BCP-LARGE

The Ball Aerospace Rapid-IV Large catalog core spacecraft is based on several prior spacecraft, including Suomi NPP and Joint Polar Satellite System (JPSS-1), both of which were under RSDO. All referenced heritage spacecraft remain operational as of 2020.

The Ball Rapid-IV core spacecraft, a Ball Configurable Platform (BCP) Large, incorporates incremental design improvements with each subsequent mission. It is a fully redundant design that provides a highly reliable platform (Ps >0.9 at 5 years) and includes comprehensive fault management to protect missions from spacecraft failure. It has excellent pointing, agility and data throughput capabilities that can be used to simplify missions and enhance data return.

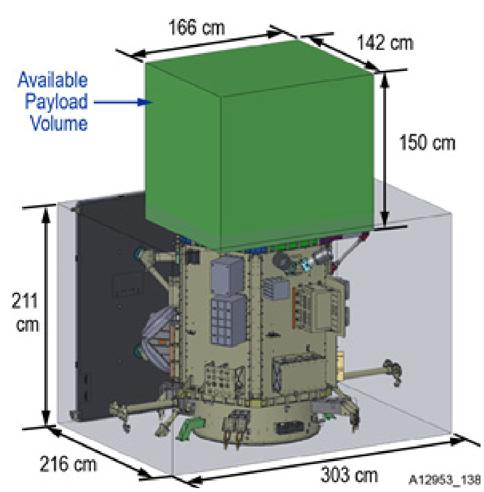
The core BCP Large spacecraft has been tailored for a variety of mission-specific applications as shown in the table on the next page. It has been configured to accommodate a variety of instruments and instrument suites, launch vehicles, ground segments, orbits, and mission profiles. The BCP Large is compatible with low-earth orbits up to 1,200 km and most inclinations. This spacecraft is compatible with EELVs, Minotaur-C, Falcon 9, Falcon Heavy, and other launch vehicles.

Structure and Mechanisms

Our high-stiffness spacecraft structure provides a large instrument volume and fits within the fairing dynamic envelope of candidate launch vehicles. A separate propulsion module interfaces with the spacecraft bus at a single bolted interface and a single electrical panel.

The bonded structure accommodates spacecraft components mounted on interior panes, enabling deployable solar array wings to be folded around the structure for launch. The external panel surfaces provide thermal radiator areas.

Solar array options include fixed panels, a single-axis drive with a simple foldout panel design and other options flight-proven on previous BCP missions.



Spacecraft Isometric. *The BCP Large spacecraft is shown with a fixed solar array as could be used in sun-synchronous, terminator orbit.*

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Ball Configurable Platform Programs	Launched and Operational Heritage Spacecraft			Rapid IV
	SNPP	WV-3	JPSS-1	
Space Vehicle Mass	2,190 kg	3,180 kg	2,190 kg	2,200 kg
Payload Mass	610 kg	500 kg	610 kg	600 kg
Fuel Mass	380 kg	380 kg	380 kg	380 kg
Orbit Average Power	1,600 W	1,300 W	1,600 W	1,600 W
Payload OA Power	600 W	525 W	600 W	600 W
Battery Capacity	80 Amp-hr (x2)	100 Amp-hr	100 Amp-hr (x2)	80 Amp-hr (x2)
Mission Life and Reliability	60 months	88 months	84 months	60 mo., Ps = 0.928 (84 mo. expendables)
Launch Vehicle	Delta II	Delta II	Delta II	Various
Downlink Data Rate	330/10 Mbps	1,200 Mbps	300/10 Mbps	300 Mbps
On Board Memory Storage	343 Gbits	2,199Gbits	343 Gbits	343 Gbits
Pointing Control (3-sigma)	<0.01 deg	<280 m (on ground)	<0.01 deg	16.7 arcsec (<0.005 deg)
Delta V	>300 m/s	>300 m/s	>300 m/s	300 m/s

Electrical Power

The power and electrical subsystem uses the highly reliable BCP power system architecture that has been successfully used on many missions. The subsystem employs a switch regulated direct energy transfer system, transferring power generated from the Sun's energy directly to the space vehicle's loads without the need for an intermediate power regulator. Solar array power output is segmented to allow precise control of current supplied to the loads and the battery; the battery regulates the bus voltage.

Propulsion

The BCP Large uses a mono-propellant hydrazine system in a segregated module. The design consists of a single positive expulsion hydrazine diaphragm tank, propellant distribution (feed system) hardware, thrusters, and thermal control

hardware. The subsystem is mounted on a dedicated structure and is an all-welded, modular construction that operates as a blowdown system. Four catalytic thrusters each provide 5.3N (1.2 lbf) thrust at BOL pressure and are canted to provide attitude control torques in all three axes.

Attitude Control

The BCP Large employs a three-axis stabilized system using reaction wheels as the primary control actuators and star trackers, an Inertial Reference Unit (IRU) and Global Positioning System (GPS) receiver as primary sensors.

The system also employs Sun sensors and magnetometers to complement the primary sensors and provide data in fault/safe mode, magnetic torque rods for backup control authority and momentum management, and propulsive thrusters for orbit attainment and maintenance.

The zero-momentum control system provides precise control torques. Electromagnets manage momentum in the presence of external disturbance torques. Star trackers provide precise attitude determination and when combined with data from the GPS and IRU, provide precise geolocation. To simplify calibration, flight algorithms are fully table-driven, allowing all sensor, actuator, attitude control, and attitude determination coefficients to be adjusted on-orbit to optimize performance.

Stowed Spacecraft. *Compact spacecraft bus allows for ample payload volume.*

Command and Data Handling

These functions are performed by an internally redundant RAD750 Spacecraft Control Processor (SCP) with a precision internal oscillator for timing, an internally redundant Command and Telemetry Unit (CTU) and Solid State Recorder (SSR) components.

Command and Data Handling (C&DH) supports the upload of new flight software on-orbit. C&DH includes two 1553 bus controllers – one dedicated to the payload interface and the other used for spacecraft functions such as star tracker and IRU communications.

The CTU provides the bulk of command and telemetry interfaces with other subsystems and payloads. This redundant device inputs and decodes real-time and stored commands and outputs high- level discrete commands or serial digital commands. It also collects data from analog, digital, and thermistor telemetry points, and formats them into a serial digital data stream. This stream is then formatted into CCSDS-compatible frames, and sent to the transmitter for downlink to the ground or stored in the CTU. The core spacecraft SSR is an internally redundant unit with a total storage capacity that can be readily resized up to 2 Tb.

Communication

This subsystem provides the interface between the Space Vehicle and the ground segment. S-band, STDN compatible command uplink and telemetry links are provided via redundant transponders.

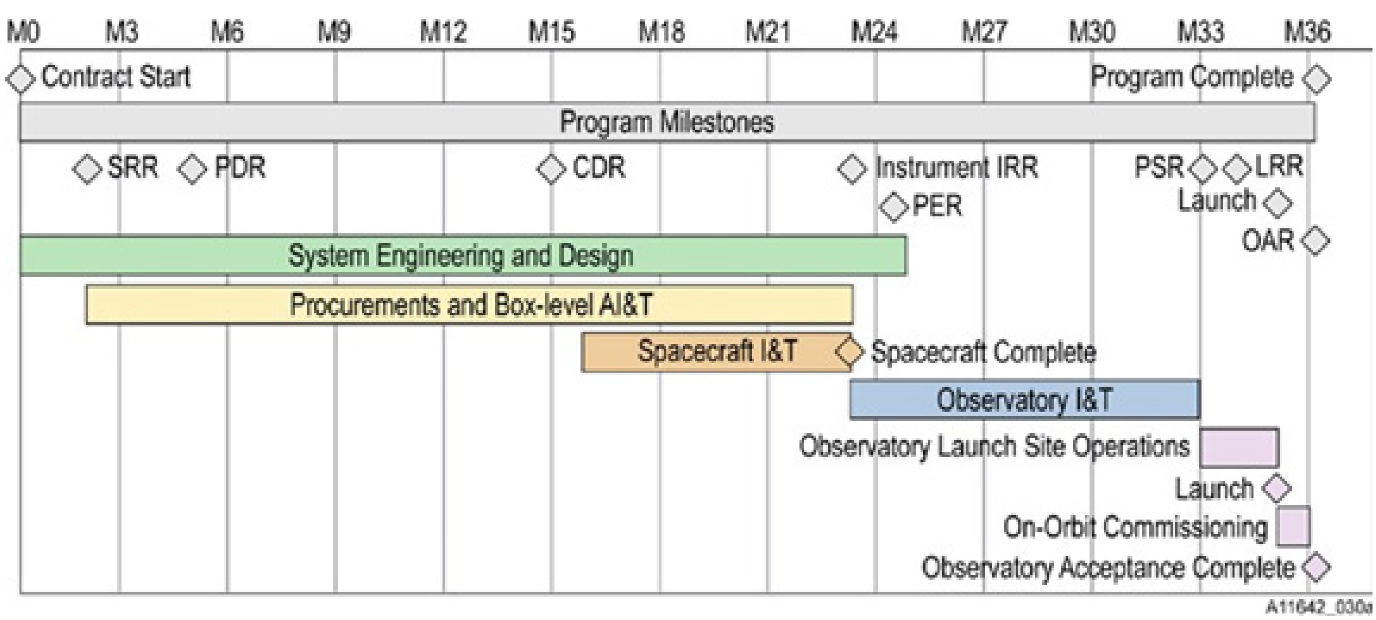
The command uplink receives real-time and stored commands as well as software table loads from ground stations. A high rate payload downlink consists of redundant X-band transmitters using a fixed, nadir oriented antenna providing Earth coverage.

Thermal Control

The BCP Large achieves temperature control and stability tailored to meet the specific needs of the payload and spacecraft components using reliable and proven techniques such as thermal isolation and individualized heater control with programmable set points. Thermal control uses passive design techniques such as Multi-Layer Insulation (MLI), standard thermal control surfaces, and thermal isolation. The payload is normally thermally isolated from the spacecraft with isolating mounts and MLI.

Flight Software

The BCP Large spacecraft flight software (FSW) is highly modular due to its table-driven architecture. Two FSW images are stored onboard to facilitate code changes on orbit if needed. Flight software has extensive on-orbit heritage and runs on a 133-MHz BAE RAD750 PowerPC single-board computer with 128 MB of RAM and 12 MB of EE-PROM. Flight software interfaces with spacecraft command and data handling and attitude control hardware, and the payload.



The typical Rapid IV program is a 36-month program which includes two months of schedule margin and a one-month commissioning phase.

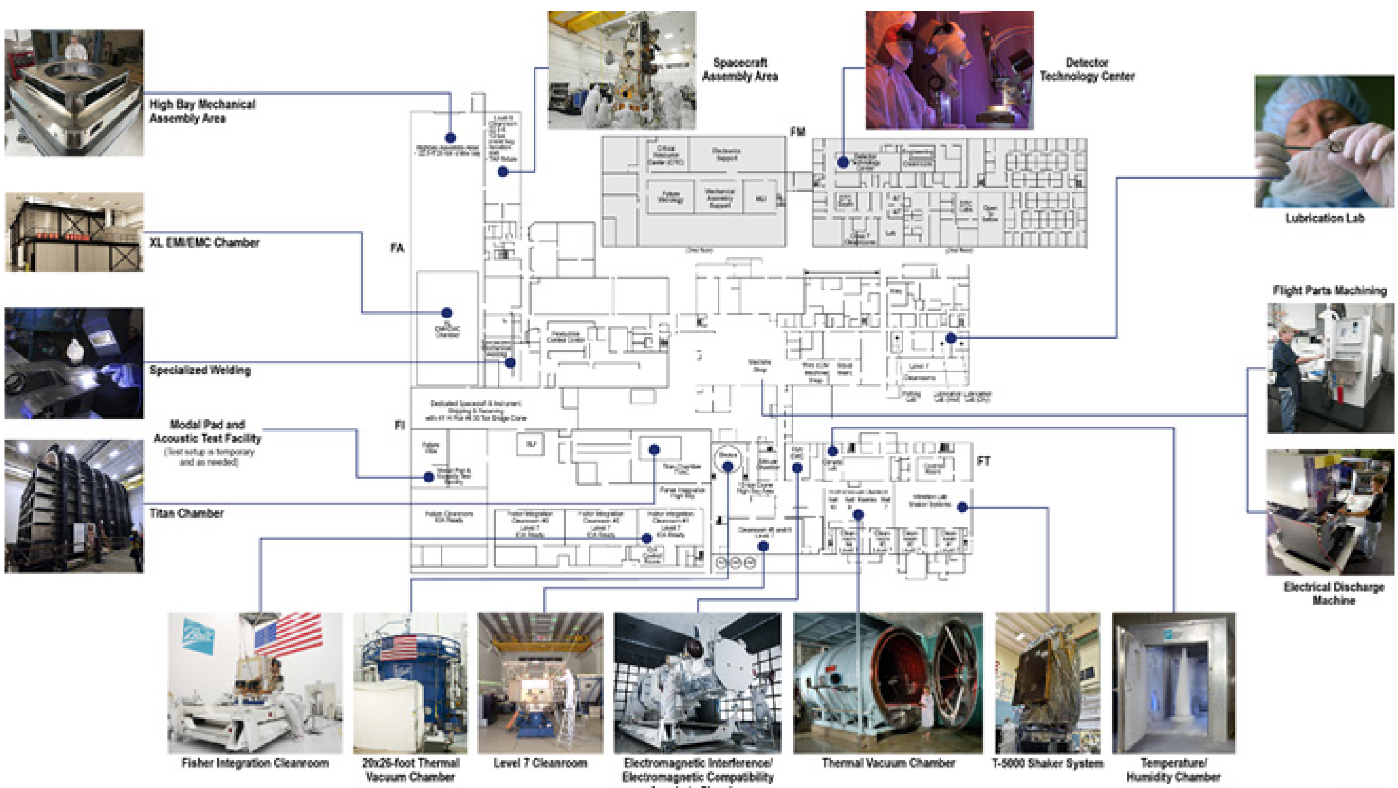
Configurable

The core spacecraft is specifically designed for ease of mission-specific reconfiguration as shown below.

Item	Capability
Data storage	Up to >5 Tb
Downlink transmission rate and bands	Up to >3 Gbps, Ka-band
High agility	Up to >4.5 deg/sec^2
High speed data interface	IEEE-1394, LVDS, Spacewire
High delta-v	300 to >1,500 m/s
High power	Up to >10,000 W
High payload mass	Up to >2,000 kg
Exquisite pointing	To <0.5 arcsec, 3-sigma

Facilities

As an end-to-end producer of space systems, Ball has all of the development and production facilities required for the design, production, assembly, integration, and test of components, spacecraft, space instruments, and fully inte- grated observatories. Facilities include an EMI/EMC Test Lab for EMI/EMC and compatibility testing nominally 10 kHz to 40 GHz, a large Semi-Anechoic Chamber, a Dynamics Lab for random, sine, mixed mode and sine burst vibration testing, Thermal Vacuum testing in small, medium and large test chambers, and a Climactic Laboratory. Ball facilities accommodate instrument needs from initial delivery, through integration with the spacecraft, and on to integrated system-level testing.



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