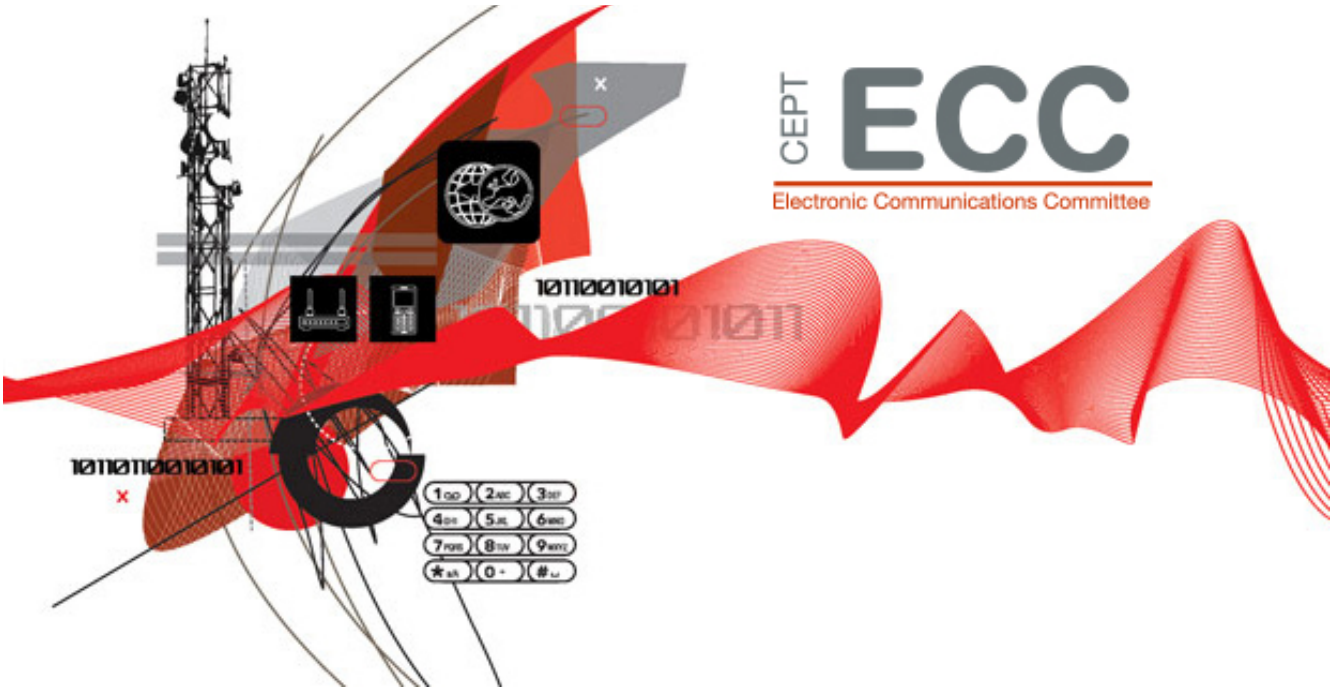

ECC Newsletter May 2020

ECC investigates the possibility of using digital equipment in maritime VHF voice communications

Very high frequency (VHF) maritime communications play a vital role in enhancing ship safety and the efficient operation of ports. Indeed, ECC Decision (19)03 states that *"analogue voice telephony is the most important form of communication in the maritime mobile service as a safety related service…"*.

Yet, in maritime bands the introduction of new digital communication channels for data is now potentially limiting the availability of analogue VHF voice channels. This is a very different experience to many areas of communication where digital equipment has resulted in greater efficiency and improved services, for example with GSM, or digital TV. More voice channels in the maritime services could be made available if they were to become digital.

Several technology options could be used for maritime VHF voice communications. The technical candidate solution is dPMR (digital Private Mobile Radio) – a technology currently used in land mobile communications as a replacement for analogue FM voice communication in both VHF and UHF bands. dPMR has been standardised by ETSI, the European standards organisation. However, it is worth noting that replacing maritime analogue VHF radio must be done in such a way that both the “old” and new technologies can be used in adjacent spectrum.

The first VHF allocations for shipping were made by the ITU, the UN's specialised agency for information and communications technology, in 1947. Twelve years later, in 1959, the ITU-R Radio Regulations Appendix 18 were introduced. Appendix 18 contains a table of transmitting frequencies in the VHF maritime mobile band as shown in Figure 1 below. The allocated frequencies are in the frequency band 156.025 MHz to 162.025 MHz. The channelisation is 25 kHz.

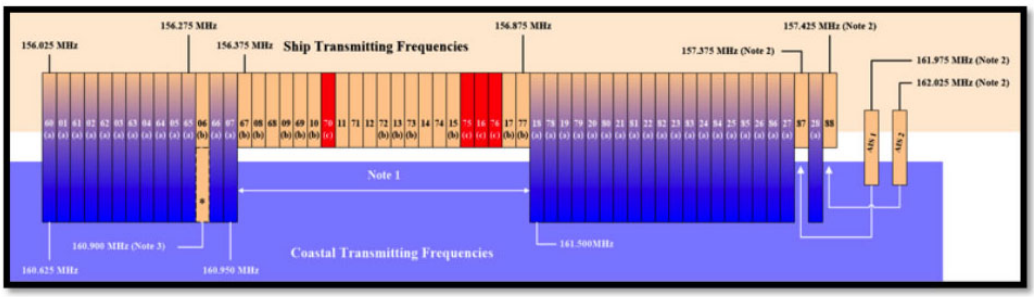

Figure 1 - ITU-R Radio Regulation Appendix 18

The most recent ECC deliverable relating to the maritime frequency bands is ECC Decision (19)03 – on the harmonised usage of the channels of the Radio Regulations Appendix 18 (transmitting frequencies in the VHF maritime mobile band).

The Decision states that *"with the exception of the automatic identification system (AIS) on channels AIS1 (161.975 MHz) and AIS2 (162.025 MHz) and digital selective calling (DSC), currently all the remaining listed channels are used for analogue voice communication. With the digital data exchange allocations in future, some channels will be used for data transfer and not for voice communication any longer. New digital radios need to be developed, which is different equipment than the current voice communication radios. As the result, the frequencies in the VHF maritime mobile band will be shared by four different systems: analogue voice telephony, DSC, AIS and digital data exchange."*

Following the publication of this Decision, the ECC's Working Group Frequency Management (WG FM) agreed to start work on a new ECC Report. This would examine the implementation of digital voice radio telephony in the VHF maritime mobile band. The report is not expected to be published until October 2021, but the initial assumption is that four digital channels of 6.25 kHz can occupy the same radio spectrum as the single 25 kHz analogue voice channel.

In addition to the practical trials of digital maritime radio apparatus, the WG FM's maritime group (FM58) will consider several issues relating to the potential introduction of digital voice. Among them are:

- Technologies must have in principle a clear migration path both from current analogue voice services to new digital voice services by allowing both digital and analogue services to co-exist in the same transceiver for the duration of the entire migration period.

- Digital voice quality should be similar or better than the analogue voice quality, especially at the edge of the radio coverage where the radio signals are weaker.
- Current technology/digital equipment must be able to detect an analogue or digital signal and switch over automatically.
- Radio transceivers from different manufacturers must be interoperable.
- The likelihood of inadvertent transmissions being eliminated after the remote shutdown of transceivers must be considered.
- Possible enhancements to the voice service, such as a form of messaging (e.g. SMS), should be considered.

So far, practical trials of digital marine VHF voice communication have been undertaken in Estonia and the Netherlands

Estonia

In Estonia, evaluation measurements were carried out in the frequency range *f = 156,7-156.8 MHz (or more precisely f = 156,709375 - 156,7625 MHz; channel K = 15;74)*. Figure 2 below illustrates the distribution of channels and Figure 3 illustrates the channel block.

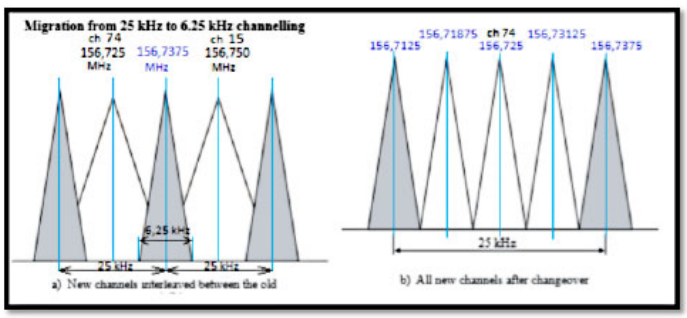

Figure 2 - Distribution of channels

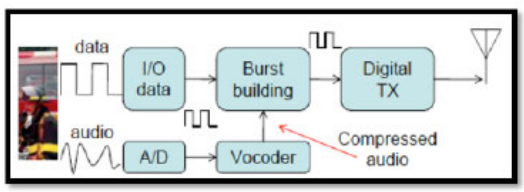

Figure 3 - Channel block-diagram

The quality of speech was assessed using a 5-point scale (1 = good without interruption; 2 = good with disruptions; 3 = distorted without interruption; 4 = distorted with interruption; 5 = impossible to understand). Measurements were made of the signal-to-noise ratio (SNR - Signal power or averaged level during transmission/noise level without transmission) with SNR assessed in adjacent channels.

The measurements were carried out between a shore station, a vessel and handheld stations around Tallinn Bay.

Figure 4 - Map of Tallinn Bay (Source: Google maps)

A vessel set out from Pirita along the edge of the Viimsi peninsula around Naissaar island in the direction of Pakri peninsula. When leaving Pirita, the quality of the digital communication with Hundipea port was assessed until the connection was lost. The signal was also tested against handheld radios, one in a vehicle, one on an observation platform and another in the Pakri lighthouse. Tables 1 and 2 below provide an evaluation of the quality of both the digital and analogue communications.

Digital						
Quality of communications [0... 5] Vessel — Pakri					Coordinates	
Distance [NM]	Stationary	Handheld-tower	Handheld plateau	Handheld on vessel	Latitude	Longitude
19,6	2		0		59°37,031 ′	24°30,303 ′
18,9	4		0		59°36,64 ′	24°29,5 ′
16,8	5	5	0		59°35,18 ′	24°26,3 ′
8,5	5	5	5	3	59°29,72 ′	24°13,85 ′
6,3	5	5	5	4	59°28,46 ′	24°10,67 ′
2,7	5	5	5	5	59°26,06 ′	24°05,64 ′
Communication between Hundipea and Pirita						
	Distance [nm]		Handheld on vessel		59°45,891 ′	24°71,8338 ′
	3,2		5			
Communication between Hundipea and the vessel						
	7,7	Intermittent	3		59°34,661 ′	24°42,529 ′
	9,8	No signal	0		59°37,009 ′	24°40,24 ′

Table 1 on the evaluation of the quality of digital communications

Analogue				
Quality of communication [0... 5] Vessel — Pakri			Coordinates	
Distance [NM]	Onboard station on vessel	Handheld on vessel	Latitude	Longitude
18,2	2		59°36,14 ′	24°28,4 ′
11,6	3		59°31,7 ′	24°18,59 ′
8,5	4	1	59°29,72 ′	24°13,85 ′
6,3		2	59°28,46 ′	24°10,67 ′
2,7		5	59°26,06 ′	24°05,64 ′
Communication between Hundipea and Pirita				
Distance [NM]	Handheld on board		59°45,891 ′	24°71,8338 ′
3,2	2			

Table 2 - Quality of analogue communications

Participants in the test were generally positive about the introduction of digital communication with the range being the same (or better) than the range for analogue communication. At the maximum distances, the digital communication remained understandable (d = 19,6 NM) while the analogue communication experienced very high noise and was not understandable.

During the digital switchover period, when the digital station and the analogue station were very close together, the digital station signal overlapped the analogue channel. This did not cause any interference during testing.

The Netherlands

In the Netherlands, the trials were conducted around the Port of Rotterdam. The port authority assisted with the trial and made available a de-commissioned vessel traffic service (VTS) centre in the middle of the city and one of their support vessels.

During the test, the Radiocommunication Agency Netherlands (Agentschap Telecom) monitored the digital apparatus to ensure it remained compliant with the relevant ETSI Standard (ETSI TS 102.658) and Radio Regulations Appendix 18. The frequency 162,500 MHz was used for analogue communication and the frequency 162,534375 MHz for digital communication (dPMR).

The two positions from where the monitoring took place were approximately 4 km from the VTS centre – Wilhelminahaven/Nieuwe Waterwegstraat and the Karel Doormanweg, which are near the waterway.

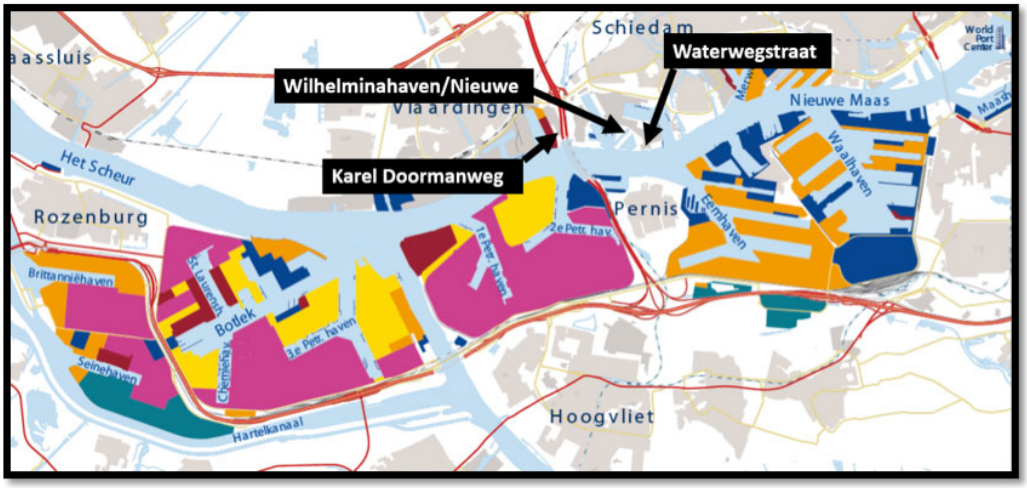

Figure 5 - Map of Rotterdam Port (Source: Google maps)

Testing was conducted between the VTS and the support vessel as it travelled around the harbour. The initial findings were:

- The range of both digital and analogue communications was very similar. The quality deteriorated due to the horizon/line of sight limitations that all current VHF radios encounter;
- In a specific area of the fairway (i.e. a navigable channel in a harbour), the quality of both digital and analogue communications deteriorated because of large storage tanks standing between the VTS and vessel which probably blocked or reflected the signal;
- When the quality deteriorated on the digital channel, connectivity was lost altogether or a "metallic/robotised" sound was experienced, whereas when it happened on the analogue channel, it caused noise;
- During the trials, interoperability between equipment from two different manufacturers was demonstrated.

The users and the observers found the digital voice quality the same or better than the analogue one. The users reported back that listening to digital voice with noise reduction made it easier and less intensive to listen. The users concluded that the digital transmission of voice enabled the same functionality of operation of the ship as for an analogue radio system.

In summary, the trials presented some positive outcomes. The completion of the ECC's Report in October 2021 is expected to assist the International Maritime Organization and ITU in assessing the benefits of implementing digital voice radio telephony in the VHF maritime mobile band.

It is expected that the maritime community will present at WRC-23 their evolution plan and apply for an agenda item for the evolution of the very high, medium and high frequency maritime band. This in turn should lead to WRC-27 amending Radio Regulations Appendix

18 to facilitate a new maritime analogue/digital channel plan. While it is still early days in this process, the signs are positive. Watch this space.

Robin Donoghue
Frequency Management Expert
European Communications Office

STIR/SHAKEN – Europe watches with interest as the United States and Canada roll out a solution for authenticating calling line identification

Fraud continues to be a major issue for the communications industry, as the percentage of total revenue lost due to fraud grew in 2019. The sector lost $28.3 billion (€26.1 billion) to fraud last year, the Communications Fraud Control Association's biennial global fraud loss survey shows. While the actual figure was down from $29.2 billion (€26.9 billion) in 2017, the percentage loss of total revenue increased from 1.27% to 1.74%. There remains no room for complacency when it comes to fraud within the industry.

Of course, revenue loss is not the only issue that arises as a result of fraud or misuse of electronic communications services. It is much harder to quantify the distress and anxiety suffered by consumers, on top of the financial cost to them and to service providers. The many different types of fraud and misuse that both service providers and consumers are experiencing is the subject of an earlier article in this series describing the A to Z of fraud types.

CLI spoofing

The above mentioned article describes Calling Line Identification (CLI) spoofing as a method whereby a fraudster manipulates the telephone number in the CLI field in the communication signalling. This leads the person they are calling to think the call has come from a different location, organisation or person. The contents of the CLI field can be manipulated for valid reasons – described in ECC Report 248 – but illegitimate CLI spoofing remains a major enabler of fraud.

The numbers that are spoofed can be fictitious numbers, real numbers assigned to end-users, or real numbers which have not yet been assigned. Numbers assigned to large organisations that are used exclusively for incoming calls are popular for fraudulent activity. One notable case of CLI spoofing which caught the headlines internationally was where the inbound telephone number of the US tax authority, the Internal Revenue Service (IRS), was spoofed by scammers who then falsely claimed to be from the IRS and sought out personal information, such as social security numbers, or demanded immediate payment of taxes by credit card from their victims. Over a period of four years, more than 15,000 victims in the United States lost "hundreds of millions" of dollars to this scam.

In the United States, CLI spoofing and robocalling – an outbound telephone call generated by a computerised auto-dialler to deliver a pre-recorded message or to connect the called party with a human operator – account for a staggering 200,000 consumer complaints to the Federal Communications Commission (FCC) every year. This equates to around 60% of all complaints it receives. The Federal Trade Commission (FTC) receives even more robocall complaints – 4.1 million in 2018. Robocalling has become a major problem in the United States and in many cases, these calls appear to originate from spoofed telephone numbers. To combat this growing problem the FCC Chairman, Ajit Pai, in a November 2018 news release, demanded the industry to implement a robust call authentication system known as STIR/SHAKEN to combat illegal CLI spoofing. In December 2019, the Traced Act was signed into law – service providers are now required to implement STIR/SHAKEN in the Internet Protocol (IP) portions of their networks within a reasonable timeframe.

Apart from being methods to mix martinis, what are STIR and SHAKEN?

A single telephone call between two people can involve multiple service providers and multiple networks. An originating service provider always knows something about the CLI associated with a call. In most cases, the caller is a customer of the originating service provider and the service provider knows the customer has rights of use to the number. In other cases, the originating service provider knows the customer but allows the customer to use a different number in the CLI field. This is common for business customers who may want to display a different number, for example, a reception or a freephone customer contact number, rather than the actual extension of the caller. It may not be possible for the service provider to validate the CLI used by the customer. And finally, sometimes the service provider only knows the entry point to the network, for example, a long distance call from overseas which may have originated and transited through other networks before arriving at the terminating network. Until recently, there was no secure mechanism for an originating service provider to communicate this type of information to a terminating service provider. This is where STIR/SHAKEN comes in.

Secure **T**elephone **I**dentity **R**evisited (STIR) is a working group of the Internet Engineering Task Force (IETF), which has developed a suite of standards to authenticate CLI. **S**ecure **H**andling of **A**sserted information using to**KEN**s (SHAKEN) specifies a practical mechanism for service providers to implement the STIR standards. Work on SHAKEN has been led by the **A**lliance for **T**elecommunications **I**ndustry **S**olutions (ATIS).

How does it work?

For almost two decades now, network operators around the world have been migrating their networks from traditional time division multiplexing (TDM) technology to IP, with Session Initiation Protocol (SIP) being the most prominent and widely used protocol for IP-based

voice telephony. There remains a significant amount of legacy TDM traffic in access networks but most core networks in Europe are already IP-based and, most importantly, scammers almost always use IP-based technology to originate calls.

STIR/SHAKEN, which works with SIP, is essentially a tool to provide terminating networks with intelligence on calls originating on, or transiting through, other networks.

When a call is made, the originating service provider can check the source of the call and create a digital signature, called a Personal Assertion Token (PASSporT), which "attests" to what it knows about the call origination. The PASSporT is used to create a SIP identity header that contains information on the calling number, called number, attestation level, and call origination using secure digital certification. There are three levels of attestation defined by the standards:

1. **Full Attestation**: The caller, and their right to use the number in the CLI field, is verified. This must be a customer of the originating service provider.
2. **Partial Attestation**: The caller, but not the number, is verified. This could be a business customer of the originating service provider, for example, which may have the capability to manipulate the CLI field in their enterprise level switch for a valid reason.
3. **Gateway Attestation**: Only the point at which the call entered the network is verified. An example of this case would be a call received from an international gateway.

STIR/SHAKEN Governance Framework

In order to digitally certify calls, each service provider must obtain a digital certificate from a certificate authority who is trusted by other service providers. A key component of the SHAKEN framework is the governance model which was developed by ATIS and industry in close cooperation with the FCC. There are a number of different entities in the governance model and their respective roles are described in Figure 1 below.

Figure 1 - SHAKEN Governance Model – Entities and respective roles (source: ATIS)

The governance authority is designed to allow for non-discriminatory representation, in the form of a board, by representatives from the electronic communications service provider community which co-ordinates with the FCC to ensure transparency in the operation of the ecosystem and co-operates on any enforcement actions.

The STI-GA board has now been appointed and operates under the auspices of ATIS. iConectiv has been appointed as the STI Policy Administrator, and several STI Certification Authorities have been approved, including Neustar and Transnexus. Since 16 December 2019, voice service providers can register with iConectiv to obtain credentials in order to acquire STI certificates from approved certification authorities.

With the technical and governance framework now in place in the United States, the challenge is to get all domestic service providers signed up as quickly as possible.

STIR/SHAKEN – Could it work in Europe?

While the technical and governance framework described above relates to the domestic market in the United States, Canada has also moved ahead with its plans to implement STIR/SHAKEN. The Canadian Radio-television and Telecommunications Commission (CRTC) requested Canadian voice service providers to complete the implementation of STIR/SHAKEN by 30 September 2020, and for some time now the US and Canada have collaborated on a cross-border implementation. On 9 December 2019, Ajit Pai, FCC Chairman, and Ian Scott, CRTC Chairman and CEO, completed the first official cross-border call using the STIR/SHAKEN authentication framework.

This development has piqued the interest of many observers in Europe particularly in the policy and regulatory domain. CLI spoofing is a major problem in Europe also. Ofcom, the UK regulator, estimates that UK consumers receive 5 billion nuisance calls each year and that CLI spoofing is a key enabling technique used by scammers and fraudsters to avoid detection. Another pressing issue is the arbitrage opportunity that was created by the introduction of the roaming regulation in the EU. Some incidents of traffic from outside the EU are being re-originated – also known as refiling – to make it look like it originated inside the EU. The motive is to exploit the price difference between the regulated low termination rate for calls from within the EU and the higher unregulated rates for calls from outside the EU. STIR/SHAKEN could play an important role in mitigating such practices.

The Electronic Communications Committee (ECC) has been liaising with ATIS over the past 18 months to gain a better understanding of the STIR/SHAKEN model and how it might be applied in a European context. The United States and Canada have clearly proven that a bilateral implementation is possible and ATIS has some ideas on a multi-lateral approach. The discussions are still at an early stage and we expect further engagement between the FCC, ATIS, CEPT member countries and the European Commission to explore

how the STIR/SHAKEN model might be tailored for implementation in European domestic markets or on a pan-European basis. This will require careful consideration of the most appropriate governance framework for STIR/SHAKEN that would meet Europe's needs.

Is STIR/SHAKEN the magic bullet for CLI spoofing?

The CLI spoofing problem, like combatting email spam, is a game of cat and mouse. As service providers get better at identifying suspicious calls, the scammers will seek out innovative ways of countering this. There are other technologies being considered to combat CLI spoofing that could complement STIR/SHAKEN. Distributed ledger technology (or blockchain) is being tested in the UK. Another technology called SOLID is also being considered. Both provide a basis for CLI validation without the need for a centralised entity.

These technologies, whether used separately or in combination, provide much-needed intelligence to those who need it to combat CLI spoofing. They provide real tools and real data to use in the fight against scammers. When combined with crowd-sourced information from call blocking and spam reporting apps, they will make it easier for industry players, regulators and law enforcement to source, identify and prosecute those involved in fraudulent activity. This includes service providers who obtain certificates from the STIR/SHAKEN ecosystem and then fraudulently sign calls as being trusted.

In short, STIR/SHAKEN on its own may not be the magic bullet to solve the CLI spoofing problem, but it is one giant leap in the right direction.

Freddie McBride
Deputy Director
European Communications Office

Quo Vadis? Fixed Service evolves towards more efficient spectrum use

In the quest for more capacity, greater flexibility and better performance, fixed wireless systems will be one of the main backhaul choices for mobile and transport networks.

Far from the spotlight of well-known areas in wireless communications such as 5G and satellite, developments in the fixed service world can often go unnoticed – even when a fundamental paradigm shift is underway.

What is fixed service?

Fixed service is an integral component in the overall telecommunications infrastructure. Fixed wireless systems are used for access and transport networks such as for trunking, multi-hop and long-haul connections. They are mainly used for mobile backhaul networks, for fixed wireless access networks and for temporary networks, such as disaster response and recovery links.

Typical users of the fixed service include telecom operators, corporate and private users. Telecom operators use it in mobile network infrastructure and fixed/mobile network backbone links, while businesses use it for private data networks and connection of remote premises, etc. Customers, meanwhile, use it for access to PSTN or other wireless broadband networks.

Fixed service in backhaul operations

To meet the ever-increasing demand for bandwidth-hungry applications, both wired and wireless solutions need to be considered as transport backhaul options for networks. Key technical requirements include the ability to handle more capacity, data throughput and to address low latency traffic. Others include overall cost effectiveness and ease of installation, as a large number of new small cell deployments are expected to address the demand for mobile broadband growth.

An evolved C-RAN-based architecture is emerging as a popular choice to deliver future 5G services. This architecture consists of three primary components — a centralised baseband unit (BBU) pool, remote radio unit (RRU) networks and a transport network. This approach could lead to a different functional split in the radio access network compared to traditional mobile networks. As a result, the radio remote unit (RRH) will no longer be located at the

same site as the base band unit (BBU). In this context, the backhaul is the link connection between the base station and higher-level network elements, whereas the fronthaul is the link connection between the BBU and RRH.

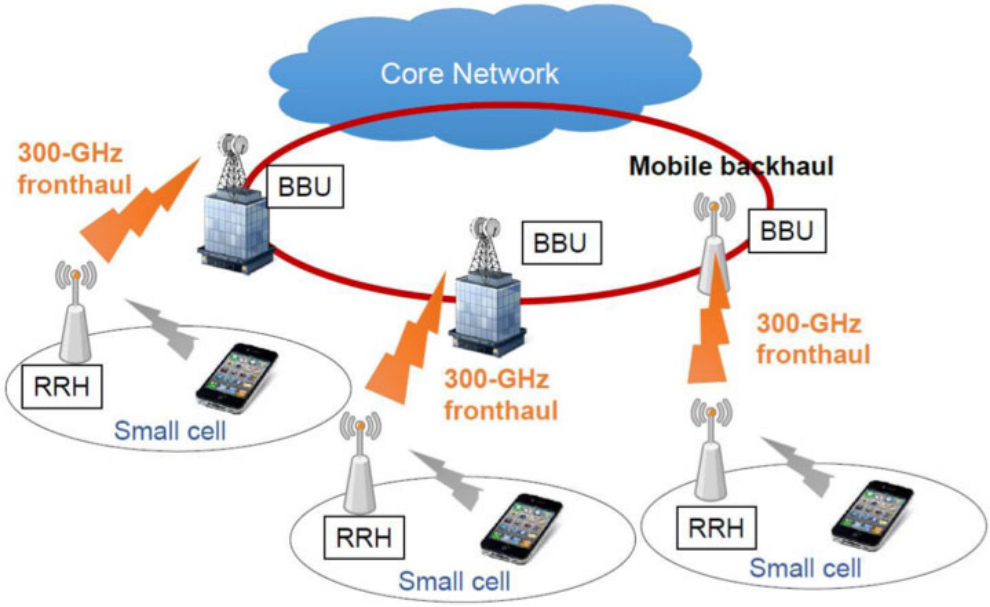

Figure 1 - Fronthaul and backhaul operation (Source: Report ITU-R F.2416-0)

According to some projections, future backhaul capacity requirements will range between 5 and 20 Gbps per base station depending on factors such as the cell type (for example, macro/small cell) and site type (for example, dense urban, suburban). Moreover, with the evolution of technologies and the availability of new spectrum, between 10 Gbps and 100 Gbps will be required to support fronthaul applications.

It should be noted that the term "X-haul" is also commonly employed in the context of development of transport network architectures. X-haul refers to the common flexible transport solution for future 5G networks, aimed at integrating the fronthaul and backhaul networks. It combines all their wired and wireless technologies in a common packet-based transport network under an SDN-based (software defined networks) and NFV-enabled (network functions virtualisation) common control framework.

Today, many industry analysts point out that microwave links are the prevailing option compared to other technologies and they currently serve on average more than 50% of macro and small cell sites. This figure does vary in different regions around the world. In order to cope with capacities reaching multigigabit/s for fixed wireless backhaul systems, several techniques have been introduced in the fixed service frequency bands, from 6 to 80 GHz. One such technique is adaptive modulation, which allows for a dynamic smooth switch between different modulation formats, increasing or decreasing the payload capacity accordingly.

Higher order modulation equipment – as high as 2048 QAM – is available. Adaptive modulation systems also have built-in automatic transmit power control functionality (see ECC Report 198), which enables transmitter power to be reduced for higher complexity formats requiring higher linearity.

CEPT has also performed studies to examine the impact of current asymmetry trends in the access and backhaul networks. ECC Report 211 primarily focuses on the use of asymmetric channel widths within the traditional bidirectional link allocation.

It should also be noted that whilst the presence of asymmetry in the access network is agreed, the degree of this asymmetry differs from operator to operator based on the services offered.

One other prominent technology, MIMO (Multiple Input Multiple Output), has been considered for fixed service, as described in ECC Report 258. The Report shows that Line-of-Sight (LoS) MIMO in point-to-point fixed service links is an efficient way of increasing capacity or availability without using more spectrum. The Report also provides a technical comparison between LoS MIMO links and a typical traditional Single Input Single Output (SISO) link.

Frequency bands for fixed service

In principle, all frequency bands available for fixed service could be used for transport networks, noting that those bands need to be assessed against technical characteristics such as appropriate transmission capacities, RF channel spacing, RF channel size availability and typical link lengths. The following picture illustrates the various frequency bands harmonised in CEPT, including the higher frequency bands 92-114.25 GHz (referred to as "W-Band") and 130-174.8 GHz (referred to as "D-Band") where CEPT harmonisation measures were developed more recently, in 2018.

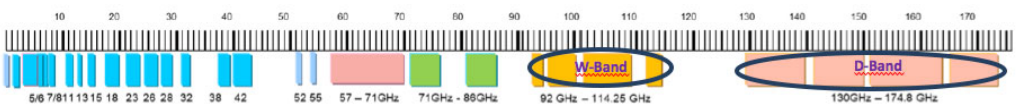

Figure 2 - FS frequency bands for harmonised channel arrangement

Although usage varies among countries in Europe, the current trends in the fixed service marketplace are for an ever-increasing provision of high bandwidth capacity for mobile network infrastructure. These very high capacity links are able to provide a viable alternative to deploying fibre optic cable in rural and in high density urban areas. Some of the frequency bands are of strategic importance and have already started to show rapid growth in terms of the number of links (13 GHz, 15 GHz, 18 GHz, 23 GHz, 38 GHz). Figure 3 below shows the rapid adoption and implementation of these traditional frequency bands for the fixed service.

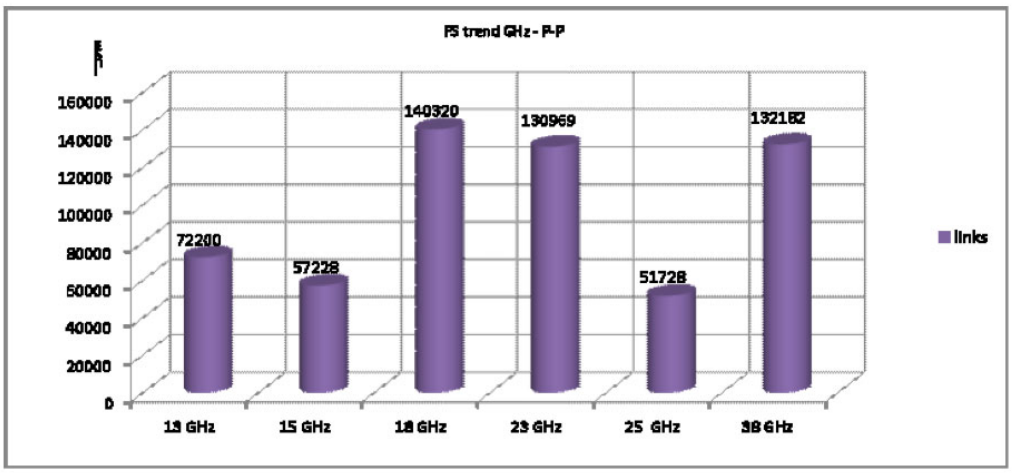

Figure 3 - Active links in 2017 (P-P only) for the FS bands (between 13 GHz and 38 GHz) (Source: ECC Report 173, Fixed Service in Europe Current use and future trends post 2016)

Moreover, according to the data gathered in ECC Report 173, there is a clear trend towards more intensive use of higher frequency bands such as in 71-76 GHz / 81-86 GHz (also known as the "E-Band") as seen in figure 4 below.

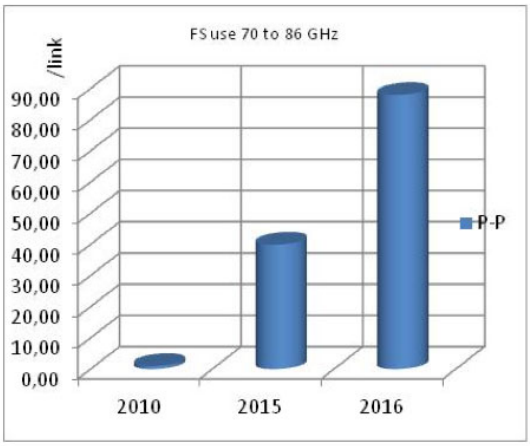

Figure 4 - Trends for the use of FS in the E-band (Source: ECC Report 173)

From a general perspective, the use of fixed service bands can be divided into three broad categories, each fulfilling specific future traffic requirements based on their distance ranges: low frequency bands, mid-range frequency bands and high frequency bands.

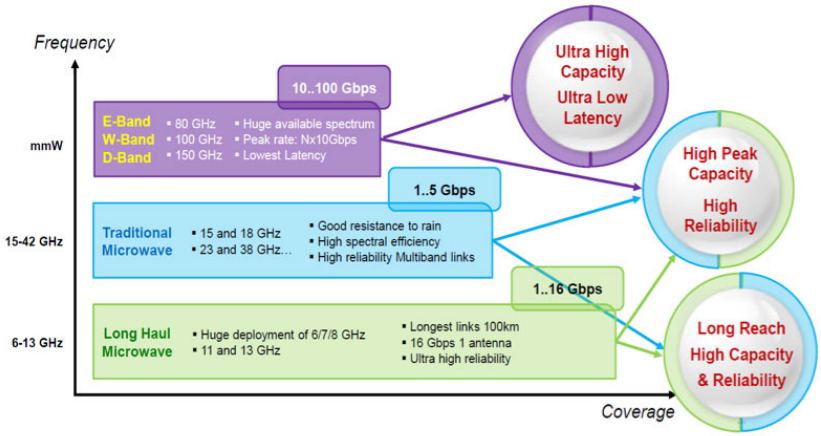

Figure 5 - Trends for the use of FS in the E-band (Source: ETSI White Paper No. 25, Microwave and Millimetre-wave for 5G Transport)

Given the new requirements for fixed link applications for covering the demands of multigigabit/s 5G transport networks, ECC Report 282 examined the frequency bands above 90 GHz. In particular, the use of the W-Band and the D-Band for very high capacity short range links have been examined. This Report studied, amongst other things, the propagation characteristics for each band, applications, use cases and technology specific issues. The Report concluded that the W-Band and D-Band have high potential to fulfil the future demands of radio links and networks and are deemed to be suitable for the capacity, latency and availability requirements for 5G following consideration of the densification of sites and deployment flexibility.

CEPT also considers that both frequency bands provide an opportunity to cope with the increasing market demand for very high bandwidth access, in particular for internet-based applications and backhaul/X-haul for next generation mobile networks. Fixed radio links may be deployed much more quickly, and in certain cases are more cost efficient than wired networks, for example, when small cells are deployed at street level on urban utilities infrastructure. As such, these bands provide sufficient capacity for terrestrial fixed links to compete or complement fibre optic-based access networks.

The harmonised channel/block arrangements for the D-Band and the W-Band are contained in ECC Recommendations (18)01 and (18)02. Both Recommendations provide the administrations wishing to use block-based assignment the necessary flexibility to derive blocks by channel aggregation. They can do this in either paired or unpaired spectrum in multiples of 250 MHz. The Recommendations also allow for flexible channel use in symmetric or asymmetric go/return inside the blocks, for example, in time division duplex, full duplex or flexible frequency division duplex.

Additionally, with a view to supporting wider channel bandwidths in the traditional fixed frequency bands from 11 to 38 GHz, CEPT reviewed the channel arrangements in 2019. It agreed on updates to the relevant ECC Recommendations (listed in table 1 below) so that

wider channel bandwidths are allowed in those frequency bands. Up to 112 MHz or 220/224 MHz will be allowed, doubling the previous maximum size available.

ECC Recommendation	Title
ERC/REC 12-03	ERC Recommendation of 1994 on harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 17.7 GHz to 19.7 GHz, amended on 29 May 2019
ERC/REC 12-06	ERC Recommendation of 1996 on preferred channel arrangements for fixed service systems operating in the frequency band 10.7-11.7 GHz, amended on 5 February 2010 and on 29 May 2019
ERC/REC/(01)02	ERC Recommendation of 2001 on preferred channel arrangement for fixed service systems operating in the frequency band 31.8-33.4 GHz, revised on 5 February 2010 and amended on 29 May 2019
T/R 12-01	Recommendation T/R of 1991 on preferred channel arrangements for fixed service systems operating in the frequency band 37.0-39.5 GHz, latest revised on 5 February 2010 and amended on 29 May 2019
T/R 13-02	Recommendation T/R of 1993 on preferred channel arrangements for fixed service systems in the frequency range 22.0-29.5 GHz, revised on 15 May 2010 and amended on 29 May 2019

Table 1 - Updated (in 2019) ECC Recommendations to allow wider channel bandwidths

As a follow-up action resulting from the update of the above-mentioned Recommendations, a study has been carried out in CEPT to analyse the possible interference (for both in-band (sharing) and out-of-band (compatibility) of using a single wide channel instead of two adjacent channels with the same total bandwidth in. The findings of the study – *draft ECC Report 319*, which is subject to public consultation – indicate that, based on worst case scenarios, such problems are negligible.

There are some promising technological developments related to Band and Carrier Aggregation, which have the potential to bring enormous increases in performance, while leaving a high degree of flexibility in the design of the backhaul/X-haul solution. So far, focus has been on bonding carriers within the same frequency band. The new concept behind Band and Carrier Aggregation is to build on a point-to-point connection, using two or more "carriers", which may even belong to different frequency bands and may have different channel sizes. The payload that could be obtained is equivalent to a single carrier connection using a wider channel and with several adaptive modulation steps. This would allow for different steps in terms of capacity or availability. More detailed discussion can be found in draft ECC Report 320, which is also subject to public consultation.

State of play

Mobile backhaul requirements will continue to drive demand for fixed wireless links particularly given the denser networks anticipated for 5G and the higher data rates they will bring.

In recent years, fixed wireless systems technology developments have enabled the delivery of multigigabit/s capacity in a quick and cost-efficient manner. In the quest for more capacity, greater flexibility, better performance and efficient spectrum use, technological innovation will continue to develop to meet market needs. In some cases, cutting-edge technologies have already been implemented for higher-order modulation, wider channels, higher frequency bands, adaptive modulation and Band and Carrier Aggregation.

Thanks to this ongoing innovation, fixed wireless systems will continue to be one of the main backhaul/X-haul transport means of choice for mobile networks. They will play an increasingly significant role in supporting the expansion of advanced mobile broadband as the widescale deployment of 5G continues.

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