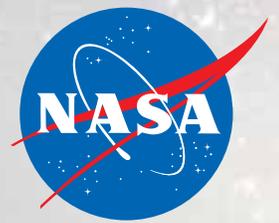


# Eagle Spacecraft

*Northrop Grumman's Versatile, Affordable Line of Spacecraft*



To meet the growing customer demand for affordable and reliable spacecraft to support a variety of mission applications, Northrop Grumman offers its Eagle spacecraft product line.

With a rich legacy of building space platforms that range from small low Earth orbit spacecraft to large observatories and deep space probes, Northrop Grumman has combined elements of these proven products into a family of Eagle spacecraft that readily serve the mission needs of our customers at an affordable price.

The Eagle spacecraft product line consists of three basic configurations for NASA's Rapid-III spacecraft catalog – the core Eagle-0 (also known outside of the RSDO catalog as the Eagle-S configuration), and the Eagle-1 and Eagle-2 configuration options -- each suited for a particular class of missions and launch vehicles. Design and product commonality across the Eagle configurations enable low cost and rapid delivery, while maintaining Northrop Grumman's commitment to reliability and mission success.

The Eagle spacecraft employ a flexible design that allows performance to be cost-efficiently tailored with existing, flight-proven component options to meet unique mission requirements that may go beyond the standard Eagle configurations.

Whether it's a one-way journey to the moon, a study of Earth's environment, or a critical operational mission, the Eagle line of spacecraft provides an affordable, rapid, reliable platform to accomplish your mission.

## **The Eagle Spacecraft Heritage**

*An evolution of flight-proven design*

The Eagle spacecraft product line is based on Northrop Grumman's highly successful portfolio of proven low-cost spacecraft that range from low Earth orbit (LEO) and geosynchronous orbit (GEO) to deep space missions. The first Eagle spacecraft flown was an Eagle-0 (Eagle-S) configuration for the Lunar Crater Observation and Sensing Satellite (LCROSS) mission. The LCROSS mission to the moon in 2009 was completed at a fraction of the cost of a typical deep space mission, demonstrating Northrop Grumman's successful application of cost-efficient design and manufacturing processes. This Eagle-0 configuration is the Core spacecraft entry in the Rapid-III catalog.

The Eagle-1 and Eagle-2 configuration options retain the avionics and flight software architecture of the core Eagle-0 offering, and enhance it with flight-proven product upgrades to support longer mission durations and accommodate larger payloads. By maintaining a common core architecture, this range of capabilities is cost-effectively enabled.



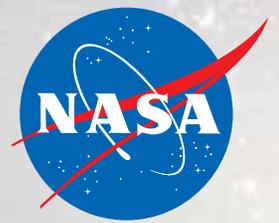
## **Flexible Design**

*Efficiently adaptable for special mission requirements*

The Eagle spacecraft product-line approach focuses on satisfying requirements for most mission applications across a spectrum of mission classes with three standard configurations that share a common core design.

Where additional tailoring is needed for special mission requirements, the Eagle architecture can readily accommodate enhancements for missions requiring higher performance in certain areas without disrupting the core product designs. Tailoring options from our existing "toolbox" of flight-proven products include increased

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pointing accuracy, high rate communications, added levels of redundancy, payload power, data storage, and propellant.

The standard Eagle spacecraft are also designed with the anticipation of readily adapting LEO configurations to GEO and deep space applications with minimal impact to the standard configurations.

By building in the accommodations for the most likely mission tailoring needs, the Eagle spacecraft product line provides customers with more demanding performance requirements the opportunity to select those performance options with only marginal cost impacts, while retaining the low-cost and low risk benefits of the core Eagle product line.

### Space Vehicle Production

*Trusted manufacturing and testing*

Northrop Grumman's Space Park in Redondo Beach, California, serves as the primary production center for the Eagle spacecraft, while facility plans may be tailored for specific missions as appropriate. The Space Vehicle Production Facility, part of a 725,000 sq. foot satellite production complex at Space Park, can support up to eight satellites in production simultaneously. This COMSEC-certified facility is the area where assembly, integration and test of Northrop Grumman's full range of spacecraft are performed.

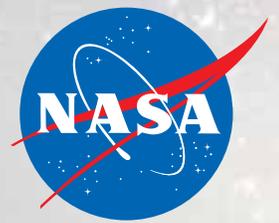
In addition to a Class 100,000 high bay with a Class 10,000 clean tent and portable thermal chamber, it also includes acoustic, thermal vacuum and vibration equipment for environmental testing to meet mission-specific requirements.

Over the years, Northrop Grumman's world-class facilities and comprehensive testing have contributed to unprecedented operational lifetimes of more than 200 scientific, military, and communications satellites flown in every kind of space environment and orbit.

Task Name	Yr 1				Yr 2				Yr 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
<b>EAGLE-0 Program</b>												
Major Milestones	◆ ARO								◆ Launch			
Spacecraft System Reviews	▲ SRR ▲ PDR ▲ CDR				▲ IIRR ▲ PER				▲ PSR ▲ OAR			
Mission Reviews					▲ MOR ▲ FOR				▲ FRR			
Flight System Development	▬											
Core Spacecraft I&T												
Observatory I&T												
Authorization to Ship (ARO + 28 months)	▬											
Launch Integration												
Initial Launch Capability (ILC)												
Launch and Mission Operations	▬											

**Eagle-0 (Core) Spacecraft Program Schedule Summary**





## Optimal Eagle Spacecraft and Launch Vehicle Matching

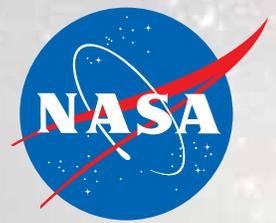
<p><b>Eagle-0 (Eagle S)</b> Secondary Payload Configuration</p> <p>EELV</p>	<p><b>Eagle-1</b> Selected Redundancy LEO</p> <p>Falcon 1e</p>	<p><b>Eagle-2</b> Fully Redundant LEO</p> <p>Minotaur IV    Taurus 3210    Falcon 9    Delta II</p>

## Launch Vehicles Compatibility

<p>EELV</p>	<p>Falcon 1e</p>	<p>Minotaur IV</p>
Eagle-0	Eagle-1	Eagle-2

The core Eagle-0 (Eagle-S) spacecraft is designed as a secondary launch payload on the EELV, and the Eagle-1 and -2 options are configured as primary launch payloads. The Eagle-1 option is optimally sized for the Falcon 1e launch vehicle. The Eagle-2 option is configured to accommodate the more demanding environments and volume constraints of the Minotaur IV launch vehicle, while also being well suited for a range of other mid-size launch vehicles.

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## Spacecraft Specifications

	Core: Eagle-0 Secondary payload configuration	Option #1: Eagle-1 Single string, LEO optimized spacecraft for sun-sync orbits	Option #2: Eagle-2 Dual string, optimized for LEO missions up to 970 km (sun-sync and non sun-sync orbits)
Core spacecraft mission heritage.	LCROSS	LCROSS	LCROSS
Launch vehicle compatibility and orbit capability.	Compatible LVs are: EELV, Falcon 9 & Taurus II. Compatible orbits include: lunar trajectory plus LEO (28° up to polar from 425 km to 1000 km), GEO, & Interplanetary	Compatible LVs are: Falcon 1e, EELV, Falcon 9 & Taurus II. Compatible orbits include: LEO sun-sync (optimal), LEO non sun-sync	Compatible LVs are: Minotaur IV EELV, Falcon 9 & Taurus II. Compatible orbits include: lunar trajectory plus LEO (28° up to polar from 400 km to 970 km), GEO, & Interplanetary
Design mission lifetime and reliability rating	Ps = 0.813 at 1 year (selected redundancy)	Ps = 0.75 at 3 year (selected redundancy)	Ps = 0.85 at 5 year (fully redundant)
Structure type description	Aluminum ESPA Ring	Hexagonal, GFRP bus structure with Al core facesheet panels.	Rectangular, GFRP bus structure with Al core facesheet panels
Type and power capability of electrical power subsystem	1 fixed solar array panel using Direct Energy Transfer & Li-Ion batteries supports up to 100 W P/L	1 fixed solar array wing using Direct Energy Transfer & Li-Ion batteries that supports up to 200 W P/L	2 articulating solar array wings using Direct Energy Transfer & Li-Ion batteries supports up to 795 W P/L
Payload mass capability	86 kg on R6 panel or 3000 kg axially	200 kg	400 kg
Interior volume	None	None	0.45m X 0.30m X 0.30m
Exterior volume	0.42 m x 0.76 m x 0.31 m	1.30 m x 1.10 m x 1.60 m	1.47 m x 1.23 m x 1.87 m
Payload electrical power capabilities	Supports up to 100 W on 28V bus	Supports up to 200 W on 28V bus	Supports up to 795 W on 28V bus
Payload data interface(s) type	Supports data rates of 100 Mbps (SpaceWire), 330 Kbps (1553B), 10 Mbps (RS-422)	Supports data rates of 100 Mbps (SpaceWire), 330 Kbps (1553B), 10 Mbps (RS-422)	Supports data rates of 100 Mbps (SpaceWire), 330 kbps (1553B), 10 Mbps (RS-422)
Payload thermal accommodations	Active with heaters, and passive with MLI and heat rejecting radiators and surfaces, materials with selective "through" conductances, and isolation	Same as Eagle-0	Same as Eagle-0
Science data storage	No onboard storage as priced. Can easily add up to four (4) 96 Gbit flight proven Data Storage Boards (DSBs) for a total of 384 Gbit or a stand alone SSR	Includes one 96 Gbit flight proven Data Storage Boards (DSBs). Chassis supports up to four (4) DSBs for a total of 384 Gbit. Can also add a stand alone SSR	Same as Eagle-1
Attitude control architecture	3-axis stellar-inertial thruster-based control	3-axis stellar-inertial wheel-based control	3-axis stellar-inertial wheel-based control
Pointing knowledge*	1550 arcsec (3σ)	60 arcsec (3σ)	22 arcsec (3σ)
Pointing stability	12 arcsec (3σ)	10 arcsec (3σ)	10 arcsec (3σ)
Slew capability	1.5°/s	1.4°/s	1.5°/s
Communication systems type and capability	S-band communications with 1 Mbps from lunar orbit (higher data rates available)	S-band communications for TTC and 25 Mbps X-band for mission data (higher data rates available)	Same as Eagle-1
Command & data handling type and capability	Central processor with RAD750, modular with cPCI and serial 1553 backplane	Same as Eagle-0	Same as Eagle-0
Means of spacecraft thermal control	Active with Heaters, and passive with MLI and heat rejecting radiators and surfaces, materials with selective "through" conductances, and isolation	Same as Eagle-0	Same as Eagle-0
Propulsion type and capability	Monoprop, with up to 800 m/s delta V	Monoprop, with up to 266 m/s delta V	Monoprop, with up to 224 m/s delta V
Known mission specific additional capabilities available at extra cost (if any)	Can add GPS, wideband comm, additional redundancy, and additional power capability	Same as Eagle-0	Same as Eagle-0

\* Higher performance available using payload data

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