



LMx

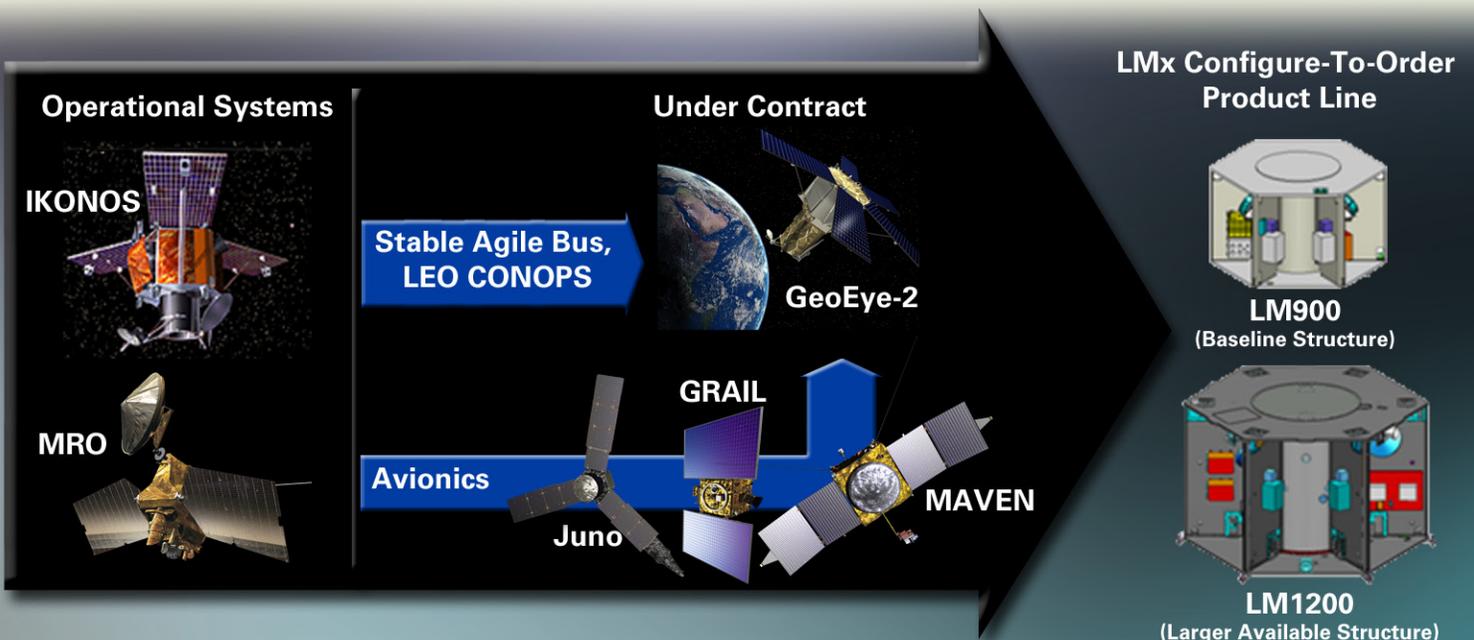
A Configure-To-Order Bus Design for Flexible Payload Accommodation and Mission Operations

LMx Bus Heritage and Evolution

Lockheed Martin has built over 100 civil remote-sensing spacecraft for various user communities. This breadth of experience has gone into the RSDO offering—LMx, a stable, precision-pointing, agile vehicle designed to address a range of remote sensing missions.

LMx is modular and can be scaled in size and performance in order to address the unique requirements of a particular mission. The baseline LMx bus uses avionics flown on our heritage spacecraft, the successful Mars Reconnaissance Orbiter (MRO) launched in 2005. The MRO product line uses a common avionics architecture developed on the earlier missions Stardust, Genesis and Mars Odyssey, and evolved through a continuous series of upgrades. The avionics line is currently used on the Juno, GRAIL, MAVEN and GeoEye-2 programs.

The LMx bus mounts these avionics on the IKONOS (LM900) spacecraft structure, an approach that provides significant payload volume in smaller candidate launch vehicles due to its low profile. The IKONOS spacecraft has completed more than ten years of on-orbit operation. Lockheed Martin also offer an alternate, larger, flight-proven structure (LM1200) for increased payload and/or propellant capacity. In both cases, the bus offers a large nadir bulkhead for external mounting of the payload and a reserved internal bay for associated payload electronics, if required.



LMx Platform Capabilities

The LMx platform was originally designed for low Earth orbit (LEO) optical remote-sensing missions with an attitude control system capable of supporting both scanning maneuvers with a linear array sensor and staring maneuvers with an area array sensor. In both modes, LMx is able to move rapidly between collection targets and provide precision pointing with low residual jitter. This heritage capability is of enormous value not just for optical imaging but also for other payloads, such as LIDAR where high stability and precise pointing are required. LMx is a

highly capable platform ideal for a whole range of remote sensing missions.

It is also a highly reliable platform incorporating full redundancy and selective cross-strapping with no credible single point failures. This combination of redundancy and mature flight-proven avionics and flight software, from our MRO product line, ensures high mission availability and extended life (with lifetime dependant on battery selection/mission orbit).

Configure-to-Order for Mission-Specific Needs

LMx is configurable. The core avionics (including our RAD750 based C&DH units and power distribution electronics), flight software and narrow-band communications equipment are standard and can interface with a set of configure-to-order sensors and actuators. Other components, such as the GPS receivers, solid state data recorder (SSDR) and wide band communications, are

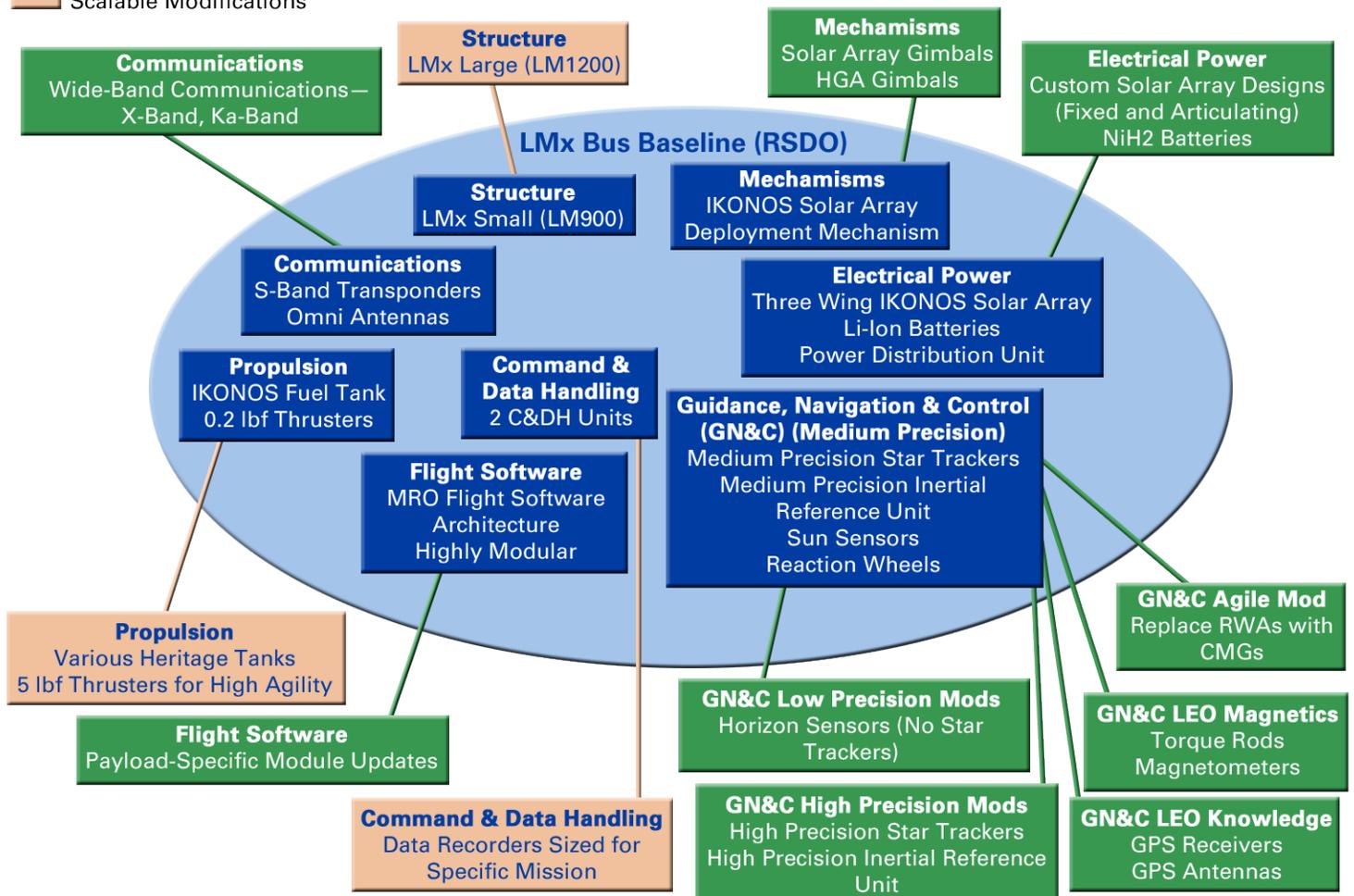
available in varying mission-unique configurations.

LMx offers a wide range of mission-specific modifications (available at extra cost) for reconfiguring or scaling the core capabilities to meet mission specific requirements, as shown in the figure below. The particular configuration required will be determined in response to mission-specific requests for offers.

Legend:

- Configure-To-Order Modifications
- Scalable Modifications

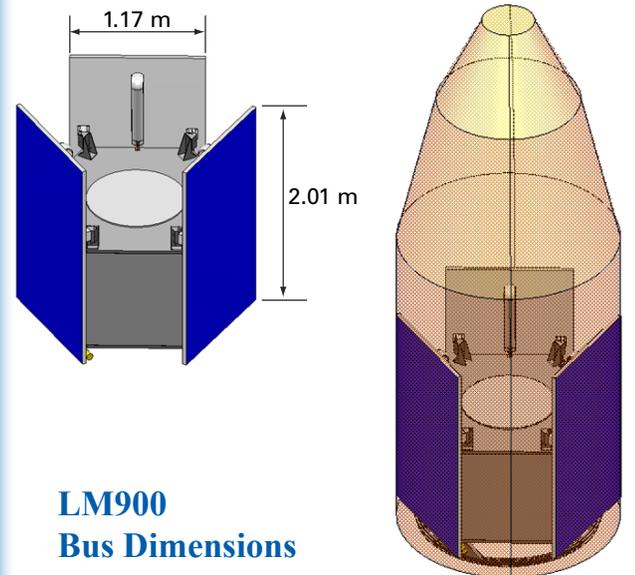
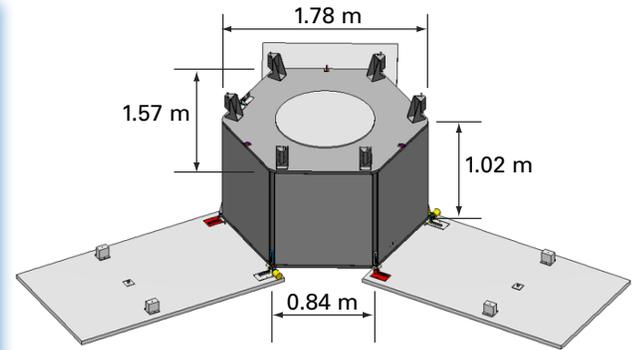
LMx Configure-To-Order Bus Meeting a Wide Range of Mission Needs



Bus Design Features

- **Structure**
 - Aluminum Honeycomb Structure—Hexagonal with Central Cylinder and Six Radial Equipment Panels
- **Command and Data Handling**
 - Centralized RAD750 Processor Control Supported by 1553B and RS-422 Serial Connections
 - Autonomous Processor Fault Protection
 - Payload Data Interfaces—LVDS, 1553B, RS-422, Spacewire (Direct to SSDR)
 - Solid State Data Recorder Selected to Meet Mission-Specific* Storage Needs
- **Flight Software**
 - Flight-Proven Package with Heritage Back to MRO
 - FSW Written in C/C++, Developed via ISO9001 Compliant Process
- **Electrical Power**
 - Three-Panel Solar Array Using GaAs Triple-Junction Cells
 - Lithium-Ion Batteries of Varying Capacity
 - Unregulated 28V Bus
- **Guidance, Navigation and Control**
 - Zero Momentum 3-Axis Stabilized Design
 - Mission-Specific* Sensors Based on Precision Requirements
- **Communications**
 - S-Band Transponders for Command and Telemetry (2 kbps U/L, 32 kbps D/L)
 - Mission-Specific* WB Systems for Data Downlink (X-Band, Ka-Band)
- **Propulsion**
 - Blow-Down Hydrazine Monopropellant System
 - Mission-Specific* Heritage Tank Sizes Available
 - Twelve 0.2 lbf Thrusters with Larger Thrusters Available for Mission-Specific* Needs
- **Thermal**
 - Passive Design with Redundant Heater Systems Controlled by On-Board Computer
 - Dedicated Bay Radiators with Direct Unit Mounting and Embedded Heat Pipes Available for Mission-Specific* Need
- **Mechanisms**
 - Heritage Solar Array Hold-Down and Deployment Mechanisms
 - Heritage Solar Array and Antenna Gimbals Available for Mission-Specific* Applications

*Mission-Specific Modifications Available at Extra Cost



**LM900
Bus Dimensions**

Taurus XL Fairing
or Larger

Bus Capabilities

	LM900	LM1200
Mission Parameters		
Lifetime (yr)	Three* with Ps=0.909	Three* with Ps=0.909
Orbit	400 to 1000 km, 0° to Sun Synch	400 to 1000 km, 0° to Sun Synch
Launch Vehicle	Minotaur IV, Taurus XL, Delta II, Taurus 2, Falcon 9, EELV	Delta II, Taurus 2, Falcon 9, EELV
Bus Dimensions (m)	Hexagon: 1.57 Flat to Flat, 1.02 High	Hexagon: 2.25 Flat to Flat, 1.52 High
Payload Mass Capacity (kg)	460	1000
Payload Power Capacity (W); Orbit Average (Peak)	427 (881)	675 (1250)
Internal Payload Volume (m)	Dedicated Bay, 0.96 x 0.84 x 0.38 Deep	Dedicated Bay, 1.47 x 1.21 x 0.68 Deep
External Payload Volume	Top Deck Area (Hex 1.57m Wide) x LV Fairing Height Limitation (within P/L CG Limitations)	Top Deck Area (Hex 2.25m Wide) x LV Fairing Height Limitation (within P/L CG Limitations)
Pointing		
Type	3-Axis Stabilized, Zero Momentum, Stellar Inertial Reference	3-Axis Stabilized, Zero Momentum, Stellar Inertial Reference
Pointing Modes	Sun, Nadir, Offset, Point Track, Inertial, Push Broom, Whisk Broom Scanning	Sun, Nadir, Offset, Point Track, Inertial, Push Broom, Whisk Broom Scanning
Pointing Control Accuracy (arcsec)	130 (3-σ)	130 (3-σ)
Pointing Knowledge (arcsec)	60 per Axis (3-σ)	60 per Axis (3-σ)
Slew Rate (deg/min) and Actuators	23 (with RWAs)	23 (with RWAs) – 162 (Heritage CMGs)
Propulsion		
Propellant Capacity (kg)	Center Cylinder Accommodates Heritage Tanks from 38 to 300	Up to 454 (Heritage Tank on Proprietary Program)
* Based on LEO Application with Baseline Li-Ion Battery; LMx Offers 5-Year Life for Other Orbits, or LEO with Other Optional Batteries		

38 Months from ARO to Spacecraft Launch



WORLD CLASS FACILITIES

The LMx program capitalizes on our existing Lockheed Martin Space Systems Company facility in Denver, CO. This facility was the home of Mars Odyssey, MGS, MRO, and the Phoenix Mars lander. It is currently home to several programs in development, including Juno, GRAIL, MAVEN, and GOES-R. Our Sunnyvale, CA plant also offers the full set of manufacturing and test facilities required of an LMx Rapid III program.



Electronics Mfg Facility



Special Test Facilities



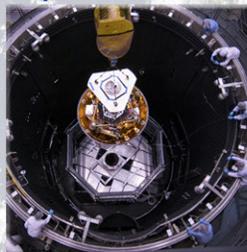
High Bays/Clean Rooms



Multifunction Test Facility



Acoustic Lab



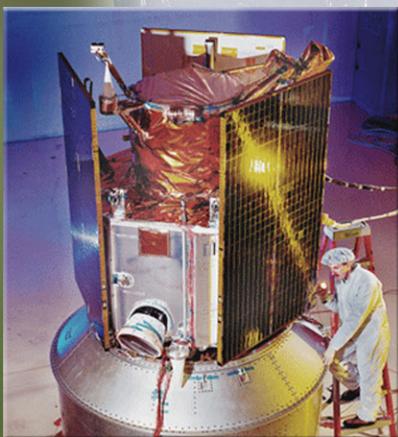
Thermal Vacuum Chambers



Test Control Center



Mission Support Area



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