advancing wireless test

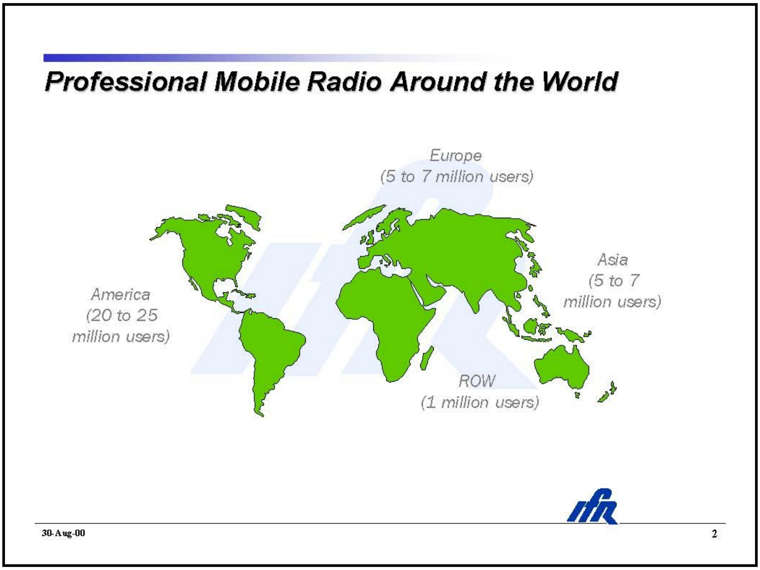
IFR, an Aeroflex Company

Introduction to TETRA

Introduction

This presentation is designed to give the reader an introduction to the new TETRA radio standard. It covers background information about the need for a new radio standard, who will use TETRA radios and what advantages they will gain.

The presentation also examines the basic test requirements demanded of both TETRA transmitters and receivers.



Professional Mobile Radio Around the World

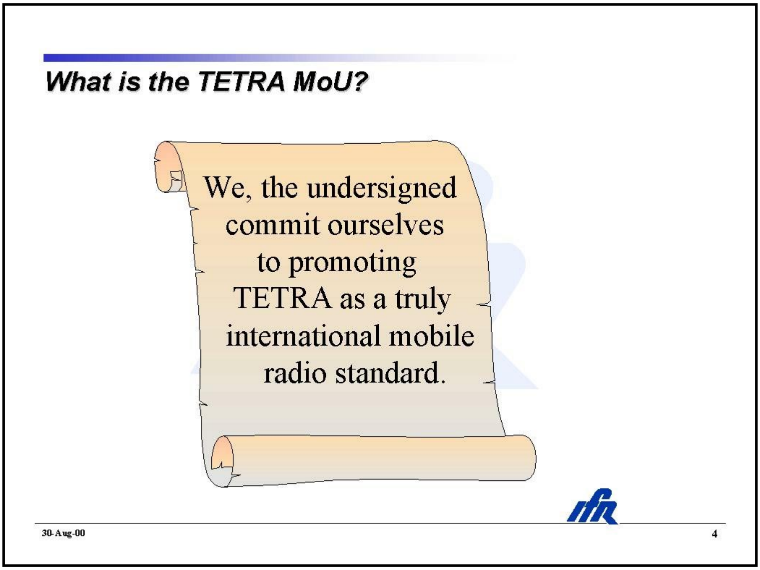
The 1998 estimated total installed base for Professional Mobile Radio (PMR) users is 30 to 40 million. It is growing at approximately 7% a year. North America has the highest density of professional mobile radio users, but the market is growing fast in Eastern Europe and parts of Asia. These regions are traditionally not users of PMR but as their markets become generally more open, the demand for radio is growing.

What is TETRA?

TErrestrial Trunked RAdio (TETRA) is a radio system defined by the European Telecommunications Standards Institute (ETSI) as a digital radio system suitable for replacing existing Professional Mobile Radio (PMR) and Public Access Mobile Radio (PAMR) for wide area networks.

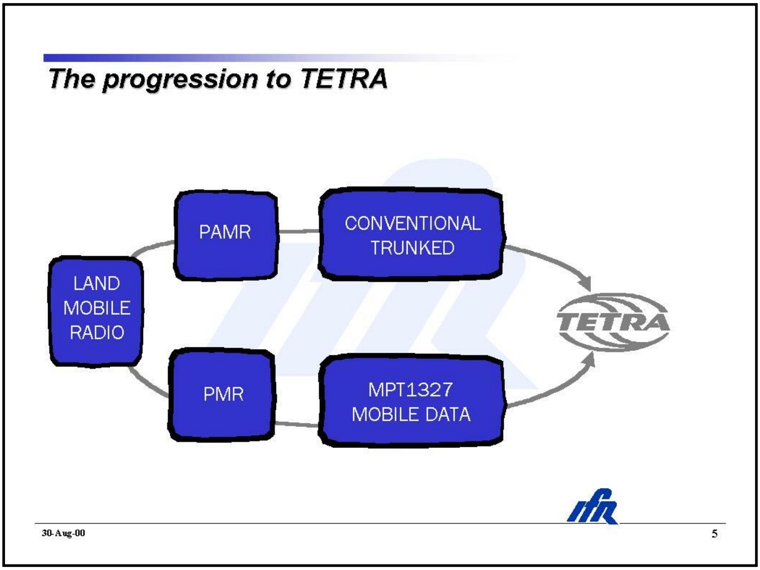
The GSM system has become a de facto global standard for cellular communication (even in parts of North America), and it is the objective of the supporters of TETRA that it also becomes a global standard.

A Memorandum of Understanding (MoU), similar to the one used to promote GSM, has been signed by major manufacturers, operators and government organizations which commits each signatory to support TETRA as the preferred solution to future digital trunked radio.



What is the TETRA MoU?

The TETRA MoU was established in 1994 to create a forum which could act on behalf of all parties interested in TETRA. Currently the MoU represents over 60 members from approximately 20 countries including manufacturers, end-user organisations, test laboratories and regulators. A number of other organizations are currently observers, who have their membership pending. The MoU activities range from those related to the radio frequency spectrum, to the preparation of radio type approval procedures. MoU members maintain close contact with all potential user groups including police authorities, utilities, manufacturers and the military.



The progression to TETRA

In a PMR system, the user owns both the radio network (base stations, switches and dispatcher consoles) and the mobile radios. Typical PMR users around the world are police forces, ambulance services, utility companies and railways.

A PAMR system is a radio network in which one company owns and operates a series of base stations and then charges other companies to use the network. In this way, small firms such as taxi companies, transport companies and couriers can use mobile radio without having to invest in expensive infrastructure.

Mobile Radio equipment ranges from simple two-way radios to trunked radios. Trunked radios are preferred by radio frequency regulators because a larger number of users can access the same frequencies or channels and by user organizations because of the additional facilities that can be included, such as interconnection and database management.

There have been a great number of different uses made of these private radio systems, resulting in a proliferation of the facilities provided by the systems. Police forces, for instance, have vastly different requirements from taxi companies, yet both use mobile radio systems. The result of this proliferation is that a large number of standards, both public and proprietary, have evolved over the years.

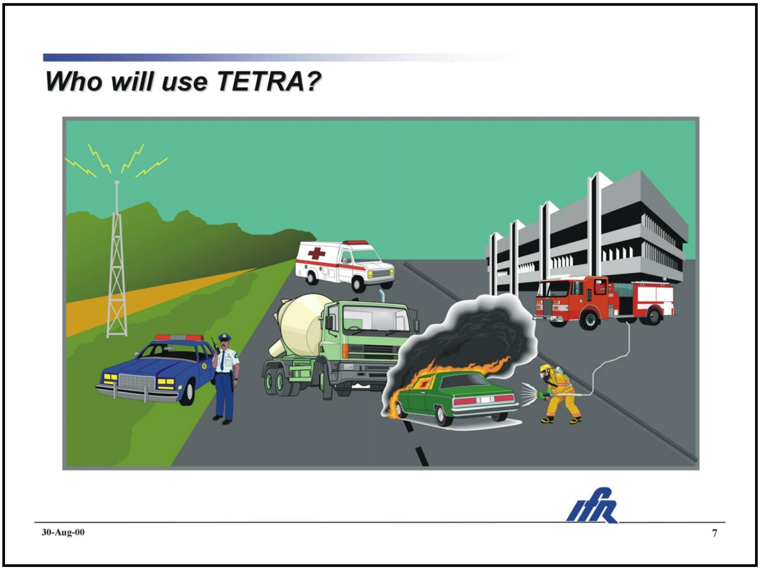
TETRA

The lack of interoperability between previous existing or proprietary standards is a serious problem. There is no guarantee that, for example, a radio system being used by the police can link directly with police in a neighbouring region or country, let alone with the local fire or ambulance services. Even de facto analog standards such as MPT 1327 are likely to have difficulties with interoperability because the “standard” allows a high degree of customization. In addition, most communications in the emergency services take place without encryption. This is a particular problem for police transmissions, which may be monitored fairly easily using unsophisticated equipment. Encryption prevents unauthorized personnel from monitoring and intercepting calls.

Against this background of diversity in radio systems the TETRA standard has been developed, providing much greater opportunities for interoperability and information security.

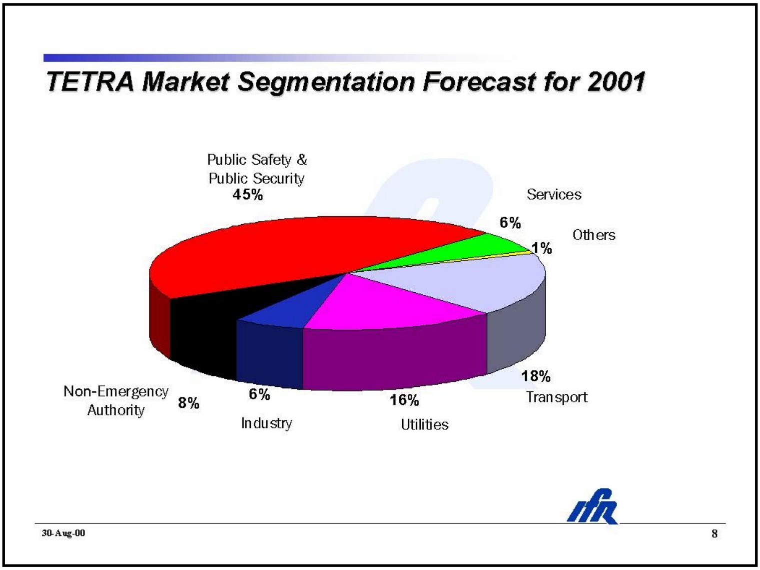
TETRA satisfies the need of both public and private network operators. The TETRA standard supports both voice and data transmission. Data can be either circuit mode or packet mode. It is not mandatory for radios to offer all modes.

TETRA offers a real opportunity for multivendor systems to be configured. It is an open standard and so any company can design and manufacture equipment to work on a TETRA system. The air interface specification should ensure interoperability between equipment from different manufacturers. Other interface specifications for terminal equipment interfacing and inter system interfacing are also open standards to further promote this principle.



Who will use TETRA?

Any application for radio communication currently supported by analog mobile radio is a target for TETRA. A driving force behind the standard development has been the exacting needs of emergency services, such as fire, ambulance and police. The police will benefit from improved security and the ability to send and receive data relating to suspects, such as finger printing. Fire services will benefit from direct mode operation in areas unlikely to have good coverage and to receive data concerning hazardous substances or building blue prints. The medical service, as suggested above may be able to provide more effective treatment at the scene of accidents and to pass medical history to where its needed. But TETRA may also be used in other areas, the railway networks could use TETRA for voice communication and signalling. Taxi firms may provide credit card debiting through TETRA. Transport companies may adopt TETRA for vehicle location.



TETRA Market Segmentation Forecast for 2001

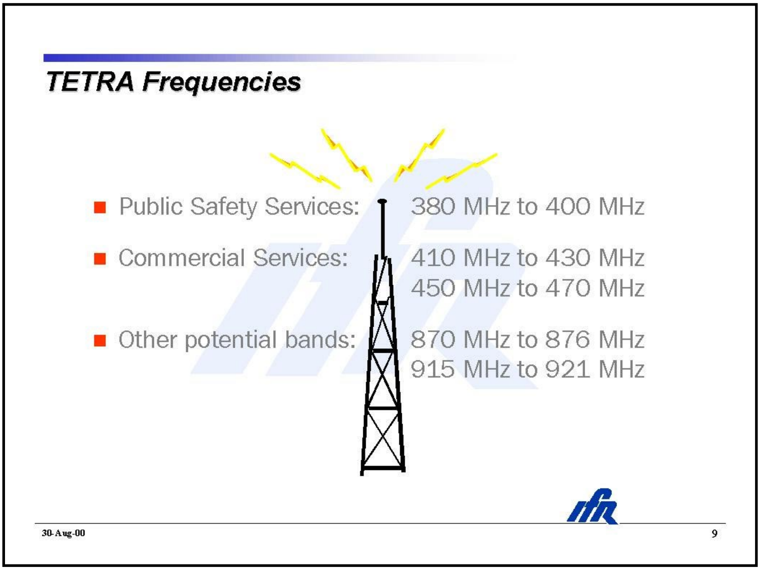
Market forecasts predict that the largest single user group for TETRA products will be public safety and public security organizations eg, fire police and ambulance services. However, the flexibility of the system means that it will have wide appeal outside of this area as well.

Large users of mobile radio are now experiencing severe limitations with existing traditional analog networks. It is difficult to obtain licences for new frequencies in many large cities. Existing networks may be congested on existing frequency allocations. Companies need to construct and maintain a large radio system infrastructure even though the company may have no fundamental competence in mobile communications. New networks or improvements to existing networks can be extremely expensive.

Replacement cycles can be long, typically 10 to 15 years meaning that companies can easily be running a communications network that is inflexible, out-dated and inappropriate to their needs.

New national or international TETRA networks will enable companies such as taxis, motor cycle dispatch riders, bus and coach operators, construction companies and retail companies to have access to modern communication systems. They will rent airtime from TETRA network providers. This will give them superior communications with lower capital and operational costs.

TETRA enhancements are expected to continue beyond 2005 as new features and facilities are added.

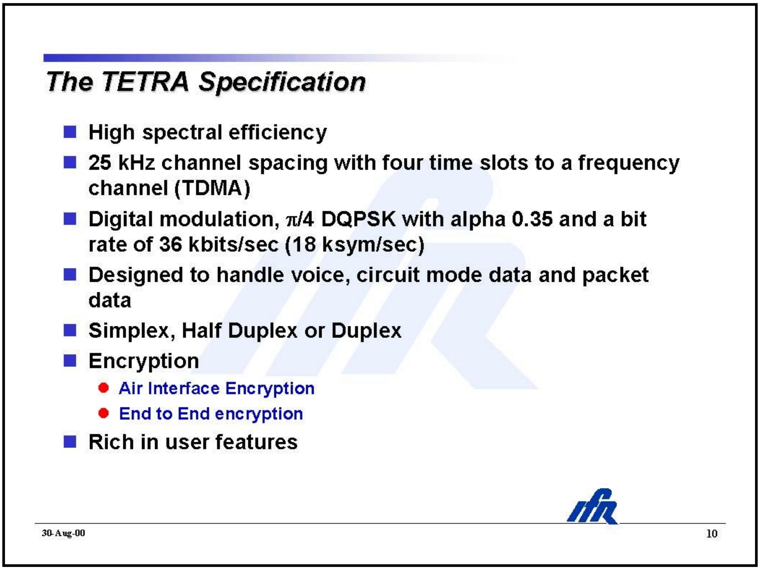


TETRA Frequencies

TETRA has been granted by NATO a European wide frequency allocation between 380 and 400 MHz for emergency services. National authorities have allocated two 5 MHz bands in this 20 MHz band.

Currently, spectrum is being made available for commercial services between 410 MHz and 430 MHz, hopefully as a European wide, common allocation so that roaming may be possible. Other potential bands exist, such as 450 MHz to 470 MHz and 870 MHz to 876 MHz (uplink) plus 915 MHz to 921 MHz (downlink).

Outside Europe the TETRA standards could be used in any frequency band, according to the circumstances of an individual country. This would require development of equipment supporting new frequency bands.



What is different about TETRA?

The TETRA standard is written so that potentially TETRA may be used within any 25 kHz channel space currently occupied by analog systems giving an immediate increase in capacity. This attribute of TETRA is what makes it attractive as a world wide digital standard.

The TETRA standard has also been designed specifically to support circuit mode data at typical rates of 2.4 to 7.2 kbits/sec. or as high as 28.8kbits/sec unprotected. Packet data is also supported.

TETRA uses phase offset differential quaternary phase shift keying modulation $\pi/4$ DQPSK with a symbol rate of 18 k symbols/s and root raised cosine (root Nyquist) filters in the transmitter and the receiver to give an overall raised cosine modulation filter.

TETRA uses digital modulation to provide high quality speech from a speech codec and uses air interface encryption. Even without encryption the modulation technique and codec ensure that messages cannot be overheard by a casual eavesdropper without access to a TETRA receiver (existing PMR systems use analog voice signals which can be listened to by general purpose receivers). The air interface encryption ensures that even if an eavesdropper has access to a TETRA receiver, the lack of access to a cipher key ensures that casual eavesdropping is not possible. Two encryption mechanisms are defined:

a) air interface encryption, which encrypts the radio path between the terminal and base station.

b) end-to-end encryption for the most critical applications where encryption is required for the transmission throughout the system to the other terminal.

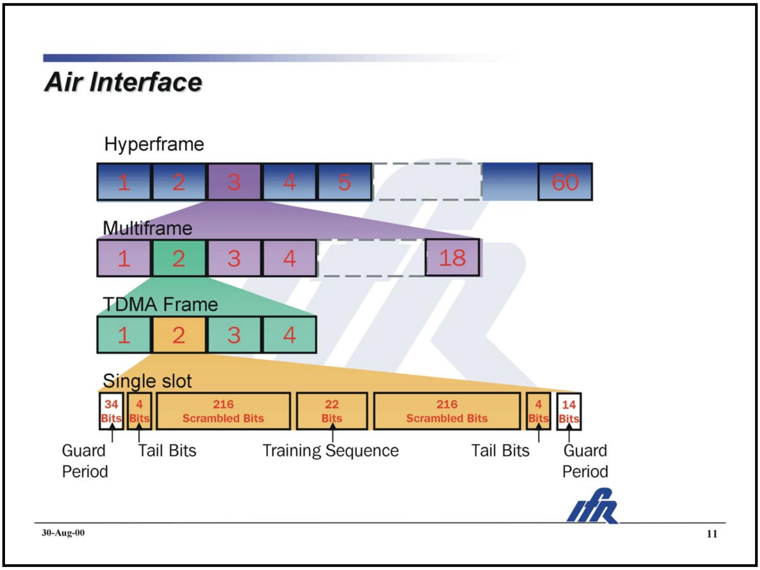


Diagram of Air Interface

Each carrier frequency is capable of supporting up to four calls (one call can include multiple users). Each call is allocated one (or more) time slots. Each time slot contains a training sequence, and may contain control information and traffic bits.

Four slots make up a TDMA frame structure and the frames are assembled in a hierarchy of multiframes and hyperframes.

The 18th frame is always the control frame and provides the basis for slow associated control channel (SACCH) and the broadcast control channel (BCCH). This provides the background control channels signalling that is always present.

The gross bit rate of one channel is 9.0 kbit/s into which speech is coded with 4.567 kbit/s net bit rate using an ACELP codec.

Bandwidth on Demand

Used Time Slots	Unprotected	Low Protection	High Protection
1	7.2 kbps	4.8 kbps	2.4 kbps
2	14.4 kbps	9.6 kbps	4.8 kbps
3	21.6 kbps	14.4 kbps	7.2 kbps
4	28.8 kbps	19.2 kbps	9.6 kbps

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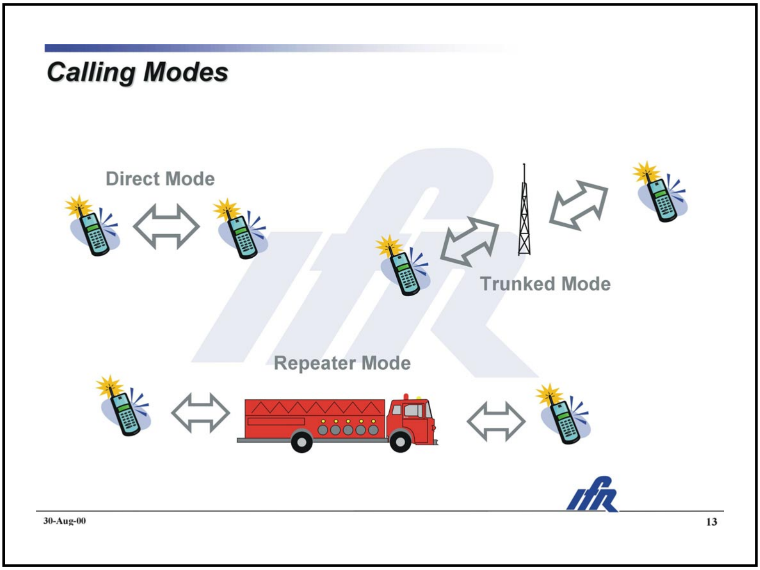
Bandwidth on Demand

TETRA systems will cater for users with differing transmission rate needs. Data rates may be improved by utilizing more than one slot and furthermore, the level of data protection can be traded for additional transmission speed.

This means that for users who need a large amount of bandwidth, for example to send slow scan video images, can grab extra timeslots if they are available and if their radios are capable of multi-slot operation. Large data files are likely to be sent using packet data as this mode has receive acknowledge protocols.



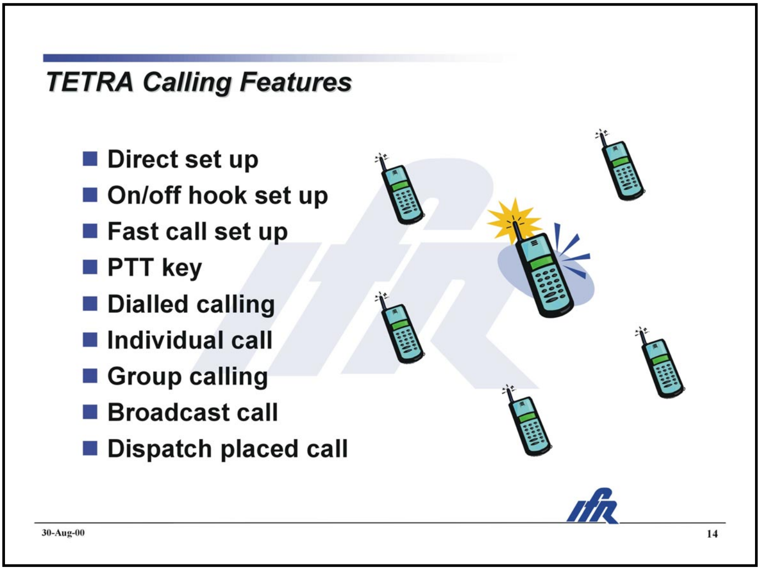
Calling Modes

The TETRA radio network enables a very flexible approach to be taken when setting up calls.

Trunked Mode: Trunked mode is the standard operating method for mobile radio systems. TETRA radios are in direct communication with a base station which assigns the channel for the call.

Direct Mode: This is a situation in which two or more terminals set up a conversation between themselves without any base station involvement. Direct mode is essential if radios have to be used out of the range of an existing base station. An example could be a remote mountain rescue. All members of the rescue team could be in contact with each other, even if there is not a local base station.

Repeater Mode: The radio in a vehicle can act as a direct mode repeater for all the nearby handheld mobiles. The higher transmitter power of the vehicle radio could enable a mobile to contact remote mobiles. If a mobile contacts a base station through another mobile, this is direct mode "gateway". A fire engine attending a forest fire could therefore act as a repeater for all the fire fighters.

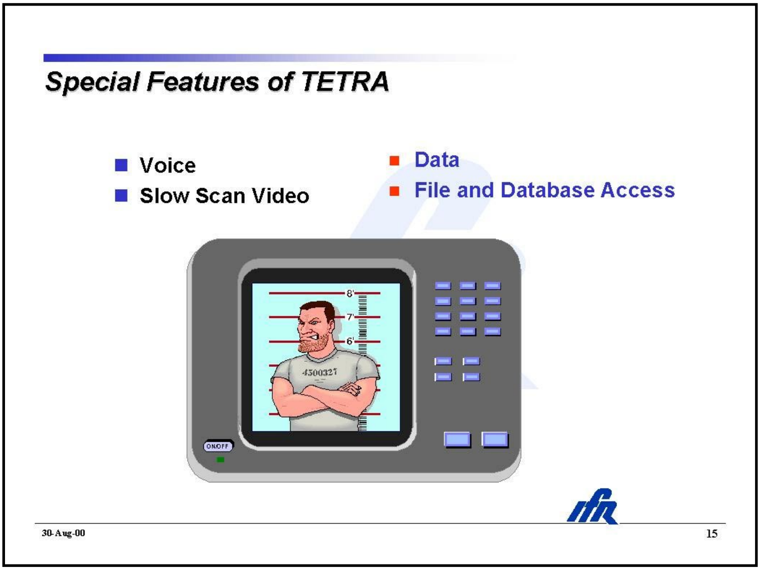


TETRA Calling Features

A TETRA radio can set up a call in under 300 ms and typically 200 ms. This means that traditional press to talk (PTT) keys can be used on the radio. Calls can be to an individual user or to groups. Groups can be pre-defined so that the caller simply identifies the group they want to contact, for example, all the fire fighters inside a building.

A broadcast call sends a one way message to all radios in a pre-defined area. This could be used by a dispatcher to locate the nearest radio user to a particular incident. It is possible for the dispatcher to select the area in which the broadcast call is transmitted.

Radio units can be configured so that they only operate with a certain geographic area. Service could be sold to a taxi company for coverage in a specific area only.



Special Features of TETRA

TETRA radios can be used for transmission of a wide variety of information. Normal voice calls are possible in simplex, half duplex and full duplex modes. This is a basic TETRA requirement but only simplex is mandatory, although technically voice transmission is not mandatory. It is theoretically possible to have a TETRA radio for data only.

Video signals or individual pictures can also be sent over TETRA radios. This means that a firefighter can enter a dangerous environment with a small video camera and send back immediate images of the scene to the control vehicle. A police officer can be sent a still image of a suspected criminal or terrorist.

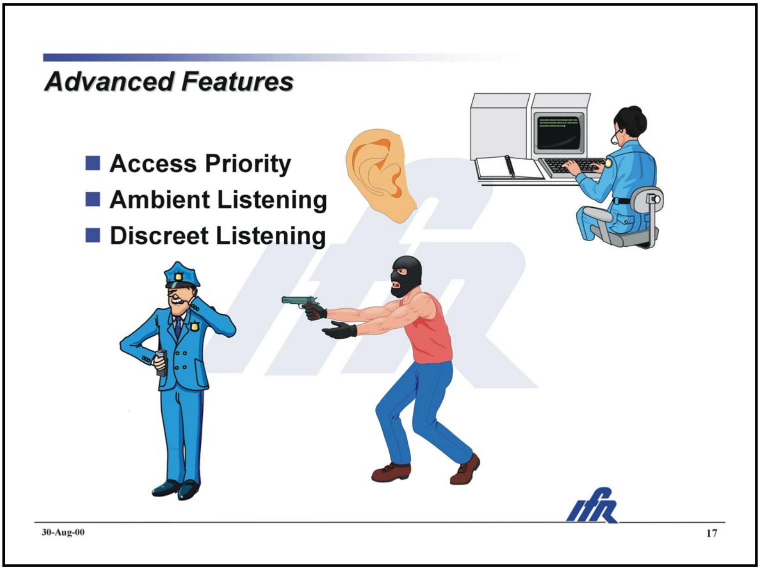
With an appropriate terminal the user of a TETRA terminal will be able to access a company database remotely. This will enable the user to call up customer histories or criminal records and display them on their radio screen. Short text messages can be sent and received as well as using the terminal for e:mail or facsimile.

TETRA Telecom Services

The TETRA network also supports many features now associated with basic telephony. For example, calls can be made to standard telephones or mobile radios. A user can see the number of the calling party on the display of their radio before responding. It is also possible to set up call forwarding to another radio. Call forwarding can be implemented under a variety of conditions, all calls forwarded to another radio; on subscriber busy, on radio not reachable, on no reply.

Other supplementary services are also offered. List search calls, when the placed call will sequence through a user defined list until it is answered. Short number dialling gives fast access to commonly called radios. Call waiting gives notification of another attempted incoming call whilst the called party is busy. Call hold enables the user to interrupt their current call, speak to a separate caller, then re-establish the original call.

Not all these services will be available to all users on all networks. Their availability will depend on the radio chosen by the user group and the way the network has been configured by the network operator.

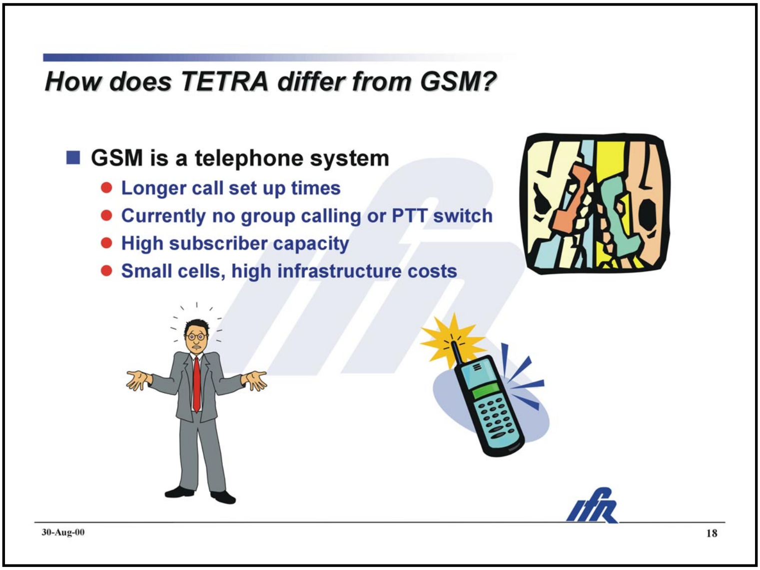


Advanced Features

TETRA is expected to be extensively used by the emergency services. Emergency services need and expect to be able to make calls even in times of high network demand. To satisfy this important requirement TETRA radios have access priority. Different users have different priority levels. If a system is busy, the lowest priority call will be dropped to handle the higher priority call. There is also the ability to handle an emergency call.

Ambient listening enables the dispatcher or authorized body to turn on a remote radio unit. In this way, it is possible to monitor possible dangerous situations. If a police officer is in a hostage situation, he may not be able to key up his radio. If the dispatcher can key up the radio without alerting the hostage-taker, the dispatcher can get a good understanding of the situation the officer is in.

In the discreet listening mode, the dispatcher, or other authorized body, can listen into any call on their network. The calling parties are unaware that they are being overheard.



How does TETRA differ from GSM?

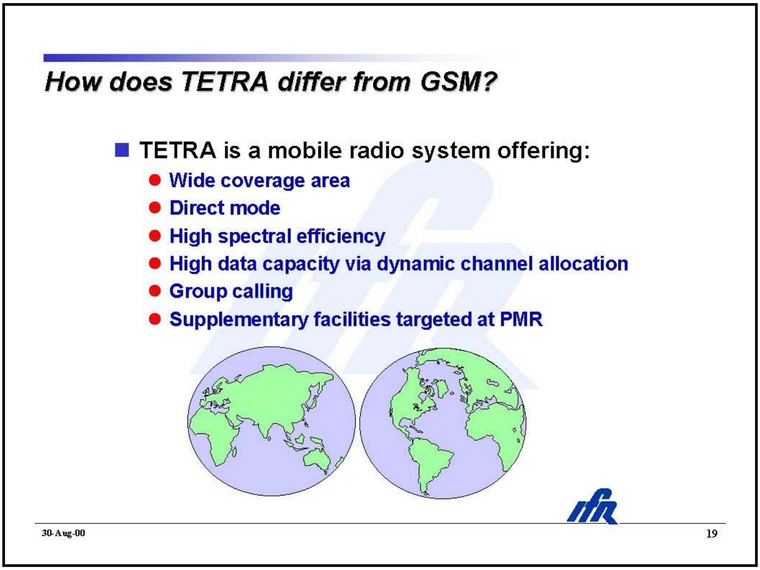
There are clear distinctions between TETRA and GSM, the two systems are not designed to compete with one another. The GSM system is essentially a telephone system and has features and attributes usually associated with telephones. TETRA has all the features that are expected of a mobile radio system and many unique features not currently available on analog mobile radio systems.

Attempts are being made by the GSM cellular operators to provide a service for PMR customers. However, this will have significant impact on the existing standard.

Essential differences between a mobile radio and cellular radio are:

Fast call set up:	TETRA - 300 ms, cellular - many seconds
Method of call set up:	TETRA - press to talk key, cellular - dialled number
Group call:	TETRA can talk to many users at once, cellular - one mobile at a time coverage
Area coverage:	TETRA big cells, geographic coverage, cellular - small cells, population coverage
Information transmitted:	TETRA - voice/ high speed data/video, cellular - voice/low speed data only
Network requirements:	TETRA - mobile to mobile, cellular - must use base station

Whilst GSM currently only offers individual call service it is acknowledged that this is open to further development along similar lines to TETRA.



How does TETRA differ from GSM?

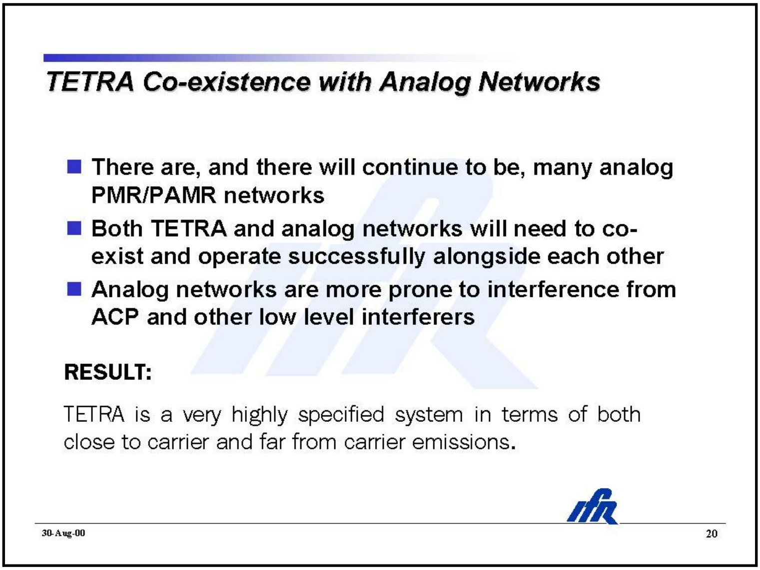
The direct mode facility is not available on cellular networks. In addition, press to talk (PTT) functions and simplex operation are not supported by cellular systems. The TETRA air interface is spectrally more efficient than GSM and the ability to grab all four timeslots for data transmission (dynamic channel allocation) enables the radio to exchange digital information at higher rates. The efficiency of the system is further enhanced by the ability to operate as a simplex system.

The manufacturers of TETRA describe the system as providing a tool box which can be adapted to individual users requirements, particularly through the use of supplementary services.

A range of TETRA supplementary services are available, but optional.

- Call authorized by dispatcher
- Area selection
- Access priority
- Priority call
- Discrete listening
- Ambience listening
- Pre-emptive priority call
- Late entry
- Dynamic group number assignment

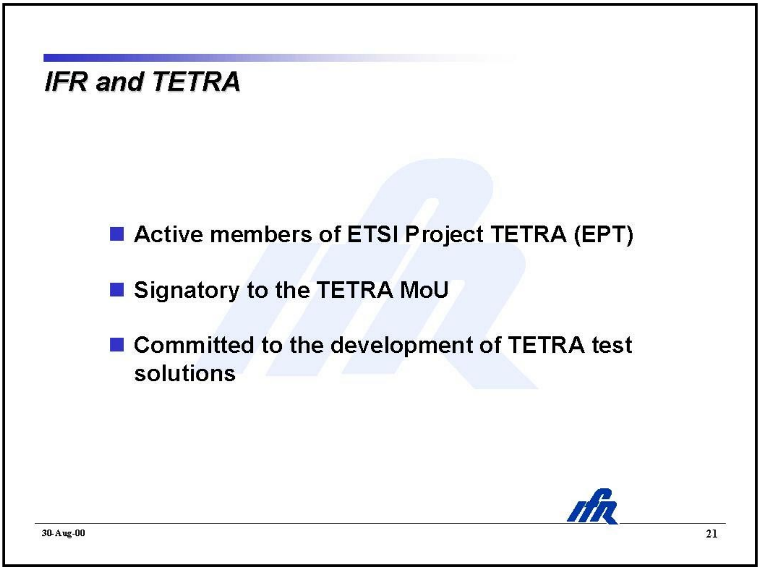
These are all essential supplementary services. Optional services such as caller ID, call forward, call waiting, call hold, call barring, charge advice, and many others will be optional to the subscriber. Some of these are recognizable as GSM services already.



TETRA Co-existence with Analog Networks

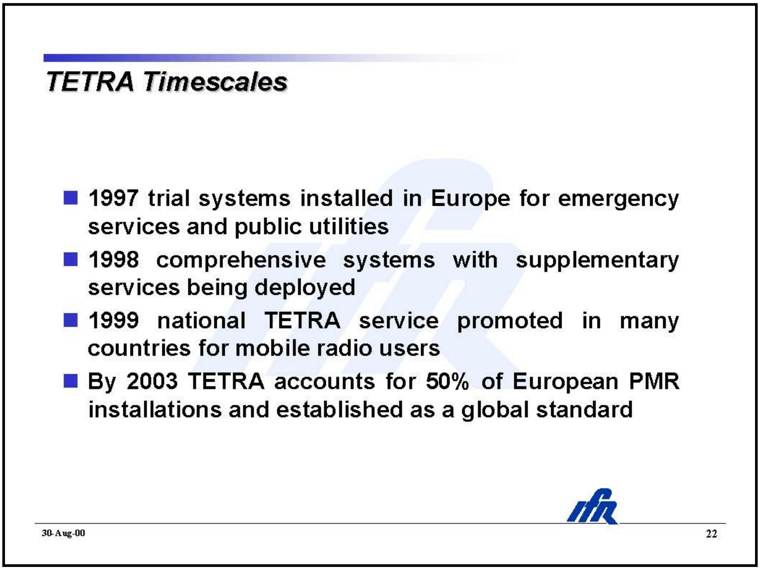
Users of mobile radio networks may continue to operate existing analog systems for many years. This means that as TETRA radio systems are introduced into a country it will inevitably have to operate alongside analog systems. It is important that neither system interferes with the other. An analog radio network will quickly show reduced performance if other low level interfering signals are present on the same frequency.

A consequence of this co-existence requirement is that the TETRA specification requires very demanding RF performance from the radios. adjacent channel power, wideband noise and discrete spurious emissions have very tight specifications.



IFR and TETRA

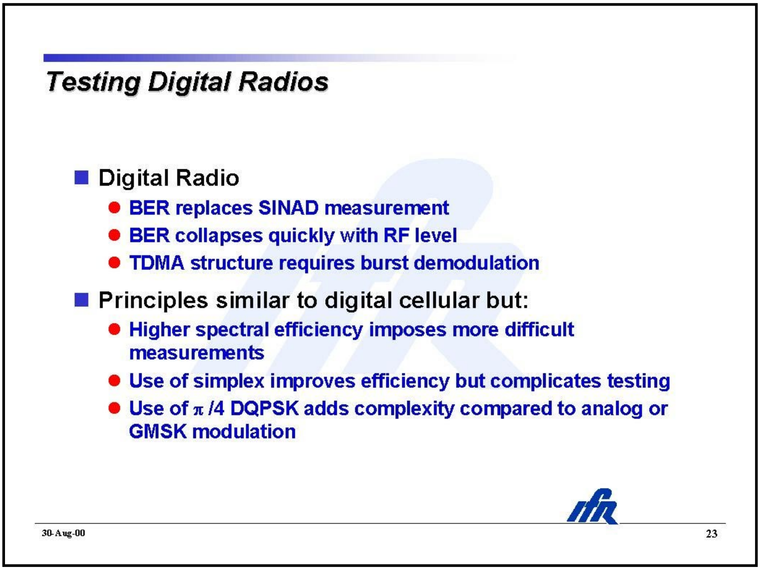
IFR (formerly Marconi Instruments) was an original signatory to the TETRA MoU in 1994. Since then, IFR has played an active role in the development of the TETRA specification. As part of IFR's commitment to the TETRA standard, new products are being developed to assist manufacturers in the design, production and support of TETRA radios.



TETRA Timescales

The first TETRA systems using trial licences were launched in 1997. These networks are targeted at emergency services and public utilities. In 1998 comprehensive TETRA networks are planned in many countries across Europe. The first national TETRA networks offering public access are expected to appear in 1999.

It is probable that TETRA networks will begin to be installed in Asia, Australasia and throughout the rest of the world by the year 2000.



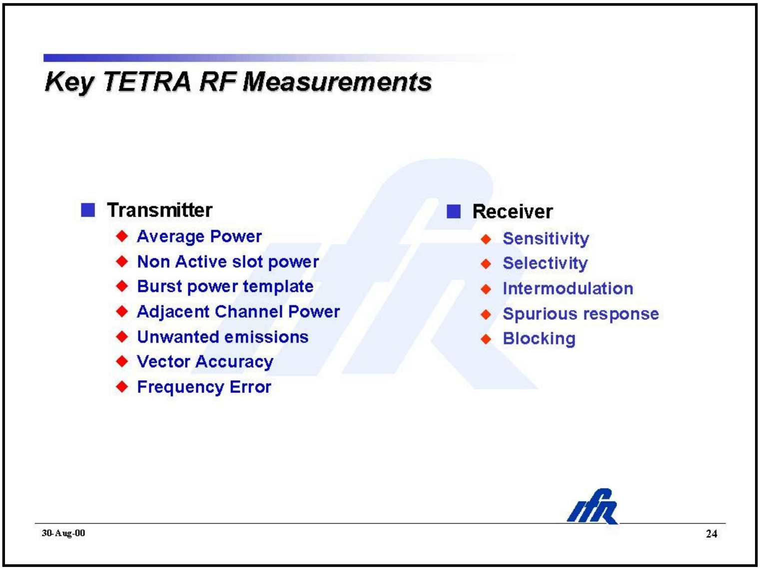
Testing Digital Radios

The move from analog to digital requires a radical change in test methodology. Some of the parameters of interest all have direct analog equivalents but others are totally different.

The classic SINAD measurement for example which for analog systems is a very reliable and representative measure of the intelligibility of a voice communication is replaced by a measurement of bit error rate, (BER). Bit errors are measured by comparing demodulated data with original data and counting over a sample period the number of errors. At this primitive level it appears very simplistic. Owing to the use of codecs to compress speech, which in the case of TETRA is an ACELP codec, some bits become more important than others which complicates BER measurements. It is no longer enough to count errors. The importance of each corrupted bit must be known as well, more important bits have more protection. The use of Forward Error Correcting techniques similarly complicates matters by recovering bit errors. Digital data with forward error correction replaces the normal gradual degradation of reception quality with a more consistent performance until a point is reached whereupon the algorithm can no longer cope and the entire system breaks down. Reception quality very quickly becomes totally unintelligible.

The TDMA nature of some digital radio systems, including TETRA adds a totally new dimension. Burst profiling and timing alignment are not parameters with an equal in analog systems. Very wide dynamic range is required to accommodate the large signal level variation.

TETRA imposes very demanding spectral purity performance unlike other digital systems principally because of the need to coexist with analog systems where interference would be caused. The modulation type has been chosen to contain the signal bandwidth yet this alone is not sufficient, very linear amplifiers are needed in transmitters.

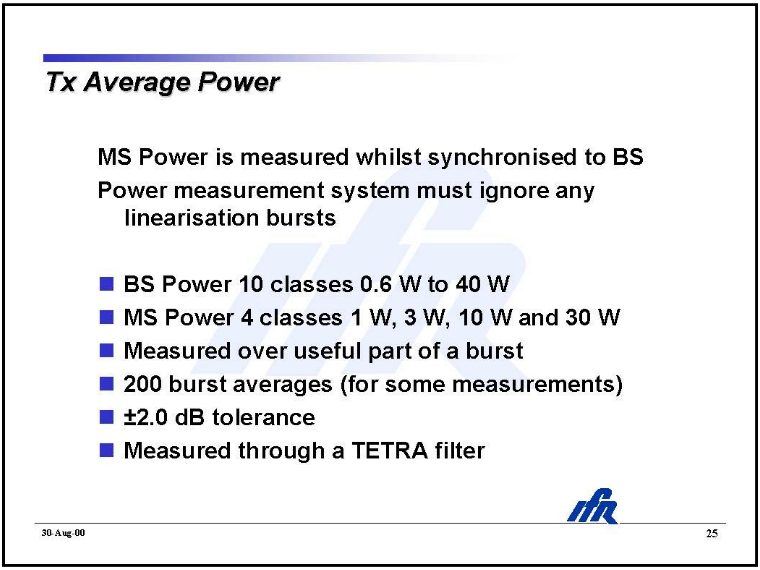


Key TETRA RF Measurements

The radio conformance tests are the basis of any production test requirement. Manufacturers will choose which subset of tests to perform and which test methodology to adopt following satisfactory completion of type approval radio acceptance tests on the design. The test performed in manufacturing will follow closely those carried out for type approval especially when the product is ultimately aimed at public safety organisations.

The test methodology may be simplified where it is otherwise time consuming or requires lots of specialist equipment.

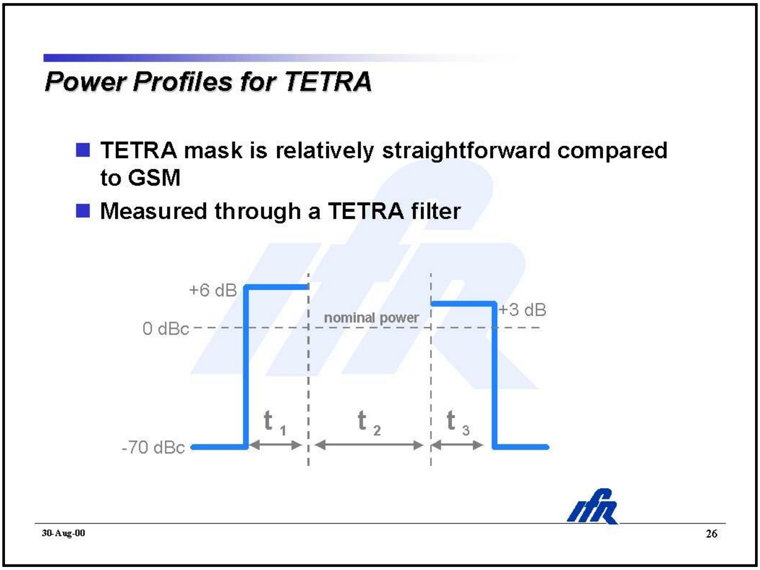
The parameters above are unlikely all to be tested on all production units but at some stage, either periodically or on a batch, manufacturers will carry out all these measurements and more.



Tx Average Power

The power output of TETRA equipment varies depending on the class of equipment and whether it is a mobile or base station. The output power classes represent maximum power capability (MS) or fixed power level (BS). The actual level of a mobile can be controlled by the mobile itself and is dependent upon received signal strength.

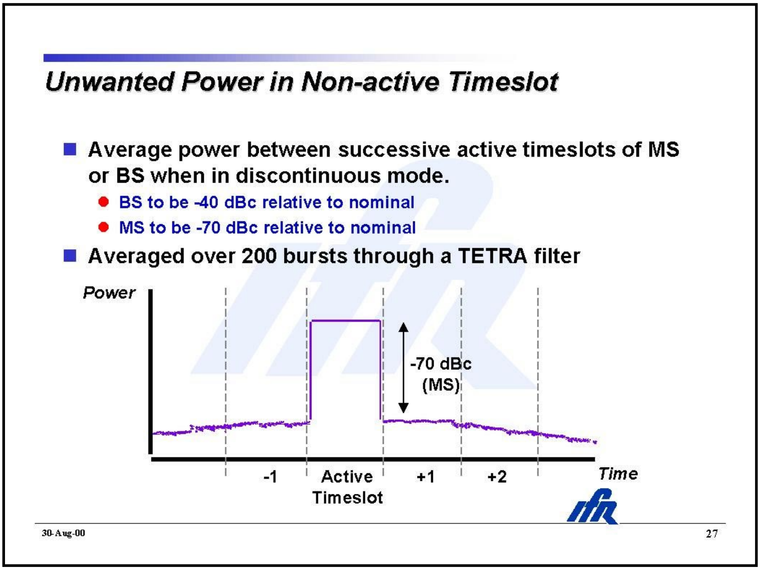
The bursted nature of TETRA makes power a difficult parameter to measure. In addition the modulation results in a non constant envelope. Average power of the burst has to be measured. TETRA power measurement specifies that measurement is made at the symbol points (because of the non-constant modulation envelope). All power measurements must be time aligned to the training sequence in the burst.



Power Profile for TETRA

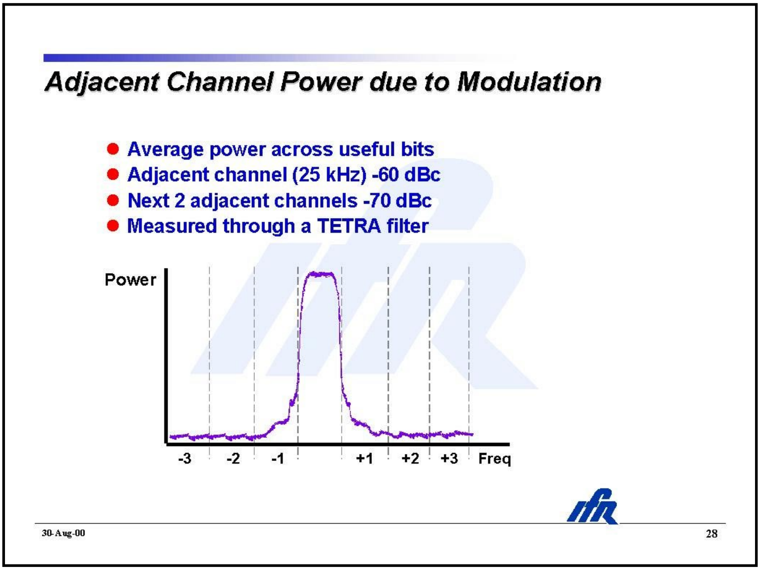
The requirement to ramp the power levels up and down in a TDMA system results in additional spread of the transmitted spectrum at times determined by the TETRA base stations.

The limit masks on the TETRA signal power ramps are relatively straight forward but power ramping needs to be carefully controlled so as not to fail ACP due to switching. Consequently, the ramp up and ramp down periods are typically 7 to 16 symbols long.



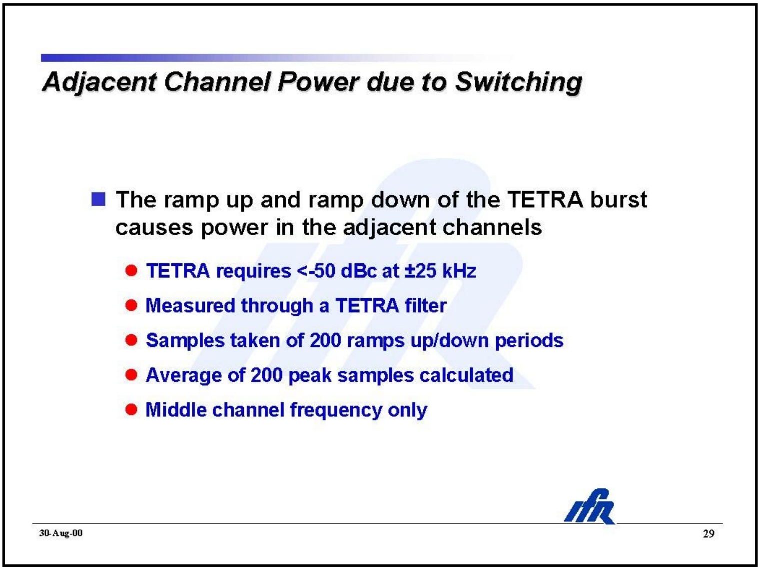
Unwanted Power in Non-active Timeslot

A non-active timeslot occurs normally between successive TETRA bursts. Non-Tx state is when the radio is not transmitting eg, simplex receive. The measurement of non-active timeslot power requires a large dynamic range to be accommodated. First the nominal level must be measured as per the previous example. This nominal level is used as a value against which the non-active slot power is measured.



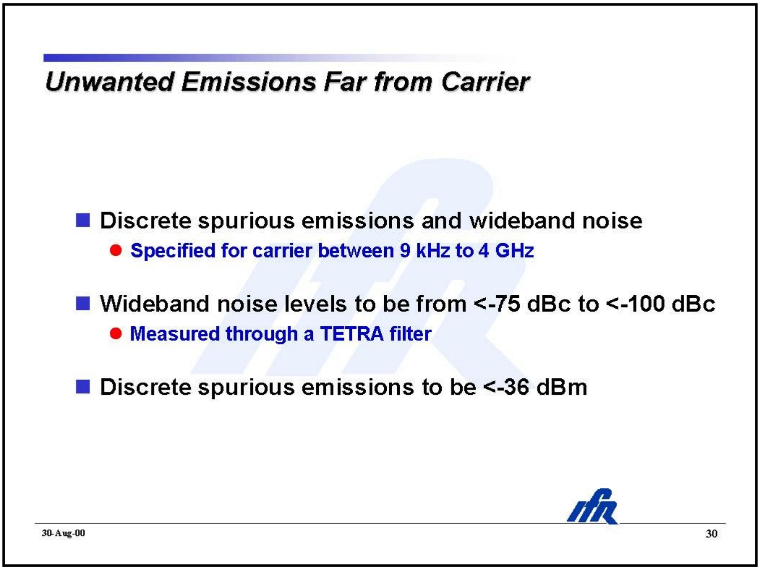
Adjacent Channel Power due to Modulation

A key transmitter measurement required on TETRA is to test for the spreading of signals into the adjacent channels. A perfect TETRA signal does not have any emissions into the adjacent channels because of the modulation scheme used. In reality small non linearities in the modulation and RF system cause the spectrum to degrade. The performance is critical to TETRA networks, where maximum flexibility in frequency allocations is required, and to prevent degradation of nearby networks. For this reason the TETRA standard imposes demanding specifications of adjacent channel power which have to be measured in a TETRA filter bandwidth. The low adjacent channel power requirements result in a need to use linearization techniques to optimize the performance of power efficient amplifiers.



Adjacent Channel Power due to Switching

The generation of power ramps must not be allowed to compromize the spectral purity of the transmitted output. Amplifiers must be switched on slowly. This parameter is distinct from adjacent channel power due to modulation which results from non ideal filter characteristics or amplifier non linearity. Relaxed limits apply during the switching periods.

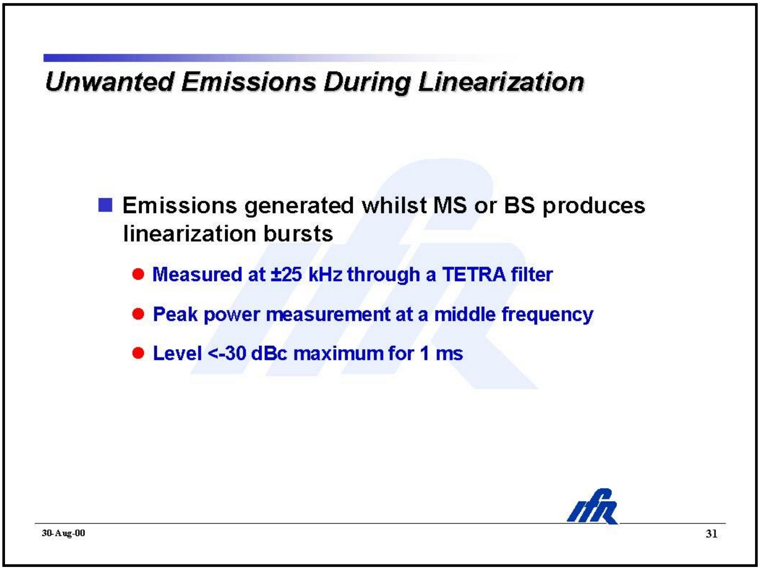


Unwanted Emissions Far from Carrier

TETRA places high demands upon broadband generated noise. This regulatory requirement is to avoid interference with other radio systems.

Wideband noise is broadband power that may be transmitted by a TETRA radio. It is measured at offsets >100 kHz from the carrier and measured through a TETRA filter.

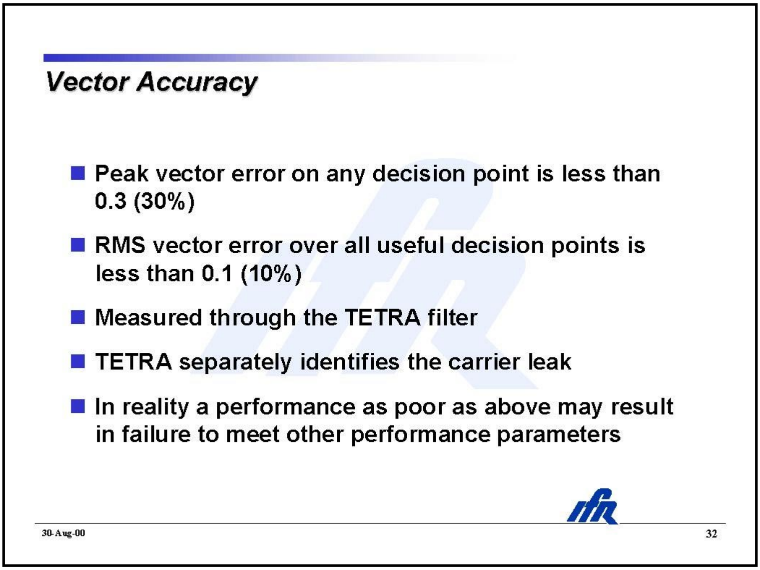
Discrete spurious emissions are defined as the average power of any discrete signal occurring during the burst transmitted by the TETRA equipment.



Unwanted Emissions During Linearization

The output power of a TETRA radio will vary with time. This is a result of the use of $\pi/4$ DQPSK modulation, which does not have a constant envelope and due to changes in power level of the radio. If the output amplifiers are non-linear then intermodulation will cause unwanted power to be present in adjacent channels.

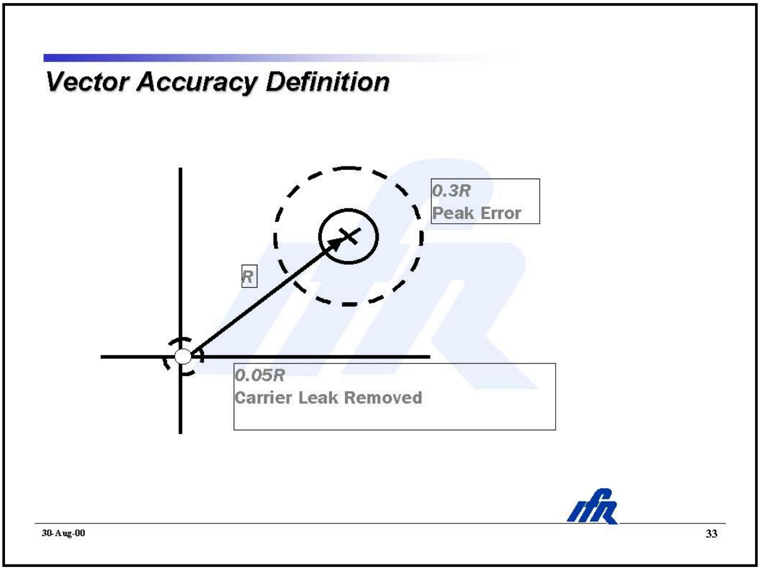
TETRA transmitters use a variety of linearizing techniques which may require periodic recalibration. In order that this technique may be employed, provision in the standard was given to allow bursts of RF to be produced called linearization bursts. To minimize the effect of these transmissions on other users the above limits were imposed. This specification is a relaxation of the normal ACP limit.



Definition of Vector Accuracy

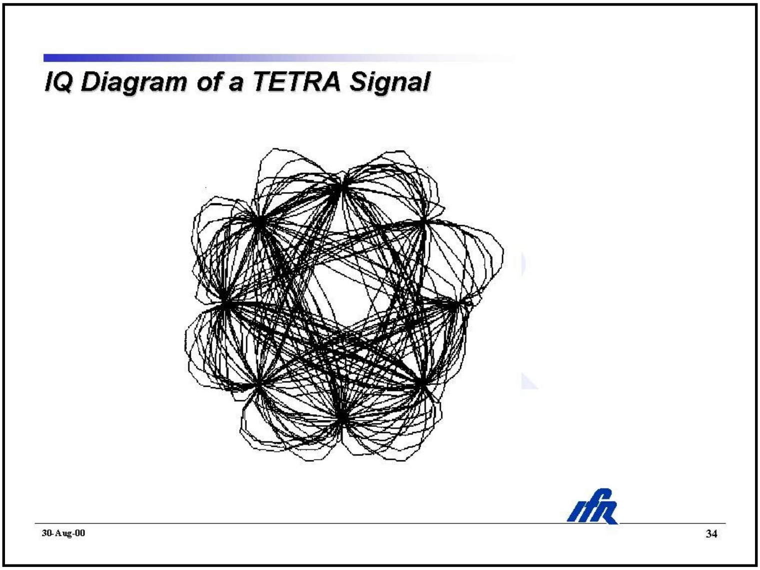
The TETRA specification defines vector accuracy in terms of error (phase and amplitude) at the decision point of a TETRA receiver after carrier leak and frequency error in the IQ modulator has been eliminated. The error is expressed as a ratio of the diameter of the error circle about the decision point compared to the diameter of circle on which the decision point lies.

The carrier leak is specified not to exceed 5%, or -26 dBc, of the total carrier amplitude.



Definition of Vector Accuracy

Vector accuracy is defined as a circle about the decision point in which the phase and amplitude of the carrier has to be. Two values are specified, the peak value and the RMS value. In both cases the radius of the error circles are expressed as a proportion (or %) of the distance from the origin of the decision point.

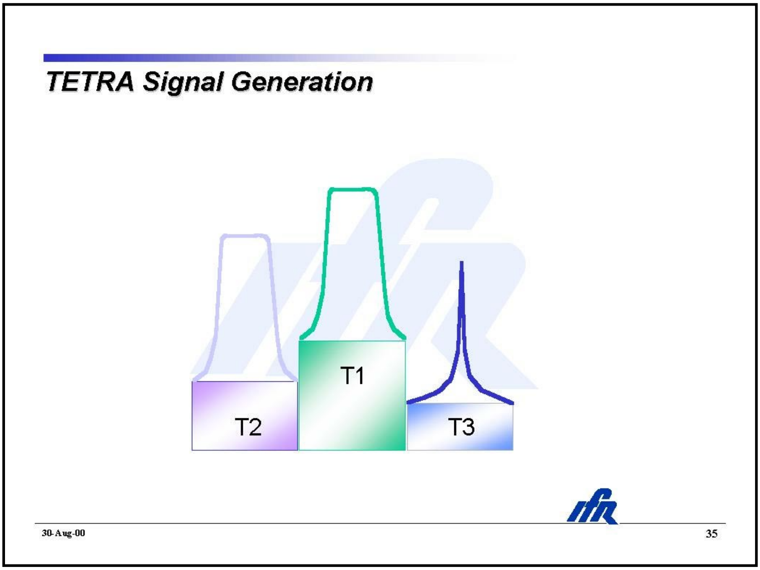


π/4 DQPSK Modulation

TETRA's phase offset differential π/4 DQPSK is shown in the above IQ diagram. With both the transmitter and receiver filters applied eight decision points can be clearly seen due to the phase offset nature of the modulation scheme. The IQ diagram also shows that the RF signal level (represented by the distance to origin) varies with time, and the peak signal exceeds the level at the decision points.

After filtering, the signal shows 8 distinct spots, referred to as decision points, when the information content of the signal is determined. The fact that the decision points are distinct spots indicates there is no intersymbol interference.

There are 8 symbol location points because the modulation technique used has a 45 degree rotation (the phase offset) between transmitted symbols. The data is conveyed in the phase transition between the symbol points, not in the symbol point itself. From any one symbol location the carrier can only move to four other symbol locations at ±45° or ±135°. In this way it is ensured that the carrier never passes through the origin, so the carrier is always present.



TETRA Signal Generation

To test TETRA receivers, three different types of test signal have been defined. Each signal has different RF and modulation characteristics to suit the specific tests being performed.

T1 In Channel Test Signal

The in channel signal, T1, is an RF carrier modulated using $\pi/4$ DQPSK at the TETRA modulation rate of 18 ksym/s, which is root Nyquist filtered with an alpha value of 0.35. T1 test signals have defined data framing. This ensures that the receiver may be controlled correctly during test and that the bit error rate can be measured.

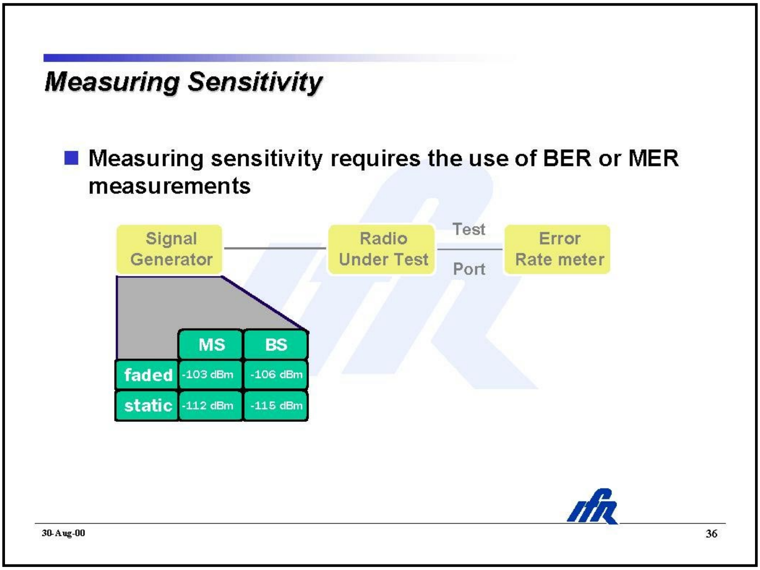
T2 Interfering Test Signal

The first interferer (T2) is used to measure the performance of TETRA receivers in the presence of adjacent and co-channel signals. The T2 test signal must also be modulated with TETRA modulation. However, the RF performance required for the T2 test signal is far more critical that for the in channel T1 test signal. In order to be suitable for making TETRA selectivity measurements, T2 must have very low levels of adjacent channel power.

For testing receivers, it is necessary to simulate a TETRA transmitter with ACP levels of <-70 dBc to avoid causing interference in the wanted channel.

T3 Second Interferer

The second interferer is used for blocking, spurious response and intermodulation attenuation testing. The TETRA standard requires T3 to be an unmodulated RF carrier with a frequency anywhere between 9 kHz and 4 GHz.

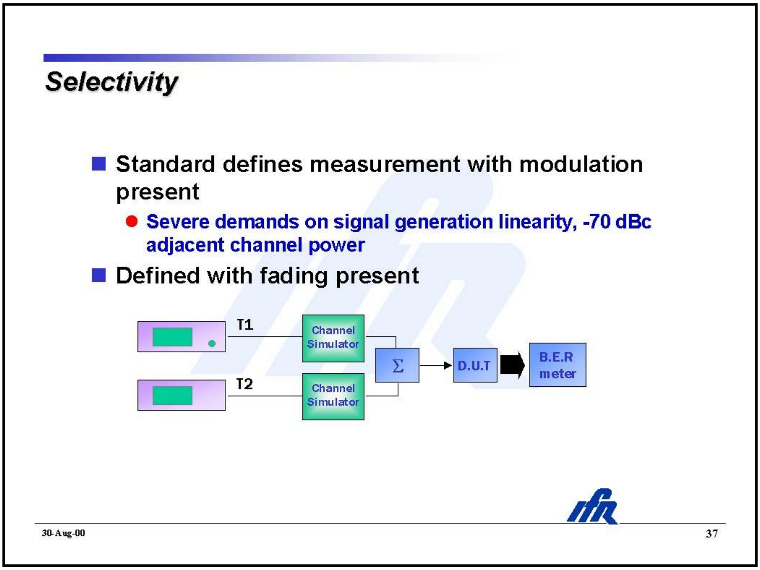


Measuring Sensitivity

Measuring the sensitivity of a TETRA radio is in principle similar to that of an analog radio but instead of performing SINAD measurements, a Bit Error Rate (BER) measurement is performed. The BER can be measured either by a customized BER meter or by requesting the radio to loop back the demodulated signal into its transmitter and for a signal analyzer or radio test set to recover the data and measure the BER. An additional complication is that a radio should be tested under conditions found in real applications where the signal exhibits fading characteristics. The TETRA standard specifies performance with faded and static receiver signals.

The specifications for a base station are more stringent that those of a mobile subscriber terminal.

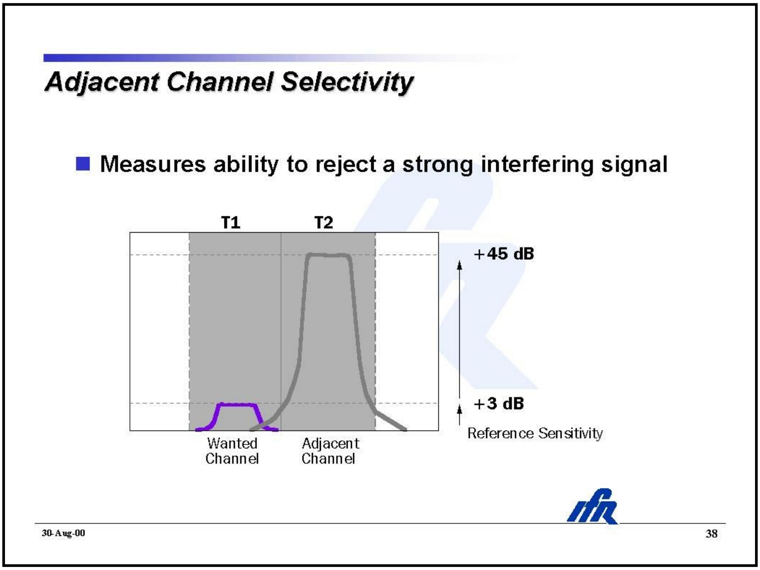
An additional complication to the sensitivity is that there is nothing very graceful about the degradation of a digital radio as the signal level drops. With analog systems the noise levels steadily increase as the RF level falls. However, with digital radios the error correction algorithms keep correcting the output until the point at which they can no longer cope and the radio ceases to function.



Selectivity

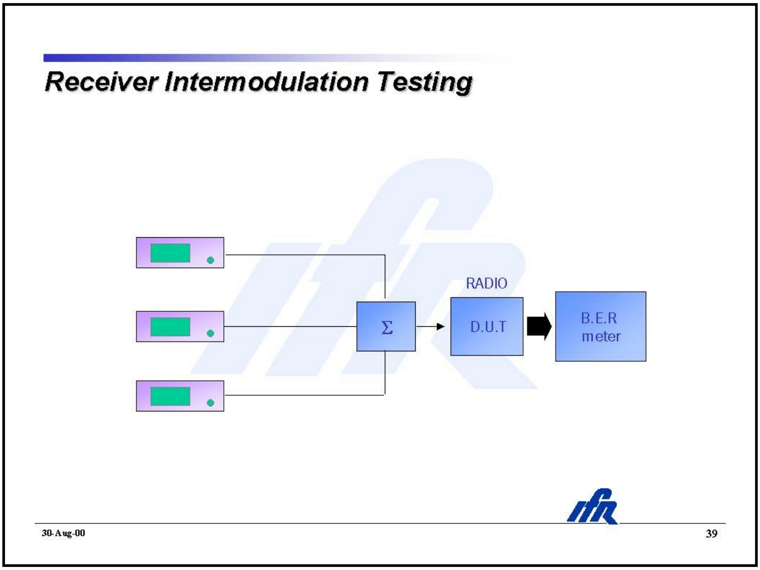
A critical parameter of the receiver section is its selectivity. Selectivity can broadly include adjacent channel selectivity, co-channel selectivity, intermodulation rejection and blocking. The selectivity measurement quantifies the ability of the receiver to reject a strong TETRA interferer in an adjacent channel and requires the use of a high performance signal generation, with low adjacent channel power of -70 dBc in a TETRA bandwidth to perform the measurement.

Both the in channel and interfering signals may be subject to terrain fading which requires the use of fading simulators.



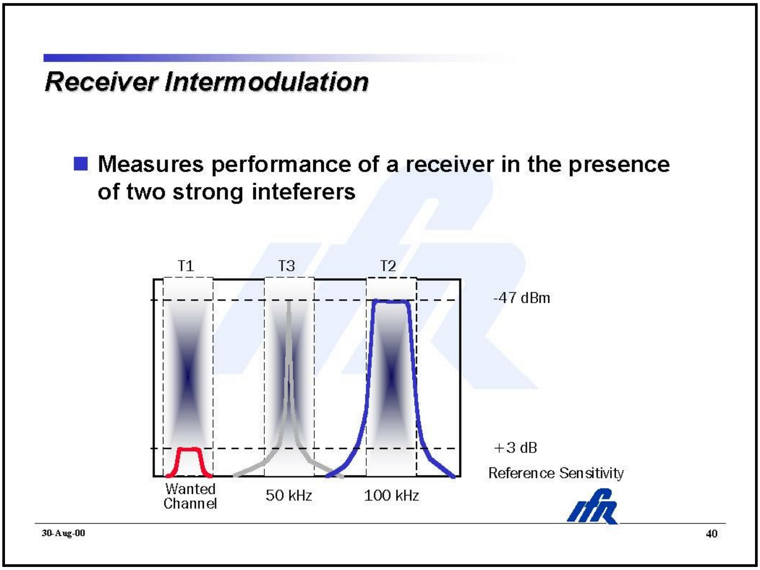
Adjacent Channel Selectivity

Adjacent channel selectivity is measured only at 1st channel offsets below and above the carrier. This interfering signal must be modulated with TETRA modulation. The in channel signal is set at 3 dB above reference sensitivity.



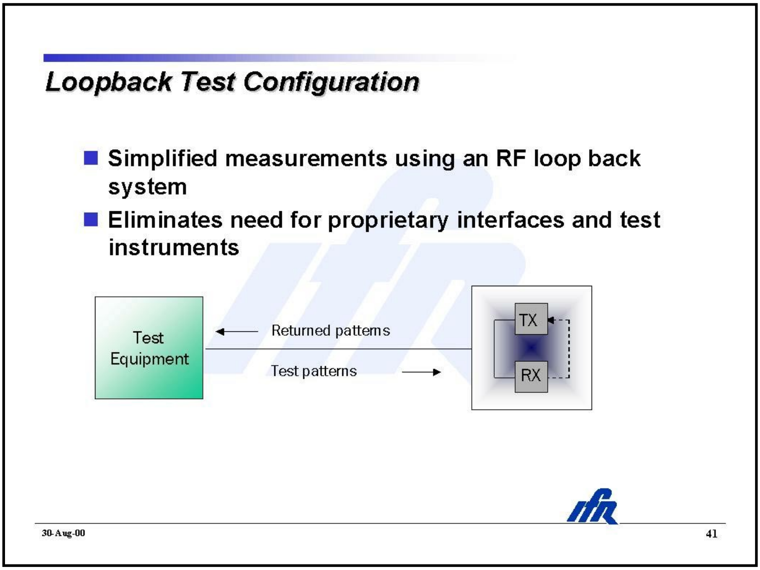
Receiver Intermodulation Testing

The performance is measured by combining the outputs from three signal sources, one providing the wanted signal and the others the interferers. Only one of the inteferers needs to be capable of generating a TETRA signal.



Receiver Intermodulation

Intermodulation rejection uses three signals. In band receiver stimulus (T1), a modulated interferer (T2) with low adjacent channel power and a CW interferer. The internally generated intermodulation products of the receiver front end will occur at the wanted channel frequency providing the interferers are correctly set. The intermodulation products will cause degradation of received BER performance.



Loopback Test Configuration

When using RF loopback testing, the test system transmits a signal to the terminal. For conformance testing of mobile or base station equipment, the use of a T1 signal with no protocol can be used to initiate loopback. For production and service testing of mobile radios only, it is possible to initiate loopback with normal call setup procedures. Loopback mode is where the demodulated data is retransmitted via the air interface to the test system. The test system can then perform both receiver and transmitter measurements without the use of proprietary interfaces, or an adapter, using parts of the normal call set-up procedures. The RF loopback method is an annex to ETS 300 394-1. This technique is ideal for both manufacturing and service tests and could be used to support conformance testing in the future. The use of a test procedure independent of proprietary interfaces ensures that testing can be performed independently of the manufacturer of the terminal and hence aids the use of multiple vendor equipment on the network.

TETRA - The future starts now!

The new TETRA radio system is destined to become a de facto global standard. It is probable that millions of TETRA radios will be manufactured and delivered to a wide variety of users over the lifetime of the TETRA standard. TETRA radios will improve the quality of the world's emergency services and give business better communications.

TETRA radios will also give more features, ultimately at a lower cost than traditional PMR. Manufacturers are ready, test equipment companies are ready and the customers are already installing their first TETRA networks.

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