# Report of WSPR tests in France from july 2008 to december 2009

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## 1-Introduction :

In mid 2008 a small group of French VHF users located in Paris area and in others places up to about 500 km distance has pointed out a need of improving beacons analysis technique for qualifying performances of their own installations. Since the propagation is varying often significantly during a single test, the traditional beacons network survey was found inaccurate and answering to only limited parts of the requirement.
More often, after any antenna installation or change somewhere far away from a permanent test signal transmission, it can be frustrating to wait until someone comes on the air for giving a significant report which is often subjective. The main requirement of this group was to find a way for exchanging automatically reports with other operators by checking reciprocal reception quality at each end as accurately as possible without needing to stay near the transceiver all the time. All these reports could be sent through Internet in an understandable format with all necessary details stored on a dedicated website allowing the tester to check the results in real time or even later.
In the same field of application it was found interesting to understand why reports are often so unbalanced and to find explanations or recommendations for improvement.
Then, considering that most of the existing VHF beacons are usually installed on dedicated sites selected for their wide open view on high hills, they are not fully representing a standard ham installation in the same region and may give a wrong idea of the real contact capabilities. Allowing the use of automatic temporary “beacons like” low power transmissions to anyone could help significantly.
Taking into account the existence of similar networks on the HF band with WSPR, it was suggested that tests would be performed at least in VHF and typically on 2m by use of the same protocol and reporting organisation in order to evaluate the benefit of such a system. For that purpose, a specific dedicated channel has been suggested for approval at the last IARU region 1 convention in Cavtat

## 2-The choice of WSPR :

The fast world-wide deployment of the WSPR network, after April 2008, particularly in the 30m band, was giving an immediate answer attractive enough for suggesting a similar deployment on other bands, particularly on 2m without modification of its existing protocol. It was found that all important parameters needed were available and their transmission efficiency optimized:

- Very narrow spectrum occupation allowing several simultaneous transmission in small bandwidth around a specific channel in the beacon sub-band
- Possibility of analysing signals deeply below the noise floor allowing use of small power transmissions
- Reporting network on Internet already existing and fully operational.

### *2.1- General presentation* :

WSPR (pronounced "whisper") stands for "Weak Signal Propagation Reporter." It has been designed by Joe Taylor (K1JT) group in addition to its well known activity with WSJT program and uses similar transmission process.
WSPR signals convey a callsign, Maidenhead grid locator, and power level using a compressed data format with strong forward error correction and narrow-band 4-FSK modulation. The protocol is effective at signal-to-noise ratios as low as –28 dB in a 2500 Hz bandwidth.

Receiving stations with internet access may automatically upload reception reports to a central database. The WSPRnet web site provides a simple user interface for querying the database, a mapping facility, and many other features. By comparing with traditional modulations assuming SSB requires S/N better than 5dB or CW better than -18 dB referred to the same bandwidth, the theoretical benefit is about 33dB above SSB and 10 dB above CW

### *2.2-Main technical specification*:

Transmit and receive sequences are organized in 2 minutes time-slots
Receive sequences start at all even-numbered UTC minute
Transmit sequences follows at a selectable Tx/Rx rate from 20% to 50%
Random organisation of sequences for avoiding repetition of signals collisions
Frequency accuracy to be better than 10Hz for an appropriate calibration
Frequency stability to be better than 1 Hz per minute
Full power transmission in USB mode with audio at 1500 Hz +/-100 Hz
Clock accuracy better than 1s
Receiver analysis RF channel width is 200 Hz
Audio occupied bandwidth is about 6 Hz
Simultaneous reception possibility of about 20 different signals in a single channel

### *2.3-Frequency plan:*

In each of the HF bands there is only one small channel of 200 Hz dedicated to WSPR activity. It seems still reasonable for most of the transceiver presently available in the market to fulfil the technical requirements and support a very wide activity on the air from thousands of users over the world.
In VHF, on the 2m band, a larger portion of the band has been required in order to insure an appropriate tuning of existing transceiver before calibration to fulfil the 10Hz frequency accuracy requirement.
It has been agreed to keep 1 kHz free for such application centred at 144.4895 MHz meaning in USB mode with 1.5 kHz audio a dialled frequency 144.488 MHz.
All tests have been performed in the IARU region1 on this narrow channel.
Calibration methods for being tuned with the best possible accuracy are detailed on the WSPRnet website (http://wsprnet.org/drupal/) in the WSPR 2.0 User guide. However, on 2m band, it can be necessary to ask for some external assistance to apply this calibration when looking to be accurately centred.

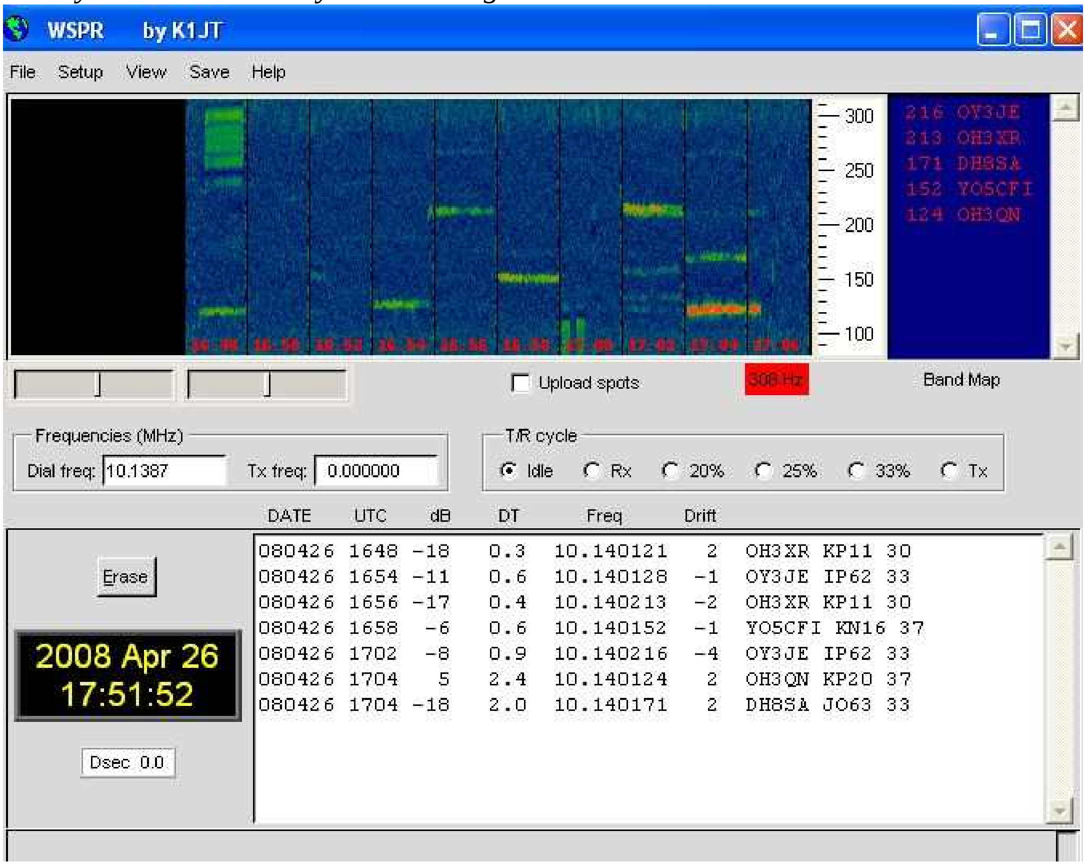
### *2.4-Reporting network organisation:*

Information transmitted contains all details locating the station (Callsign and Maidenhead grid locator) and its output power (expressed in dBm). It is supposed that propagation path, antenna gain and cable losses are the same in both ways (receive and transmit) in order to simplify comparisons on each side.
On the receiver side S/N (SNR), frequency, drift and timing differences are measured and recorded locally. All these data can be reported at the end of each sequence, after signals has been received and recognized, automatically through a dedicated Internet connection to the file concentrator of the WSPRnet. They can also be stored independently and sent later to this concentrator remotely through specific connection.
All the results are placed on a table refreshed every 2 minutes. As soon as all bands are delivering a wide amount of data it is usually necessary to select the useful information needed band by band, date by date and call-sign by call-sign.
These selected data can be extracted in an appropriate format in order to be analysed locally in specific tables (i.e Excel spreadsheets) and build local statistics of what is needed.

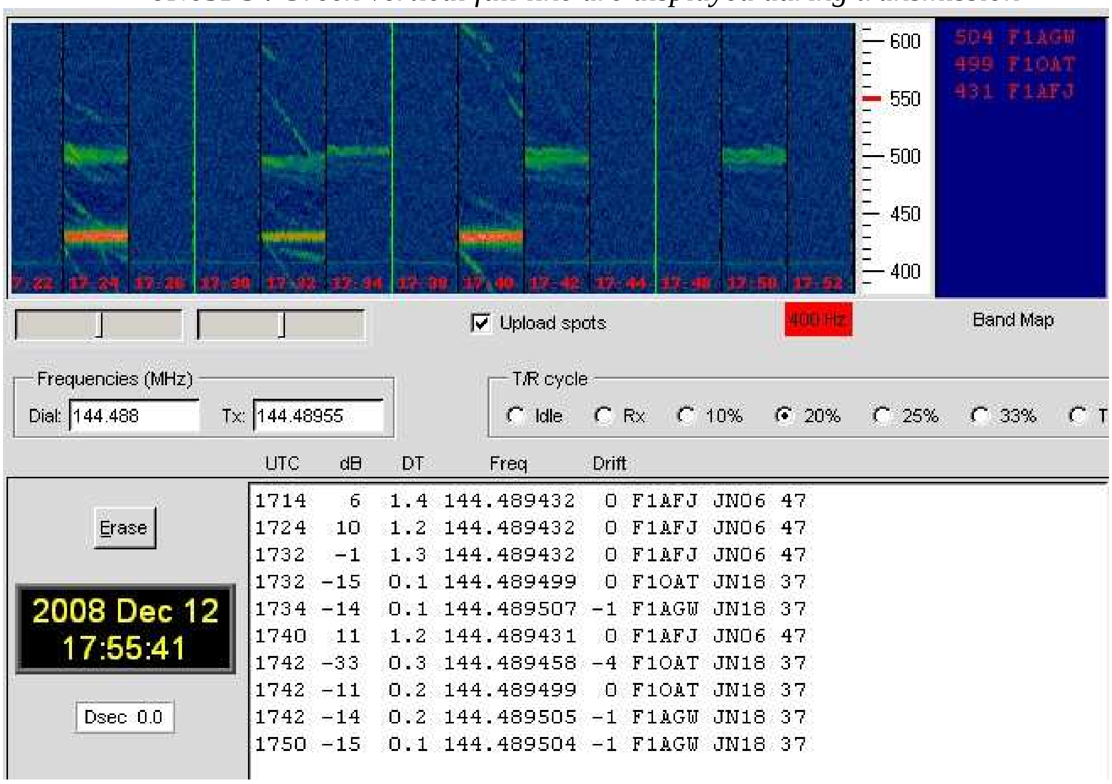
### *2.5-Typical output on PC screen:*

The following pictures show typical examples of what is displayed during the tests and what data are available by selection on the concentrator of WSPRnet.

*30m activity in a "receive-only" monitoring mode wit 2s calibrated time slots and results table*:




*2m activity in transmit and receive mode under quiet conditions at long distances by F6BYJ in JN05FS . Green vertical full line are displayed during transmission*



*Real time spot data base on WSPRnet website all world-wide activity reported (7 bands on this sample) for only a part of a one time-slot record:*

## Spot Database

Specify query parameters

100 spots:

| Timestamp | Call | MHz | SNR | Drift | Grid | Pwr | Reporter | RGrid | km | az |
|---|---|---|---|---|---|---|---|---|---|---|
| 2010-01-22 16:52 | W1MNK | 14.097125 | -19 | 1 | EL87uv | 5 | WB9GHD | DM12kv | 3371 | 288 |
| 2010-01-22 16:52 | N8JK | 7.040107 | -2 | 0 | EM79 | 5 | KD0AR | EN90rw | 415 | 66 |
| 2010-01-22 16:52 | M0POQ | 10.140173 | -13 | 0 | IO91ij | 2 | PA0QRB | JO22iv | 442 | 65 |
| 2010-01-22 16:52 | IQ4DJ | 10.140224 | -14 | 0 | JN54mq | 1 | PA0QRB | JO22iv | 1023 | 335 |
| 2010-01-22 16:52 | K7LG | 10.140160 | -23 | -1 | DM04se | 1 | W4HBK | EM60 | 2969 | 89 |
| 2010-01-22 16:52 | N5BFB | 10.140173 | -21 | 0 | EM13pa | 1 | W4HBK | EM60 | 956 | 105 |
| 2010-01-22 16:52 | WB3ANQ | 10.140196 | -16 | 0 | FM19rc | 1 | W4HBK | EM60 | 1354 | 228 |
| 2010-01-22 16:52 | IQ4DJ | 10.140282 | -15 | 0 | JN54mq | 1 | DG9AW | JN58kh | 403 | 358 |
| 2010-01-22 16:52 | DG8YHH | 7.040090 | -21 | -1 | JO32rg | 5 | LA6TPA | JP54rl | 1377 | 8 |
| 2010-01-22 16:52 | IQ4DJ | 10.140234 | -26 | 0 | JN54mq | 1 | DG7RJ | JN58th | 406 | 6 |
| 2010-01-22 16:52 | PA3MET | 7.040103 | -1 | -1 | JO22ma | 5 | LA6TPA | JP54rl | 1434 | 12 |
| 2010-01-22 16:52 | WB3ANQ | 10.140199 | -12 | 0 | FM19rc | 1 | W8NWA | EM66nd | 967 | 253 |
| 2010-01-22 16:52 | K7LG | 10.140158 | -12 | -1 | DM04se | 1 | KO7M | CN87xp | 1526 | 350 |
| 2010-01-22 16:52 | M0POQ | 10.140190 | -20 | 0 | IO91ij | 2 | F6BIA | JN19dq | 316 | 125 |
| 2010-01-22 16:52 | IQ4DJ | 10.140242 | +1 | 0 | JN54mq | 1 | F6BIA | JN19dq | 863 | 313 |
| 2010-01-22 16:52 | M0POQ | 10.140218 | -6 | 0 | IO91ij | 2 | F6EWB | IN93hh | 899 | 180 |
| 2010-01-22 16:52 | PA3GNZ | 10.140249 | -19 | 0 | JO21rv | 5 | F6EWB | IN93hh | 1082 | 211 |
| 2010-01-22 16:52 | DK5MB | 14.097040 | -25 | 0 | JN68bi | 10 | W3GXT | FM19ol | 6783 | 298 |
| 2010-01-22 16:52 | W1MNK | 14.097095 | -4 | 0 | EL87uv | 5 | W3GXT | FM19ol | 1384 | 20 |
| 2010-01-22 16:52 | DK5MB | 14.097042 | -11 | 0 | JN68bi | 10 | VE6OG | DO33fn | 7586 | 329 |
| 2010-01-22 16:52 | W1MNK | 14.097097 | -12 | 0 | EL87uv | 5 | VE6OG | DO33fn | 3824 | 327 |
| 2010-01-22 16:52 | DK5MB | 14.097047 | -16 | 0 | JN68bi | 10 | DJ9PC | JN59po | 152 | 337 |
| 2010-01-22 16:52 | F6GIG | 28.126062 | -13 | 0 | JN18fv | 5 | IK4GBU | JN54pl | 833 | 123 |
| 2010-01-22 16:52 | IQ4DJ | 10.140269 | -12 | 0 | JN54mq | 1 | F6EWB | IN93hh | 1004 | 266 |
| 2010-01-22 16:52 | DO4ATK | 1.838090 | -13 | 0 | JO51qs | 5 | OH8HTG | KP34di | 1642 | 26 |

*Extracted data displaying signals received by one station (F1VL in JN03RX) on 2m only. Distance between stations and antenna azimuth are calculated and displayed*

## Spot Database

Specify query parameters

Using spot archive (no automatic refresh). 100 spots:

| Timestamp | Call | MHz | SNR | Drift | Grid | Pwr | Reporter | RGrid | km | az |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008-12-10 11:08 | F6ABJ | 144.489513 | -17 | -1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-10 11:08 | F6ABJ | 144.489493 | -21 | -4 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-10 11:04 | F6ABJ | 144.489514 | -15 | 0 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-10 10:28 | F6ABJ | 144.489510 | -13 | 0 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-10 10:20 | F6ABJ | 144.489505 | -19 | 1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-10 10:20 | F6ABJ | 144.489519 | -25 | -1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-09 21:02 | F6ABJ | 144.489516 | -12 | -1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-09 20:20 | F6ABJ | 144.489515 | -17 | 1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-09 20:08 | F6ABJ | 144.489515 | -14 | 1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-09 20:02 | F6ABJ | 144.489517 | -14 | 1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-09 19:02 | F6ABJ | 144.489515 | -20 | -1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |
| 2008-12-05 13:46 | F1AFJ | 144.489503 | -20 | 0 | JN06ht | 10 | F1VL | JN03rx | 322 | 168 |
| 2008-12-05 13:14 | F1AFJ | 144.489502 | -22 | 0 | JN06ht | 10 | F1VL | JN03rx | 322 | 168 |
| 2008-12-05 12:36 | F6BYJ | 144.489534 | -12 | 0 | JN05fs | 10 | F1VL | JN03rx | 214 | 158 |
| 2008-12-05 12:24 | F6BYJ | 144.489536 | -26 | 0 | JN05fs | 10 | F1VL | JN03rx | 214 | 158 |
| 2008-10-16 18:54 | F6ABJ | 144.489495 | -11 | -1 | JN25qh | 200 | F1VL | JN03rx | 343 | 246 |

*Extracted data displaying signals received at one selected station (Rx of F6ABJ in JN25QH) from another one (Tx of F1OAT in JN18CP) at 442 km*

## Spot Database

Specify query parameters

Using spot archive (no automatic refresh). 78 spots:

| Timestamp | Call | MHz | SNR | Drift | Grid | Pwr | Reporter | RGrid | km | az |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008-12-23 21:10 | F1OAT | 144.489510 | -27 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 18:04 | F1OAT | 144.489510 | -27 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 15:58 | F1OAT | 144.489510 | -27 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 15:48 | F1OAT | 144.489510 | -27 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 14:24 | F1OAT | 144.489510 | -26 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 14:04 | F1OAT | 144.489511 | -28 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 13:46 | F1OAT | 144.489510 | -24 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 13:38 | F1OAT | 144.489511 | -25 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 13:18 | F1OAT | 144.489510 | -20 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 12:56 | F1OAT | 144.489511 | -21 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 12:46 | F1OAT | 144.489510 | -24 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 12:34 | F1OAT | 144.489510 | -25 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 12:26 | F1OAT | 144.489510 | -24 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 12:14 | F1OAT | 144.489510 | -25 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |
| 2008-12-23 11:34 | F1OAT | 144.489511 | -25 | 0 | JN18cp | 5 | F6ABJ | JN25qh | 442 | 146 |

## 3-Performances test applied on 2m

### *3.1-Local tests*

At short distances (below 15 km) signal strength received from a fixed transmission is stable enough (better than 1 dB) as soon as directive antennas are used assuming that direct path widely dominate all reflected paths. This stability allows comparisons of configurations or gain estimations through accurate and calibrated analysers on the reception side. Similar facility exits with WSPR through the SNR reporting with additional benefits from reciprocal reports over a wide dynamic range, automatically recorded and easily processed.

In addition to SNR reports, the transmitted power on each end is also declared and can be compared on reciprocal reports of adjacent timeslots. This information allows to fixing which minimum power would be necessary for insuring successful communication on each mode and in both way. In addition, it can also shows if any difference exists in the reception at each end when referring to identical transmission by appropriate corrections of the reports on each side.

Since WSPR was basically designed for HF applications, noise figure in these bands are more often fixed by the environment and antenna gain is limited. In this case there is usually no confusion on the transmitter power definition.

On VHF many beacons usually declare their radiated power sometimes by theoretical ERP or EIRP derived from the output power of the transmitter and an estimated antenna gain. This is not critical as soon as they don't need to declare any received SNR. With WSPR the way to declare the power transmitted has to be clearly defined as it allows additional analysis like a budget link balance check. It was suggested to keep the same reference point than in HF at the transceiver antenna plug. This is traditionally what any operator declares when he describes his station. However in VHF, the presence of mast head LNA suggests that this point should be at the antenna connection of the LNA. In this case the power to declare should be lowered by application of the cable loss between the transmitter output and this reference point.

This difficulty has been clearly pointed out through a comparison made between a station installed in a noisy suburban area (F2MM at 5 km south of Paris) and the other (F1EBN 25 km away) in a rural and quiet area. After corrections of the SNR received with the difference between the powers declared, there was still an 18 dB unbalance on the SNR. This wide difference have been explained by the use of a standard equipment with no external devices on

the noisy suburban end (no need to increase RX sensitivity in such a case !) and a mast head LNA at the other end. An appropriate power declaration would have shown 15 dB difference, instead of 18dB, due to 3 dB cable loss from the transceiver to the reference point, 4 dB difference on noise figures and 11 dB desensitisation by the man made noise of the suburban environment, verified through local field measurement.
These local tests have confirmed the ability of decoding signals down to -28 dB SNR at 100% and sometimes more. It has been estimated to -30 dB at 50% and -32 dB at less than 10%

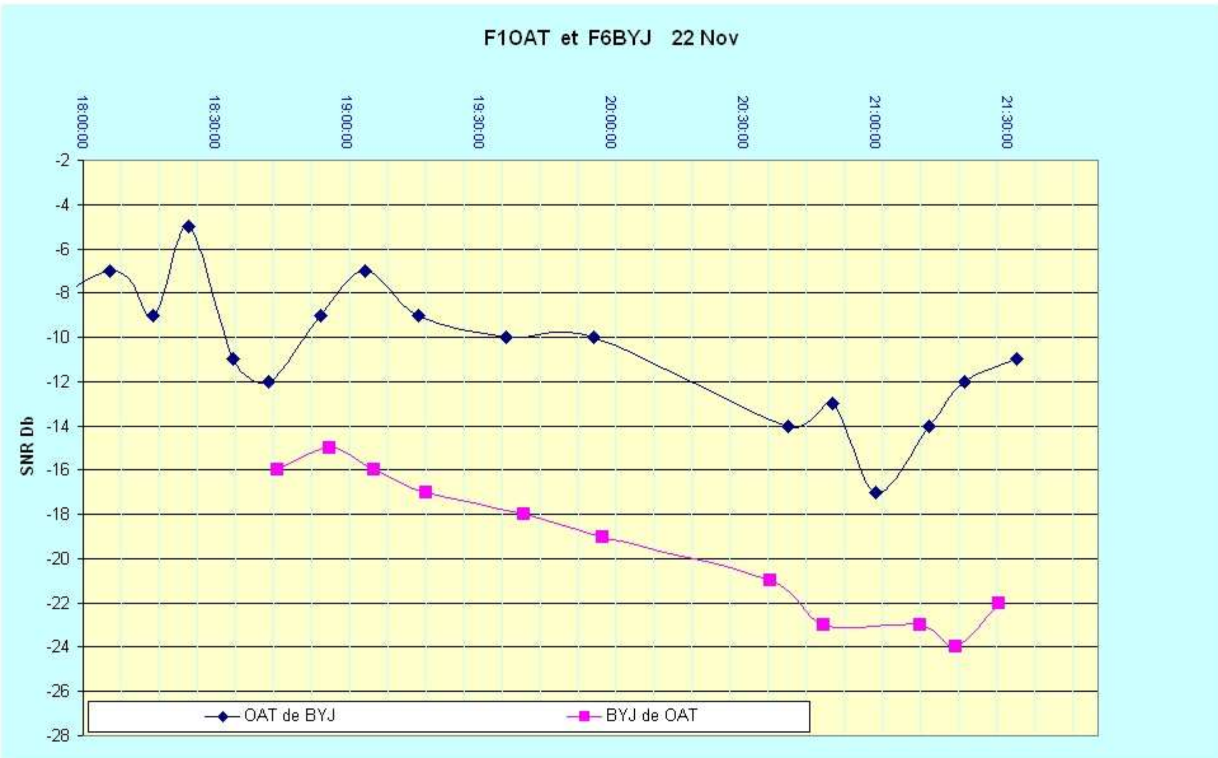
### *3.2-Long distance tests :*

Above 50 km and even with highly directive antennas the propagation variation affects significantly signals strength and SNR. This can be noticeable during the 2 minutes sequences even if the short term fading can be neglected by the decoding averaging process. Long term fading, tropospheric influence, reflection on mountains or moving airplanes, diffractions and all kind of masking effects are source of distortion affecting significantly the WSPR decoding efficiency.
As usually it is suspected that the WSPR protocol, defined mainly for HF communications, may not be fully appropriate for VHF. However, tests have been made with this assumption and the objective of fixing the application limits through appropriates statistical analysis of the recorded data and copy of screen pictures
Typical test results are presented hereafter.

### *3.3-Reciprocal propagation effect :*

The following picture gives an analysis example by extracting data from the WSPRnet website and a specific processing. As soon as reciprocal surveys cannot be done during the same 2 minutes time slot, propagation changes may occur and the SNR cannot be compared on each side. However, by averaging the results taking into account the propagation evolution it seems possible to estimate these differences.

*SNR evolution between F1OAT (JN18CP) and F6BYJ (JN05FS) distance 346 km on the 22nd of November 2008*



By taking this graph into account it is clearly shown a difference of about 8 dB between the reported SNR. F1OAT announced 5 W (37 dBm) and F6BYJ announced 10 W (40 dBm). This 3 dB difference is in opposition with the average 8dB differences found on SNR reports meaning that F6BYJ had a reception advantage of 11 dB on this link at this date.
An estimation of the power needed for allowing a SSB contact (5 dB/SNR) when the WSPR SNR is -10 dB at F6BYJ or -18 dB at F1OAT shows without any antenna change.
For F1OAT : 37+(10+5) = 52 dBm or 160 W
For F6BYJ : 40+( 18+5)= 63 dBm or 2 kW !!
It was clear that there was a problem at F1OAT side which seems to be corrected since this date according to latest report found on the WSPR database.

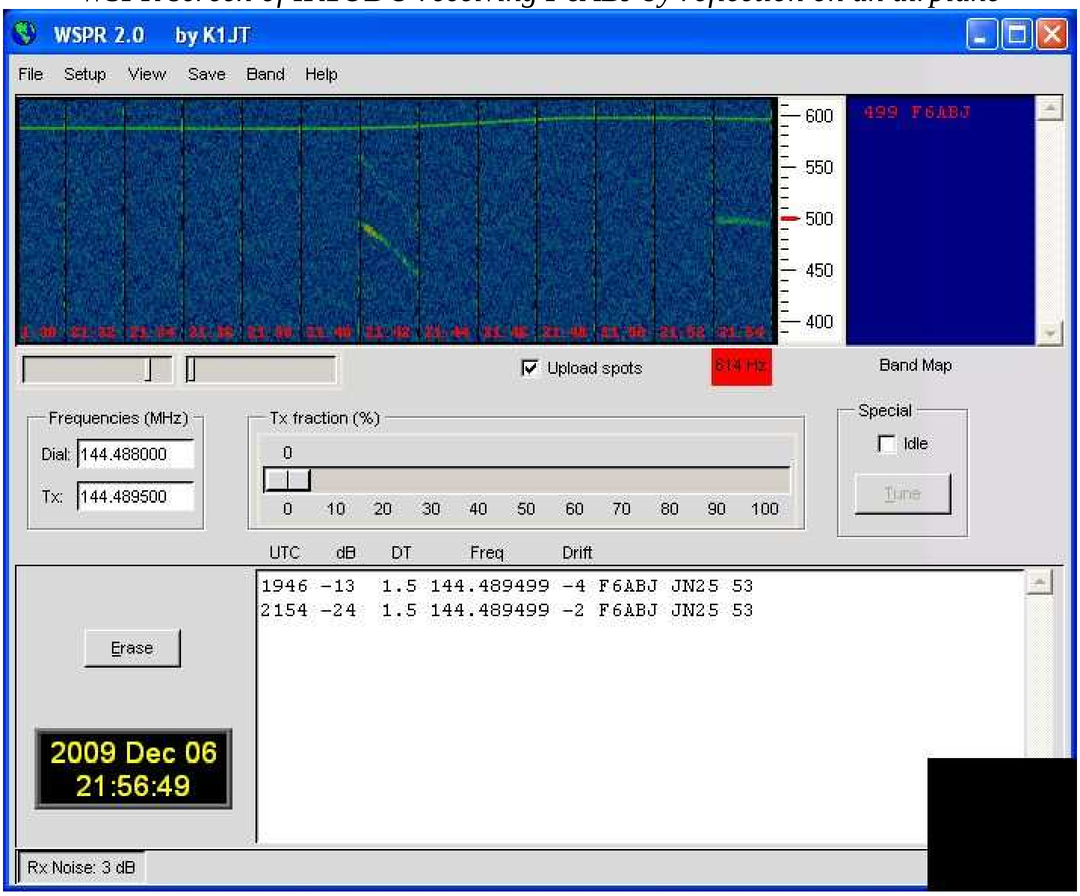
### *3.4-Doppler on reflected signals:*

Pictures of the program screen have often shows significant frequency drifts varying slowly during the analysis timeslot. There could be several reasons :

- Slow frequency drift of the transmitted signal from thermal effects within the transceiver
- Reflection on a moving object i.e an airplane

As it could be verified through other reports of the same time slot that the transmitter did not moved the reflection hypothesis became the only answer. A typical example of such a situation was found through a report by IK1ODO in JN35SQ (near Torino) of F6ABJ signals in JN25QH (near Grenoble). Even if the distance between them is not great (173 km) the Alps mountain of the Mont Blanc area is fully blocking any direct path. Many stations have succeeded some contacts in SSB or CW by taking benefit of diffractions at the top of the Mont Blanc but they were at a greater distance of it than F6ABJ and IK1ODO who cannot find any similar path being too close of the mountain feet.
The screen picture sent by IK1ODO is clearly showing the F6ABJ signal drift of 4 Hz or 2 Hz at different time slots of the day, the last one showing the weakest report at a quasi stable level during 2 minutes

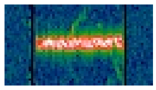
*WSPR screen of IK1ODO receiving F6ABJ by reflection on an airplane*



Knowing that F6ABJ is transmitting with 50 W on an omni-directive antenna supposed to have about 6 dB gain (he reports the ERP instead of the Tx output), we can assume reasonably that with 500 W and 10 dB more gain on a greater Yagi a SSB contact is possible through such a path (20 dB improvement over the present configuration achieving sometimes -15dB SNR). By knowing the air-traffic time table over the Alps one can even predict the appropriate time for such a contact !

### *3.5-Others effects to investigate :*

Several pictures on WSPR screen have shown strange effects needing more investigations.
On the copy presented above from F6BYJ it can be noticed a duplication of the F1OAT signal each of the trace staying quasi parallel at a quasi constant level. Sometimes the 2 traces have been decoded in the same time slot like on the 12$^{th}$ December 2008 at 17:42 UTC, one being reported at -33 dB SNR with a 4 Hz drift, the other at -11 dB with 0 Hz drift.
A first explanation could be that the weakest trace is coming by reflection over a plane but with a constant phase difference with the strongest one. Similar cases have often been reported by observers and would need more investigation for being clearly explained.

Other strange figures has been found with lateral scatters on the main trace like this: 
In this case we have yet no clear explanations and further investigations are needed. It was noticed than in this case the decoding performances even with no drift have to be lowered. Several cases even at -15 dB SNR didn't worked.

## 4- Applicable limits on 2m :

The results shown through all these analysis demonstrate that most of the existing transceivers on the market are stable enough after a preheating period of about 30 minutes before starting the real tests. In any case, it is not recommended to transmit at full power and more often at less than 50% of the maximum available otherwise it would need an external clock for stabilizing the internal frequency synthesizer.
However, their frequency accuracy is often far from the 10 Hz requirement. Several corrections have been applied up to 500 Hz to fulfil the specifications.
Through these preliminary remarks, it seems that the 2m band is probably the upper limit for recommending use of WSPR in VHF. If test are performed above like on 70 cm UHF, it would certainly need a very stable external clock.
In addition there is still some doubt for claiming that the Forward error correction applied for HF band is fully appropriate for 2m. Anyhow, results are quite satisfactory by taking into account the observed results of the test, considering the availability of the product and its easy MMI.

## 5- Conclusion :

In the beginning of the test period the active group was made of 5 to 6 active stations and it has grown quickly after a few months to about 15. Now to day and according to the WSPRnet database, there is about 110 users in Europe and 60 in Japan. The distribution over Europe is approximately 35 in France, 23 in United Kingdom, 12 in Italy, 11 in Russia, 5 in Germany, 4 in Switzerland, 3 in Spain, 3 in Poland, 3 in Austria, 3 in Denmark, 2 in Greece, 2 in Sweden, 2 in Netherlands and 2 in Belgium.
Even with this amount of activity the channel is very far from being saturated and there is not enough permanent transmission to draw any propagation map as efficiently as for HF bands even if this can be done with the existing beacons. It is also demonstrated that the 1 kHz channel recommended for its application is wide enough for allowing several hundreds of permanent transmissions and keep enough space for thousands temporary users.

In any case, if the WSPR protocol allows deep analysis below the noise level, the length of the test time slot is not appropriate for fast propagation evolution like MS or any short burst application. It seems well matched to analysis of traditional tropo conditions and mainly for specific point to point applications or for qualifying remotely some radio sites.
Application of WSPR in UHF and SHF looks too critical according to the technical requirements on the frequency accuracy already difficult on 2m.
Compared to well known applications like JT65 developed also by K1JT and widely used for EME contacts or even very long distance ones in VHF, WSPR seems to have a better sensitivity but time slots are longer and reception may often vary too fast on 2m so that frames have a greater probability of being lost during deep fading holes.
In general, this experimental test has been successful and we are convinced that this technology should be supported as many others for improving the efficiency of all kind of traffic on the 2m band.