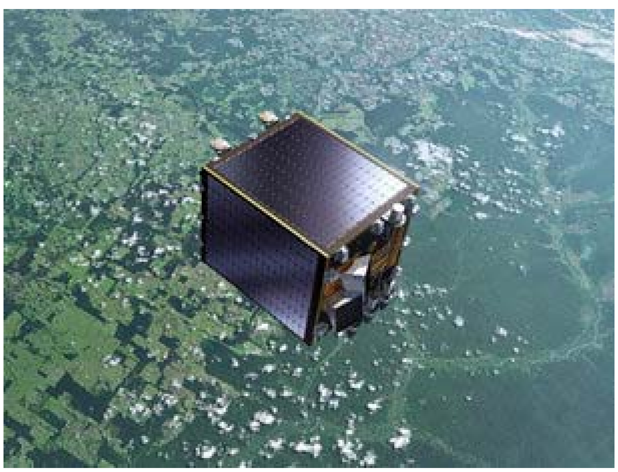
USN Support of Proba-V in North Pole Alaska

Universal Space Network (USN) has been contracted to provide additional ground station support for the Proba-V mission from the USN North Pole Alaska ground station. This support is receive only. USN maintains an array of large aperture tracking antennas at this station. USN is supporting the Proba-V downlink today under an FCC Special Temporary Authority (STA) and is pursuing a receive only license for the life of the mission.

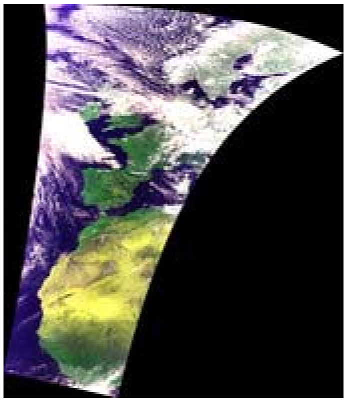
Universal Space Network
Address: 1465 Bradway Road, North Pole, Alaska 99705
Phone number: 907-490-3064
Latitude: 64° 48’ 16.61” North
Longitude: 147° 30’ 0.87” West
Altitude:146 meters MSL

About Proba-V

Proba-V is a vegetation imaging satellite launched by the European Space Agency. The spacecraft is norad ID = 39159 and registered by France with the ITU.



Proba-V satellite
The Proba-V satellite may only be slightly larger than a washing machine, but it is tasked with a full-scale mission. This miniature satellite is designed to map land cover and vegetation growth across the entire globe every two days. Over the last decade 'Proba' has become synonymous with small high-performance satellites, designed around innovation. The two previous satellites in the series were demonstration missions to give promising technologies an early chance to fly in space. They were overseen by ESA’s Directorate of Technical and Quality Management. Although designed as a demonstration mission, the success of the first Proba satellite led to it being operated as an Earth observation Third Party Mission. Proba-1 carries a high-resolution imaging spectrometer.



Vegetation swath
Proba-V, however is different from the outset: this new mission will start serving as an operational Earth observation mission as soon as its six-month commissioning phase is complete, supplying data to an existing – and eagerly waiting – international user community. The 'V' stands for Vegetation – a lighter but fully functional redesign of the 'Vegetation' imaging instrument previously flown on France's full-sized Spot-4 and Spot-5 satellites.

Launched on 7 May 2013, Proba-V has been designed to continue the supply of this much needed imagery for applications such as climate impact assessments, water resource management, agricultural monitoring and food security estimates.

Analysis

Proba-V is an NGSO space station in an 820 Km altitude orbit at an inclination of 98.7°. Due to the NGSO type orbit its antenna pattern impinging upon the earth is dynamic. This analysis is intended to show how the RF pattern impinges upon the ground station area in North Pole Alaska and surrounding areas.

Figure 1 below shows the total passes calculated for a typical day that are visible from USN's Alaska ground station. Note that not all 10 passes each day will be supported, typically only two each day will be taken.

Proba-V
```
1 39159U 13021A   15097.16845750  .00000099  00000-0  63656-4 0  9990
2 39159 098.6652 177.8153 0004362 164.1357 195.9962 14.22868732 99540
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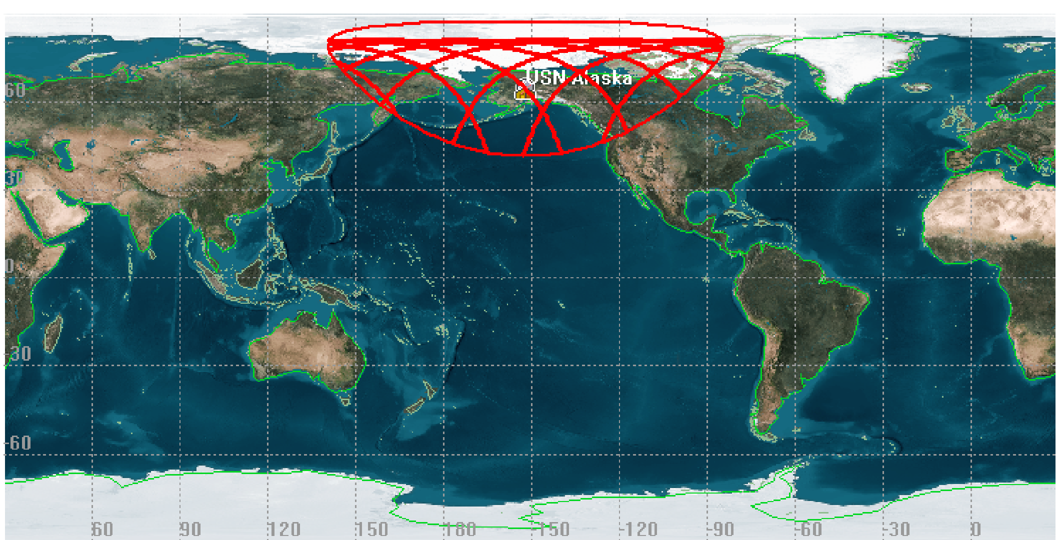

Figure 1 - USN Alaska coverage of Proba-V on a typical day 7 April 2015

USN Alaska possible passes for Proba-V on a typical day

Pass	Start Time (UTCG)	Stop Time (UTCG)
1	7 Apr 2015 01:03:26	7 Apr 2015 01:13:43
2	7 Apr 2015 02:42:29	7 Apr 2015 02:51:26
3	7 Apr 2015 04:20:21	7 Apr 2015 04:30:12
4	7 Apr 2015 05:58:09	7 Apr 2015 06:09:58
5	7 Apr 2015 07:37:15	7 Apr 2015 07:50:08
6	7 Apr 2015 09:18:33	7 Apr 2015 09:30:13
7	7 Apr 2015 11:03:30	7 Apr 2015 11:09:09
8	7 Apr 2015 19:41:24	7 Apr 2015 19:51:14
9	7 Apr 2015 21:21:14	7 Apr 2015 21:33:53
10	7 Apr 2015 23:01:25	7 Apr 2015 23:13:54

Downlink RF Specifications

Proba-V's downlink consist of a highly filtered OQPSK with symbol rate of 84.8Msps. 98% of the energy is contained within a 100MHz bandwidth and thus the emission designator is 100M0G2D. The center frequency is 8090.0 MHz, and polarization is RHCP.

Figure 2 below represents the spacecraft transmit antenna's beam pattern. The colour red indicates the dominant polarization of RHCP, while the blue indicates LHCP. Theta of 0 is the boresight of the antenna that is nadir pointing towards earth. The antenna is rated at a +3.0 dBi gain maximum and typically for any visible satellite pass the worst case gain is approximately -1.0 dBi since the edge of the antenna pattern is not visible due to the combination of orbital altitude and the earth's curvature.

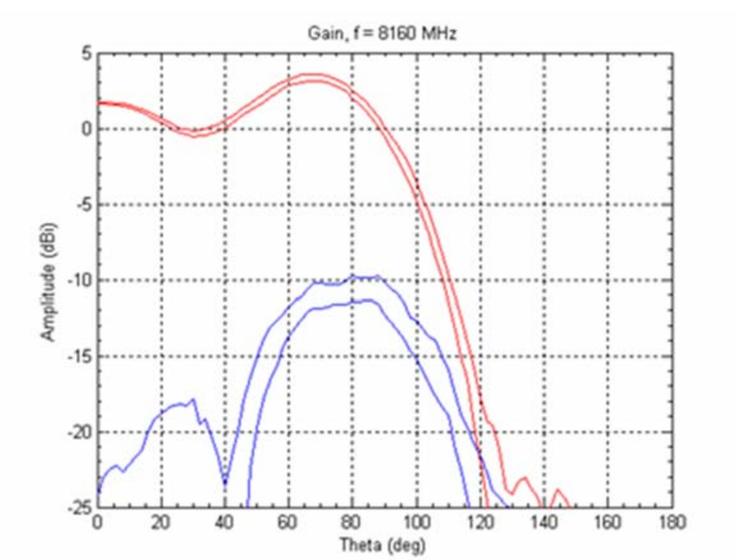

Figure 2 – Static spacecraft antenna pattern

During a direct overhead pass taken at USN Alaska, the space station impinges a dynamic pattern on the earth as shown in figure 3. Note the blue grid in the figure represents radio frequency impingement on the earth during this direct overhead pass. Figure 4 shows the nominal flux density delta power impinging in the area as the space station is directly overhead. Note that the yellow shaded area is in the 0 to +1 dBi contour of the pattern and the red shaded area is in the 0 to +3 dBi contour of the pattern.

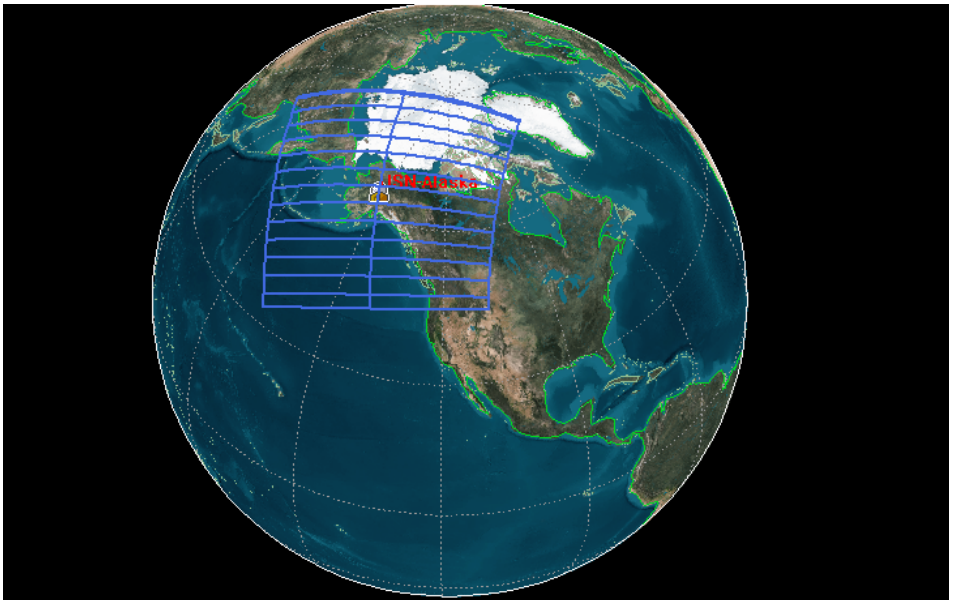

Figure 3 – Overhead pass RF impingement on earth

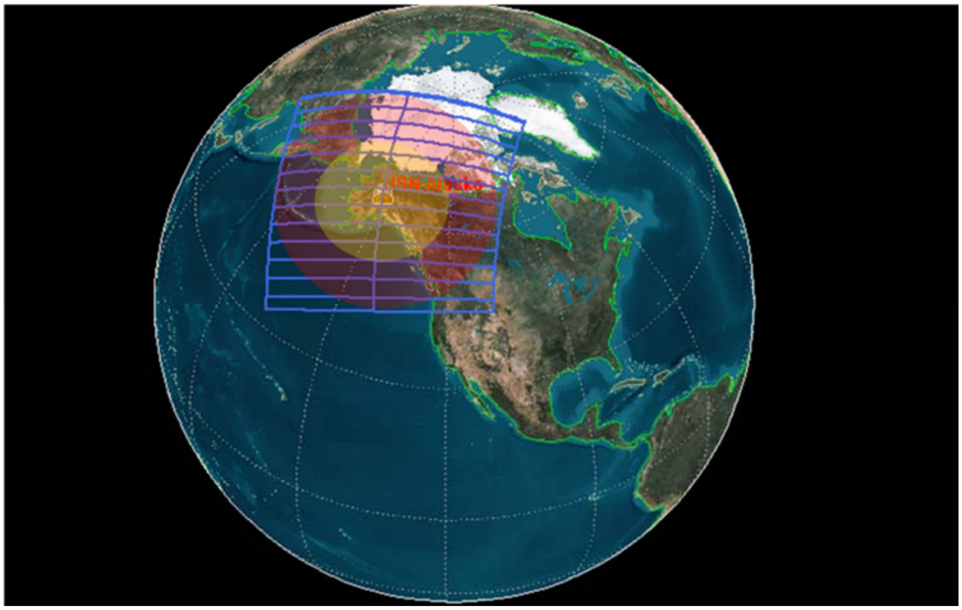

Figure 4 – RF flux density delta power at moment of overhead

Power Flux Density (PDF) impinging on the Earth

The Flux density is calculated as:

$$\boldsymbol{Flux\ density = EIRP\ \div (4\,\pi\, Rse^2)}$$

Where $\boldsymbol{Rse}$ is the distance from spacecraft to the ground.
Where $\boldsymbol{EIRP}$ is the Effective Isotropic Radiated Power of the Spacecraft.

Data from the spacecraft vendor indicates that the maximum EIRP of Proba-V is 13.0 dBW (10.0 effective watt transmit power into a +3 dBi antenna). The altitude (and thus the closest distance to earth during an overhead pass) is = 820 Km. Converting 13.0 dBW to scalar watts = 19.95 watts transmitted at 8090 MHz

Therefor:

$$\boldsymbol{Flux\ density = \ 19.95\ \div (4\,\pi\ *\ \ 820,000\ meters^2)}$$

PDF = 2.361 x 10^{-12} Watts/meter^2
Or
PDF = 2.361 x 10^{-13} mW/cm^2
Or
PDF = -116.3 dBW/meter^2
Or
PDF = -160.2 dBW/meter^2/4KHz worse case (using occupied BW = 100MHz)

Table 1 shows the PDF versus the incident angle as seen from ground.

Incidence Angle	PDF (dBW/m2/4KHz)
0	-163.2
5	-161.7
10	-160.7
15	-160.5
20	-160.2
25	-160.2
30	-160.3
35	-160.7
40	-161.2
45	-162.2
50	-162.7
55	-163.1
60	-163.2
65	-163.2
70	-162.4
75	-162.2
80	-161.7
85	-161.5
90	-161.4

Figure 5 shows the compliance of PDF on the earth surface with NTIA and ITU specifications. Note this shows the worst case PDF on an overhead pass at the closest possible distance of spacecraft to ground. Most Proba-V passes will produce a lower PFD.

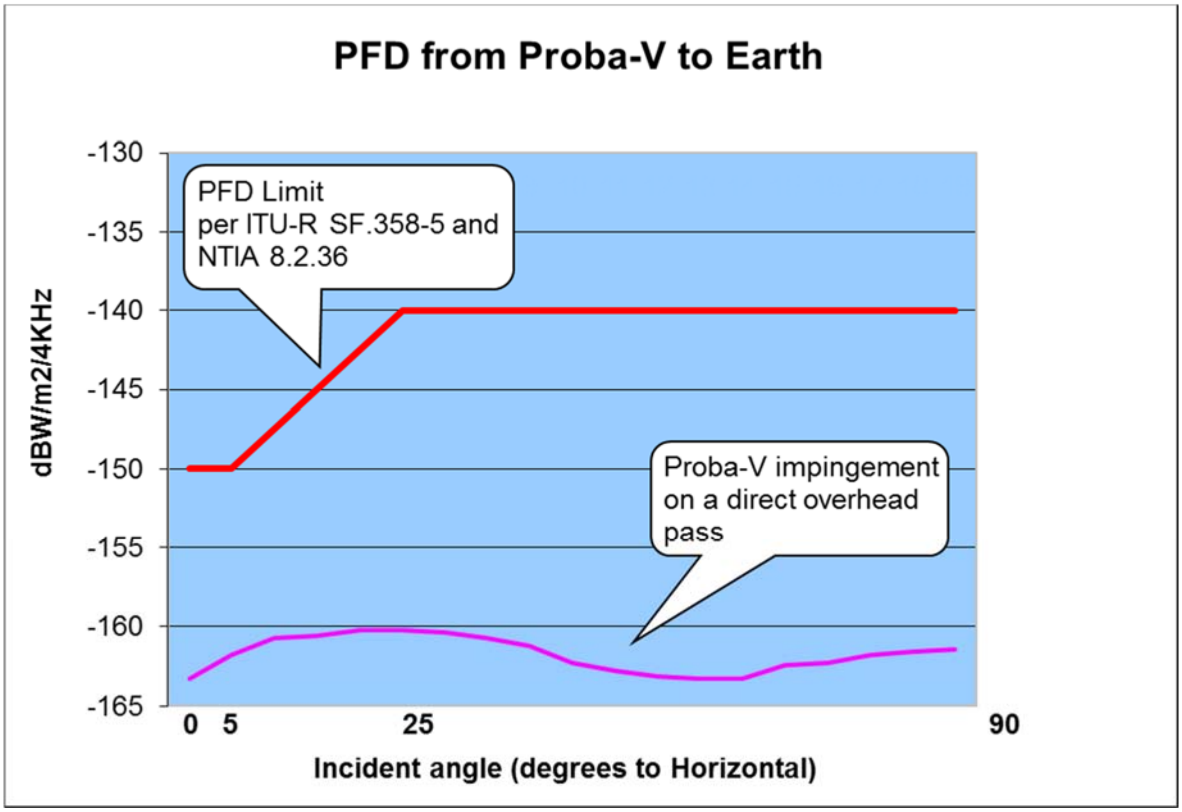

Figure 5 – Proba-V PDF incident on the earth's surface

Proba-V ITU Registration

UNION INTERNATIONALE DES TÉLÉCOMMUNICATIONS
BUREAU DES RADIOCOMMUNICATIONS

INTERNATIONAL TELECOMMUNICATION UNION
RADIOCOMMUNICATION BUREAU

UNIÓN INTERNACIONAL DE TELECOMUNICACIONES
OFICINA DE RADIOCOMUNICACIONES

RÉSEAU À SATELLITE SATELLITE NETWORK RED DE SATÉLITE	PROBA-V	SECTION SPÉCIALE Nº SPECIAL SECTION No. SECCIÓN ESPECIAL N.º	API/A/6584
		BR IFIC / DATE BR IFIC / DATE BR IFIC / FECHA	2687 / 08.02.2011
ADM. RESPONSABLE RESPONSIBLE ADM. ADM. RESPONSABLE	F/ESA	NUMÉRO D'IDENTIFICATION IDENTIFICATION NUMBER NÚMERO DE IDENTIFICACIÓN	110540883
LONGITUDE NOMINALE NOMINAL LONGITUDE LONGITUD NOMINAL	NGSO		
RENSEIGNEMENTS REÇUS PAR LE BUREAU LE / INFORMATION RECEIVED BY THE BUREAU ON / INFORMACIÓN RECIBIDA POR LA OFICINA EL			02.11.2010

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Any administration which believes that unacceptable interference may be caused to its existing or planned satellite networks or systems shall communicate its comments to the publishing administration, with a copy to the Radiocommunication Bureau, within four months after the date of this publication.

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DATE LIMITE POUR LA RÉCEPTION DES COMMENTAIRES
EXPIRY DATE FOR THE RECEIPT OF COMMENTS
FECHA LÍMITE PARA LA RECEPTIÓN DE LOS COMENTARIOS
08.06.2011

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