechanical design, material, construction, layout, inspection, and many, many others are screened and evaluated to the highest levels possible, to ensure the lowest probability of failure over a shorter mission life, lower radiation requirements and lower cost.

Commercial datasheets provide limits to component values but do not address lot to lot variation, visually scrutinize the construction, eliminate weaker parts electrically by overvoltage testing, reverse biasing, or burn-in testing, or evaluate robustness for environmental effects such as shock and vibration, constant acceleration, or temperature changes. This is called “element evaluation” and is commonplace for high reliability designs and completed well before construction takes place.

Printed circuit boards, substrates, enclosures, lids, terminals, and all other mechanical items are also scrutinized for materials, plating, dimensions, and many others.

Engineers want as much confidence as they can get from commercial parts and screening because they cannot afford the cost and timeframe required for more extensively vetted high reliability designs. They are relegated to performing more analyses, reducing mission life, adding circuit redundancies, or additional radiation shielding to improve the probability for mission success. The balance point is somewhere between the two extremes.

Commercial	L-Series	High Reliability
No Flight Heritage	No Flight Heritage	Multiple Decades of Flight Heritage
Limited Component Traceability	Limited Traceability With Data Packet	Full Traceability with Operator Dated and Signed Travelers
Non-Homogeneous Lots	Non-Homogeneous Lots	Homogeneous Lots with Single Lot Date Codes
No Element Evaluation or Radiation Lot Acceptance Testing (RLAT)	COTS or Class B Elements and Total Dose and Single Event Latch-up Platform Validation	Class K Element Evaluation per MIL-PRF-38534 and 100krad+ Wafer Lot Specific RLAT
Few, if any, QA Visual Inspections	Few, if any, QA Visual Inspections	Multi-Point QA and Source Inspections at High Magnification
Data Electronically Stored	Data Pack optional	Data Electronically Stored with Printed Data Pack and Review Provided
Basic Circuit Analysis Performed	MTBF, Electrical and Thermal WCCA Performed	WCCA Electrical, Derating, Thermal, Mechanical, Radiation, and Others
Unswept Quartz	Swept Quartz	Swept Quartz
2 or 3-point Crystal Mount	4-point Crystal Mount on all except XO	4-point Crystal Mount
Best Commercial Assembly Practices	Best Commercial Assembly Practices	QA Assurance per MIL-PRF-55310 Class-S and MIL-PRF-38534 Class-K