A Configure-To-Order Core Spacecraft (Bus) Design for Flexible Payload Accommodation and Mission Operations

LM100 Core Spacecraft (Bus) Overview, 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—LM100, a stable, agile, and high-precision-pointing vehicle designed to address a range of remote sensing missions. It was designed to work with precision optical payloads. LM100 represents a modular family of spacecraft that can be scaled up or down in size and performance to address the unique requirements of a particular remote sensing or space physics (astrophysics, heliophysics, etc.) mission for up to three years of life.

The baseline LM100 bus uses single string avionics flown on our heritage spacecraft, the Interface Region Imaging Spectrograph (IRIS) program launched in 2013 that is still in operation. The IRIS spacecraft employs the Moog Broad Reach (MBR) avionics suite which also has heritage from our XSS-11 program for the Air Force. For our baseline LM100 offering, we retain the IRIS-based avionics and structure that accommodate internally and/or externally-mounted payloads in smaller candidate launch vehicles.
**LM100 Platform Capabilities**

The LM100 is a 95 kg bus that is capable of accepting a range of remote sensing payloads. With the baseline complement of two solar arrays, the bus is capable of providing an orbit average payload power of 155 W. With larger arrays, this can be increased to 373 W. The 3-axis stabilized bus can support payloads of up to 152 kg and maintains a pointing capability of 200 arc-sec per axis with 40 arc-sec knowledge (3-σ), and slew rates of 0.25 deg/sec.

The Command and Data Handling subsystem uses the Moog Broad Reach Integrated Avionics Unit which has very successful flight heritage on the IRIS, XSS-11, TACSAT2, and AMS missions. It satisfies all requirements for Commanding, Telemetry, Data Handling, Electrical Power Controls, Payload Storage as well as the Flight Computers that host our Flight Software. It provides Spacewire, LVDS, 1553, RS422, and analog interfaces for payloads. The baseline configuration provides 48 Gbit SDRAM for store and forward payload data.

**Mission-Specific Configure-to-Order**

LM100 is configurable and 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. Components such as the global positioning system (GPS) receivers, propulsion, and wide-band communications options, are available in varying mission-unique configurations. The particular configuration required will be determined in response to mission-specific requests for offers.

In the baseline configuration, data is downlinked through an X-band transmitter at 15 Mbps which is scalable up to 50 Mbps. Command and control is handled through an S-band transponder with uplink rates of 2 to 128 kbps, and downlink rates of 4 kbps to 5 Mbps.

The LM100 bus structure uses a monolithic machined 6061-T6 Aluminum spacecraft structure consisting of eight bays. The forward, aft, and inner panels are honeycomb construction with aluminum face sheets. Bus equipment is housed in the eight outer bays. Four reaction wheels are housed in the outer bays close to the spacecraft center of gravity. Electronics equipment are mounted to closeout panels that are also the exterior radiators for each bay. In the baseline configuration, the payload is bolted directly to the forward structure of the bus. Payloads can also be mounted through rigid or isolating struts to mount points on the nadir deck. In the bus structure inner octagonal cylinder, an additional section, 97,000-cm³ is available for payload boxes.

**Structural Configuration**

**LM100 Configure-To-Order Bus**

*Meeting a Wide Range of Mission Needs*

Legend:  
- **Configure-to-Order Modifications**
- **Scalable Modifications**
**Bus Design Features**

**Structure**
- Monolithic machined aluminum frame with aluminum face sheet and honeycomb core panels, and eight machined aluminum radiators

**Command and Data Handling (C&DH)**
- Centralized RAD750 processor control supported by 1553B and RS-422 serial connections
- Autonomous processor fault protection
- Payload data interfaces—LVDS, 1553B, RS-422, Spacewire
- Integral Solid State Memory sized to meet mission-specific* storage needs

**Flight Software**
- Flight-proven package with heritage back to XSS-11 and IRIS
- LMSSC GN&C flight software autocoded from Simulink as application layer of the MBR Bus manager software

**Electrical Power**
- Two-panel solar array using GaAs triple-junction cells
- Lithium-Ion battery of varying capacity
- Unregulated 28V bus

**Guidance, Navigation and Control (GN&C)**
- Zero momentum 3-axis stabilized gyro-less baseline design
- Mission-specific* sensors based on precision requirements

**Communications**
- S-band transponder for command and telemetry (2 to 128 kbps U/L, 4 kbps to 5 Mbps downlink) through omni antennas
- X-band transmitter for science data (15 – 50 Mbps D/L) through omni antenna
- Mission-specific* wideband systems for data downlink (Ka-Band)

**Propulsion**
- Mission-specific* blow-down hydrazine monopropellant system available

**Thermal**
- Passive design with redundant heater systems controlled by on-board computer
- Dedicated radiators with direct unit mounting and embedded heat pipes available for mission-specific* needs

**Mechanisms**
- Hold-down and deployment mechanisms
- Heritage solar array and antenna gimbals available for mission-specific* applications

**Launch Vehicle Compatibility**
- Baseline launch compatibility: Pegasus LV
  - Compatible with Minotaur I, Minotaur IV, Taurus XL, Taurus II, Athena IIc, Falcon 9, and Atlas V

*Mission-specific modifications available at extra cost

**Bus Capabilities**

**Mission Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifetime</td>
<td>1-3 yrs w/ selected redundancy (IRIS: Ps&gt;0.822 for two year mission duration)</td>
</tr>
<tr>
<td>Orbit</td>
<td>LEO 400 to 1000 km, 0° to Sun Synchronous</td>
</tr>
<tr>
<td>Launch Vehicle</td>
<td>Pegasus XL, Minotaur I, Minotaur IV, Taurus XL, Taurus II, Athena IIc, Falcon 9, Atlas V</td>
</tr>
<tr>
<td>Bus dimensions</td>
<td>Octagonal structure 103 cm across flats, 40 cm high (core bus structure)</td>
</tr>
<tr>
<td>Payload mass capacity</td>
<td>152 kg</td>
</tr>
<tr>
<td>Payload power capacity: base, max</td>
<td>155 W (orbit average), 373 W (orbit average)</td>
</tr>
<tr>
<td>Internal payload volume</td>
<td>90,000 cm³</td>
</tr>
<tr>
<td>External payload volume</td>
<td>Octagonal 103 cm, 139 cm high tapering to 65 cm diameter at 175 cm high</td>
</tr>
</tbody>
</table>

**Pointing**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>3-axis stabilized, zero momentum</td>
</tr>
<tr>
<td>Pointing modes</td>
<td>Sun, nadir, offset, inertial</td>
</tr>
<tr>
<td>Pointing control accuracy</td>
<td>200 arcsec per axis (3σ)</td>
</tr>
<tr>
<td>Pointing knowledge</td>
<td>40 arcsec per axis (3σ)</td>
</tr>
<tr>
<td>Pointing stability (jitter)</td>
<td>5 arcsec/sec (3σ)</td>
</tr>
<tr>
<td>Slew rate</td>
<td>0.25 deg/s</td>
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**Propulsion**

| Propellant capacity | Mission-specific                                     |
The LM100 program capitalizes on our existing Lockheed Martin Space Systems Company (LMSSC) facility in Sunnyvale, CA. This facility was the home of IRIS, Hubble Space Telescope, Spitzer Space Telescope, Polar Orbiting Environmental Satellite System (POES), Defense Meteorological Satellite Program (DMSP), IKONOS, and GeoEye-2. Our Denver facility is available to support the Sunnyvale facility as required. This facility is home to several Mars missions, the Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx), and the Geostationary Operational Environmental Satellite (GOES-R).

World Class Facilities

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