

Iridium NEXT SensorPODs: Global access for your scientific payloads

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ABSTRACT

The operational Iridium constellation is comprised of 66 satellites in low Earth orbit at 781 km and inclination of 86.4°, resulting in unprecedented 24/7 coverage and real-time visibility of the entire globe. Recently, through funding from the National Science Foundation (NSF), Iridium has been utilized for a unique scientific experiment called the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE). AMPERE provides real-time magnetic field measurements using the existing Iridium constellation as part of a new observation network to forecast weather in space.

In February 2007, Iridium announced Iridium NEXT, a novel design for a second-generation satellite constellation. Anticipated to begin launching in 2015, Iridium NEXT will maintain the existing Iridium constellation architecture of 66 cross-linked low-Earth Orbit (LEO) satellites covering 100% of the globe. Iridium NEXT will also offer new Earth and space observation opportunities through hosted payloads (up to 50 Kg) on the Iridium NEXT satellite network. Recently, Iridium introduced a new hosting concept called “SensorPOD” for smaller scientific payloads (up to 5 Kg). SensorPODs will offer unique benefits such as unprecedented spatial and temporal coverage, and real-time relay of data to and from SensorPODs. SensorPODs are housed in a 4U frame (20 cm x 20 cm x 14 cm). Scientists provide just the payload; all other spacecraft bus functions such as power, data transfer, and attitude control are provided by Iridium NEXT. This access to space comes at a fraction of the cost of a dedicated mission such as 3U or larger Cubesat. These SensorPODs can be hosted as a constellation on all 66 satellites. Such experiments can achieve a mission life of several years (10 year SV design life) as compared to significantly less mission life achievable for a Cubesat mission.

IRIDIUM NEXT OVERVIEW

Starting in 2015, Iridium expects to begin launching its next generation of communication satellites. The new spacecraft will replace Iridium’s current constellation of 66 LEO satellites – the world’s largest commercial satellite system. Known as Iridium NEXT, the new constellation has a built-in capability for hosting additional sensor payloads on the communication satellites which could be used for a wide range of Earth observation and government missions. Like Iridium’s current “Block I” system, the Iridium NEXT constellation will consist of 66 cross-linked, LEO satellites in six orbital planes intersecting over the North and South Poles. Iridium NEXT will have extensive built-in redundancy in the space and ground segments, with multiple backup spare satellites in orbit, and backup gateway and command and control facilities, ensuring a high degree of network survivability and resiliency. The cross-linked satellites and fully meshed network architecture provide real-

time transmission of data from satellite sensors to end users on Earth. Moreover, the satellite data links can be used to relay data in real time from terrestrial applications such as unattended remote sensors; vehicle, personnel, and asset tracking systems; oceanographic buoys; underwater gliders; and unmanned weather stations to end users around the world. The Iridium constellation creates a real-time two-way data stream from both ground and space sensors to any location desired by the user.

OVERVIEW OF HOSTED PAYLOAD CONCEPT

When Iridium began planning for the next generation satellite constellation, Iridium NEXT, in 2007, a decision was made to set aside a small but meaningful fraction of mass, volume, power and bandwidth for a payload that could be easily added to the spacecraft during the integration and be launched with the Iridium NEXT satellites. These hosted payloads would be situated primarily on the Earth facing surface, but other

mounting locations as required by the mission could also be considered. A private-public partnership (PPP) model was developed to offer unprecedented capability to public bodies such as space agencies, DoD, international government agencies for deploying remote sensing, weather and climate observation sensors at a fraction of the cost of flying a dedicated mission.

TECHNICAL DESCRIPTION OF IRIIDIUM NEXT AND THE HOSTED PAYLOADS

Iridium NEXT

The first generation Iridium satellite constellation, launched from 1997 through 1998, is expected to provide a commercially acceptable level of service to subscribers beyond 2015 when Iridium NEXT satellite launches start. The current Iridium constellation is also expected to provide continuation of service during the transition period to Iridium NEXT (2015 to 2017). The planned Iridium NEXT system (See Figure 1) will be backward compatible with first generation Iridium devices and will replace the existing constellation with an even more powerful and capable network of satellites. In June 2010, Iridium selected Thales Alenia Space (TAS) as prime contractor for the Iridium NEXT constellation development and deployment. TAS has further selected Orbital Sciences Corporation as a subcontractor for integration of Iridium NEXT satellites and the hosted payloads in a facility located in Gilbert, AZ.



Figure 1 Iridium NEXT constellation

The Iridium NEXT system is expected to maintain Iridium’s current unique architecture that provides truly global coverage, with expanded capacity, higher data speeds, new services, flexible payload architecture capable of supporting future product enhancements, cost effectiveness in maintaining and operating the network, and a design to host secondary payloads. See Figure 2 for constellation parameters.

Iridium NEXT Specifications	
Constellation	66 satellites in 6 orbital planes
Orbits	Polar
Altitude	780 km
Inclination	86.4°
Orbital period	100 minutes
Expected Launch Window	2015-2017
Risk mitigation	Multiple in-orbit spares, redundant backup Earth station

Figure 2 Iridium NEXT constellation specifications

Iridium NEXT – Hosted Payloads

The Iridium NEXT satellite is being developed with the ability to accommodate a hosted payload primarily on the nadir facing surface. A standard interface between the hosted payload and NEXT satellite has been defined in the Secondary (Hosted) Payload Specification, which is part of the NEXT System Performance Specification. The top level hosted payload accommodation requirements are shown in Figure 3.

Iridium NEXT Hosted Payload Specifications	
Weight	50 kg
Payload Dimensions	30 x 40 x 70 cm
Payload Power	50 W average (200 W peak)
Payload Data Rate	<1 Mbps, Orbit average ~100Kbps

Figure 3 Iridium NEXT Hosted Payload Top Level Specification

Additional requirements are as follows:

- Hosted Payload Center of Gravity (CG) must lie inside the defined volume
- Power allocation of 5000 watt-minutes per orbit up to 200 watts peak
 - For Example: 50 watts x 100 minutes = 5000 watt-minutes, or 200 watts x 25 minutes = 5000 watt-minutes
- Payload Data Rate up to 100 kbps for 90% of orbit, and <1 Mbps for remaining 10%

The accommodation of these payloads on Iridium NEXT satellite is conceptually shown in Figure 4.

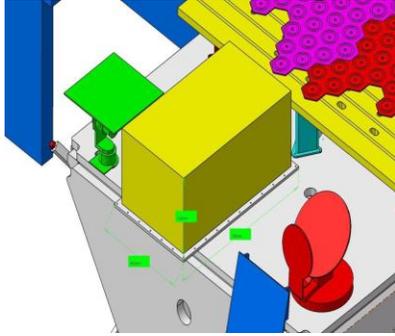


Figure 4 Iridium NEXT Hosted Payload Envelope

DATA HANDLING FOR HOSTED PAYLOAD SENSORS

Although the satellites in the Iridium system are primarily designed to support the Iridium communications mission, they have been adapted to accommodate hosted payload missions. Mission data and sensor telemetry and command data for these missions can be transported in near real-time utilizing the K-band network of cross-links between satellites, feeder links to the ground, and teleports connecting the satellites through earth stations to a Multiprotocol Label Switching (MPLS) cloud called the Teleport Network.

Iridium operations manage deployment and operation of the Iridium system. Iridium NEXT would retain the capability to turn off the hosted payload, in an extreme emergency situation, to preserve the health of the Iridium satellite. Iridium enables a hosted payload command and data path to an MPLS cloud. A customer designated sensor operations facility would manage the hosted payloads in-orbit on the Iridium NEXT satellite using the command and data path provided by Iridium operations. These functions include:

- Sensor operations tables
- Updating software or firmware
- Data stream management (pull or push from the MPLS cloud)
- Anomaly resolution

This Hosted Payload Operations Center will provide the data processing capability for the sensor data. It will receive the data stream from the MPLS cloud and processes the data for end users. End users can provide feedback to sensor operations and data processing.

BENEFITS OF HOSTED PAYLOADS ON IRIDIUM NEXT

Hosted payloads offer a customer the following value proposition:

- **Unprecedented geospatial and temporal coverage** – 66 interconnected satellites with coverage over the entire globe
- **Low latency** – Real-time relay of data to and from payloads in space
- **User control** – Data collection and hosted payload access seamlessly through Iridium infrastructure or private gateways
- **Cost effective** – Access to space at a fraction of the cost of a dedicated mission
- **Exclusive** – No other opportunity like this is likely to become available in the coming decades.
- **Consistent with 2010 U.S. President’s National Space Policy** – Commercial capabilities, cost effective access

IRIDIUM NEXT SENSORPOD

A SensorPOD is a virtual container (enclosure) that is a designated subset of the total Iridium NEXT hosted payload volume and is applicable for small payloads and payload suites that only require a small portion of the available volume. See Figure 5.

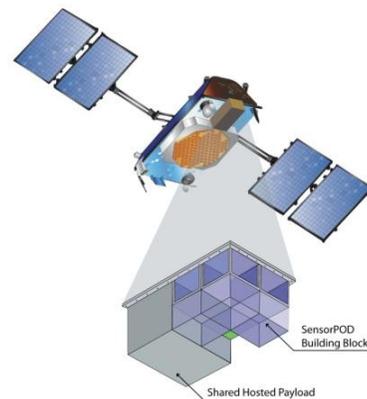


Figure 5 Iridium NEXT SensorPOD

SensorPOD “containers” can be arranged in varying configurations (i.e., stacked like blocks) to support many different customer experiments. SensorPOD geometries can also be scaled on a case-by-case basis to accommodate specific customer payload needs. SensorPODs are designed to be located and oriented in the hosted payload volume to provide both Nadir and/or RAM Fields-of-View (FOV) options. An example of a notional configuration which includes a combination of a “Primary” Nadir-viewing SP and multiple “Secondary” SensorPODs is shown in Figure 6.

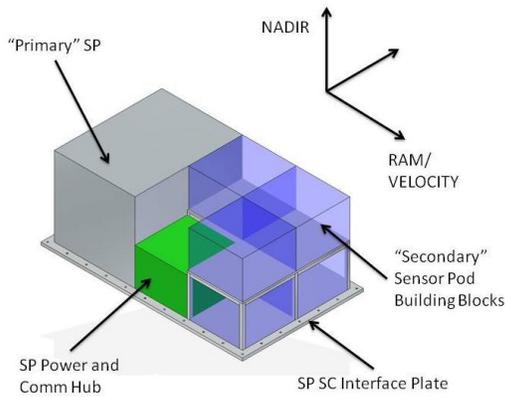


Figure 6 Iridium NEXT SensorPOD Details

Customers can fill each SensorPOD volume with one or several payloads as long as they remain within overall SensorPOD volume, mass, power and communication allocations. Customer Payloads are provided with mechanical and thermal interface mounting plates and conditioned electrical power and communications via a hub through external harnesses. A summary of the SensorPOD technical resource allocations is listed in Figure 7.

SensorPOD Specifications	
Mass	4-5 kg
Volume	20 x 20 x 14 cm
Power	5W (Ave), 10W (Peak)
Data Rate	10 kbps (Ave), 100 kbps (Peak)
FOV	RAM and/or Nadir Viewing

Figure 7 SensorPOD specifications (Subject to change)

BENEFITS OF SENSORPOD

A SensorPOD hosted on Iridium NEXT provides some very unique benefits that are otherwise not possible:

- Unprecedented global measurements from 66 Iridium NEXT satellites carrying SensorPODs
- Answers to pressing Earth and space science questions with critical scientific impact
- Enables new discoveries in climate, atmosphere, oceans and space weather
- Real-time global data for policy and decision makers
- A platform for developing new innovation from the next generation of scientists and engineers.

Iridium SensorPOD, when compared with alternatives such as cubesat, shows that not only hosting a scientific payload on Iridium brings benefits that can only come from a cross-linked commercial LEO constellation but it may also come at significantly lower lifecycle costs. See Figure 8.

Item	Iridium NEXT SensorPOD	3U Cubesat
Payload Mass	4 - 5 Kg	< 1Kg
Constellation Formation	Built in capability for 66	Cost Prohibitive
Data Delivery	Real Time	Hours
Access to Space	Driven primarily by Iridium business, multiple launches starting in 2015	Undetermined, Opportunity driven,
Ground Infrastructure	Included	Must be built
Altitude	780 Km	Low to ensure de-orbit
Coverage	Global using multiple orbits	Single Orbit
Mission Life	Up to 10 years	6 months to 1 year
Power, communication, attitude control	Provided by host	All systems needed inside
Payload Life cycle Cost	< \$150 K per Kg/Year	\$250 K – 300 K per Kg/Year

Figure 8 Iridium NEXT SensorPOD vs. Cubesat High-value/Low-risk Proposition

IRIDIUM NEXT – HOSTED PAYLOAD SCHEDULE

Iridium has developed a decision time line to defer finalization of hosted payload missions to the maximum extent possible within the constraints of the Iridium NEXT program. Technical interfaces to include a particular mission must be finalized by the Spacecraft Preliminary Design Review (PDR) expected to take place in Q1 2012. Iridium is currently working with the following development schedule, shown graphically in Fig 9.



Figure 9 Iridium NEXT Development Schedule Showing Key Dates for Hosted Payloads

SUMMARY

Iridium NEXT represents an once-in-a-lifetime opportunity to host additional remote sensing, weather and climate monitoring, and DoD payloads on the world's largest commercial satellite constellation, which will provide 24/7 low-latency visibility over the entire Earth's surface and its atmosphere. Hosted payloads on Iridium NEXT will provide an unmatched opportunity to meet Earth observation and government mission requirements in the near term at a fraction of the cost of designing, building, launching and maintaining dedicated platforms in space. Iridium would offer these benefits to a hosted payload mission in a manner that is inherently less risky than many other alternatives.