

FM- HD- Radio Field Trial Results under European Frequency Planning Conditions

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ABSTRACT

FM-Radio in Europe uses different Frequency planning and some transmitting parameters are not the same as in the US. Field- and Lab-Testing by Ruoss AG/Radio Sunshine Lucerne Switzerland shows in an interim Report to the Swiss OFCOM Dec 06, already after the first part of the Work very promising perspectives to use FM-HD-Radio in Europe as easy as in the US, and to go on Air operationally as early as second half of 2009. The Project, funded by the Radio-Industry and supported by the OFCOM will continue during 2007 ,to demonstrate more of the HD-Radio Capabilities with Translators/ Boosters ,RDS-AF Functionality, extensive Indoor testing and a European Set of HD-Radio planning Parameters. Many European Countries started HD-Radio Trials as well, and even Trials in Germany are expected in the first half of 2007.

HISTORY

In respect to digital Radio, Europe is known as (commercially questionable!), successful 100% DAB-Eureka 147 Area and the „image“ of IBOC in Europe is very poor. Almost “unproven” Arguments are distributed like “technically not feasible in Europe because of many differences in the FM-System, including mix-up with am-HD-Radio Questions. Also based on the big DAB-Investments (and Commitments of the BIG-Players and Authorities) , and an European digital FM-System on its Way (DRM+) to be finalized, comprehensible-wise no one is really interested in a “foreign” FM-Digital Alternative.

One should also not overlook, that not even one European Country has a commercially profitable DAB-Operation very soon, with the eventual Exception of UK where there is the Chance to become profitable within some Years from now. (CGap, the biggest UK-Operator predicts “digital break even” for 2010). More so, some thousands of local and regional (one Program-) Broadcasters are not so sure anymore that a Multiplex-Technology is the proper Solution for them, and that maybe more feasible and economically viable systems with a slow evolution path to digital should be found.

That's why the Swiss OFCOM and the Association of Private Broadcasters (VSP), started to support our Initiative to do some HD-radio Field Trials and to follow any other kind of FM-digital System who could be an alternative.

Nowadays this is on the Way to change dramatically, thanks to several testing sites all over Europe; especially in Switzerland where the OFCOM granted the first European HD-radio Test License for 2 Years to Ruoss AG/Radio Sunshine.

Of course, there is no doubt about the fact, which especially DAB+ (new audio codec and new error correction), when introduced very fast, is a very good solution for multiprogramming-Broadcasters and for large area coverage (SFN's).

FIELD AND LAB TEST- SET UP

For the Field Testing the Main Transmitter of Radio Sunshine (88.00Mc, located at around 400 Meter HAAT , with Mountains in approx 10 , 20 and 40Km behind the coverage Area) is used in a High Level Combined Standard Hybrid-Mode with 3500 Watt analog and 35 Watt digital Power. The Main Coverage Area is the Town of Zug and Vicinity. (Radio Sunshine has a total of 14 Transmitters to cover Central Switzerland) See Figure one: Simplified Excerpt of critical Field Test Area.

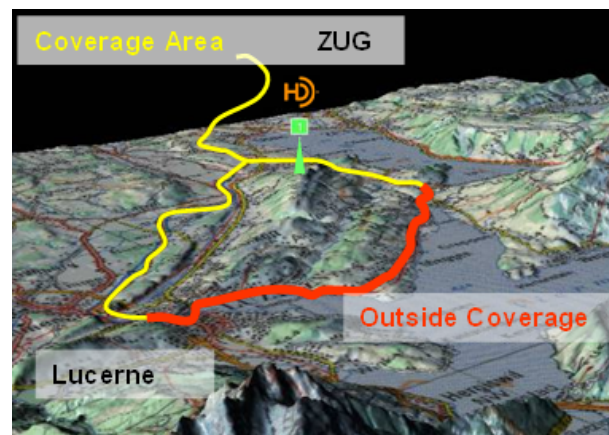
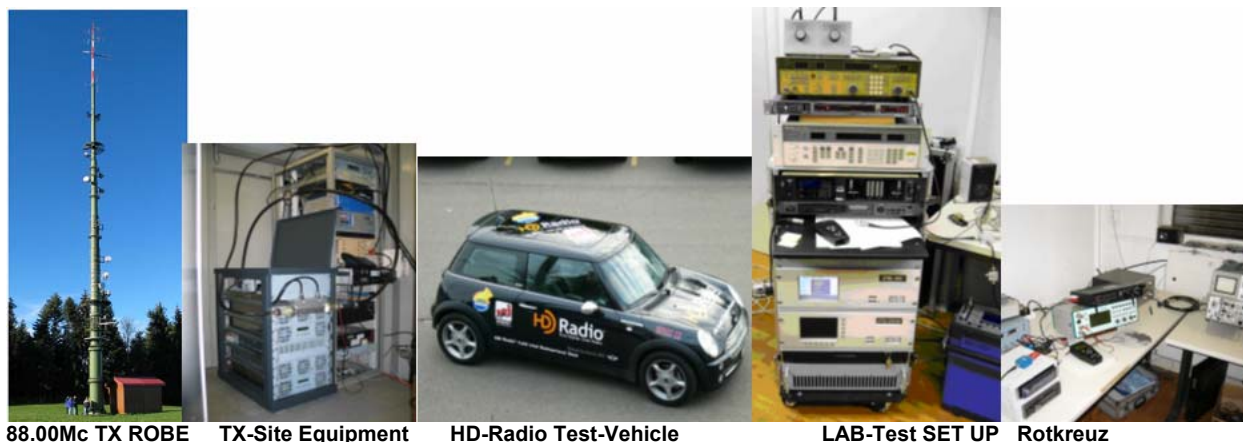


Figure 1



The Content transmitted in 24/7 Multicast Mode is:

- Radio Sunshine analog FM
- Radio Sunshine digital (HD 1) 48kbs
- Radio Energy Zurich digital (HD 2) 32kbs
- Service digital (HD-3) 15kbs, Voice: Traffic, Weather, Sport, Events...
- PAD HD-display 1kbs

A second Transmitting Equipment together with other FM- and Test- Equipment Is used for Lab-Simulations and testing.

For the first Part of the Trial a Number of JVC, SANYO and Kenwood Car-Receivers are used together with some Table Tops from POLK and Boston Acoustics. ADA Receivers are used for Reference. 12 FM-Receivers where used for LAB testing, 3 Walk-Radio/Cell phone, 3 Car, 4 portable, 2 Compact HiFi.

DEVIATION AND MPX-POWER ISSUES

The FM-System in the US uses 75uS Pre-Emphasis, a maximum Deviation of 50Kc and MPX Power above 0dBr. Europe uses 50uS Pre-Emphasis, a 75Kc max. Deviation and max. MPX Power Levels ranging from 0dBr to “some dBr” depending on Country and “best practice”. Some European Countries only allow a max. of 0dbr MPX Audio Power Other Countries like Switzerland allow +3dBr , and some Countries using even higher MPX-Levels . See Figure 2 for Typical used Peak Deviation and MPX-Power for all HD-Radio (LAB- and Field)-testing.

All our testing so far, shows clearly that „the European Values“ of Peak-Deviation/Pre-Emphasis, and MPX-Power Levels (up to 6dBr), do not give any relevant Limitations for the use of the HD-Radio System

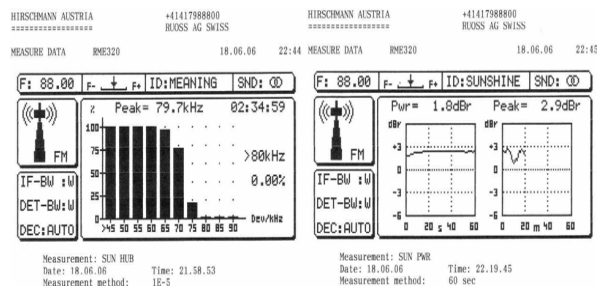


Figure 2

The simple Explanation why HD-Radio works “easy” with European higher Deviation is, that the HD-System was designed to work with higher SCA carriers like 76 and 96Kc in the us , and that there is a FAC (First Adjacent Canceller) in the System.

HOST COMPATIBILITY

Is the European Receiver Universe different from the US? Not really, but in most Countries in Europe, portable and INDOOR-Listening of FM-Radio is much more important than in the US. Actual Figures from Switzerland shows that approx. 2/3 of all Radio Listening is Indoor /Portable! This means that Portable Receivers has to be tested as well as Car-Receivers. Home- Stereo’s are a bit less important nowadays because they are mostly connected to Cable and not to an Aerial (anymore).

Earlier Receiver Studies from Nozema (Netherlands, 1998) and the Swiss OFCOM in the Year 2002 indicated that a greater part of the portable Receivers even are not able to meet the min SNR Requirement and the min RF-Selection Criteria’s as it is recommended by the ITU-R BS-412-9, BS.415-2 and ITU-R BS.641 Rules suggest.

Figure 3 shows the SNR Performance (with and without HD-Signal) of a non Representative Sample of typical European FM-Receiver.

The Good News is, that in the last some few Years, the FM-Receiver in the Cell-Phones ,PDA's , PMP's and in the Low-Cost Portables and Walk Radios get very good Receivers, in Respect to SNR and Selectivity built in.

SNR (in dBA) of typical European FM Receivers:

	CAR I	CAR II	Home-Stereo I	Home-Stereo II	New Walk-Radio FM/DAB	New Cell phone	Old Mini-Portable	Old Walkradio Portable
FM-Only	56	56	69	68	54	53	47	47
HD-ON	56	55	67	62	52	51	46	46

Figure 3

Not even one Complaint from a Listener (> 50 000 FM-Receiver involved on 88.00Mc) about SNR – Reduction from HD-Radio Sidebands, nor a Complaint about RDS-AF Function , what is very important in the Test-Area (more than 4 different Frequencies needed for FM-analog Coverage around Lucerne/Zug)

The SNR- Influence of the 2 digital HD-Radio Side-Bands on Europe's FM-Receiver Universe at the Time of operational Introduction of HD-Radio will be very minimal, and the commonly used planning Criteria on minimum SNR Performance can be met. No any Influence on RDS-AF Function was detected so far.

Extended Hybrid and Multicast

Simple LAB- Measurements and Comparisons with Extended Hybrid Operation did not give relevant differences to the Measurements carried in the US. However, to get best possible SNR-Protection for some of the existing High Performance FM-Receiver, I would actually recommend waiting with the Full-Extended Hybrid Operation till after initial operational Introduction in European Radio- Markets. Looking from marketing perspectives, of course Multicast is a Must right from beginning!

FIELD TEST RESULT

Digital Coverage in the FM-Coverage Area

Within the FM-Coverage Area the digital Coverage for (all digital Content) is perfect and 100% stable with Car Receivers. Examples see in Figure 5. As also can be seen that, coverage Extension happens in Areas where FM analog is unusable (black /blue and green in the Figure 4) because of strong Multi-Path Reception, but

with sufficient Field strength and an off Spectrum protection. Figure 4, shows the FM analog Quality (ITU, 5 Grade Scale) of almost the complete Reception Area of the 88.00 Mc Transmitter. Almost all of the Green/Blue and Black Parts of that Picture will have digital Reception with some blending to analog. The Coverage of the Additional Content is smaller than for the Host-Program, because of no blending Feature. This Results are not yet “validated” for complete Indoor Reception in all that Area where Car-reception is good. See also “Indoor portable Reception “

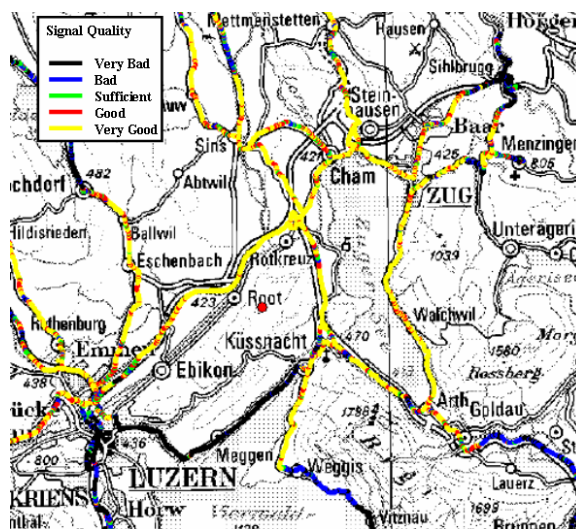


Figure 4

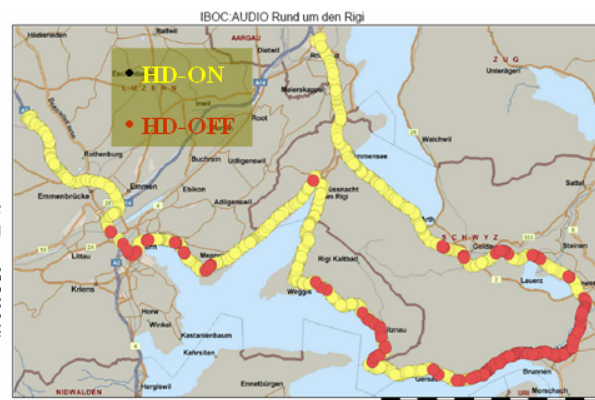
RDS- AF Functionality / Host compatibility

The Main-Transmitter of Radio Sunshine (88.00Mc) is used by more than 50 000 FM-Receiver. In the first 9 Month of Operation with the HD-Radio Signal, no one Complaint from Listeners (on 88.00, or close other Frequencies) was received about Additional Noise or distortions. Also there is no any Complaint about the RDS-AF Functionality.

This is a clear Indication that HD-Radio can be introduced on existing FM- Transmitters in a European Frequency Planning Environment.

Indoor portable Reception

Untill now, very little Indoor Reception Experiences are made. Extensive Indoor testing with 40 or more Portable Receivers distributed to Listeners in the fringe Area of the 88.00Mc Transmitter will take place in Part II of the Trial. We already know that compared to the Street- Field strength in the critical Areas, we have around 15 -20dB “Headroom” for digital Reception. Based on the common used Number of 14 dB for FM Building Penetration, we are very confident that the



Indoor-Results will be very promising, with the Exception that we cannot yet quantify the influence of today's typical indoor noise environment on digital reception in the FM-Band. To achieve deep Indoor Reception, approx. 60dBuV/Meter at 2 Meter (commonly used in Switzerland for actual FM planning) will be necessary.

HD-Robustness at High Speeds

Because 88.00Mc is a relatively "well protected" (in Respect to ITU 412-9 Recommendation), additional "artificial" Interferers on both sides of 88.00Mc where needed to simulate digital Reception robustness in fast moving vehicles. Compared to actual Lab-Results some Degradation could be recognized, but at maximum allowed ITU-412 interfering Levels, the digital Reception still is very robust. More "quantifiable" work will be done on this Issue in Part II of the Trial.

LAB-TESTING RESULTS

For LAB-testing the ITU-R-BS-412-9 and ITU-R-BS 641 Recommendation for FM Planning and Measurement is taken as basic Reference. Because FM-HD-Radio Hybrid Operation is a Mixture between an analog and a digital System and as example, because the 2 HD-Sidebands are redundant, some of the recommended Procedures are not anymore useful for HD-Radio Considerations or does not make much Sense. Also today's Station's Sound design produces somewhat other Spectral Densities as at the Time the Recommendations were made. For judging the HD-Radio System we must have different Set of Protection-Ratios for the following Interfering Situations:

D to A: (Digital to Analog)

An HD-Station interferes with an analog only FM-Station

A to D:

An analog only Station's interferes with a HD-Station

D to D:

Interference between Digital Hybrid Stations

For A to D and D to D one will also need different Protection Ratios for stationary/portable and Reception in fast moving vehicles. To get realistic Numbers, both Sidebands have to be interfered at the same Time.

Some subjective evaluation of the Difference between a FM modulated signal interfering an analog FM-Signal and an OFDM HD-Signal interfering an analog FM-Signal at the typical HD-Signal Differences has to take place.

Later there will be also a need for Full Digital Mode Protection Ratios

For the D to A and D to D Measurements, as for the Off Air Signal, Figure 6 shows the typical used RF-Spectrum for Hybrid and Extended Hybrid Operation.

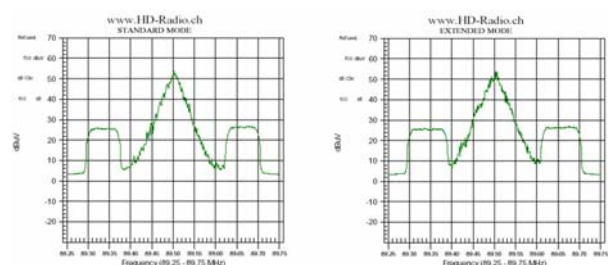


Figure 6

Critical Spectrum Issues?

For the D to A Measurements the same Receivers as for the Host compatibility were used.

For A to D and D to D- Measurements, HD- Radios from Sanyo, JVC and Kenwood was used.

CO-Channel and 400Kc Interfering Situations or not critical at ITU- Limits and the same as in US, so no special additional attention is necessary for this Situations.

Figure 7 shows European 100Kc Interferer at ITU 412-Limit. This Constellation is not critical for D to A, A to D and D to D Interference. The analog Interference is always stronger as Interference from digital Sidebands. Depending on the FM Receiver, more than 10dB "Headroom" was measured on the ITU Limit.

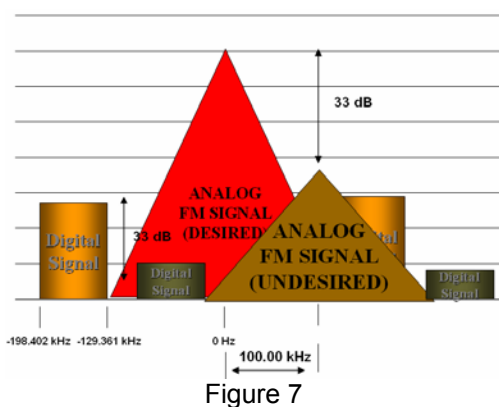


Figure 8 shows the 300Kc Interference Situation at ITU-412-9 Limit. This Constellation is not critical for D to A, A to D and D to D Interference. The "Headroom" to ITU-412-Limits is only "some dB's", depending on Receiver, and symmetrical Interferers, both strong at same Time, can be critical in fast moving Vehicles.

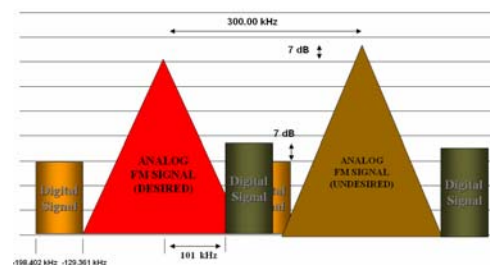


Figure 9 shows the worst possible Constellation for Europe with both Sidebands Interfered with a HD Signal at ITU Limits. This is the most critical Situation in the Field, (same as in the US), and is fortunately not standard practice to happen in the Coverage Area in most European countries. It is not common as well, that

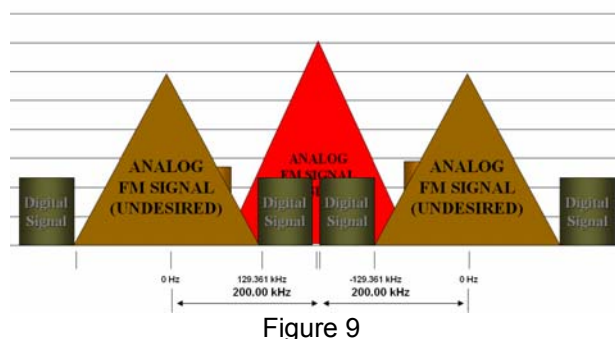
if one strong +200Kc Interferer exists that at same Time and Place there is also a strong - 200Kc Interferer.

D to A: as long as the Listener does not use a HD-Radio, the max Stereo- SNR can be reduced well below the recommended Value. In practice, almost all today's CAR-Receivers will blend to MONO (produces approx. 20 dB better SNR) during this kind of strong Interference, and the average Listener will not notice.

Home-Stereo's with individual Aerial (does nowadays exists only in rare Cases) will have degraded noise Performance, and "old" Receivers with poor RF-Selectivity (and missing Low Pass after Demod) will have analog Interference before they notice the additional Noise from the OFDM Signal.

Therefore it is recommended (to protect the existing FM Receivers) that special Attention has to be taken for 200Kc Interferer Situations, especially when both sidebands are affected.

A to D and D to D Interference at ITU-Limits will still produce stable HD-Radio reception for the wanted Signal.



New FM-HD-Radio Planning Rules?

If the ITU-R- 412-9 Recommendations are respected in a way as it was "common practice" for the earlier FM-Planning in Europe, and the estimated near future average FM- Receiver-Performance is used, no new Rules are necessary to implement HD-Radio in Europe! Following Exceptions may apply:

- avoid symmetrical, (and same Time /same Location) 200Kc Interferers in the Coverage Area
- try some Headroom at 200 Khz Frequency Difference (average 7dB would be great)
- Use 60dBuV /Meter at 2 Meter at Edge of Coverage Area
- Correct eventual earlier "non conforming 200Kc Interferers" in the Coverage Area

In Europe, the same Interferers (+/- 200Kc) are the HD-Radio System-Limit as in the US! And not as told around for Years 100 and 200Kc !

Figure 10 shows typical LAB-Test Configurations as they were used for preliminary Protection ratio measurements.

Receiver Sensitivity

Coming as no big surprise, all tested Car HD-Radio Receivers has very good Sensitivity and very good FM-

analog Performance as well. HD-Radio uses same proven FM-Radio RF-Front-end as it is known for very long Time. The Car Receivers we measured so far works all in digital Mode a bit below 30dBuV at the Receivers Antenna Input. The first Generation Tabletop's are some dB less sensitive

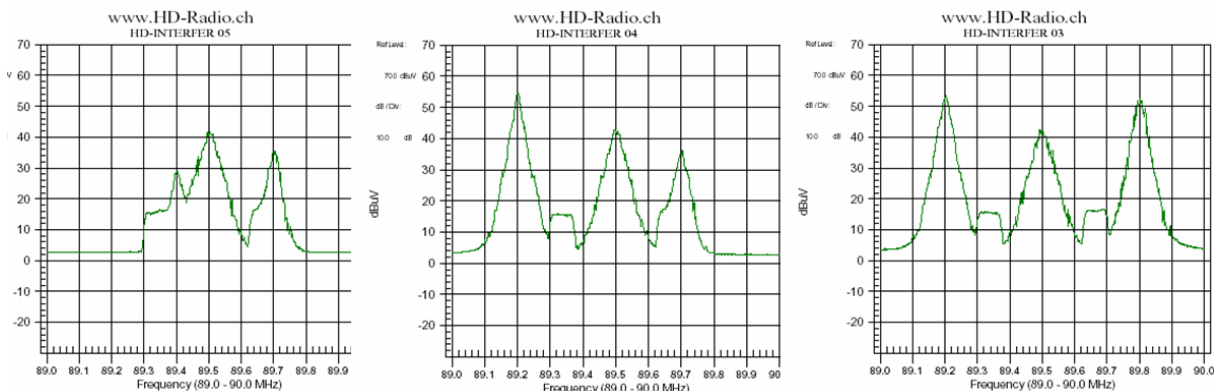


Figure 10

How selective are today's FM-Receivers?

Unfortunately not all Receivers in the actually existing FM-Radio Universe have the same performance when it comes to selectivity. As Figure 11 shows, there are dramatically big differences between Receivers.

As Example at 200Kc Frequency Difference, a relevant part of the Receiver Universe (BAKOM Study 2003) is more than 20dB worse than the ITU Recommendation (portable /mobile), but another Group of Receivers (especially Car-Receivers) is up to more than 50dB better than ITU-R is looking for.

The good News is, that with the Exception of 100Kc, the actual FM-Receiver-Chips built in, in cheap portable Receivers and Cell phones are much better as some Years ago, and are reaching ITU 412-9 min. Performance.

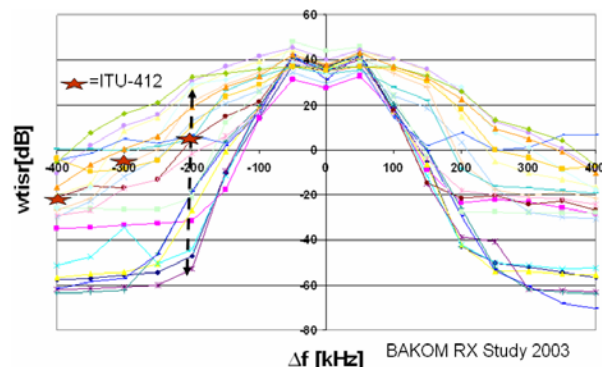


Figure 11

HD-Radio an (ETSI) Standard?

The initial Steps have already been taking to make HD-Radio a European ETSI (European Technical Standard Institute) Standard. An Important Part of the is Process will be the inclusion of the European RDS Standard with the AF-Functionality (Alternate Frequencies), because in contrary to the US, an average Private Broadcaster has a high number of Translators and not just one Main Transmitter.

OTHER FM-HD-Radio TRIALS IN EUROPE

HD-Radio's growing popularity in Europe has led to some "HD-Radio Tourism" to our Location in Central Switzerland for a Test-Drive with one of our Test-Vehicles and a Laboratory Demonstration of all critical Protection Ratio Issues. It is a Fact, that almost all "critical Visitors" (only had "heard of", and "read about" HD-Radio in US) becomes real "Fan's" of the Digital FM Idea after the Demonstration in the Field and in the LAB.

Some of the leading OEM's for the German Automotive Industry have started to use central Switzerland is the Test-Place for there HD-Radio Equipment.

Even after the Announcement by the World DAB-Organization about the soon arrival of the far more efficient new DAB+ (with AAC+ Audio Codec, which is very similar to HDC used by HD-Radio, and the

better Error Correction) the European Interest from Regulating Bodies and Private Broadcasters is still growing very strong.

In France (Towercast and NRJ-Group, backed from Sirti) doing intense testing since April 2006 in the Paris Area with 2 HD-Transmitter on-air, in a critical "European frequency Assignment". Poland and Ukraine are actually also running some HD-Radio Tests.

Actual new plans for HD-Radio Trials and Interest in HD-Radio (we know of at time of writing) in Europe includes:

- Austria (Krone-Hit-Vienna and others)
- Italy (RVR with some Broadcasters in north Italy, Aeranti Corallo-Radio Association)
- Germany (several independent projects ,)
- Romania
- Czech Republic
- Bosnia

THE KEY ADVANTAGES OF FM-HD-RADIO™

HD- Radio can become the "optimum" Path for European "one Program Broadcaster" to the digital Radio Age. The Advantages are obvious:

- Same frequency and same basic FM-infrastructure
- Additional services possible on the same frequency
- Better quality of service in the coverage area
- Backwards compatible with FM (simple communication!)
- Slow evolution without much cost for the broadcaster
- EMC Issues practically non-existent
- Good indoor and portable reception achievable
- Less Translators/Boosters as for analog only Operation

NEXT STEPS

Even with the very positive Results so far, more detailed Investigations in the Lab and in the field are necessary before Regulating Bodies can start issuing operational Licenses for HD-Radio. Following the major steps in our Trial Project till end of 2007:

- Comparison between FM and HD-Radio™ „indoor“ coverage
- Support for OFCOM Lab-Measurement for HD-Radio Protection Ratio for all major operating Constellations and all major Receiver Segments.
- Consequences (if there are any) on FM-planning for FM-HD-Radio- implementation in Switzerland (and Europe), comparison with USA and ITU-412-9 recommendation

- Translators and SFN-Boosters for HD-Radio in the field (and RDS-AF Functionality test)
- Implementation and operation costs in Comparison to FM operation , and other digital Platforms
- Implementation Comparison with other digital FM-Systems like DRM +
- Support of timely creation of operational HD-Radio operational licensing Guidelines
- More general awareness in Europe for FM-HD-Radio , including at Receiver Manufacturer Level , for "Multiplatform Receivers"

The Presentation of the Progress and the Results will be presented during the second HD-Radio days in Lucerne, Switzerland on 4./5. October 2007. To stay informed on the "Work in Progress", see WWW.HD-radio.CH . The Final Report for the OFCOM is planned for December 2007. An operational start up of HD-Radio is estimated for approx. 3./4. Quarter 2007.

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