The Digitalization of the FM-Band in Europe

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ABSTRACT

Even in the DAB+ Area, the FM-band enjoys a large and growing popularity. The interest in a supplemental standard for local and regional broadcasters is a real demand.

At present there are 3 possible means of FM-Digitalization, HD-Radio™, DRM+ and FMeXtra.

This paper, concentrates on HD-Radio trials in Europe, the results so far, and what more steps has to be taken to obtain operational licenses for broadcasters.

The main differences in the FM-spectrum between US and Europe are explained as well as the interpretive differences between "formalistic-, planning-, lab testing-viewpoints and results" and the real world implications and results in the field.

To back the efforts on the European Level, the European HD-Radio Alliance (EHDRA) was founded a year ago.

The first Steps to make the HD-Radio Standard (NRSC-5, ITU-R BS.1114-2) a European ETSI Standard and get the International Coordination and Planning Issues studied at ECC-Level are on the Way. The ETSI harmonization standard work item received approval at their last meeting in France.

For a general HD-Radio overview and global update, see the Paper of Gereon Joachim iBiquity Digital Corporation in this proceedings.

INTRODUCTION

With respect to digital radio, Europe is known as a 100 percent DAB Eureka-147 area, and the image of in-band, on-channel digital in Europe is very poor. Unproven arguments against IBOC are disseminated, like "technically not feasible in Europe because of many differences in the FM system," and there is confusion of FM with AM HD Radio system questions.

Based on large DAB investments and a European digital FM system (DRM+) on its way to finalization, it is understandable no one is really interested in a "foreign" FM digital alternative.

However, not even one European country has a commercially profitable DAB operation yet (with the eventual exception of the United Kingdom, where there is the chance to become profitable some years from now; CGap, the biggest U.K. operator predicts "digital break even" for 2010).

Moreover, some thousands of local and regional (single-program) broadcasters are no longer so sure that a multiplex technology is the proper solution for them; perhaps more feasible and economically viable systems with a slow evolution path to digital should be found.

That's why the Swiss Federal Office of Communications (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 that could be an alternative.

The Swiss OFCOM granted the first European HD-Radio™, test license at the end of 2005 for two years to Ruoss AG/Radio Sunshine. This license was extended until the end of 2008, and a total of three different frequencies are now allowed to be tested simultaneously.

Since field testing began, and especially after the successful HD Radio Days in Lucerne in October 2006, HD Radio broadcasting has begun to gather a lot of positive interest in Europe. The "false statements" about HD Radio technology have started to fade away, piece by piece. A good example of such false statements was that European FM deviation will have to be reduced below 50 kHz peak deviation, and the audio multiplex power to –6 dBr, to make it work. This argument has now completely disappeared.

However, some critics says, that the tests with the Radio Sunshine transmitters in Lucerne and Rooterberg are with too small transmitting power. The critics speculating that with a High Power transmitter all would be very different as the findings in the Swiss trial.

Therefore we were very pleased that Radio Regenbogen initiated the first Field trial in Germany on one of their existing high power FM-transmitters in Heidelberg.

SWISS-FIELD-TRIAL AND LAB TEST SETUP

For IBOC field testing, the main transmitter of Radio Sunshine (88 MHz, located at around 400 meter height above average terrain, with mountains approximately 7, 13 and 25 Km behind the coverage area) is used in a high-level combined standard hybrid mode with 3,500 watts analog and 35 watts digital power. The main coverage area is the town of Zug and vicinity; Radio Sunshine has a total of 16 transmitters to cover Central Switzerland, see Fig. 1. The content transmitted in 24/7 multicast mode is:

- Radio Sunshine analog FM
- Radio Sunshine digital (HD1) 48 kbps
- Radio Energy Zurich digital (HD2) 32 kbps
- Service digital (HD3) 15 kbps, voice, traffic, weather, sport, events
- PAD HD-display 1 kbps

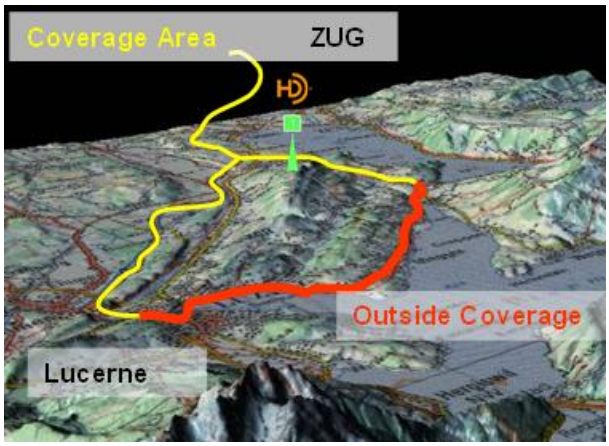

Fig. 1*: Simplified map of critical field test area*

A second transmitting setup together with other FM 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 tabletop radios from Polk and Boston Acoustics. ADA receivers are used for audio quality reference.

Twelve FM receivers were used for lab testing: three Walkman radio/cell phone type, three car radios, four portable and two compact HiFi's.

A second on air transmitter in Lucerne (97.1Mc) is used for translator and RDS AF function tests.

Deviation and PMX Power Issues

The FM system in the United States uses 75 µsec pre-emphasis, a maximum deviation of 75 kHz and multiplex power above 0 dBr.

Europe uses 50 µsec pre-emphasis, a 75 kHz maximum deviation and maximum MPX power levels ranging from 0 dBr to "some dBr" depending on country and "best practice." Some European countries only allow a maximum of 0 dBr MPX audio power while other countries like Switzerland allow +3 dBr, and some countries use even higher MPX levels. See Fig. 2 for typical peak deviation and MPX power for all HD Radio lab and field testing *[Ed. Note: For European radio broadcasters, the International Telecommunications Union established a modulation density specification that uses the integrated value of the power in the audio modulation of the FM signal to define "peak" modulation levels. This reference of 0 dBr is equal to a 19 kHz average deviation over a 60 second integration interval, which is typically much lower than modulation used by an FM station in the United States.]*

All our testing so far shows clearly that "the European values" of peak-deviation, pre-emphasis and MPX power levels (up to 6 dBr) do not give any relevant limitations for the use of the HD Radio system.

Host Compatibility

Is the European receiver universe different from that of the United States? Not really, but in most countries in Europe, portable and indoor listening of FM radio is much more important than in the U.S.

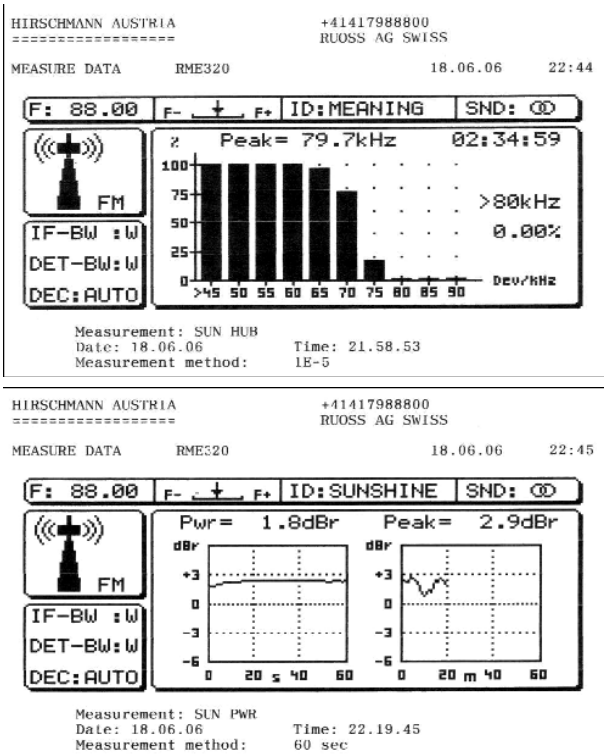

Fig. 2: *Measurement of typical peak deviation and audio multiplex power used at the Radio Sunshine transmitter network. The recorded values are at the 'edge' of what is allowed in Switzerland.*

Actual figures from Switzerland show that approximately 2/3 of all radio listening is indoor/portable. This means that portable receivers have to be tested as well as car receivers. Home stereos are a bit less important nowadays because they are mostly connected to cable systems and no longer to an antenna.

Earlier receiver studies from Nozema (Netherlands, 1998) and the Swiss OFCOM in 2002 indicated that a greater part of the portable receivers are not even able to meet the minimum signal-to-noise ratio requirement and the minimum RF-Selection criteria as recommended by the ITU-R BS.412-9, BS.415-2 and ITU-R BS.641 rules. Fig. 3 shows the S/N performance (with and without HD signal) of a sample of typical European FM receivers.

The S/N influence of the two digital HD Radio sidebands on Europe's FM receiver universe at the time of operational introduction of HD Radio technology should be very minimal, and the commonly used planning criteria on minimum S/N performance can be met. No influence on RDS-AF function was detected so far.

	CAR I	CAR II	Home Stereo I	Home Stereo II	New Walk-Radio FM/DAB	New Cellphone	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**

Fig. 3: *SNR (in dBA) of typical European FM receivers*

Extended Hybrid and Multicast Operation

Simple lab measurements and comparisons with extended hybrid operation did not show any relevant differences to the measurements made in the United States.

However, to get best possible S/N protection for some of the existing high-performance FM receivers, I would actually recommend delaying full extended hybrid operation until after initial operational introduction in European radio markets to minimize any potential interference to existing receivers. However, since October 2007 we use 120kbs multicast without any noticeable degradation or listener complaints. Looking from a marketing perspective, of course, multicast is a must, right from beginning, if not the major reason that broadcasters in other countries have implemented the HD Radio system.

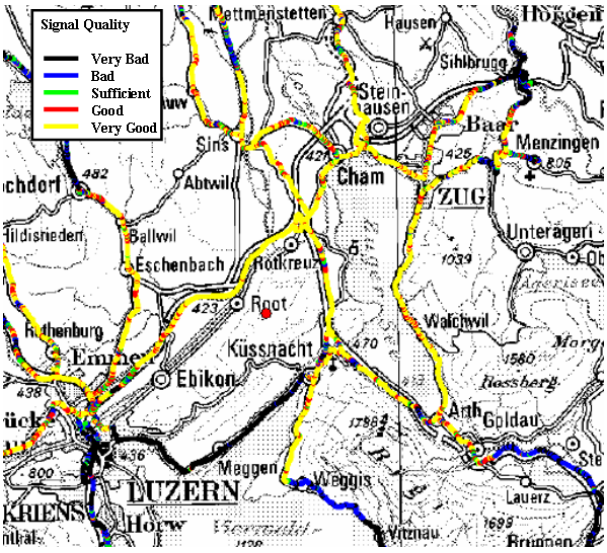

Fig. 5: *Measured coverage quality of the analog FM signal of Radio Sunshine's main transmitter at 88 MHz. The different colors represent the five-grade CCIR scale for audio quality.*

SWISS FIELD TEST RESULTS www.hd-radio.ch

Digital Coverage in the FM Coverage Area

Within the FM coverage area the digital coverage for all digital content is perfect and 100 percent stable with car receivers. For examples see Fig. 4.

It also can be seen that coverage extension happens in areas where FM analog is unusable (black/blue and green in Fig. 5) because of strong multipath reception, as long as there is sufficient field strength and off-spectrum protection from first, second and third adjacent channel.

Fig. 5 shows the FM analog quality (ITU, five-grade scale) of almost the complete reception area of the 88 MHz transmitter. Almost all of the green/blue and black areas will have digital reception with some blending to analog. The coverage area for the multicast content is smaller than for the host program because there is no blending feature. These results are not yet validated for complete indoor reception in all of the areas where car reception is good.

RDS-AF Functionality/ Host Compatibility

In the first 18 months of operation with the HD Radio signal during our testing, not one complaint was received from a listener (more than 50,000 FM receivers on 88 MHz) about S/N reduction from HD Radio sidebands.

Nor were there any complaints about RDS Alternate Frequency function, which is very important in the test area (more than four different frequencies are needed for FM analog coverage around Lucerne/Zug). This is a clear indication that HD Radio broadcasting can be introduced on existing FM transmitters in a European frequency planning environment.

One of our trial-sponsors (Harman Becker, Germany) produced some Prototype FM-HD-Radios with RDS-AF feature. In the Field it was shown that RDS-AF works fine with HD-Radio and finds and stays first with another transmitter carrying the same program with HD.

Indoor Portable Reception

Extensive indoor testing where made with approx 40 portable/table top receivers, distributed to listeners in the fringe area of the 88 MHz transmitter, and in the urban area of the Lucerne city center.

Based on the commonly used factor of 14 dB for FM building penetration, and the average field strength at the fringe of the licensed area, we assumed to have approx

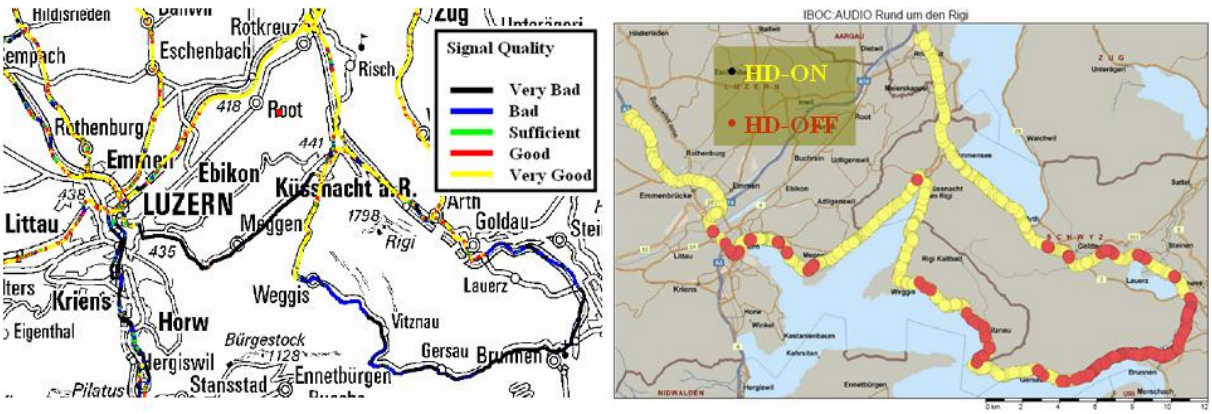

Fig. 4: *Digital coverage at the fringe and outside of FM analog coverage area. In strong multipath areas (like the sections with the black color on analog graph) there is much better digital than analog coverage.*

14-18dB “headroom” for digital reception above sufficient Stereo analog Reception.

The test-reports made together with the listeners (some measurements where taken at listeners premise when the HD-Radio receivers were taken back) shows that our assumption about home receiving capabilities are correct. However there were some additional findings:

- Some listeners use FM-analog Radio at incredible low quality levels, especially outside of the licensed area and deep indoors. Often only in mono, and even this not in good quality!
- Man made noise (urban area, living area with PC, LCD screen and more) at receiving Levels below approx 42dB/uV/meter can result in drop of HD Reception where FM analog is somewhat less susceptible
- Nowadays building construction (like special window glasses) can create substantial additional penetration loss

For the long term implementation of HD-Radio it is advisable, especially in conjunction in multi transmitter networks to take care of the minimum field strength for Hybrid FM Operation at or outside of the licensed area. This is especially true, if one is looking for deeper indoor reception.

HD Robustness at High Speeds

Because 88 MHz is relatively “well protected” within the licensed area (in respect to ITU 412-9 recommendation), additional “artificial” interferers on both sides of 88 MHz were 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 412-9 interfering levels the digital reception still is very robust for all tested receivers.

The same reception robustness is valid for Indoor “fixed” reception as long as there is a minimum field strength for stereo reception.

As a general rule for Europe, one can say that as long the FM-analog stereo Reception is not moderate to strongly interfered, the HD Reception is robust. For some special Extended Hybrid multicast application, there could be some additional restriction in case of very strong 100 KHz interferers when present at same time with other strong interferers.

SWISS LAB TESTING RESULTS

For lab testing the ITU 412-9 and ITU-R BS.641 Recommendation for FM Planning and Measurement is taken as the basic reference. Because FM HD Radio hybrid operation is a mixture of an analog and a digital system, and because the two HD sidebands are redundant, some of the recommended procedures are not useful any longer.

Also today’s station audio processing produces somewhat other spectral densities than at the time the recommendations were made. For judging the HD Radio system we must have a different set of protection ratios for the following interfering situations: D to A (Digital to Analog), an HD Radio station interferes with an analog-only FM station; A to D, an analog-only station interferes with an HD Radio station; and D to D, interference between digital hybrid stations.

For A to D and D to D, one also will need different protection ratios for stationary/portable and reception in fast-moving vehicles. To realize realistic numbers, both sidebands have to receive interference at the same time. Some subjective evaluation of the difference between an FM signal interfering with an analog FM signal and an OFDM HD Radio signal interfering with an analog FM signal at the typical HD Radio signal differences has to take place.

Fig. 6 shows the typical RF spectrum for hybrid and extended hybrid operation.

Critical Spectrum Issues?

For the D to A measurements, the same receivers as for the host compatibility tests were used. For A to D and D to D measurements, HD Radio receivers from Sanyo, JVC and Kenwood were used. Co-channel and 400 kHz interfering situations are not critical at ITU limits and the same as in the United States, so no special additional attention is necessary for these situations.

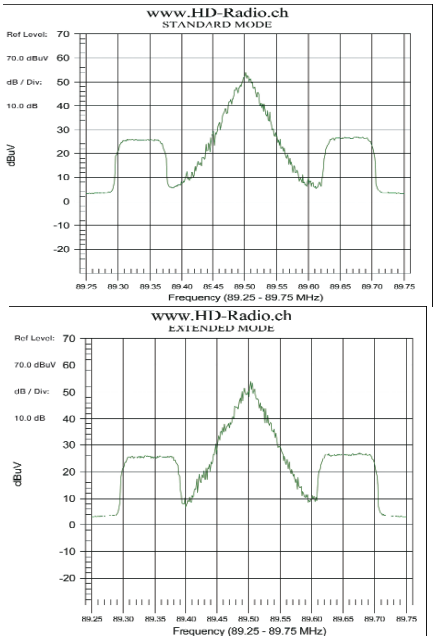

Fig. 6: *RF spectrum measurements for hybrid and extended hybrid operation during the HD Radio technology field trial in Switzerland.*

Fig. 7 shows European 100 kHz Interferer at ITU 412-9 limit. This allocation condition is not critical for D to A, A to D and D to D interference. The analog interference is always stronger than the interference from the digital sidebands. Depending on the FM receiver, more than 10 dB of headroom was measured on the ITU limit.

Fig. 8 shows the 300 kHz 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 412-9 limits is only "some dBs" depending on the receiver, and symmetrical interferers, both strong at same time, can be critical in fast-moving vehicles.

Fig. 9 shows the worst possible condition for Europe with both HD sidebands interfered with at ITU limits. This is the most critical situation in the field (same as in the U.S.) and is fortunately not standard practice in most European countries. It is uncommon to find stations with strong interferers at both +200 kHz and –200 kHz adjacent channels.

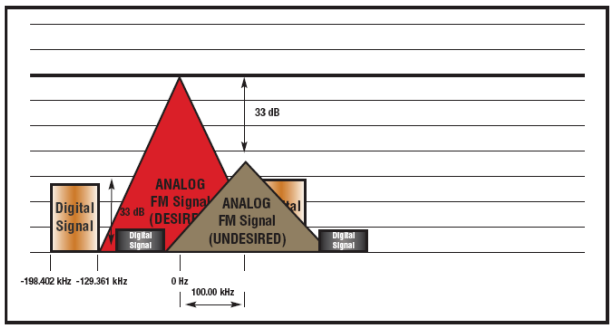

Fig. 7: European 100 kHz interferer at ITU 412-9 limit

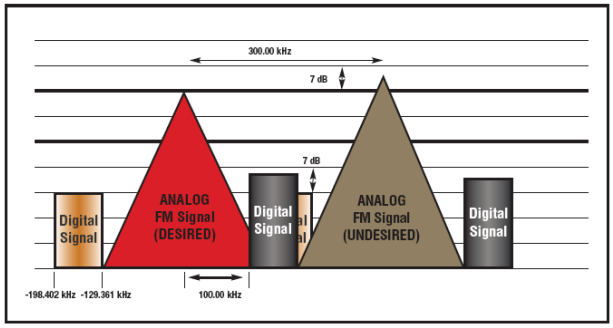

Fig. 8: European 300 kHz interference situation at ITU 412-9 limit

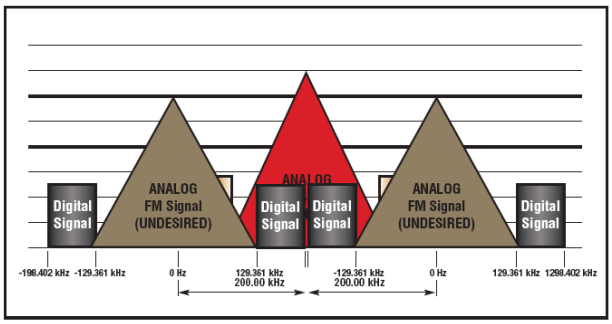

Fig. 9: Worst-case spectrum allocation condition for Europe, both sidebands interfered with an HD Signal at ITU 412-9 limits (same as in U.S.)

D to A Interference

When the listener does not use an HD Radio receiver, the maximum stereo S/N can be reduced well below the recommended value. In practice, almost all of today's car receivers will blend to mono (producing approximately 20 dB better S/N) during this kind of strong interference, and the average listener will not notice.

Home stereos with individual aerials, which these days exist only in rare cases, will have degraded noise performance, and "old" receivers with poor RF selectivity (and missing low-pass filter after demodulator) will have analog interference before they notice the additional noise from the OFDM signal. Therefore it is recommended that special attention be paid in 200 kHz interferer situations, especially when both sidebands are affected, to protect the existing FM receivers.

A to D and D to D interference at ITU limits will produce stable HD Radio reception for the wanted signal.

Is the FM Spectrum density the same, all over Europe?

Not all countries in Europe do have the same FM-Spectrum density. There can be huge differences between countries and between regions within a country. Spectrum density is not the same over all of Europe!

Examples: (referred to US and average EU at +/- 200kHz)

- Turkey : extremely dense in Ankara/Istanbul
- Germany/Switzerland: dense
- Ukraine/Poland: not very dense
- Italy very dense(north Italy)

The differences, how to respect the ITU-412-9 Planning Rules are very different from country to country, as well as the "Test Procedures" to verify this.

As long as the ITU-412-9 Planning Standards are met, HD Radio technology works fine! But if it does not, do not blame it on the technology, but rather, no-respecting the (old) rules, namely for the +/- 200 kHz spacing.

LAB-Testing in general

Almost all FM- laboratories testing in Europe is done without background noise, (USA does, as well as it is common in the communications Industry worldwide) but the real world nowadays looks very different as Fig 10 demonstrates in an impressive way. In this example there is no one 100kHz "slot" with an FM Signal below approx 20dBuV/Meter resulting in a so called"interference limited network". Compared with nowadays Noise Limits of FM Receivers this means an overall performances degradation of approx 20-30dB. This makes many of the measurements under "interference free conditions" in the laboratory very questionable.

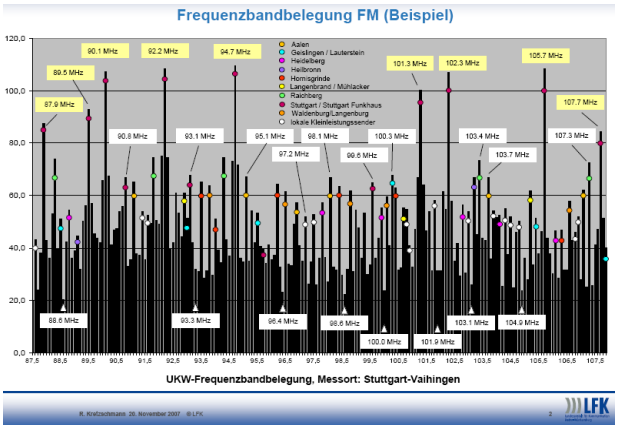

Fig 10: *Example of dense FM spectrum around Stuttgart: No 100kHz "slot" below 20dBuV/Meter. Source: LFK*

Interferer Simulation

In the USA there are now > 1500 broadcasters on air using exactly the same 200kHz frequency spacing as Europe does. Therefore the overall system limit in US is should be the same the same as in Europe!

Because still a lot of Europeans do not recognize these circumstances: we built a complete live multi-interferer simulation, see Fig 11

***Fig 11**: Multi-interferer Presentation at HD-Radio-Days II Lucerne October 2007.Three FM Carriers with/without HD-Signal, arbitrary frequency and level*

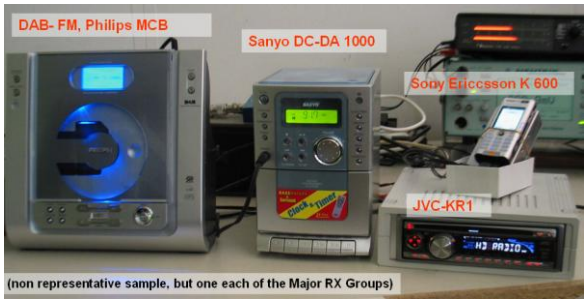

***Fig 12:** 4 DUT (Device under Test) representing major receiver categories. One worse, one very close, one better, and one extremely better than ITU-412-9*

In this Simulation 3 HD-Radio Hybrid Signals could be allocated in any specific spectrum allocation. (+/- 100 - +/- 400kHz at arbitrary level ratio)

Four receivers, representing 4 typical receiver-categories (see Fig. 12 and Fig. 13) were connected to the same RF-Input signal and the audio output was selected bye the PA-mixer for subjective comparison.

Major results: (with level ratios near or exceeding the ITU-412-9 planning rules)

Strong 100kHz interferers generate analog distortion way before interference by the OFDM HD signal is heard, on all Receivers

With +/-200kHz Interferers on Receivers with ITU 412-9 minimum specification or worse, and the analog distortion is heard before the OFDM interference. In contrary as better the receivers are, compared to the minimum specification as earlier one hears first degradation by the OFDM Signal instead of the analog interference. Under "clean" Lab conditions with very good car receivers the difference can be 20 and more dB's.

No noticeable differences at 300 and 400kHz Interferers.

Receiver Sensitivity and RF-selectivity

Coming as no big surprise, all tested car HD Radio receivers had very good sensitivity and very good FM analog performance as well. HD Radio receivers use the same proven FM radio RF front end as current radio receivers. The car receivers we measured so far worked in digital mode a bit below 30 dBuV at the receiver antenna input. The first generation tabletop radios are a few dB less sensitive.

How selective are today's FM receivers? Unfortunately not all receivers in the existing FM radio universe have the same performance when it comes to selectivity. As Fig. 13 shows, there are dramatically big differences between receivers.

As an example at 200 kHz frequency separation, a relevant part of the receiver universe (BAKOM Study 2003) is more than 20 dB worse than the ITU recommendation (portable/mobile), but another group of receivers — especially car receivers — is up to 50 dB better than the ITU-R is looking for.

The good news is that with the exception of 100 kHz interferers the actual FM receiver chips built in cheap portable receivers and cell phones are much better as some years ago, and are reaching ITU 412-9 minimum performance.

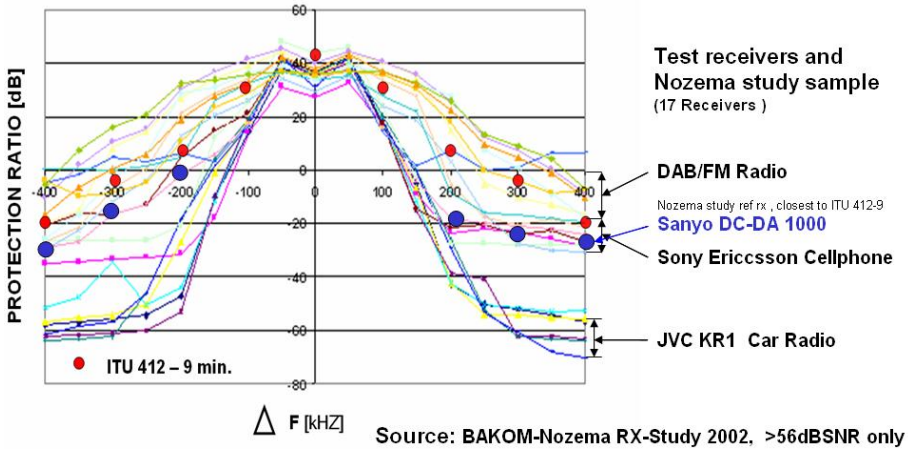

***Fig 13:** The extreme differences between different nowadays receivers: At 200 kHz distance, new car- to port able- receivers can be easy 1:1000 (60dB!), or even more!*

FM HD RADIO FIELD TRIAL IN GERMANY

A project team consisting of Radio Regenbogen (Private commercial Broadcaster), T-System Media broadcast (Infrastructure Provider) and the LFK (German State Media Authority of Rhineland-Palatinate) conducted a FM-HD-Radio Trial, from Dec. 1. 2007 till Feb 29. 2008. An Extension of trial for some more months, for indoor testing, is inquired.

Field trial test bed:

- A 10dB Injector (and a PBF) was added as the only new elements in the analog RF-Transmission chain of the 102.80 MHz transmitter "Heidelberg". (High Level combining) analog ERP: 45,000 Watt, see Fig 14.
- **Content:**
  - Regenbogen analog
  - Regenbogen digital
  - Regenbogen Gold
  - Regenbogen Comedy
  - PAD
- **Operating Mode:**

  Standard Hybrid Multicast, 96kbs
- **Potential Interferer Situation,** see Fig 15

Initial position in Germany for the German commercial radio sector:

- DAB+ NOT the ideal platform for regional broadcasters
- FM-Digitalization is seen as possible alternative for of DAB

Aims of the project

- Recognize potential technical compatibility problems on the existing FM coverage of the "neighbor frequencies"**.** Therefore an existing high power transmitter site in a critical frequency environment is used, and not a test transmitter.

Considerations before the start of the trial

- Theoretical analyses of the potential interfering zones
- Measurement points and routes fixed
- Lab testing on BOS and flight security
- Large agreement regarding critical frequency allocation that the trial place Heidelberg might represent the worst potential impairments in Germany for HD radio reception (+/-200kHz) of the actual receiver universe
- Strong impairments with Klassik Radio, Antenna Bayern and Radio Ton (less strong with HR4 and RPR1 and Wissenbourg) expected/feared

The first Results from the German Trial

- Amount of concrete and relevant listener complaints after 3 months: ZERO!
- Test-drives including subjective comparison shows very good results
- **10M Reference test point measurements shows some network incompatibilities (6 to 10dB) but the subjective comparison did not show any noticeable degrading.** See Fig. 16
- **HD radio technology works (practically for the real users) very well in these delicate, interference-limited areas, but, HD radio system is partially not net compatible and inadmissible formally, based on the actual "set of rules". The differences between "theories and experience" need some explanation!**
- **Some of the current FM planning seems not to obey all "own set rules", what does not simplify "convincing people".**
- **The Trial Report will be presented in October 2008 at LFK-Stuttgart**

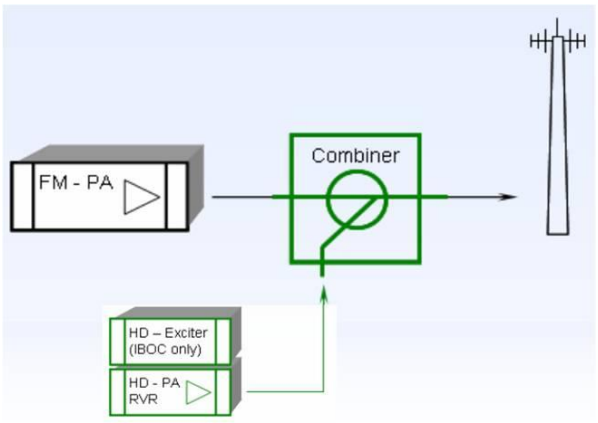

Fig. 14: *Schematic diagram .In the analog RF-path, the Combiner is the only added element to the transmission chain to inject the HD-Signal*

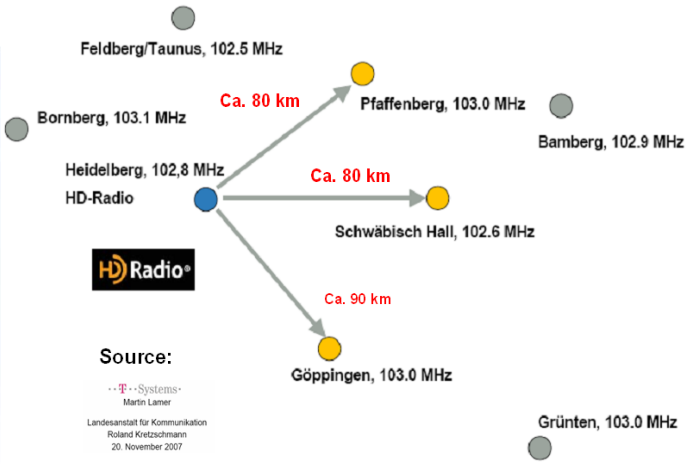

Fig.15: *Potential Interferer situation for Klassik Radio (103.0), Antenne Bayern (103.0), Radio Ton (102.60) and HR4 (102.50)*

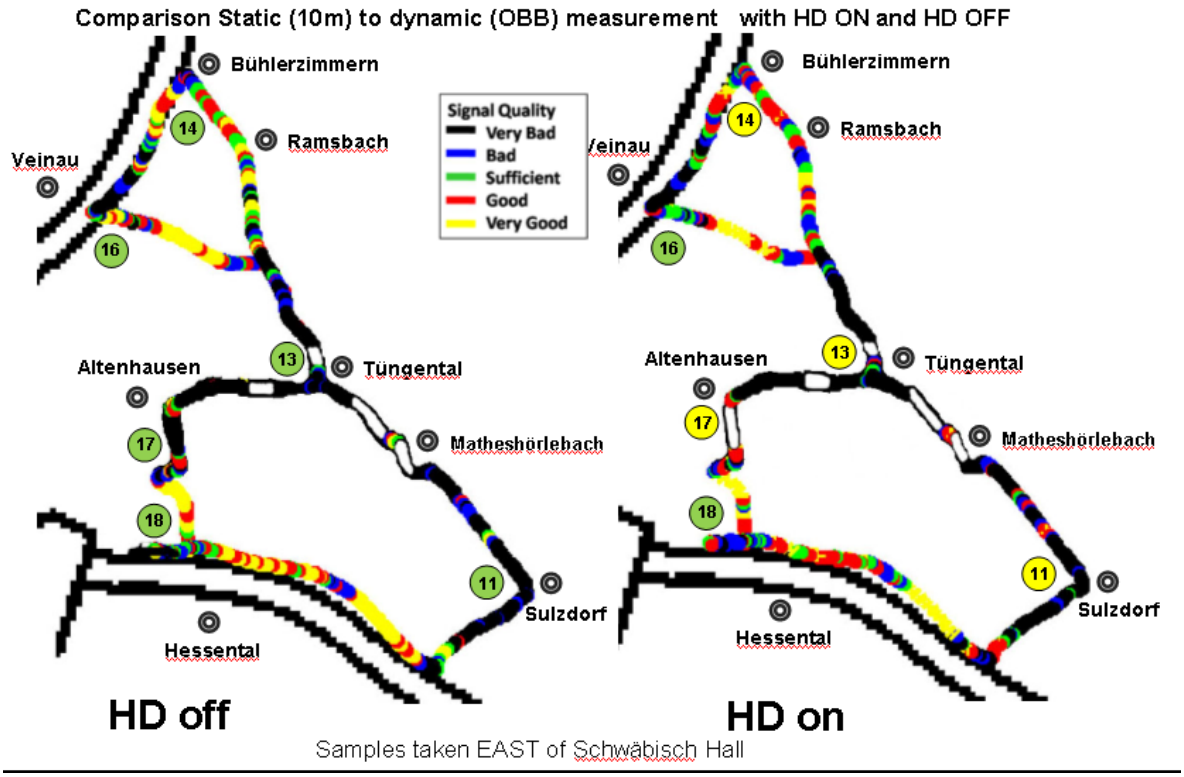

Fig.16: *Methodic difference between 10m Reference Point measurements and subjective quality measurement in the streets. Numbers in Green= Network compatibility is ok, Numbers in Yellow= NOT network compatible*

Large difference between theory and practice?

There seems to be very large differences between theoretical, laboratory and planning considerations and the effective subjective listener experience in the field.

There are several reasons for this and there is a need for some more work on this to quantify these reasons. The most substantial once are:

- With insufficient reception quality, (car-) receivers blend automatically to mono reception.
- Nowadays the FM Networks are mostly interference and not noise limited. This leads to the fact that most possible "HD-Radio" disturbances are covered.
- Today audio processing is typically employed. This results in a subjective improvement.
- The not representative consideration of the actual "receiver universe", the today typical kind of radio usage, and the unweighted geographical representation at the border of the coverage zone, can lead to a clear over-estimation of the number of effectively concerned radio listeners.
- The used reference-point-method (10M above Ground, according to 5R4) is rather unsuitable for the evaluation of the today's radio listener behavior and for the appropriate reception quality.
- The met assumptions over the subjective interfering effect of the digital-OFDM signal (for today typical receivers) are too pessimistic or not representative

New FM HD Radio Technology Planning Rules?

If the ITU 412-9 recommendations are respected as was "common practice" for earlier FM planning in Europe, and if estimated future average FM receiver performance

is used, no new rules are necessary to implement HD Radio technology in Europe.

The following provisions may apply:

- Avoid symmetrical, (and same time/same location) 200 kHz interferers in the coverage area.
- Provide some headroom at 200 kHz frequency difference;
- Use 60dBuV/meter at edge of coverage area.
- Correct earlier non-conforming 200 kHz interferers in the coverage area.

In Europe, the same interferers (+/- 200 kHz) are the HD Radio system limit for the existing analog FM receiver universe as in the United States!

Fig. 17 shows typical lab test configurations as they were used for preliminary protection ratio measurements.

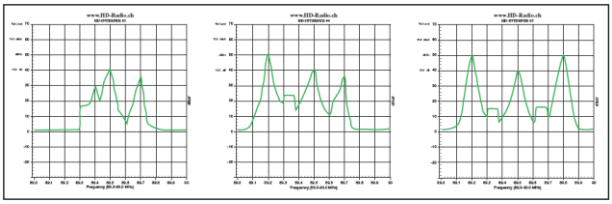

Fig. 17*: Typical lab test configurations with 'European 100 and 300 kHz interferers' as they were used for preliminary protection ratio measurements*

HD Radio System has to become an ETSI Standard!

IBOC or HD-Radio is not a European "unknown"! In the ITU-R BS1114.2, HD-Radio is recommended as "Digital System C".

The initial steps have already been taken to make the HD Radio system an ETSI-Standard (European Technical Standard Institute). The initial application by iBiquity for a NWI (New Work Item) at ETSI was made in May 2008. Actually the work is on a System Requirements Document (SRD) on request of ETSI TG17.

A part of this process will be the inclusion of the European RDS standard with the AF-Functionality (Alternate Frequencies), because in contrast to the United States, 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 technology's growing popularity in Europe has led to some "HD Radio tourism" to our location in central Switzerland for a test drive and a laboratory demonstration of all critical protection ratio issues.

Almost all unbiased visitors, who previously had only heard of and read about HD Radio implementation in the United States, become real fans of the digital FM idea, after demonstrations in the lab and in the field.

Fig. 18 and 19 shows the test cars used for driving around the visitors to the HDS-Radio Field Trail in Lucerne and vicinity.

Fig. 18: *BMW 745D with DAB-FM-HD-Radio Receiver Multiplatform*

Fig 19: *BMW-mini equipped with JVC-KR-1 HD-Radio receiver*

Some of the leading OEMs for the German automotive industry and some German car manufacturers have started to use central Switzerland as the test bed for their HD Radio equipment.

Examples of car manufacturers include BMW, Daimler, Harmann Becker, Visteon and more. Even after the announcement by the World DAB Organization about the arrival of the far more efficient new DAB+ (with AAC+ audio codec, which is similar to the HDC used by the HD Radio system, and with better error correction) the interest from regulating bodies and private broadcasters in Europe in HD Radio technology is still growing strongly.

In France, Towercast and NRJ-Group, with backing from SIRTI, have been doing intense and successful testing in the first half of 2006 in the Paris area with two HD Radio transmitters on the air, in a very critical European frequency assignment. Mainly based on media political reasons, France applauded in the meanwhile DMB for Radio Services. Poland and Ukraine are also running several extensive HD Radio tests.

Other new plans for HD Radio trials and interest in HD Radio technology in Europe that we know of, include Austria (Krone-Hit-Vienna and others); Romania (2M-PrimaTelecom, Baia Mare); Czech Republic(Radio Hana); Bosnia and the Extension of the Heidelberg trial in Germany.

Next Steps

Even with the positive results so far, more detailed investigations in the lab and in the field are necessary before regulatory agencies can begin issuing permanent operational licenses for HD Radio broadcasting.

Following are the major steps in the different trial projects:

- Comparison between FM and HD Radio reception for indoor coverage
- Determine the consequences (if any) on FM planning for FM HD Radio implementation in Switzerland (and Europe), and a comparison with U.S. and ITU 412-9 recommendations
- Translators and single frequency network boosters for HD Radio transmissions in the field (and more RDS-AF functionality test)
- Implementation and operation costs in comparison to FM operation and other digital platforms
- Support of timely creation of operational HD Radio operational licensing guidelines
- More general awareness in Europe for FM HD Radio transmission, including at the receiver manufacturer level for multi-platform receivers
- Implementation comparison with other digital FM systems like DRM + and FMeXtra

OTHER FM DIGITALISATION PLATFORMS

DRM in the FM Band, DRM+

DRM+ is a part of the DVB family and an extension of DRM for the FM Band. The world-wide first field tests have taken place in Hannover and Kaiserslautern, Germany.

Throughout March, April and May 2008, the University of Applied Sciences Kaiserslautern has broadcast its experimental radio station across the southwest German city in digital on 87.6 MHz using DRM+ in order to test this extended version of the DRM digital radio standard. Germany's Federal Network Agency, the University of Applied Sciences Kaiserslautern and the German State Media Authority of Rhineland-Palatinate have carried out extensive field tests to validate the trial.

The first Part of the Trial Results was presented end of May 2008 at the FHK in Kaiserslautern.

Please visit www.drm-radio-kl.eu for further information on the trial and the project or at www.drm.org .

It is planned that ETSI standardization as an extension of the existing DRM standard will take place in the year 2008 or2009.

The DRM+ schedule sees the start in FM gaps between 2009 and 2015 and the partial disconnection of UKW between 2015 and 2020, see Fig 20

To help for easier start up, it is the intention to use the VHF-Band I .

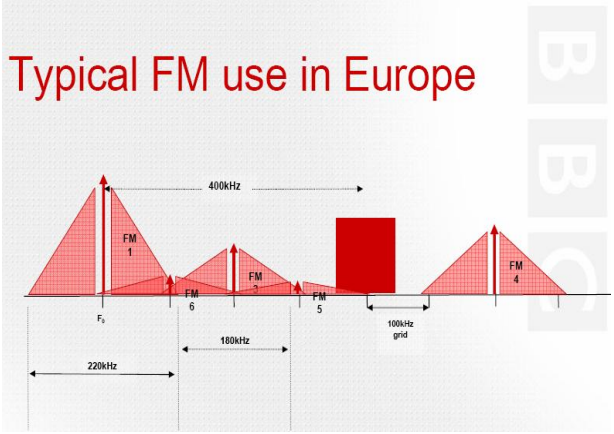

***Fig 20**: Example: DRM+ Signal in „400Khz Gap" Source : PPT Lindsay Cornell, BBC, DRM+, 2007*

I personally believe that DRM+ "GAP-Operation"is (in spectrum dense networks) more difficult than FM HD Radio Hybrid Operation. This, mainly because of the fastidious aspects concerning, "Co-Location", power levels and digital robustness.

DRM+ does not allow real Simulcast (without switching of fthe existing analog carrier) possible, except with "separated Frequencies", see Fig. 20.

As the DRM+ system is not completed, standardized and still in testing, there are virtually no DRM+ receivers available yet, except some samples.

An operational introduction including a minimum receiver selection in the market is not expected before the year 2010

FMeXtra

Since approximately end of 2006, FMeXtra began with first field testing activities in Europe. In early 2007, Radio 1 from Norway was first to test the FMeXtra system in Europe, followed by trails in Netherlands, Italy and more.

The substantial differences between the FM-HD Radio system and the main characteristics of FMeXtra are:

- FMeXtra is a subcarrier system, in principle a large DARC, see Fig. 21
- Smaller net audio data capacity (except when no RDS and MONO only)
- No full digital mode possible
- Good compatibly to existing, formal regulations
- Operational Introduction possible at very low cost, even lower than FM-HD Radio transmission
- In particular regarding multipath and mobile reception, the achievable coverage is very limited (no real data available, but the system has no multipath immunity).
- No widespread receiver offers in sight, except the portable Aruba receiver

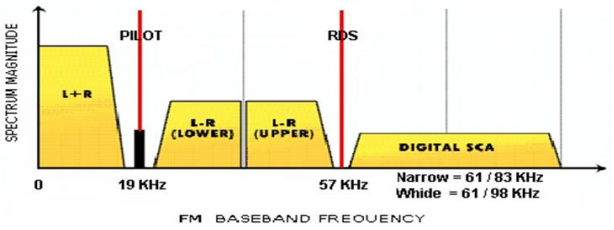

***Fig. 2**: FM-Baseband layout of FMeXtra*

Simultaneous (HD+FMeXtra) trial planned in Switzerland as part of HD Radio trial.

Dutch radio broadcasters stopped the FMeXtra trials (one does not see a chance for a broad market penetration). Later they started testing again, but no technical results released yet.

In Heilbronn Germany, extended testing was done in autumn 2007 in Partnership of FMeXtra, T-Systems Media broadcast and the German State Media Authority of Rhineland-Palatinate. The Frequency 89.10 was used with 500 watt ERP. No final report published yet, but the summary preliminary results remark this:

"The FMeXtra transmission reacts extremely sensitively to nonlinear distortions in the channel. Therefore FMeXtra will be difficult to be used under difficult (multipath) topographic propagation conditions. FMeXtra will work well under ideal reception conditions, like in direct sight of the transmitter proximity or with the use of a directional antenna "

For more Information about FMeXtra's activities in Europe see at www.adven.it , www.broadcastpartners.nl and www.dreinc.com

THE KEY ADVANTAGES OF FM HD RADIO TECHNOLOGY

HD Radio transmission can become the optimum path to the digital radio age for European single-program broadcasters.

The advantages are obvious. The broadcaster can continue to use almost all of his existing transmitter and translator sites and equipment. Compared to the total operating cost of an FM distribution network, only minor reinvestment for the startup of the digital operation is needed.

As our actual experience so far shows, not all translators have to be modified to digital. Radio Sunshine has a total of 16 sites. For a minimum of 80 percent HD Radio coverage approximately 10 sites will be needed to be modified to HD Radio technology. In contrast to the United States where typically one commercial licensee has only one transmitter per program stream, a typical European private broadcaster has an average of more than five translators per program stream. This further use of the existing broadcast infrastructure gives the broadcaster the unique chance for a controlled slow evolution to digital at low cost.

To be able to use the same FM channels for the programming and other content is an extremely valuable marketing advantage for the broadcaster.

As additional advantages the broadcaster receives better quality of service within his coverage area and good indoor reception. Portable and indoor reception is important in Europe because it counts for more than 2/3 of total radio listening hours.

HD Radio® EHDRA european alliance HD Radio® FOR EUROPE

EHDRA = European HD Radio Alliance

For the success of HD Radio technology in Europe it is critical that broadcasters and the industry begin to show interest in this technology and its development. This is the reason why in September 2007 the European HD Radio Alliance (EHDRA) was founded at IBC Amsterdam. The main Tasks of the alliance are:

- General awareness and knowledge of FM HD Radio technology in Europe
- HD Radio standardization for Europe
- Operational implementation and coordination rules
- Elimination of hurdles for operational introduction

Today the alliance already has more than 50 Members in numerous European countries. Most of the full-EHDRA-Members are broadcasters and European broadcast equipment manufacturers. All European broadcast related Industries and interested organizations and persons are welcomed to become members. More at www.ehdra.org

CONCLUSIONS

- If one takes the overall economic (refinancing) view of the broadcasters and their radio listeners as reference, then FM HD Radio technology is at present clearly the best possibility for a digitization of the existing FM-Band while retaining analog broadcasting. This is particularly true, regarding economic favorable gradual digitization, marketing, hybrid-simulcast-operation and existing receiver offer.
- The FM HD Radio operating experience in the field is positive. Some more work is required, especially at the "regulatiory level"
- The influence and the restrictions to the existing FM analog-receiver universe (the real "commercial" listeners!) are very minimal
- FM HD Radio transmission can be the most efficient and economical way to become a digital terrestrial radio broadcaster in Europe (mainly for one program broadcasters) and permits them additional program streams with no additional bandwidth allocation.
- FM HD Radio broadcasting is not a competition for DAB, but an additional platform making a lot of sense since it permits greater public services with no additional spectrum allocation to a broadcast station.

ACKNOWLEDGMENTS

Very special thanks to all the Sponsors of the HD Radio technology Field Trail Switzerland. Only with their extensive support with labor and finances, was it possible to run the field trial in Switzerland and some of our European wide HD-Radio technology promotion so soon the first broadcasters in Europe can receive permanent operational licenses instead of trial permits.

M.A. Ruoss is founder and owner of Ruoss AG, Electronic Media Consultants and chairman of Radio Sunshine, both in Switzerland. www.RuossAG.ch ,www.HD-Radio.ch Aug. 5.2008