SATELLITES WITH A COLLINEAR ANTENNA

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Radio amateurs have not yet been able to cross the Atlantic Ocean in the high bands (145 MHz up), but we have to say in terrestrial communications. Great efforts are being made to achieve this challenge, large installations, high powers and digital protocols related to extremely weak signals, such as JT65, developed by K1JT Joe Taylor.

The proposal of this article is to guide you, step by step, so you succeed in communicating from Spain to the Center-East of the United States, with the installation of V/UHF that you already have. Taking advantage of present low-orbit satellites, but without elevation rotor systems, nor rotor control systems through interfaces and a PC, neither controlling the frequency of the Doppler with a computer. Even more, without digital modems, in voice!. Even more, without a full-duplex station capable, as simple as a FT-857 or similar. What do you think, take on the challenge?.

THE SATELLITES

We do not have to pay to play whit a ham satellite, it is free!. With our radio amateur license is enough. If you try it and you like it, you could cooperate with AMSAT (The Radio Amateur Satellite Corporation); this is a worldwide association that promotes this very enjoyable branch of our hobby.

Unfortunately the only satellites which have a footprint that allow us to cross the Atlantic are SSB satellites. There are FM satellites, which would simplify this article more, but its footprint does not allow this type of communications, because its orbit is very low.

At the moment there are only two operational satellites that allow us to achieve the DX we propose, the FO-29 launched in 1996 and the AO-07 launched in 1974. In this article we are going to concentrate on the FO-29, because it is easier of using.

The FO-29 is a satellite of low orbit, and among their features I highlight those that interest us in the TABLE 1.

FO-29

Linear Transponder:

Uplink:	145.900 - 146.000 MHz LSB/CW	Center: 145.950 MHz
Downlink	435.800 - 435.900 MHz USB/CW	Center: 435.850 MHz

Beacon:
435.795 MHz – CW (12 wpm)

TABLE 1.- FREQUENCIES OF FO-29 SAT

WHEN WE CAN DO THE DX

First of all, we have to find out if our satellite is active, or rather, if it has been active in the last passes. We can see it in the web page of AMSAT:

http://www.amsat.org/status/

It will show the TABLE 2, and we have to look at the line where FO-29 is, if the last passes are in blue, then the satellite has been active. We are lucky, the FO-29 SAT has been and is one of the most reliable and long-lived satellites we have ever had.

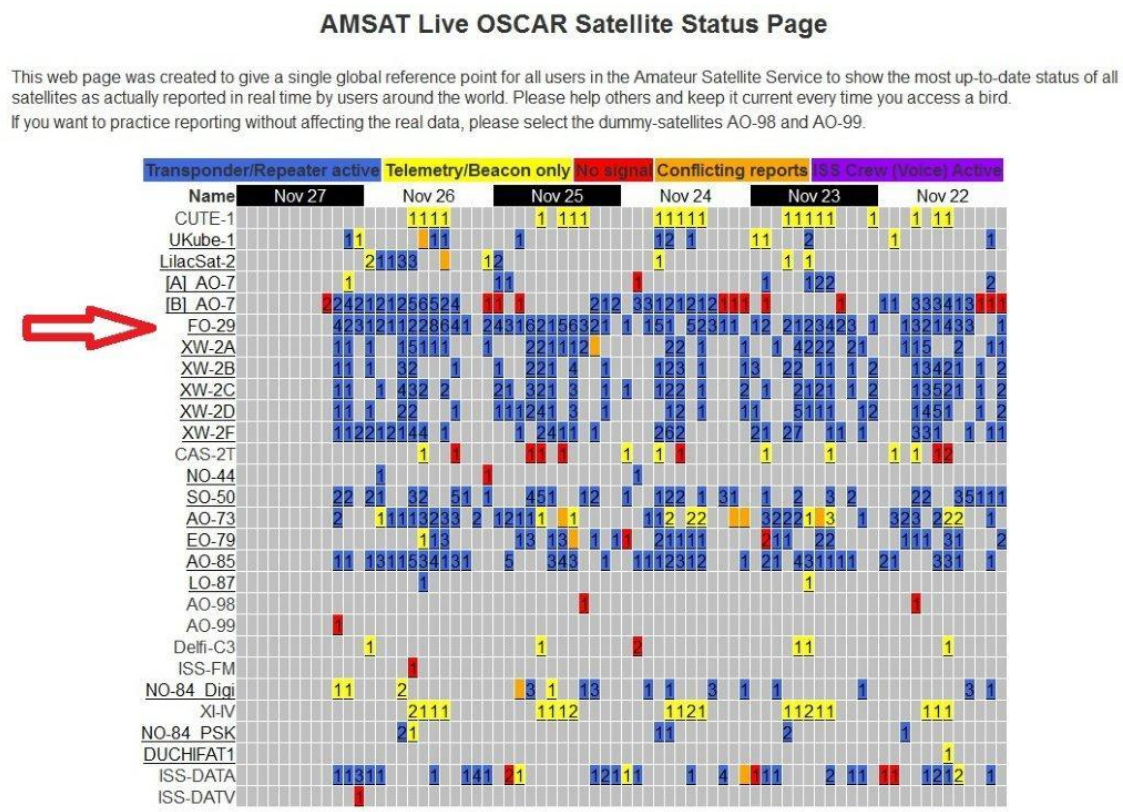


TABLE 2.- AMSAT SATELLITE STATUS PAGE

If it is active, we have to find out when we are on the satellite footprint. But for our DX, the United States of America and Spain should be into the sole, and this only happens between 5 and 7 times per week and for a very short period (less than 12 minutes). To know when this happens, AMSAT has a webpage that shows the pass prediction:

http://www.amsat.org/track/index.php

And in it, we must fill in only 4 data:

- The satellite, in this case FO-29
- How many passes do we want to predict, we will choose 50, which is the maximum.
- Our locator, with 4 digits is enough (we will use as example IM78cx)
- And the elevation above sea level (an approximation will suffice, we will use as an example 220m)

The data will be filled as we can see in FIGURE 1.

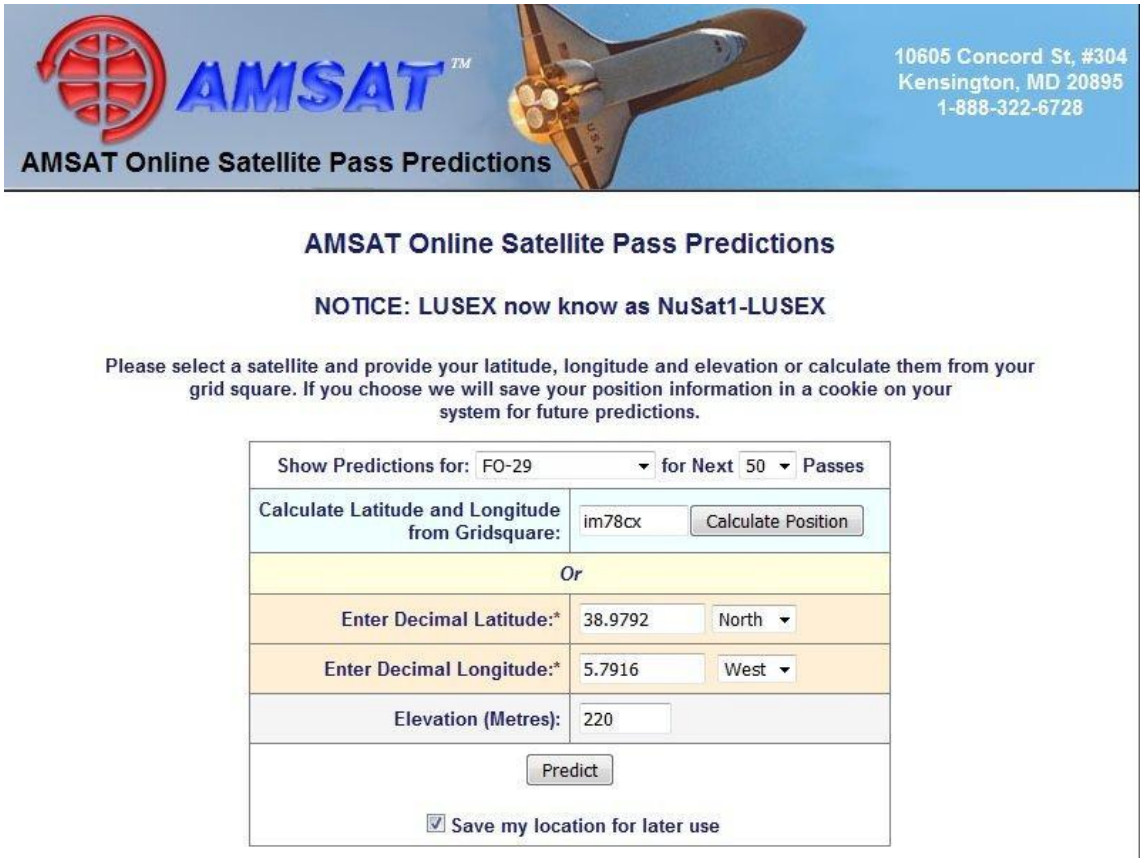


FIGURE 1.- AMSAT PASSES PREDICTION PAGE

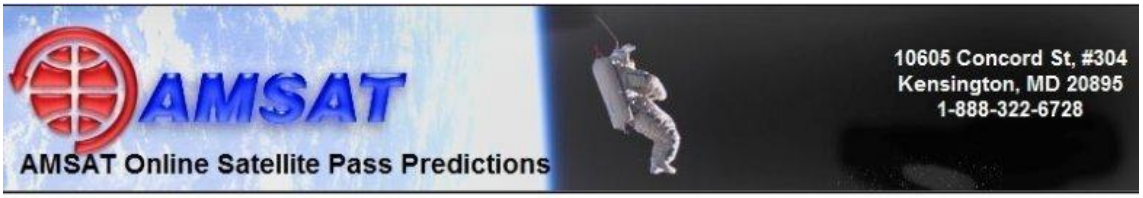
If we also mark "Save my location for later use", we will no longer have to type our locator and altitude in subsequent queries.

It will show the TABLE 3, with the following 50 passes of the satellite over our locator. But to achieve our DX we should only look at those lines that fulfill:

- Maximum elevation <10 degrees (low passes)
- AOS Azimuth > 180 degrees (passed to the West)

That is, very low passes toward the West. I have marked them with a red arrow in the TABLE 3. As I will explain later it is not necessary to have any more data, but if you have some tracking program such as ORBITRON or SATPC32, you will be able to see the footprint of the satellite, that will be of the type shown In FIGURE 2 and FIGURE 3. In both figures you can see the program gives us information of azimuth, elevation and uplink/downlink frequency, in addition the azimuth and elevation of a known station with which we intend to make a QSO. In our example we have selected the locator EM97. Our location is shown as a white cross and that of our partner as a black cross. All this information is additional that will not be essential to make the DX.

We already know when we need to be alert and we can program our alarm clock 10 minutes before, to be ready. Satellites are like trains, they do not wait for anyone!.



AMSAT Online Satellite Pass Predictions - FO-29

View the current location of FO-29

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
24 Dec 16	21:37:51	00:09:00	53	4	79	119	21:46:51
24 Dec 16	23:20:14	00:17:04	18	54	100	182	23:37:18
25 Dec 16	01:05:57	00:14:52	357	22	298	233	01:20:49
25 Dec 16	09:33:19	00:13:06	122	18	63	4	09:46:25
25 Dec 16	11:16:44	00:15:24	177	54	256	342	11:32:08
25 Dec 16	13:07:16	00:06:42	247	3	274	301	13:13:58
25 Dec 16	22:25:45	00:15:08	32	19	91	155	22:40:53
26 Dec 16	00:10:17	00:17:03	8	60	292	206	00:27:20
26 Dec 16	01:57:08	00:10:50	345	8	303	262	02:07:58
26 Dec 16	08:41:54	00:07:37	85	4	58	22	08:49:31
26 Dec 16	10:21:54	00:14:57	150	48	67	354	10:36:51
26 Dec 16	12:08:05	00:13:30	205	18	264	329	12:21:35
26 Dec 16	21:33:03	00:08:39	55	4	81	117	21:41:42
26 Dec 16	23:15:09	00:17:15	19	50	102	180	23:32:24
27 Dec 16	01:00:47	00:15:21	358	24	300	230	01:16:08
27 Dec 16	09:28:32	00:12:38	120	16	60	6	09:41:10
27 Dec 16	11:11:45	00:15:20	175	59	252	343	11:27:05
27 Dec 16	13:01:49	00:07:36	244	3	270	305	13:09:25
27 Dec 16	22:20:44	00:15:08	33	18	92	153	22:35:52
28 Dec 16	00:05:10	00:17:23	9	65	299	204	00:22:33
28 Dec 16	01:51:52	00:11:35	347	9	305	259	02:03:27
28 Dec 16	08:37:21	00:06:35	80	3	54	26	08:43:56
28 Dec 16	10:17:00	00:14:52	147	43	63	355	10:31:52
28 Dec 16	12:02:59	00:13:37	203	20	262	330	12:16:36
28 Dec 16	21:28:12	00:08:12	57	3	83	114	21:36:24

TABLE 3.- FO-29 PASSESS

WHAT FREQUENCY WE HAVE TO USE

I could tell you the frequencies and we would end soon, but it is better to understand further as a linear transponder of a satellite works.

A linear transponder is like a cross-band repeater, but it has a bandwidth of 100KHz. In a simple approximation working in the center of the transponder, if we uplink at 145.950, we will hear our own voice (if we have a full-duplex equipment) or only the other stations answering you call (if the equipment is half-duplex) at 435.850 +/- 5 KHz. Thus:

- Upload frequency: 145.950 LSB
- Download frequency: 435.850 +/- 5 KHz USB

Over the Atlantic Ocean there are not many stations, as we are a weak station and learning, we can set in the center of the transponder. When you have further experience, you will learn that it is better to split a little from the center, but you have to know that it is a reverse transponder, so if we uplink 10 KHz below (145.940 KHz), we will hear 10 KHz above (435.860

+/- 5 KHz), but we will take advantage of this feature when we have already managed to achieve our first DX.

Do not forget that the uplink is in LSB and the downlink in USB.

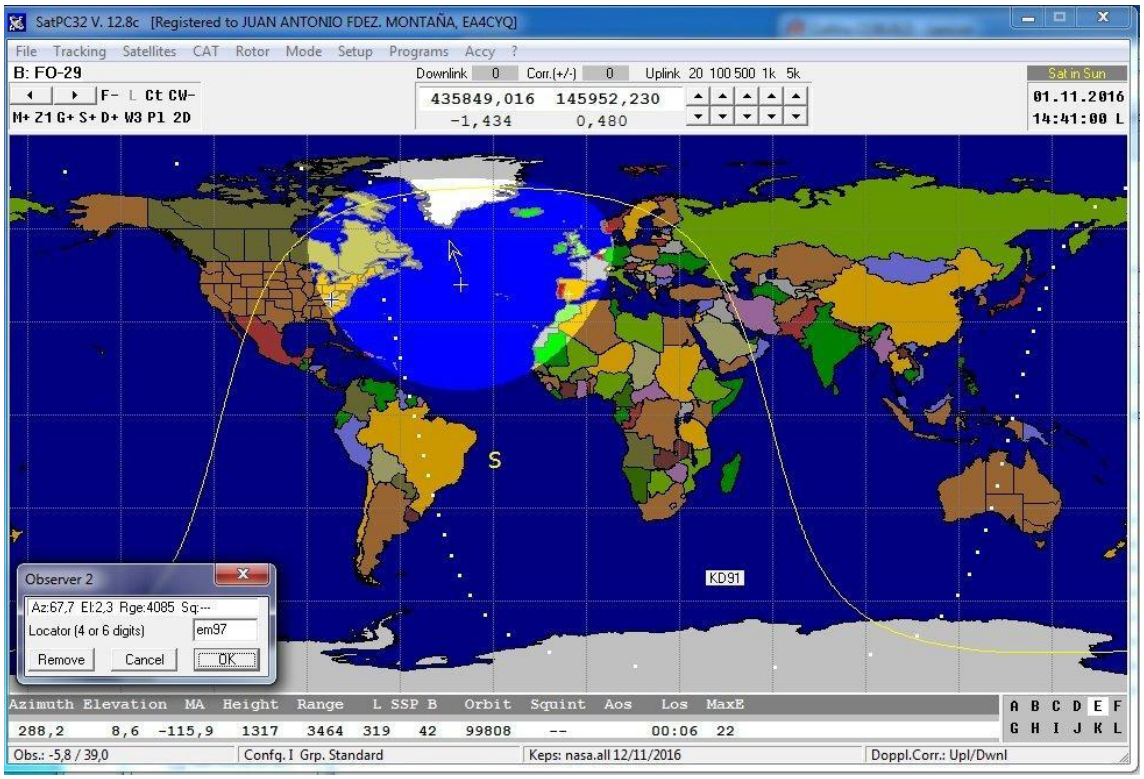


FIGURE 2.- FO-29 TOWARD THE WEST

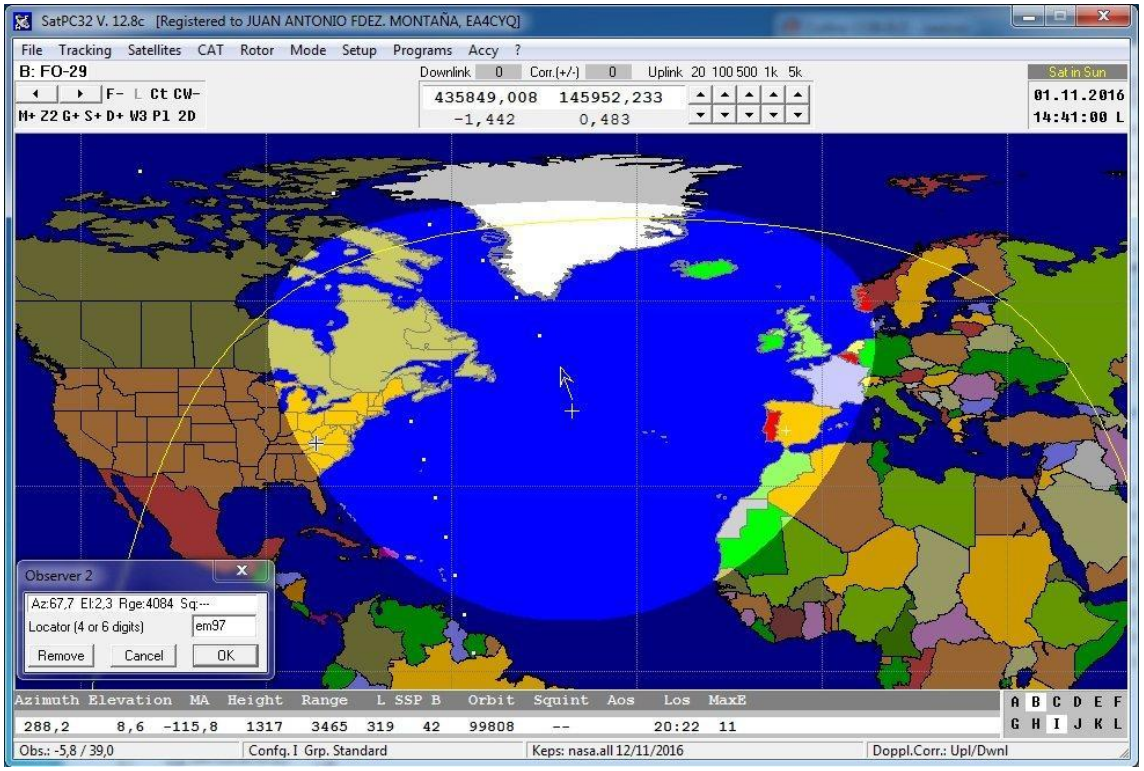


FIGURE 3.- FO-29 TOWARD THE WEST ENLARGED

You have to know also that when we uplink in 145.950 MHz the satellite repeats exactly us in 435.850 MHz. But as the satellite is moving with respect to us a phenomenon known as "DOPPLER Effect " happens. This means that we will receive the satellite downlink some KHz above 435.850 MHz when the satellite is approaching us (beginning of the pass (AOS)), at the exact frequency when it is at its highest point and some KHz below 435.850 MHz when it is moving away from us (at the end of the pass (LOS)).

This variation can be up to +/- 10 KHz in high elevation passes, because the satellite moves very fast with respect to us. But in the low passes, which are the ones that interest us, it moves more slowly with respect to us and it will not be more than +/- 5 KHz.

WHAT KIND OF ANTENNAS WE NEED FOR THIS CHALENGE

We do not need a satellite station with an elevation system for our antennas or omnidirectional antennas with a high angle radiation lobe to achieve this DX. We need a station for terrestrial communications, as if we were to work a "far away" repeater, as much as more than 3000Km.

Therefore we will need any of the following types of antennas:

- A high gain V/UHF collinear antenna, in the UHF band must have between 11 dB and 13 dB. Antennas similar to the Diamond X500 or X700 will be usable.

- Yaguis for V/UHF of similar gain that is yaguis of about 2m or 3m of boom.

It is also important to use low loss and as short as possible coaxial feed line, and it will help us a lot, but it will not be essential a preamplifier (LNA) in the UHF band. In the VHF band, that we use in the uplink side, it is enough the power that gives our usual equipment, between 25 and 40W. With practice you will realize that with 5W or 10W the communication is affordable.

The satellites rotate themselves, beside the RF pass through the atmosphere, all this cause changes of polarity. As we are working with linear polarity we will see a slow fading in the uplink/downlink which will make us to lose and recover the signal soon, but you will become familiar with it.

We will not need to install any tracking software or rotor controllers, etc.

HOW WIL WE KNOW IF OUR STATION IS DX CAPABLE

A main rule to work satellites, is that we should never transmit if we do not listen, because if we do it we will be interfering other QSOs in progress, especially in FM satellites.

Fortunately, the FO-29 has a CW beacon that continuously transmits if the satellite is operational. In the TABLE 1 we can see this frequency is 435.795 +/- 5 KHz USB.

Therefore I will only have to listen during the pass on this frequency by moving the dial up and down 5 KHz around 435.795 MHz. If we listen to the CW beacon, our station is ready for the

DX!

OPERATING TECHNIQUE

To sum up, I will relate the steps:

1) Verify if the satellite is operational at http://www.amsat.org/status/

2) Check the UTC time of the pass at http://www.amsat.org/track/index.php
and select the passes of less than 10º of elevation toward the West.

AMSAT Online Satellite Pass Predictions - FO-29 View the current location of FO-29							
Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
25 Dec 16	13:07:16	00:06:42	247	3	274	301	13:13:58

TABLE 4.- PASS OF FO-29 SELECTED

3) If our antenna is omnidirectional skip this step. If it is directional and its radiation lobe is not very narrow, 3 positions in its orientation will suffice. When the satellite emerges (AOS), when it disappears (LOS), and one in the center of the pass which we will estimate by averaging. We can see it in the example of TABLE 4.

- (AOS) 13:07:16 UTC will aim to 247º (AOS Azimuth)
- (LOS) 13:13:58 we will aim to 301º (LOS Azimuth)
- (Center Pass):
    - TIME: 13:10 = (13: 07 + 13: 13) / 2
    - ORIENTATION: 274º = (247º + 301º) / 2 (Max El Azimuth)

4) Check that we receive the beacon at 435.795 +/- 5 KHz USB. And if we receive it:

5) Set the transmission in 145.950 LSB and when you stop transmitting try to receive stations calling you in 435.850 +/- 5 KHz USB. If we have a full-duplex transceiver we could listen to ourselves and there is where we could listen to stations calling us. But you can work successfully with a half-duplex transceiver.

I'm sure that on the other side of the Ocean you will be able to do the DX with some American station.

If you do, you have a lot of probability, you are surely hooked on this exciting world of ham satellites.

You can use this same technique in the passes toward the East, which I marked in the TABLE 3 with green arrows, and you can see in FIGURE 4 and FIGURE 5 the footprint of them. These passes will let you to make contacts with all of Europe and Asian Russian.

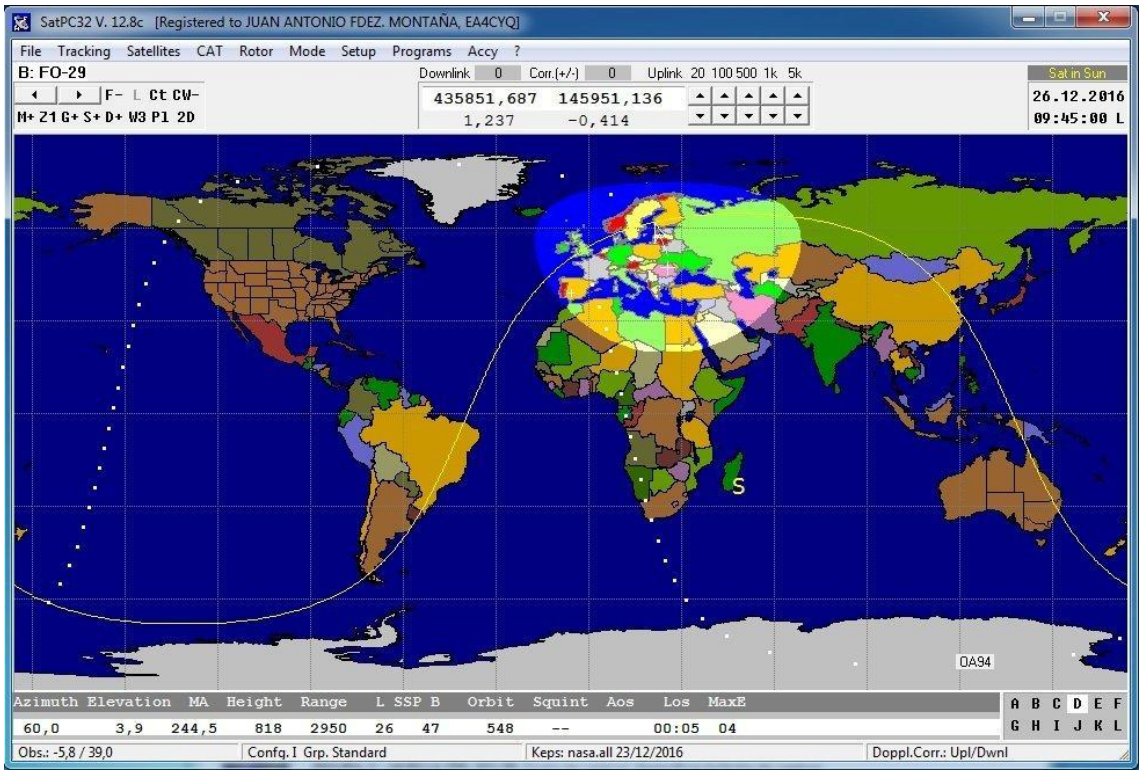


FIGURE 4 .- FO-29 PASSES TOWARD THE EAST

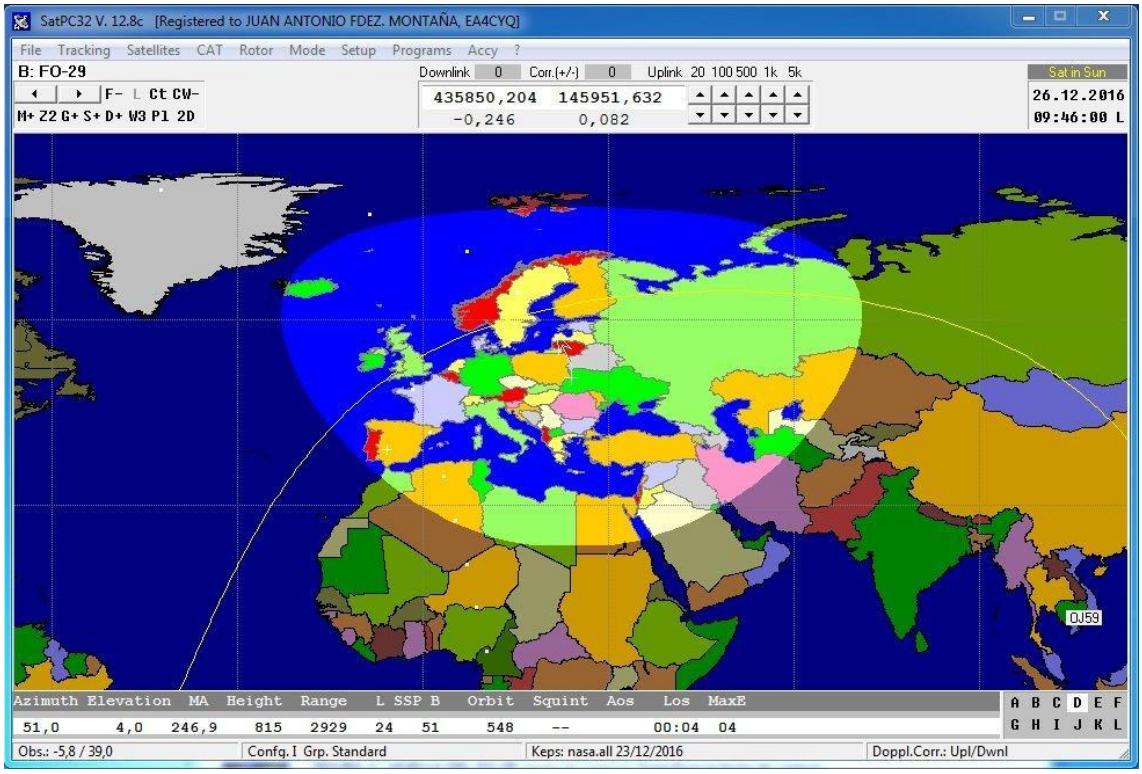


FIGURE 5.- FO-29 PASSES TOWARD THE EAST ENLARGED

Just make two considerations:

- As they are very low passes, if in the East or West you have obstacles you will not be able to work the satellite, buildings, mountains, etc. So you have to study your possibilities well and take advantage of the best passes.

- In these low passes you have to fight with the surrounding noise produced by human activity, if you are in a noisy environment it may not be possible to communicate with this technique. But this should not discourage you, you have to know that if you decide to take part in the world of satellites with an antenna elevation system, when the antenna exceed the 20º elevation the own lobe of the antenna loses gain towards the ground and the noise virtually disappears , If we add that when the satellite is higher we have less losses to cross the atmosphere in a more perpendicular way, we will be able to make contacts much more easily. This ground noise is what has moved me to dedicate almost exclusively to space communications since 2000.

This article has the intention you try to make only the first contact and you feel hooked. This same technique can be used for other SSB and FM satellites, but this will be achieved with practice, after you have made several contacts with this wonderful FO-29 satellite.

I hope to listen you very soon . . .

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