Harvey Lisz



Satellite Coordination Issues

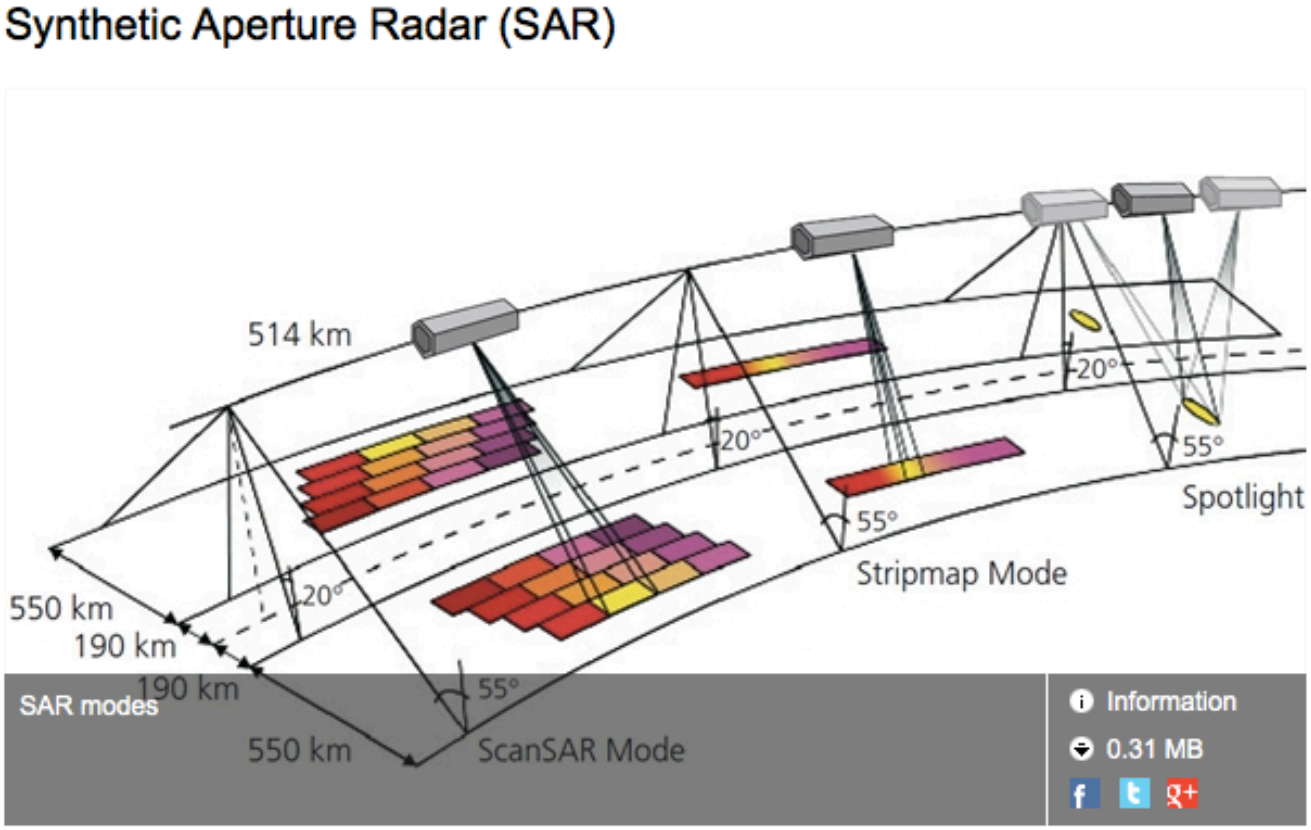
Harvey Liszt
ALMA & NRAO, CHARLOTTESVILLE

Several kinds of Issue

- Interference into RAS bands from outside
  - Iridium MSS 1616–1626 ➔RAS 1610.6-1613.8
  - GLONASS RNSS 1593-1610 ➔RAS 1610.6-1613.8
- Dangerous transmission between RA bands
  - CloudSat 94-94.1 GHz cloud radar
- Powerful orbiting broadband EESS radars, until now well-separated from RAS rcvrs
  - Broad allocations over wide frequency range
  - RAS has no rights to this spectrum …
    - Though expanding it further begins to impinge

I. Orbiting EESS(active) SAR

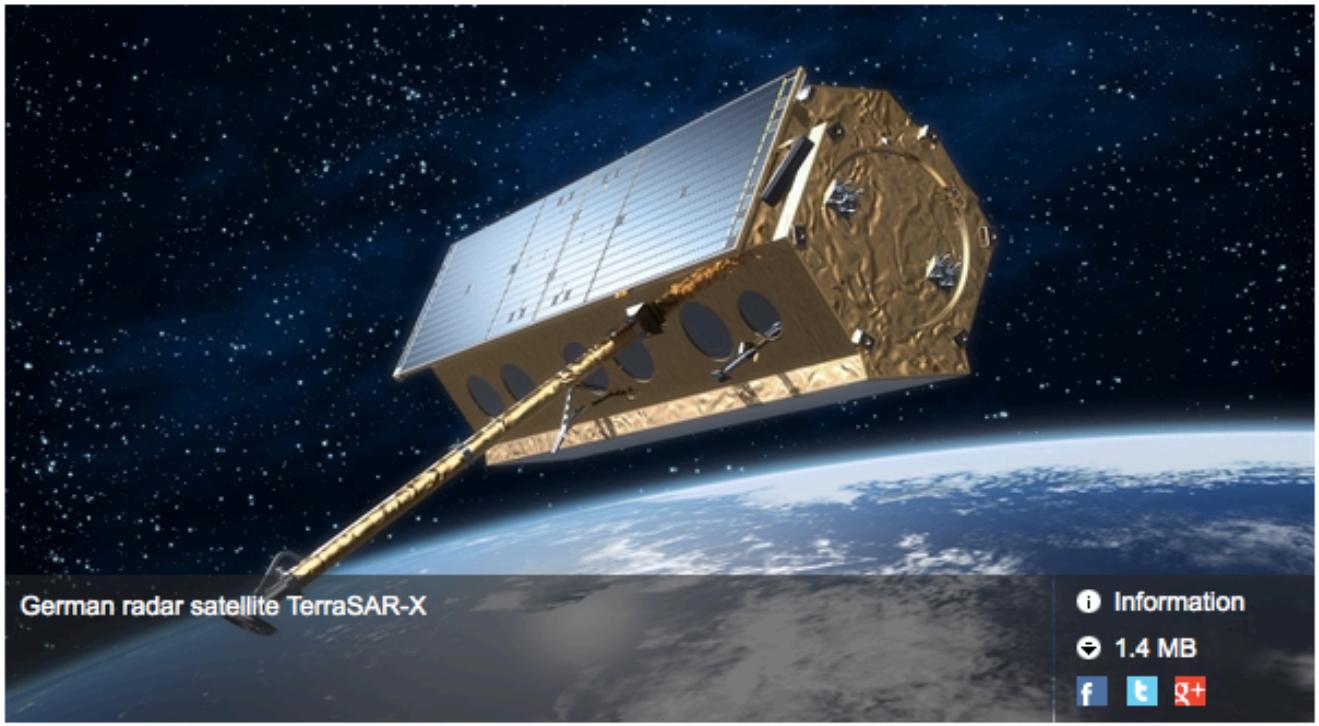
Powerful imaging radars in various bands over much of the spectrum above 1 GHz



Orbiting EESS SAR *etc.*

Powerful imaging radars in various bands over much of the spectrum above 1 GHz

TerraSAR-X - Germany's radar eye in space



Orbiting EESS SAR *etc.*

RAS cannot modify its antenna control systems to avoid looking at all these satellites, cones of avoidance too large, numerous, fast-moving

RAS can only avoid these radars completely by not receiving photons in their bands

This was not a problem in the past because RAS receiver bandwidths were small

Orbiting EESS SAR *etc.*

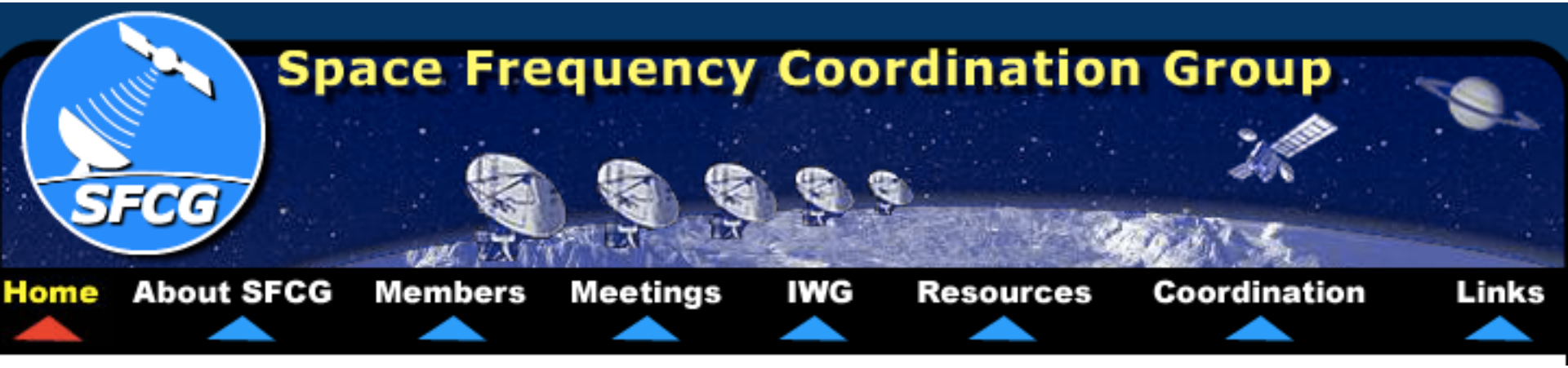
AI 1.12 (WRC15) will broaden the 9300 - 9900 MHz allocation by 600 MHz

9300-9500
EARTH EXPLORATION-SATELLITE (active)
SPACE RESEARCH (active)
RADIOLOCATION
RADIONAVIGATION
5.427 5.474 5.475 5.475A 5.475B 5.476A

9500-9800
EARTH EXPLORATION-SATELLITE (active)
SPACE RESEARCH (active)
RADIOLOCATION
RADIONAVIGATION
5.476A

9800-9900
RADIOLOCATION
Earth exploration-satellite (active)
Space research (active)
Fixed
5.477 5.478 5.478A 5.478B

https://www.sfcgonline.org



Active Sensor Information for Radio Astronomers

At SFCG-30, the SFCG agreed to assist radio astronomers in protecting their sensitive receivers from damaging interference from spaceborne radars used for Earth observation and remote sensing by providing useful links and related information.

Active Sensors Look-Up Table

Currently Operational Spaceborne Active Sensor Missions (Updated: June 2011)				
Mission	**Agency**	**ITU Name**	**Frequency (MHz)**	**Radiated Power (W)**
Aquarius Scatterometer	NASA	AQUARIUS	1260	200
ERS-2 SAR/WS /RA[1]	ESA	ERS-1	5300/5300/13800	4800/4000/134
RADARSAT-1/2 SAR	CSA	RADARSAT-1A RADARSAT-2C RADARSAT-2D RADARSAT-2E RADARSAT-2F	5300	5000
ENVISAT ASAR/RA-2	ESA	ENVISAT	5300/13575, 3200	4800/114, 65
COSMO-SkyMed	ASI	COSMO SKYMED	9600	2800
TerraSAR-X SAR	DLR	TERRASAR	9650	2260
JASON-1 (OSTM) SSALT	CNES	PROTEUS-TPFO	5300, 13575	25, 7
JASON-2 (OSTM) SSALT	CNES	JASON2	5300, 13575	25, 8
MetOp ASCAT	ESA/EUMETSAT	METOP	5300	120
QUIKSCAT SEAWINDS[2]	NASA	QUIKSCAT	13400	110
TRMM PR	NASA/JAXA	TRMM	13800	518
CLOUDSAT CPR	NASA	USCLOUDSAT	94050	1500

This table is also available in MS-Word format. Additional information on Envisat and Metop sensors is also available. At SFCG-31, document SF31-9DR1 on "Potential Damage to RAS Sites by EESS (active) Systems" was presented by NASA providing calculations of the power levels received vis-à-vis power levels given in Report ITU-R RA.2188.

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RADARSAT-1/2 SAR	CSA	RADARSAT-1A RADARSAT-2C RADARSAT-2D RADARSAT-2E RADARSAT-2F	5300	5000
ENVISAT ASAR/RA-2	ESA	ENVISAT	5300/13575, 3200	4800/114, 65
COSMO-SkyMed	ASI	COSMO SKYMED	9600	2800
TerraSAR-X SAR	DLR	TERRASAR	9650	2260
JASON-1 (OSTM) SSALT	CNES	PROTEUS-TPFO	5300, 13575	25, 7
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https://www.sfcgonline.org

SF31-9DR1

Table 8 – Comparison of Typical Power Flux Density Levels at Earth's Surface with RAS Threshold Values

Parameter	Sensor type				
	SAR	Altimeter	Scatterometer	Precipitation radars	Cloud profile radars
Radiated power (W)	4400	20	4000	1013	1500
Antenna gain (dB)	36.4	43.3	34	47.7	63.4
Orbital altiude (km)	225	1 336	785	400	705
Incidence Angle (deg)	21	0	32	0	0
PFD (dB(W/m^2))	-45.8	-77.2	-50.4	-45.3	-32.7
RAS Threshold (dB(W/m^2))	-60	-60	-60	-60	-45
Margin (dB)	-14.2	+17.2	-9.6	-14.7	-12.3

https://www.sfcgonline.org

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II. CloudSat 94-94.1 GHz EESS

Powerful nadir-pointing cloud-mapping radar in narrow slice between RAS bands

CloudSat 94-94.1 GHz EESS

Powerful nadir-pointing radar in narrow spectrum slice between RAS bands

92-94
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION

5.149

94-94.1
EARTH EXPLORATION-SATELLITE (active)
RADIOLOCATION
SPACE RESEARCH (active)
Radio astronomy

5.562 5.562A

94.1-95
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION

5.149

CloudSat 94-94.1 GHz EESS

Powerful nadir-pointing radar in narrow spectrum slice between RAS bands

RAS must avoid looking near zenith when CloudSat passes anywhere near overhead

Easy in principle, but movable antennas are transported only when pointing straight up

Most online antenna control systems track CloudSat using current TLE & have alarms

CloudSat 94-94.1 GHz EESS

Also a terrestrial weapon known as the "active denial system"

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Developed by Raytheon in Tucson not far from the ARO 12m telescope on Kitt Peak!

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Raytheon asked for an STA to drive the ADS in the hills near the telescope!

CloudSat 94-94.1 GHz EESS

Also a terrestrial weapon known as the "active denial system"

NSF was funding a bunch of guys who were flying a totally UNLICENSED 94 GHz transmitter below the CloudSat track

Developed by Raytheon in Tucson not far from the ARO 12m telescope on Kitt Peak

Raytheon asked for an STA to drive the ADS in the hills near the telescope!

CloudSat 94-94.1 GHz EESS

JPL contacted NRAO in 2005, had to stay in US because of ITAR issues …

At a time when the US wanted to classify orbital elements!

NRAO publicized CloudSat to RAS as soon as possible, well before launch

RAS took many actions, in concert with JPL and EESS

CloudSat 94-94.1 GHz EESS

JPL organized an informational website with orbit predictions

ALMA published memo 504, 1st mention of destruction of RAS receiver

IUCAF set up a website and negotiated a coordination agreement with SFCG

IRAM wrote a detailed report for CRAF

ARO 12m results were shown at CORF

www.iucaf.org/CloudSat

Radio Astronomy and CloudSat

Radio Astronomy and Clo... | The New York Times - Bre... | patricia ready santiago - ... | P2GBestPractices < DSO/... | Cycle2P2G < DSO/Cycle2 ... | P2Gf2fApril2014 < DSO <...

www.iucaf.org/CloudSat/

patricia ready santiago

Radio Astronomy and CloudSat

This page in MSWord | Search the Web

Contact JPL | Contact IUCAF | Contact NRAO

IUCAF / IUCAF-CloudSat /

Radio Astronomy & CloudSat

About CloudSat

JPL Technical Info
ALMA Memo 504
CloudSat Home

CLOUDSAT ORBIT

Orbit Main Page

TLE New+Archived

Overpass prediction

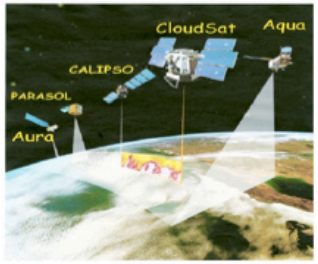
Non-Cloudsat TLE

Space-track.org
Why Space-track?

Access & tools *via* Celestrak *(easier)*

Celestrak Home
Orbit Elements (TLE)
Orbit Codes

PocketSat+ (PDA's)



21 Sept 2011 -- Cloudsat is reconfiguring after a period of inactivity

Cloudsat, the 94 GHz cloud orbiting radar, has been off the air since April after suffering a spacecraft battery anomaly. Tests are nominally scheduled to begin next week to determine whether it can be brought back into service. There are several important changes in CloudSat operation associated with these events.

Although at about the same altitude, CloudSat is no longer part of the so-called A-train of satellites, and hence no longer has the old 16-day repeating orbit. Orbital elements (the so-called TLE) may be downloaded and used as before and the NASA orbital website is still operational (see links below).

Because of the power supply issues, CloudSat will no longer be able to operate in eclipse, i.e. when the earth under it is in nighttime. It might still be visible at night, while emitting in daylight, at very low elevations.

The satellite is still pointed downward near the nadir, but its variability is no longer controlled to within 1 degree of the nadir. Its deviation from the nadir is somewhat uncertain and could be as large as 6 degrees, although the engineers are hoping to eventually fix this and return control to within 1 degree of nadir. This means that the cone of avoidance is much larger than before and NASA suggests that radio telescopes might wish to cease 94 GHz operations during the daytime if they cannot ensure avoidance of this wider cone.

CloudSat orbiting, radar operates 2 June 06, see CloudSat home page, &/or use links at left here for orbit & overpass info

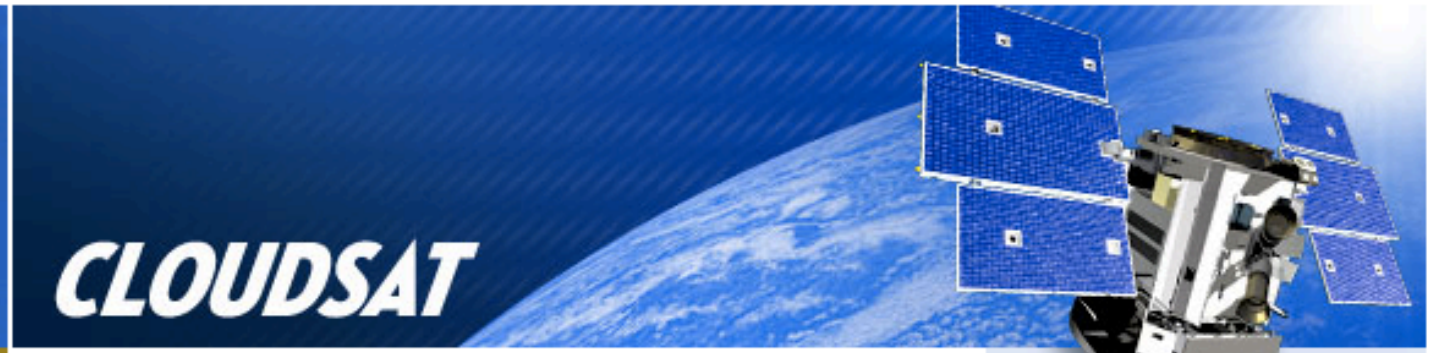
http://cloudsat.atmos.colostate.edu/

Colorado State University — Department of Atmospheric Science

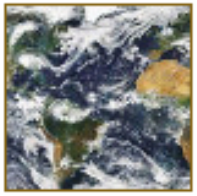
NASA — Jet Propulsion Laboratory, California Institute of Technology

+ NASA Home Page
+ NASA CloudSat Portal

JPL HOME | EARTH | SOLAR SYSTEM | STARS & GALAXIES | SCIENCE & TECHNOLOGY



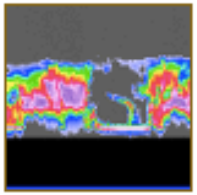
- Home
- Overview
- Mission
- Instrument
- News
- Data
- Cloud Art
- Publications
- Education
- Science Team



7 MARCH 2014 | *CloudSat* News Article

Cloudy Forecast

The biggest source of climate uncertainty is white and fluffy.



18 OCTOBER 2013 | *CloudSat* Overpass

Typhoon Francisco

CloudSat intersects just west of the eye of Typhoon Francisco on October 17, 2013 in the West Pacific.

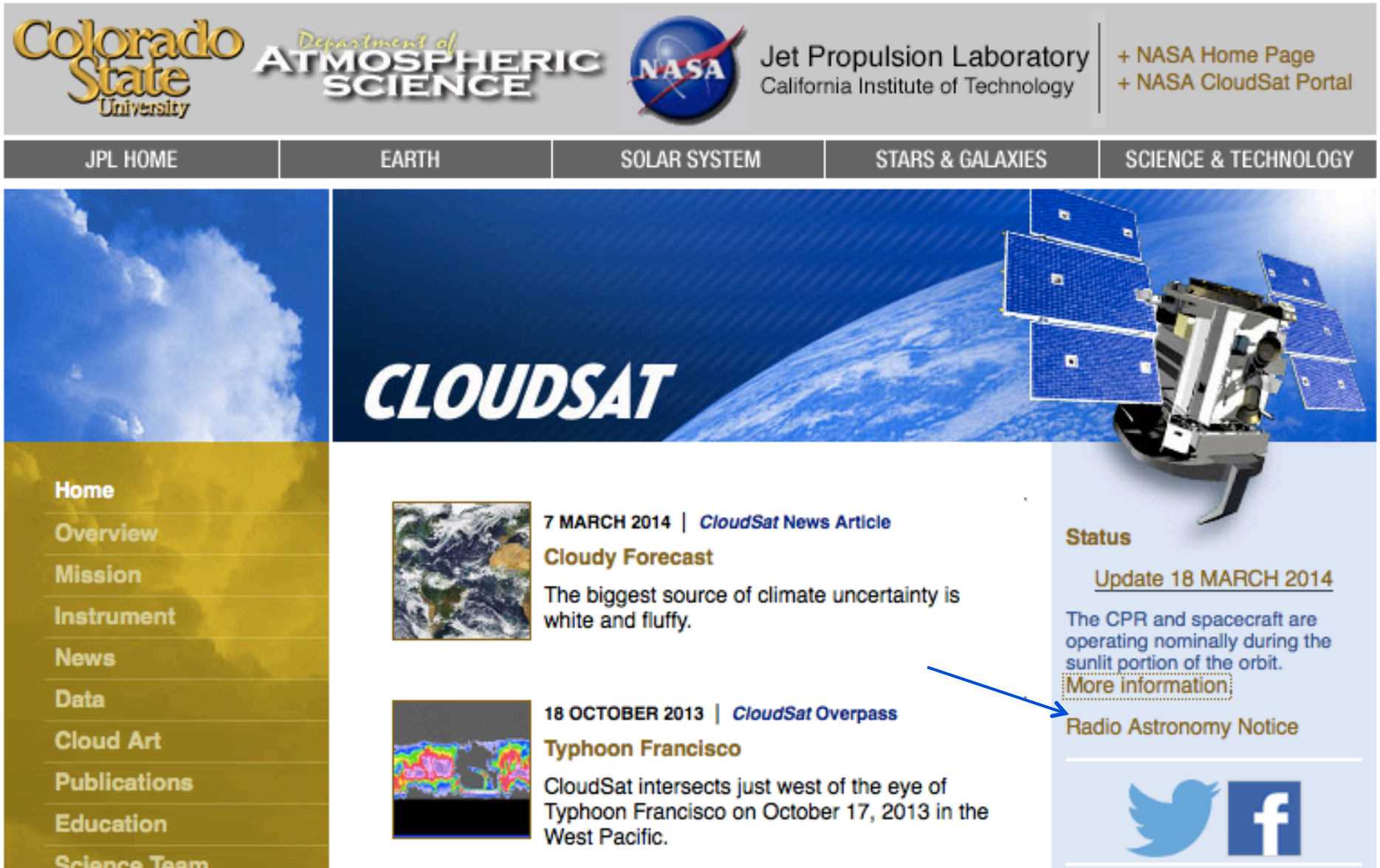
Status

Update 18 MARCH 2014

The CPR and spacecraft are operating nominally during the sunlit portion of the orbit.
More information

Radio Astronomy Notice

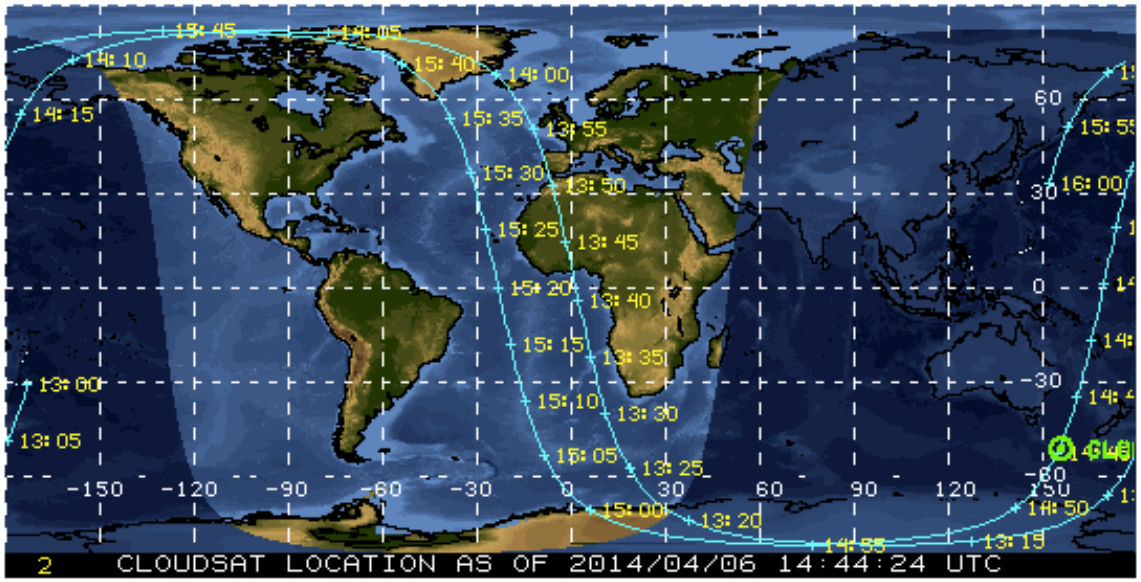
http://cloudsat.atmos.colostate.edu/



www-angler.larc.nasa.gov/cloudsat/

CloudSat Orbital Prediction

CloudSat location on 2014/04/06 14:44:24 UTC: Lat=-50:24:15 Lon=155:37:27



Where is CloudSat? Click here to track current position *(updates every 60 sec)*

CloudSat Orbital Prediction Tools

- **Daily Ground Track Plots (GIF format)**
- **Daily Ground Track Files (ASCII format)**
- **Calculate CloudSat closest approach estimate to radio astronomy sites**

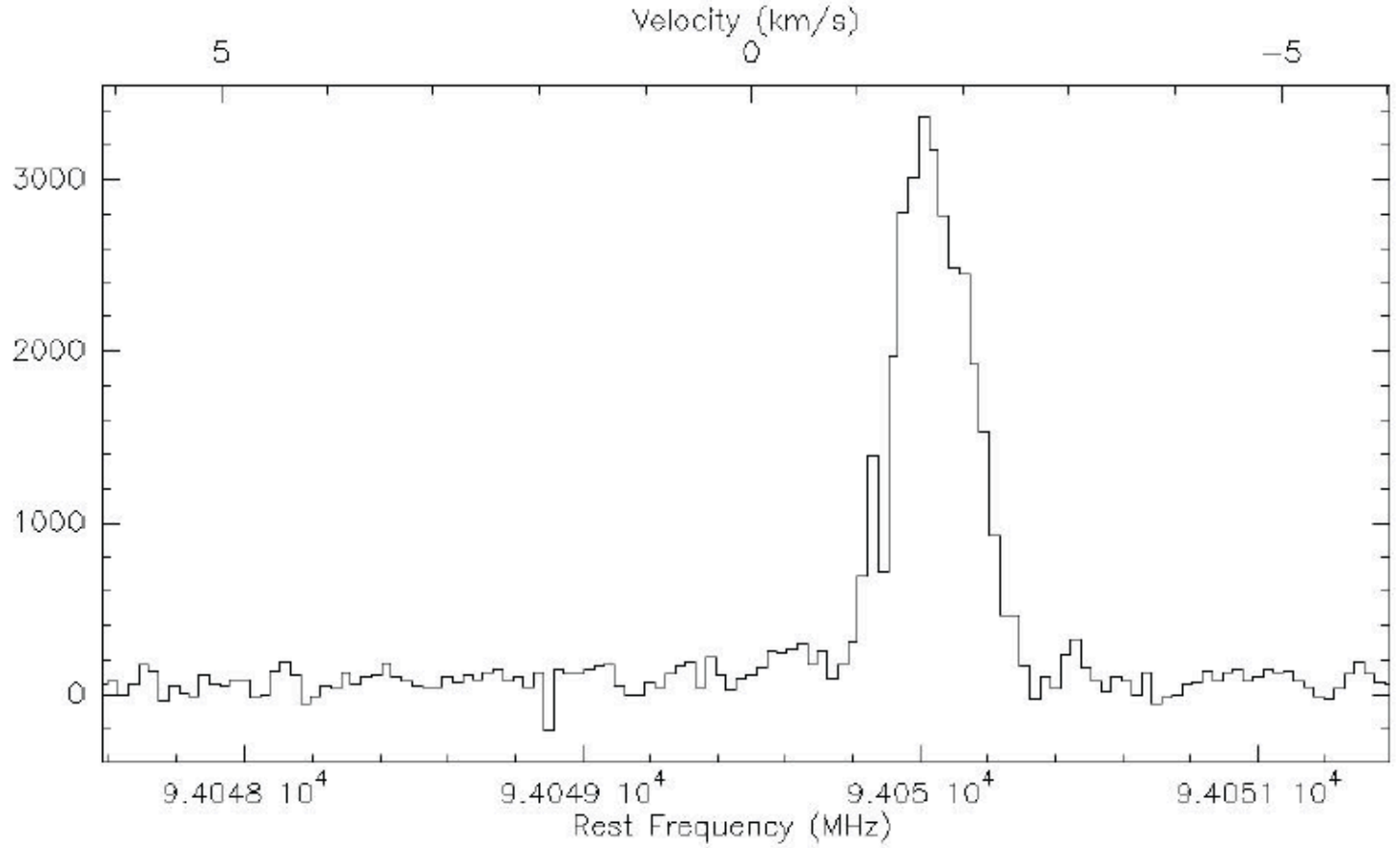
But can RAS really see CloudSat?

But can RAS really see CloudSat?

HELL, YES!

CloudSat 94-94.1 GHz EESS

A scan from the ARO 12m at large offset, pulse sidelobes are not visible on this scale



RECOMMENDATION ITU-R RA.1750

Mutual planning between the Earth exploration-satellite service (active) and the radio astronomy service in the 94 GHz and 130 GHz bands

recommends

1 that as early as possible in the design cycle of such an EESS (active) cloud radar system, contact should be established between the EESS (active) designers and operators and with radio astronomy sites – the international organization IUCAF may provide the initial link between the EESS operators and potentially affected radio astronomy observatories;

2 that close contact between radio astronomers and the operators of the EESS (active) system should be maintained throughout the design and operational life-cycles of all systems which are subject to sharing in the 94 GHz and 130 GHz bands such that each party is apprised of pertinent developments within the other;

3 that the design and operation of systems operating in each service should be performed so as to account for sharing to the greatest practicable extent;

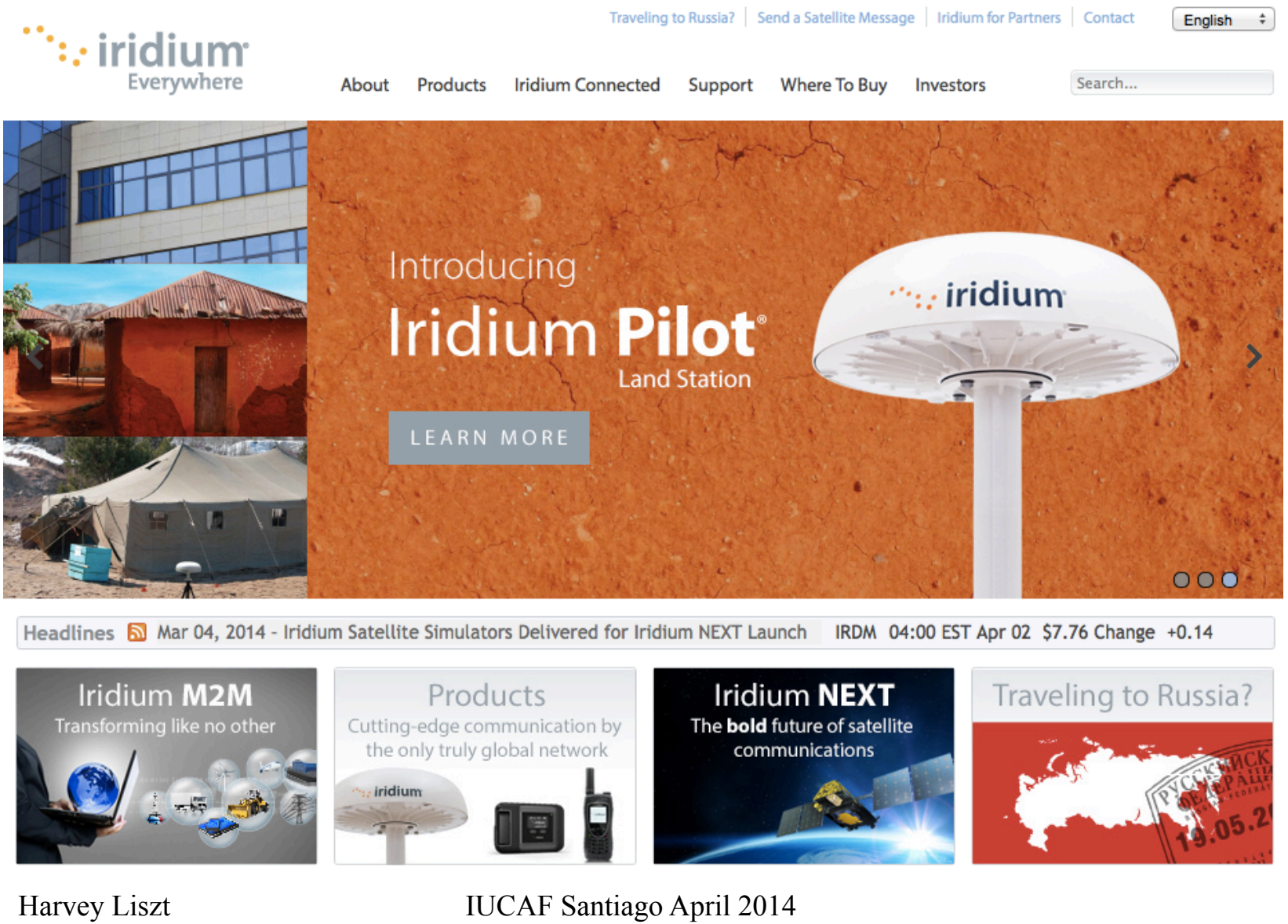
4 that the considerations relevant to sharing given in Annex 1 should be taken into account in the design and operations of such systems;

5 that the example provided in Annex 2 of the impact upon one instrument operating in the radio astronomy service from one satellite operating in the EESS (active) should be taken into account in the design and operation of stations of both services.

Questions for EESS

- Isn't it time to trigger RA. 1750 for the EarthCare mission?
- What is the right way to do that?

III. Interference - Iridium



III. Interference - Iridium

RR 5.372. Harmful interference shall not be caused to stations of the radio astronomy service using the band 1610.6-1613.8 MHz by stations of the radiodetermination-satellite and mobile-satellite services (No. 29.13 applies).

29.13 § 10 Administrations shall take note of the relevant ITU-R Recommendations with the aim of limiting interference to the radio astronomy service from other services.

III. Interference - Iridium

- MSS first launched mid-late 90's
  - Iridium TDMA up, down links 1621-1626 MHz
  - Globalstar CDMA uplink at 1610 – 1618
- Both went bankrupt in early 2000's
  - Iridium caused loss of US $7,000,000,000 to Motorola, other parties
- On the eve of de-orbiting, Iridium was bought by a shady venture capital fund
- Lower edge of Iridium operating band now 1617.8 MHz, may go to 1616 MHz

Interference to RAS - Iridium

- Early tests at NRAO showed RFI from high-order intermodulation products
  - Despite promises of no interference to RAS
- NRAO and NAIC signed coordination agreements to regain partial RFI-free use
- CRAF signed agreement w/ promise of RFI free operation over Europe starting 2006
- VLA had to stop observing 1612 MHz because of other incompatibilities, *not* RFI, a LightSquare - like issue

Regulatory response - Iridium

RESOLUTION 739 (Rev.WRC-07)

Compatibility between the radio astronomy service and the active space services in certain adjacent and nearby frequency bands

invites administrations

1 to take all appropriate and practicable steps, from the design phase onward, to ensure that unwanted emissions are minimized from space stations that are planned to operate in one or more space service allocations, in order to avoid exceeding the threshold levels of unwanted emissions identified in Annex 1 at any radio astronomy station;

Regulatory response - Iridium

RESOLUTION 739 (Rev.WRC-07)

Compatibility between the radio astronomy service and the active space services in certain adjacent and nearby frequency bands

resolves

1 that an administration takes all reasonable steps to ensure that any space station or satellite system being designed and constructed to operate in the bands in Annex 1 meets the values given therein at any radio astronomy station operating in the corresponding bands identified in this Annex;

2 that in the event that during construction and prior to launch it is determined that, after having considered all reasonable means, the unwanted emissions from the space station or satellite system cannot meet the values given in Annex 1, the administration that notified the space station or satellite system contacts, as soon as possible, the administration operating the radio astronomy station to confirm that *resolves* 1 has been fulfilled, and the concerned administrations enter into a consultation process in order to achieve a mutually acceptable solution;

Regulatory response - Iridium

TABLE 1-2

epfd thresholds[(1)] for unwanted emissions from all space stations of a non-GSO satellite system at a radio astronomy station

RNSS (space-to-Earth)[(3)]	1 559-1 610	1610.6-1 613.8	NA	NA	–258	20	–230	20	WRC-07
MSS (space-to-Earth)	1525-1559	1610.6-1613.8	NA	NA	–258	20	–230	20	WRC-07
MSS (space-to-Earth)	1 613.8-1626.5	1610.6-1613.8	NA	NA	–258	20	–230	20	WRC-03

NA: Not applicable, measurements of this type are not made in this band.

(1) These epfd thresholds should not be exceeded for more than 2% of time.

(2) Integrated over the reference bandwidth with an integration time of 2000 s.

(3) This Resolution does not apply to current and future assignments of the radionavigation-satellite system GLONASS/GLONASS-M in the band 1559-1610 MHz, irrespective of the date of reception of the related coordination or notification information, as appropriate. The protection of the radio astronomy service in the 1610.6-1613.8 MHz band is ensured and will continue to be in accordance with the bilateral agreement between the Russian Federation, the notifying administration of the GLONASS/GLONASS-M system, and IUCAF, and subsequent bilateral agreements with other administrations.

What's the Iridium problem now: I

Iridium continues to generate well-documented detrimental RFI

ECC Report 171 available at

http://www.erodocdb.dk/doks/doccategoryECC.aspx?doccatid=4

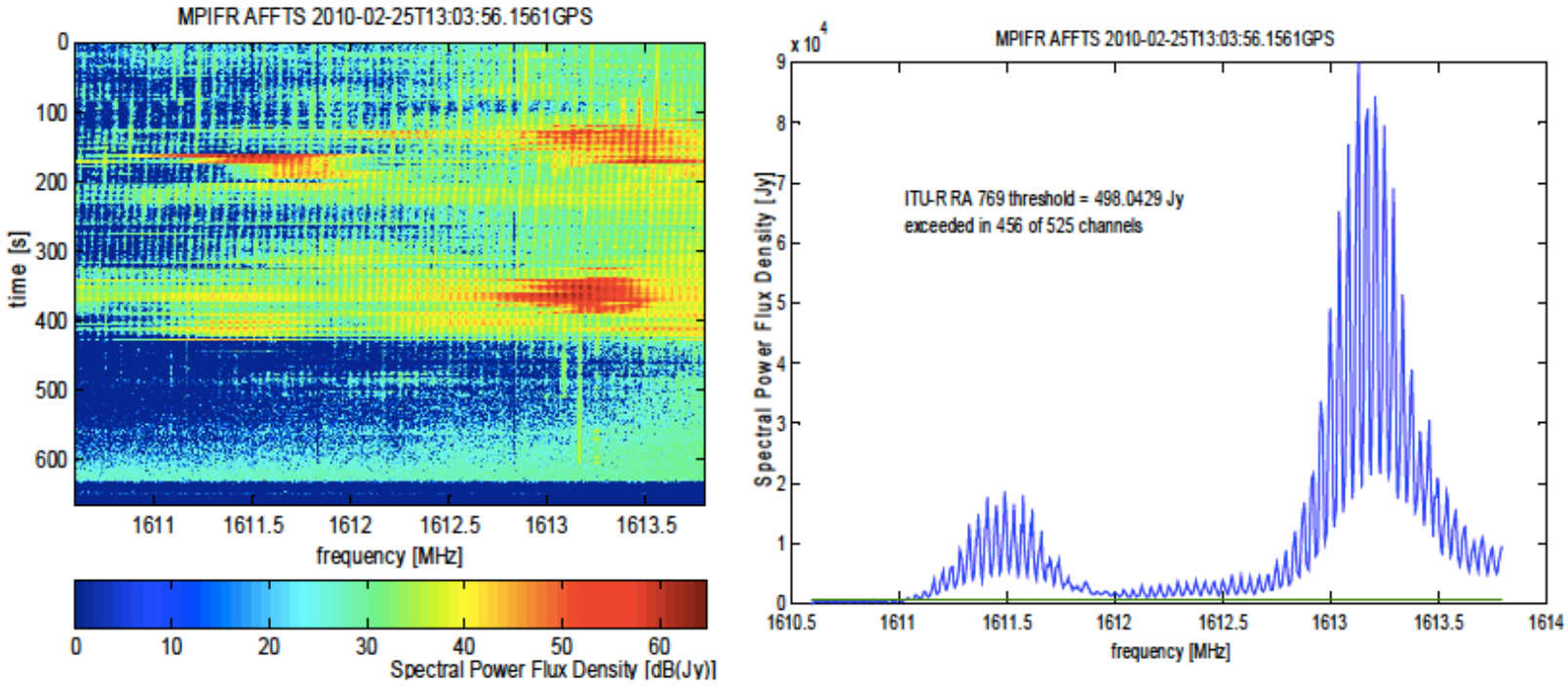


Figure 11: Calibrated spectrogram (left) and average spectrum (right) of Iridium 97 unwanted emissions in the band 1610.6-1613.8 MHz

What's the Iridium problem now: II

Iridium and the FCC have not responded to ECC complaints about RFI from the existing constellation

What's the Iridium problem now: III

Iridium designed a new generation of satellites without consulting RAS

What's th em now: III

Iridium 360°

Connecting in more ways than ever

< Previous Next >

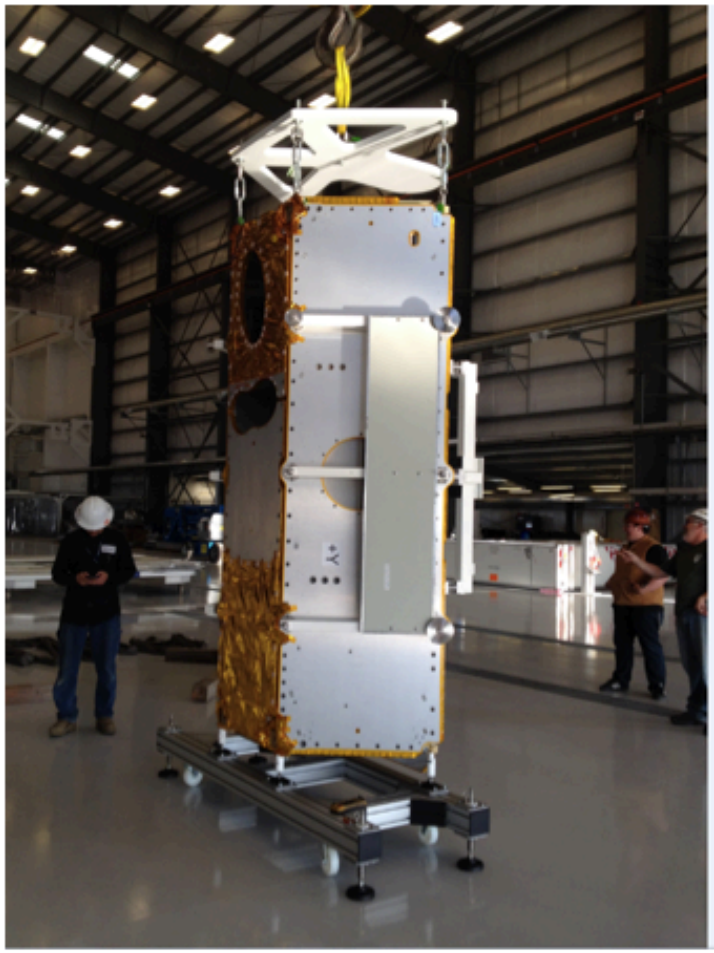
Iridium NEXT 'rockets' from design to testing in latest milestone achievement

March 4, 2014 | Iridium | no comments

Tweet 7 Like 3 Share 27 Print PDF

Today, we're happy to announce the Iridium NEXT constellation has reached an important milestone, moving the project from the design phase and into testing and launch preparedness. Thales Alenia Space has delivered two complete high-fidelity satellite simulators and a number of low-fidelity simulators to our launch partner SpaceX. The simulators, representing satellite flight units, are the exact volume, have the same mechanical interface and mass properties of actual satellites and will be used in a variety of launch tests.

The completion of this milestone is testament to our continued progress toward the launch of Iridium NEXT. After years of hard work and planning with our Iridium NEXT Mission Team partners, we're excited to see the program coming together. Read more about the simulators here.



Harvey Liszt

What's the Iridium problem now: IV

Iridium and the FCC have not responded to a CRAF/IUCAF letter detailing concerns about lack of consultation

What's the Iridium problem now: V

Iridium has indicated to CRAF and NSF that the new constellation will not operate RFI-free at all times due to operational costs to Iridium

What's the Iridium problem now: VI

Iridium is trying to impose 3-day advance notice to ensure temporary, localized freedom from RFI

What's the Iridium problem now: VII

In the US, this is what's known as "spectrum sharing"

One man's spectrum sharing is another man's harmful interference

What's the Iridium problem now:VIII

In the US, this is what's known as "spectrum sharing"

One man's spectrum sharing is another man's harmful interference

RR 5.372. Harmful interference shall not be caused to stations of the radio astronomy service using the band 1610.6-1613.8 MHz by stations of the radiodetermination-satellite and mobile-satellite services (No. 29.13 applies).

§ 25.213(a)(2)
Mobile-Satellite Service space stations transmitting in the 1613.8-1626.5 MHz band shall take whatever steps necessary to avoid causing harmful interference to the radio astronomy facilities listed in paragraphs (a)(1)(i) and (ii) of this section during periods of observation

What's the Iridium problem now:IX

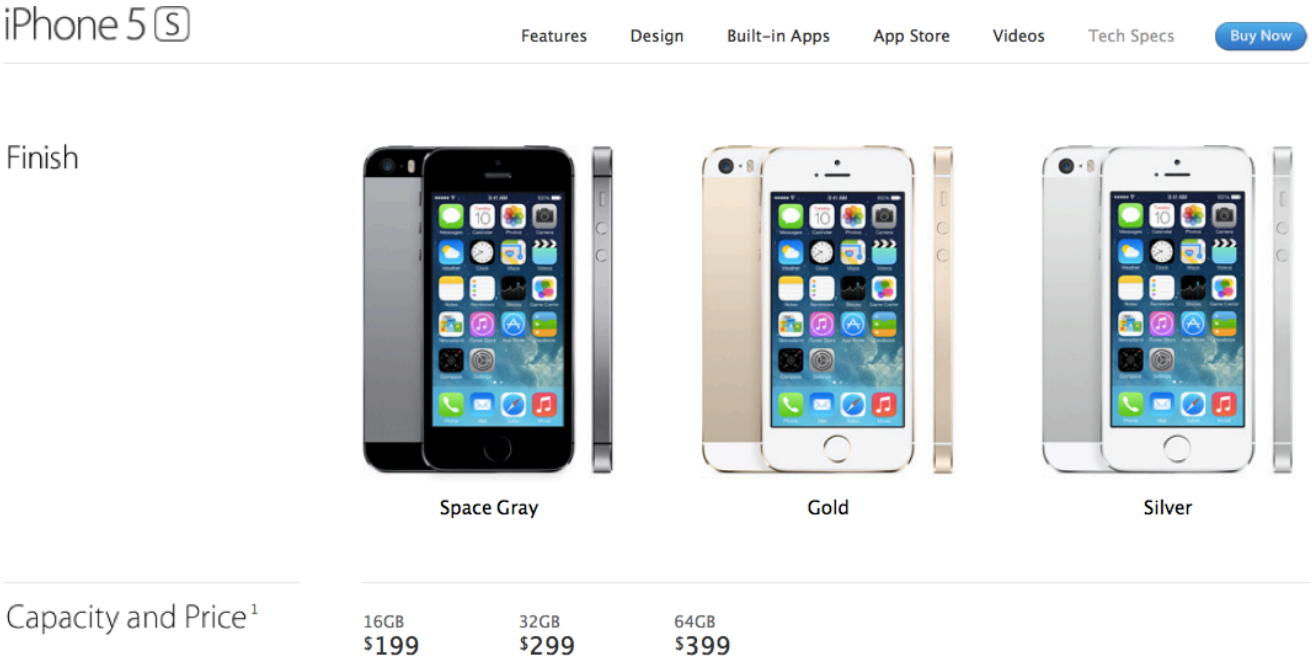
In short, Iridium is trying to impose the US rules and extended spectrum use on the rest of the world, while also interpreting "during periods of observation" to its own advantage

Interference to RAS - GLONASS

- Summary memoir in 2002 by R. Jim Cohen
- iPhones now have GLONASS receivers

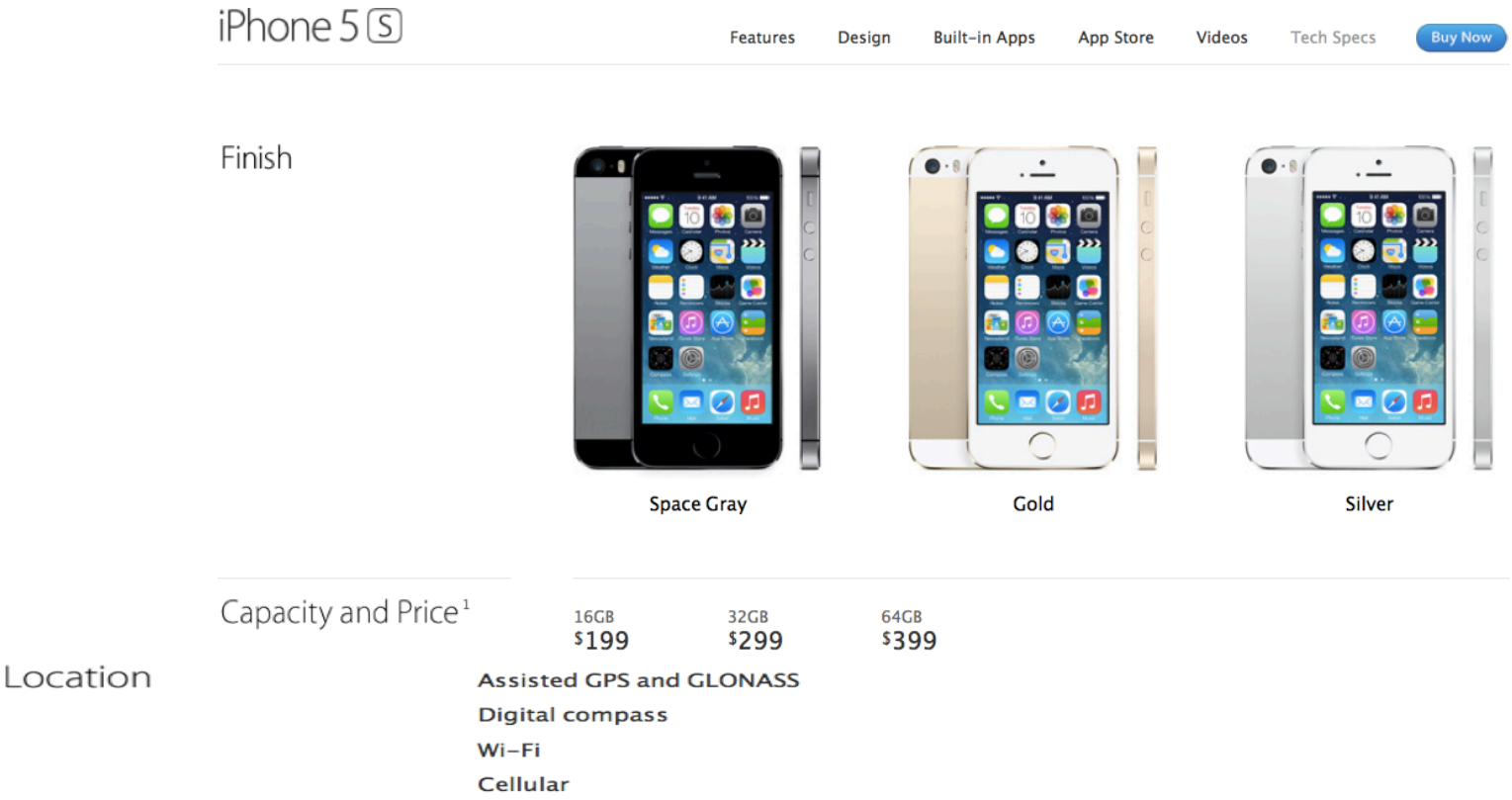
Interference to RAS - GLONASS

- Summary memoire in 2002 in R. Jim Cohen
- iPhones now have GLONASS receivers



Interference to RAS - GLONASS

- Summary memoire in 2002 in R. Jim Cohen
- iPhones now have GLONASS receivers- really



Interference to RAS - GLONASS

- GLONASS operating over Region 2 now

Interference to RAS - GLONASS

- GLONASS operating over Region 2 now

A Russian GPS Using U.S. Soil Stirs Spy Fears

Pedro Ladeira/Agence France-Presse — Getty Images

A technician from Russia's space agency at a monitor station that opened in Brazil.

By MICHAEL S. SCHMIDT and ERIC SCHMITT
Published: November 16, 2013

WASHINGTON — In the view of America's spy services, the next

FACEBOOK

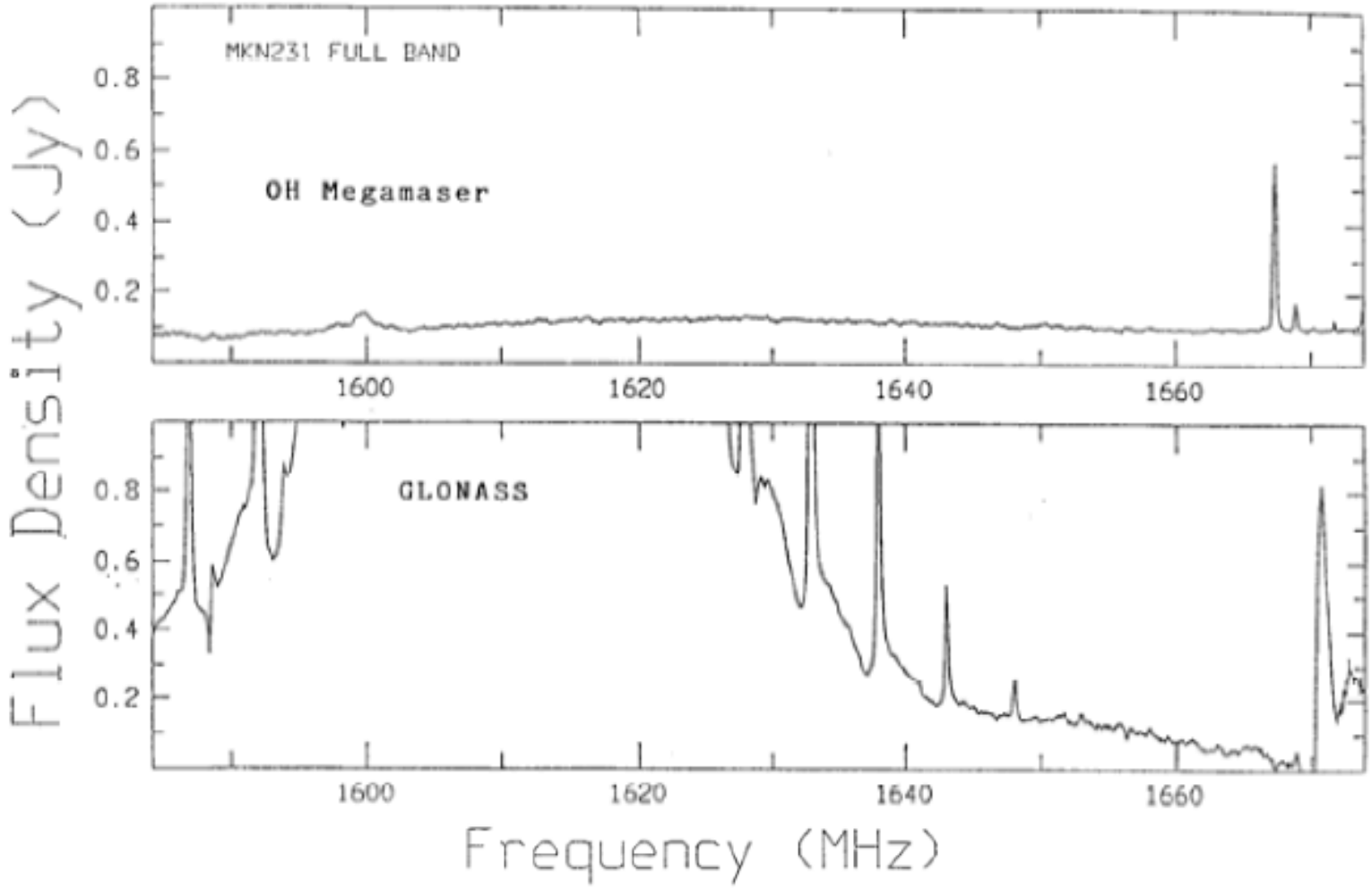
Harvey

Interference to RAS - GLONASS

- Summary memoire in 2002 in R. Jim Cohen
- iPhones now have GLONASS receivers
- GLONASS operated, interfered in1982
  - Before RAS had a primary allocation at 1612
  - RFI at 1660 – 1670 MHz where RAS primary
- RAS allocation at 1612 MHz upgraded to primary in 1992 to protect from RNSS *etc*.

Interference to RAS - GLONASS

- Massive interference during 1992 campaign



Interference to RAS - GLONASS

- Consent agreements in 1993, 2002 w/IUCAF

Fig. 5. Willem Baan signing the GLONASS-IUCAF accord in Moscow, 4th November 1993. Jim Cohen and John Ponsonby from the IUCAF delegation are standing behind. General Vladimir Durnev, head of the GLONASS delegation, is seated holding his papers; the lady is Nina Labusova, the translator.

Interference to RAS - GLONASS

- GLONASS changed their operating channels
- By 2006, RFI only at lower edge of RAS band but GLONASS dug in their heels and refused to pursue further mitigation
  - "Filters failed to work in vacuum of space"
  - Said they had fulfilled agreements with IUCAF
  - Succeeded in being exempted from Res. 739 at WRC-07
    - not one administration supported RAS at WRC

Regulatory response - GLONASS

TABLE 1-2

epfd thresholds[(1)] for unwanted emissions from all space stations of a non-GSO satellite system at a radio astronomy station

RNSS (space-to-Earth)[(3)]	1 559-1 610	1610.6-1 613.8	NA	NA	–258	20	–230	20	WRC-07
MSS (space-to-Earth)	1525-1559	1610.6-1613.8	NA	NA	–258	20	–230	20	WRC-07
MSS (space-to-Earth)	1 613.8-1626.5	1610.6-1613.8	NA	NA	–258	20	–230	20	WRC-03

NA: Not applicable, measurements of this type are not made in this band.

(1) These epfd thresholds should not be exceeded for more than 2% of time.

(2) Integrated over the reference bandwidth with an integration time of 2000 s.

(3) This Resolution does not apply to current and future assignments of the radionavigation-satellite system GLONASS/GLONASS-M in the band 1559-1610 MHz, irrespective of the date of reception of the related coordination or notification information, as appropriate. The protection of the radio astronomy service in the 1610.6-1613.8 MHz band is ensured and will continue to be in accordance with the bilateral agreement between the Russian Federation, the notifying administration of the GLONASS/GLONASS-M system, and IUCAF, and subsequent bilateral agreements with other administrations.

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GLONASS-M exempted

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GLONASS has been allowed to pretend that it and IUCAF formall concluded their arrangement