

Unparalleled Reach, Unrivaled Coverage

Iridium Satellite is the only mobile satellite service offering pole-to-pole coverage over every square inch of the Earth's surface. Iridium's constellation of 66 low-earth orbiting, cross-linked satellites provides critical voice and data services for regions not served by other communication networks. Voice and data are routed among the satellites without touching the ground, creating a highly efficient and reliable connection.



Dr. Om Gupta

RELIABLE • CRITICAL • LIFELINES

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Iridium NEXT



Global Climate Observation with Iridium NEXT Constellation Hosted Payloads

A Public-Private Partnership
Federated by GEO



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Progress on the Opportunity

Background

This unique and innovative opportunity to monitor many key parameters of global climate change by flying 66 hosted payloads on the Iridium NEXT constellation has been under development since 2007. The concept was first introduced to GEO members at the GEO IV Ministerial Summit in Cape Town in 2007. Reviews were completed by CNES, ESA, NOAA and NASA in 2007 and 2008, with great interest shown by other Agencies and organizations such as DST (South Africa) and the Canadian Space Agency. A general discussion of the program was held at the Royal Society in London in January 2008.

GEO concluded in 2008 that four missions stand out as prime candidates for flying on the Iridium platforms which would also be of benefit for climate observation. These are altimetry, broadband radiometry (Earth's radiation budget), multi-spectral imaging (ocean and land) and GPS radio occultation. There are several additional missions which could provide additional climate/ weather observations of interest to various groups. The consensus was that a constellation approach to sensing, using the real-time communications backbone of Iridium, will enable unprecedented geospatial and temporal sampling, with a move from R&D-driven space programs to operational monitoring of the effects of global climate change.

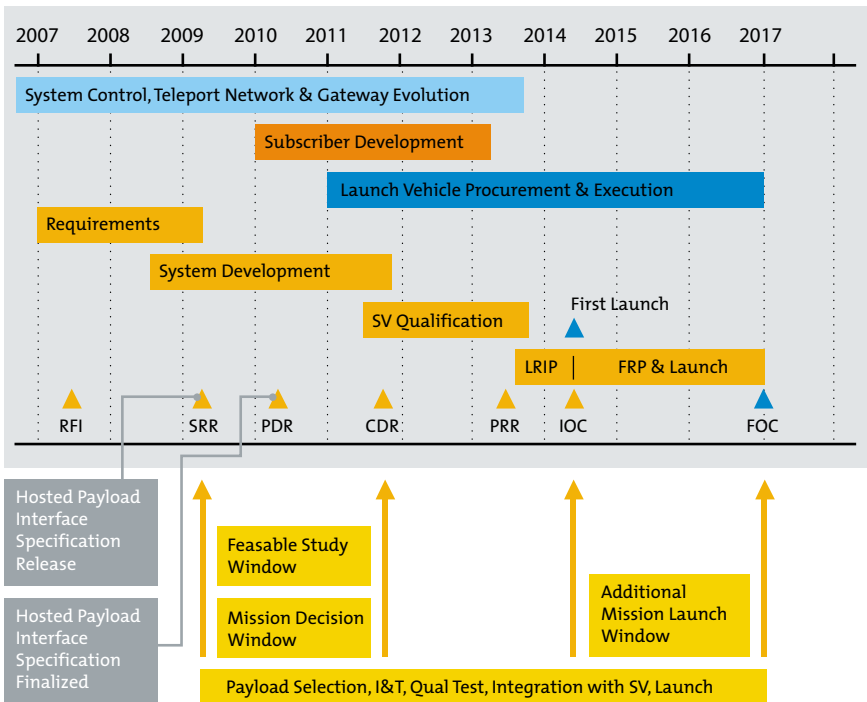
Forward Look

Independent detailed studies were conducted for each mission recommended by GEO and reports on each mission have been published. The Altimetry study was done by CNES, CLS and Thales Alenia Space; GPSRO by NASA/JPL; Earth Radiation Budget by Rutherford Appleton Laboratory, Imperial College and SEA Ltd; and the Ocean and Land Imager by ACRI and TAS. To request copies of these reports, please refer to the contacts on the back cover.

The Iridium NEXT and hosted payload schedule is given on the following page. This schedule provides Earth observation community adequate time to develop missions, and plan for them with resources, funds, sensor specification, ground segment planning and data handling. This

process has already been started in some countries and now is the time for Expressions of Interest and approaches to be made to agencies or governments for support. There is still time to add new missions, for example, the infra-red bolometry mission to observe forest fires is actively under consideration. The cost of integration, hosting and launch of payloads, the data stream and the ground segment, for the 15 year life of the constellation, is extremely competitive and a fraction of the cost of conventional missions. This demonstrates the value of sharing the commercial infrastructure in the Public-Private Partnership and supports the aims and objectives of

GEOSS to both ‘augment the current and planned programs and in a cost effective manner.’ Selection of a Prime contractor for Iridium NEXT is through a competition between Lockheed-Martin and Thales Alenia Space which has just been completed. Iridium expects to pick a single company as a Prime during Q2 2009 and initiate full scale development of NEXT constellation leading up to start of the launch campaign in 2014. GEOSS community is urged to collaborate with each other, and work through Public agencies funding plans and budget cycles to enable climate observation through hosting of payloads on NEXT.



Meeting the Needs of Society

The Partnership will meet the following criteria required of Earth observations:

- Contribute to the major scientific questions of the day
- Benefit Society (application and policy)
- Provide key data for the long-term observational record
- Create synergy with other observing systems
- Possess a high degree of readiness (technical, resources, and people)
- Be affordable (the mission and annual support)
- Show risk mitigation and strategic redundancy

Hosted Payloads on NEXT address the Themes of the GEOSS 10-Year Implementation Plan:

GEOSS THEME	FUNCTION	INFORMATION FROM SENSOR DATA
Agriculture	Sustainability & desertification	Land use & change of use; drought; crop diversity
Biodiversity	Monitoring & conservation	Loss/change of habitat (e.g. coastal, terrestrial, ice)
Climate	Variability & change	Global climate change; Earth's radiation budget (ERB)
Disasters	Natural & man-made	Tsunami & extreme weather early warning; wild-fires
Ecosystems	Management & protection	Fisheries; ocean color; forest canopy
Energy	Management of resources	Sea state; tide & wind for renewable energy
Health	Environmental & security	Monitoring marine pollution; crop management
Water	Resources & global cycle	Ice loss; sea level change; ocean currents
Weather	Forecasting & warning	Atmospheric humidity & temperature soundings; ERB

The Iridium NEXT Constellation

Specification and Key Facts

IRIDIUM NEXT

Constellation:	66 Satellites in 6 planes of 11
Orbit:	Polar at 780 km
Inclination:	86.4°
Period:	101 minutes per orbit
Launch:	2014 – 2016
Mission Life:	15 years to beyond 2030
Risk Mitigation:	6 in-orbit spares

HOSTED PAYLOADS

Payload Weight:	50 kg
Payload Dimension:	30 x 40 x 70 cm
Payload Power:	50 W average (200 W peak)
Payload Data Rate:	<1 Mbps
Validation:	Platforms on Earth transmit data to the observing satellite for <i>in situ</i> calibration

KEY FACTS

Coverage :	100% of the globe; unprecedented geospatial & temporal coverage
Data Delivery:	Near real-time via Iridium's cross-linked network
Temporal Validity:	<1hr for disaster early warning & now-casting to diurnal, seasonal, annual, decadal & long term variability
Cost Efficiency:	Sharing of commercial infrastructure in a public-private partnership
Cost Estimate:	Mission dependent, flexible business models, please contact Iridium

Altimeters

Monitoring sea-surface height, wave height, wind speed; ice height

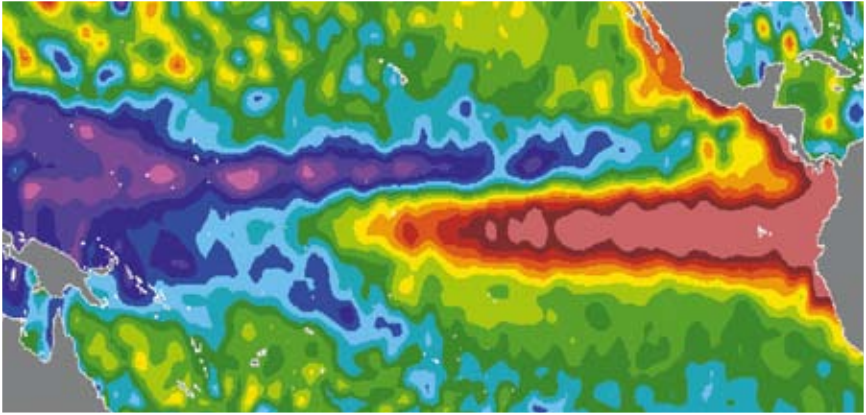


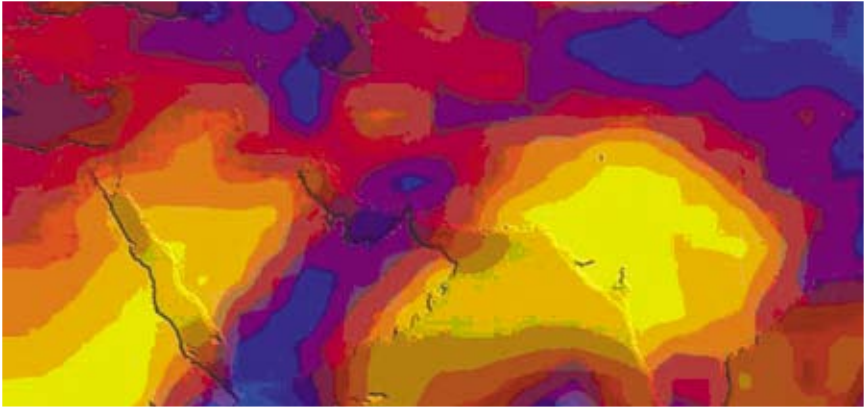
IMAGE OF SEA LEVEL ANOMALIES SHOWING THE EFFECT OF EL NIÑO, 30 Nov 1997.

Source: ESR – Envisat Data from DEOS, Delft University of Technology, Netherlands

Number:	Up to 24 sensors, 4 in each plane
Description:	Radar altimeter (Ku band)
Swath:	5-10 km, nadir pointing
Time scales:	<<1 hour Extreme weather events; flood now-casting
	1 hour Sea surface & significant wave height, wind speed; storm surges
	Operational use – ocean forecasts for shipping etc.
	1 day Wave Assimilation Models; tides, currents and eddies
	1 month Lunar cycles; El Niño events; hydrology
	1 year Ocean circulation patterns
	10 year Inter-annual variations and changes
	>10 year Prediction of sea level rise & changes in circulation
Readiness:	Commercially available; minor development
	Feasibility study ongoing by CNES (France) for GEO
Synergy:	NEXT mission: Imagers. Jason missions
Cross-cutting:	Climate, Disasters, Energy, Water, Weather

Broadband Radiometers

Measuring the Earth's radiation budget



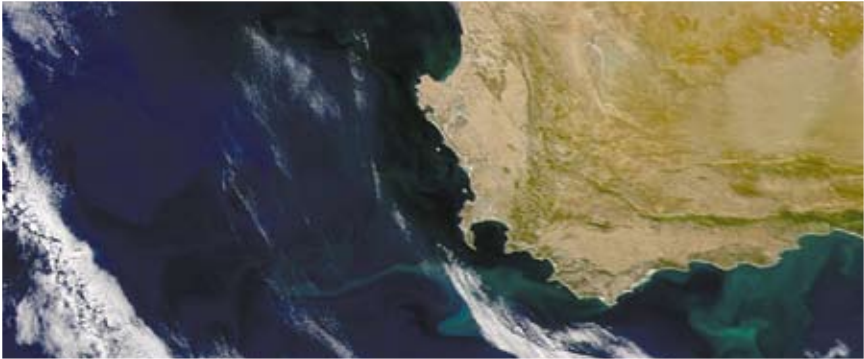
HEAT WAVE OVER PAKISTAN.

Source: Bruce Wielicki and Takmeng Wong, and the CERES Science Team at NASA Langley Research Centre; Images courtesy Tom Bridgman, NASA GSFC Scientific Visualization Studio.

Number:	Up to 18 sensors, 12 minimum
Description:	Broadband radiometer; 0.3 to 4 and 0.3 to 100 um
Spatial resolution:	50 km threshold and 10 km objective
Time scales:	3 to 6 hr Full coverage of the planet 1 hour Monitoring of heat waves 1 day Day-night variation in radiative fluxes 1 month Averaged shortwave & longwave fluxes on global grid 1 year Seasonal variations in ice and cloud albedo 10 year Inter-annual variations >10 year As a major driver of climate, the radiation budget is one of the key and least known parameters needed to monitor and predict global climate change
Readiness:	Commercially available; minor development with several options available. Feasibility study completed by RAL, SEA Ltd. & Imperial College (UK) for GEO
Synergy:	NEXT mission: GPSRO
Cross-cutting:	Climate, Disasters

Multi-spectral Imagers

For ocean color & land imaging



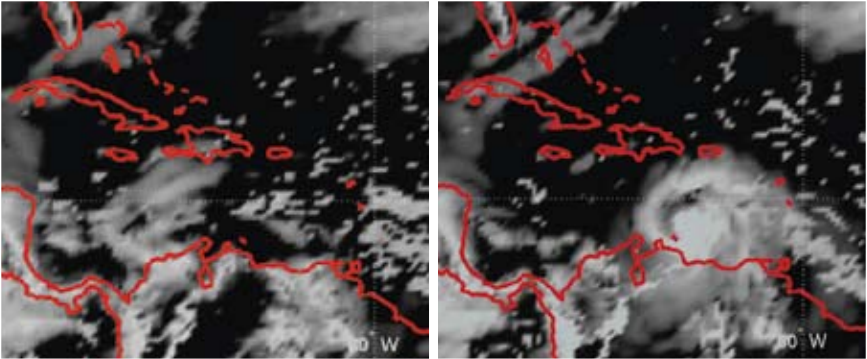
UPWELLING OF NUTRIENT RICH WATERS AND ASSOCIATED PHYTOPLANKTON BLOOMS (Off South Africa, May 2001)

Source: *The SeaWiifs Project, NASA/Goddard Space Flight Centre and Orbimage*

Number:	9 sensors for optimum revisit time
Description:	Multi-spectral; UV-VIS, 400 to 1040 nm
Swath:	250 km; 250 to 300m resolution
Time scales:	Ocean: 1 day Coastal diurnal variation; marine operations & fisheries 1 year Seasonal changes (N & S hemisphere) Land: 1 day Disaster remediation; wildfires 1 year Deforestation; desertification; crop monitoring; change in biodiversity Ice: 1 day Ice extent 1 year Seasonal and inter-annual changes in ice fields
Readiness:	Commercially available; minor development of MERIS. Feasibility study completed by ACRI (France), TAS (France) for GEO
Synergy:	NEXT mission: Altimeters
Cross-cutting:	Agriculture, Biodiversity, Climate, Disasters Ecosystems, Health, Water

GPS Radio Occultation

Sounding of atmospheric humidity & temperature and Space Weather

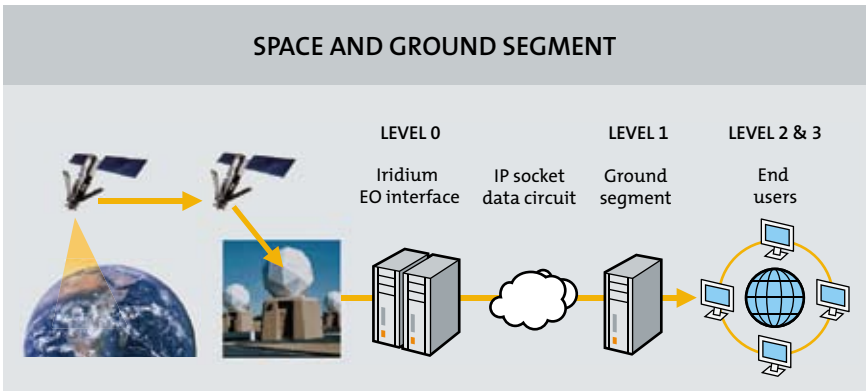


DEVELOPMENT OF HURRICANE ERNESTO.,
Aug 2006 Computer generated model without and with (right) COSMIC data.

Source: UCAR COSMIC visuals and media gallery; COSMIC News: Images courtesy Yongsheng Chen, NCAR, USA

Number:	Minimum 12 sensors, 24 recommended
Description:	GPS receivers; precise orbital determination
Swath:	Limb viewing; 600 soundings per satellite per day
Time scales:	The instruments provide accurate & precise global profiles of temperature and humidity at high temporal and spatial resolution Total electron content of ionosphere & density profiles for Space Weather <<1 hour Tracking extreme weather events, including hurricanes and high precipitation 1 hour Weather now-casting 1 week Weather forecasting 1 year Seasonal variations in the hydrologic cycle 10 year Climate variability and change in hydrologic cycle;
Readiness:	Stratosphere – troposphere exchange processes Commercially available; mission ready. Feasibility study completed by JPL-NASA (USA) for GEO
Synergy:	NEXT mission: Radiometers
Cross-cutting:	Climate, Disasters, Water, Weather

Ground Segment & Validation



- Level 0:** Data from the sensors on each satellite are fed through the Ka band cross-links that make up the constellation network, then down to the Iridium ground stations at Tempe, USA or Svalbard, Norway. The typical latency between sensing and receiving data at the ground station is 5 seconds and dedicated servers will immediately route the data on to Level 1 processors.
- Level 1:** The data may be received by as many data centres as are competent to process it. The raw data are calibrated, subjected to quality control, converted to a standard format and archived. The GEO community has the responsibility for this segment.
- Level 2:** The calibrated data are then passed on to the primary users on relevant time scales (i.e. near-real-time for early warning centres and now-casting or at intervals that suit the operational needs). This will fulfil the outreach requirements of GEOSS.
- Level 3:** Where there is added value to be gained from the data, the products may be sold to commercial enterprises for their own ends (e.g. merging and binning data from different sensors).
- Validation:** The Iridium constellation offers the unique possibility of data validation in real-time by using the constellation data communications functions, whereby remote platforms on the Earth's surface (land, ice or sea) and in the atmosphere can transmit data directly to the observing satellite overhead. Likewise, programs can be downloaded to the remote platforms from laboratories via the satellite network. This is a very powerful tool for calibration and the control of data quality.