DECT-5G: Accelerating Industry and Economy

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1 EXECUTIVE SUMMARY

Objective – This paper will inform industry professionals, managers, visionaries and a wider public about 5G, the industrial/economic benefits of DECT-5G, and its role as a 5G Radio Interface Technology (RIT) within the global ITU standards framework (IMT-2020).

What is 5G? – 5th generation mobile communications, 5G, is a major development which goes beyond simply voice, video and ever-faster data. Ultra Reliable Low Latency Communications (URLLC) are seen as a key economic benefit of 5G. Flexibly supporting multiple applications, 5G will transform industries and enable new ones to emerge.

What is DECT? – DECT began life as a local-area wireless voice and data standard. Billions of DECT devices are today used worldwide, in dedicated spectrum and in many industries – media, entertainment, hospitality, healthcare, smart homes, enterprise, manufacturing et al. DECT, like cellular, has continually evolved; today it delivers high reliability, ultra low energy consumption and low latency (1-4ms) across these industries.

What is DECT-5G? – DECT-5G is a local area RIT, complementary to 3GPP, optimized as a cost-efficient solution that will allow early implementation and deployment of 5G URLLC and local area, high density, vertical market applications. It supports the full services and features of legacy DECT, more efficiently and reliably, plus the new capabilities of 5G. ETSI TC-DECT submitted its RIT description to ITU in 2018.

For Media and Entertainment: DECT-5G's URLLC capabilities will support wireless studio, conferencing, ENG and audio (PMSE) production, with professional Quality of Service. It will enable reliable content distribution with low-latency, audio synchronicity, immersive 3D, augmented reality and remote presence for home and business users.

For Enterprise, Healthcare and Hospitality: DECT-5G offers a smooth evolutionary path for these industries, extending today's mission critical tools in terms of reliability, battery life, low latency and higher bandwidth, whilst delivering low Total Cost of Ownership.

For Smart Homes and Buildings: DECT-5G extends support for ultra-reliable, low latency, machine-type applications and automation. Combined with DECT's embedded support for roaming and hand-over, such services can be provided with seamless coverage across a campus of buildings.

For Industry 4.0: DECT-5G's major potential lies in low latency and high reliability URLLC-type applications. Its structure is well suited to the important class of cyclic traffic (closed loop machine control) and should readily fulfill all industrial control requirements.

Government Priorities – Governments recognize the economic importance of industry transformation and have noted industry concerns over loss of control over assets which threaten to delay adoption and deployment of 5G.

Accelerating Industry Adoption and Economic Benefits – DECT-5G will allow industries a safe way to explore and prove local area, mission critical, IoT services, e.g. in eHealth and manufacturing (Industry 4.0), whilst ensuring full interoperability with 3GPP 5G infrastructure. DECT-5G offers a route for such industries to deploy 5G at lower risk, retaining core business assets under their own full control, thereby accelerating early investments, speeding up their learning curves and providing a way to secure earlier economic benefits for the organisations, society and our national/regional economies.

2 INTERNATIONAL STANDARDS AND THE ROLE OF DECT

Commercial Wireless Telecoms: From 2G to 5G – The economic impact of wireless telecoms since deregulation in the 1980s has been profound. Early markets for wired analogue phones quickly transitioned to cordless home phones, soon augmented by bulky and expensive analogue car phones. The 1990s saw the arrival of digital 2G - in Europe, DECT and GSM. Since 2000 the capabilities of cordless and mobile phones have brought ever advancing connectivity and services, powering the information age.

The 5G Market Opportunity – 5G is the latest evolution in this journey, perhaps a revolution. Whilst prior generations transformed personal communications and access to information, 5G extends this to embrace machine communications and new markets, in the process transforming today's industries and creating new ones. 200m 5G subscribers are forecast in 2022, rising to 1.6bn in 2025 [1].

2.1 INTERNATIONAL STANDARDS: FROM 2G TO 5G

2G Standards – DECT and GSM were the first standards created by ETSI, the European Telecommunications Standards Institute. DECT rapidly displaced first generation phones, offering high quality, high density, local area, telephony and paging. GSM offered similar capabilities targeted for wide area outdoor/mobile use. The DECT base standard, EN 300 175, was published in 1992. Economies of Scale through the 1990s saw costs/prices fall rapidly, driving volume and worldwide deployment. DECT evolved from 'Digital European Cordless Telephony' to become 'Digital Enhanced Cordless Telecommunications', reflecting technology and standard enhancements and global markets. GSM similarly evolved from 'Groupe Spéciale Mobile' to become 'Global System for Mobile'.

3G and 4G – In 1992 the International Telecommunications Union, ITU, allocated spectrum for the next generation of wireless telecoms, 3G and sought global harmonization of its ***Radio Interface Technologies (RITs)*** under the name IMT-2000, International Mobile Telecommunications-2000 [2]; this which would include a wide range of multimedia applications, services and terminals. ETSI enhanced the DECT standard, with high-level modulation modes and higher data rates, to fulfill the IMT-2000 requirements. The ITU evaluated the enhanced DECT standard and included it in the ***Set of Radio Interface Technologies***, ***SRIT***, for IMT-2000 [3]. Reflecting the ongoing evolution of the Internet and burgeoning demand for higher bandwidth services, a similar approach was followed by ITU for **4G**, leading to the IMT-Advanced Recommendation [4].

IMT-2020 (5G) – In 2015 ITU-R published IMT Traffic Estimates for the years 2020-2030 [5] and IMT Vision for 2020 and beyond [6]. Technical requirements for 5G [7], compared with IMT-Advanced, in many cases increased by 10x or more, see Figure 1. Like its predecessors (1G/Analog, 2G/Digital, 3G/IMT-2000, 4G/IMT-Advanced), 5G targets significant evolution of core technology, network infrastructure, spectrum and energy efficiency but its usage scenarios go well beyond 2G-4G, see section 2.2 below. Both 3GPP and ETSI TC DECT announced plans to offer candidate RITs for IMT-2020 [8].

ETSI TC-DECT's DECT-5G candidate RIT description, DECT-2020, was submitted to ITU in autumn 2018, to be followed by full technical details/analysis by June 2019

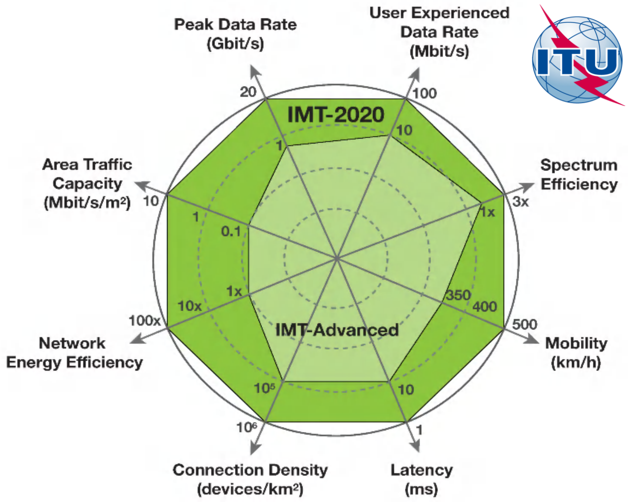

Figure 1: ITU-R Requirements for IMT-2020 [6]

2.2 5G Usage Scenarios

More than just higher speeds, 5G's three primary usage scenarios are shown at the triangle apexes of Figure 2, representing the extremities of 5G's core capabilities:

- ***Enhanced Mobile Broadband – eMBB*** – envisages "Fibre-Like" speeds, 10x that of 4G, supporting use cases such as Video Holography, Augmented Reality et al.
- ***Ultra Reliable Low Latency Communications – URLLC*** – envisages high reliability Quality of Service (QoS), low latency and low power (battery operated devices), for healthcare, audio, process automation and other mission critical applications.
- ***Massive Machine Type Communications – mMTC*** – envisages wide uses cases such as Smart City IoT applications, high Quality of Experience in high speed mobile deployments (e.g. 500km/h) and remotely located applications (e.g. wind turbine sensor/control).

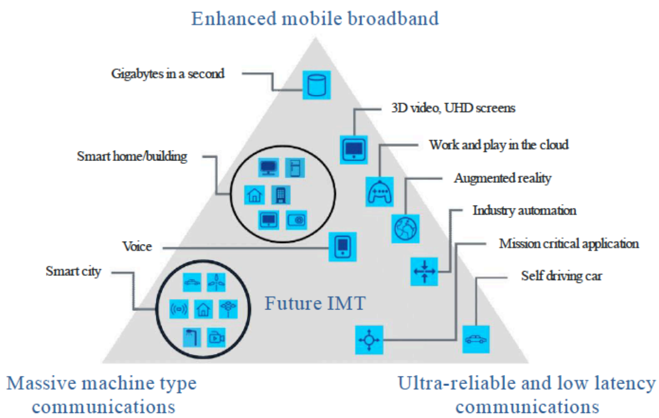

Figure 2: The IMT-2020 5G Use Case Scenarios [6]

5G is being specified and designed to enable other industries, flexibly supporting multiple dedicated applications, not simply voice, video and ever-faster data

A 5G Set of Radio Interface Technologies, SRIT – 5G's diverse scenarios span orders of magnitude, in terms of data rate and latency, from multiGb/s video and Virtual Reality applications, to low data rate wide area sensing and local industrial control. Proponent IMT-2020 Radio Interface Technologies will have to be, and can be, complementary, reflecting the IMT concept of a Set of Radio Interface Technologies, SRIT. The DECT-5G RIT brings proven application and technology maturity, specifically to URLLC and mMTC.

Indoor Capacity and Robust, Reliable, Coverage will be Vital to 5G Success. Today 80% of data traffic is generated indoors; UN forecasts show world urban population as 54% in 2015, rising to 66% by 2050. Indoor environments, where people spend most of their time (work and home), are much more heterogeneous than outdoors ones, in terms of access technologies and services. Despite a competitive environment where cellular systems have migrated their services indoors, DECT and ULE have secured high market share and built success by delivering robust, reliable, high capacity indoor solutions.

DECT's Focus – Such arguments underpin the suitability of DECT-5G as a complement to 3GPP's RITs. DECT's support for URLLC and local mMTC is mature, proven and low cost; today's chipsets already deliver low latency, URLLC-type capability, whilst DECT's embedded roaming and hand-over capabilities, complemented by DECT Ultra Low Energy, ULE, deliver seamless campus coverage in long life and mission critical mMTC-type scenarios, including monitoring, industrial automation and multi-site hospitals today.

DECT-5G is a local area RIT, highly complementary to 3GPP 5GNR and NB-IoT, supporting economically important URLLC and localized high-density vertical market applications with a cost-efficient solution allowing early implementation

2.3 Evolution of DECT's Radio Interface Technology (RIT) and Capabilities

DECT's Radio Interface Technology (RIT) – As GSM evolved through 2G/3G/4G, so DECT developed its own parallel path. Whilst 4G focused upon ever-faster data rates, DECT evolved from cordless domestic and enterprise telephony and paging to deliver a range of mission-critical indoor IoT-type applications in vertical markets. DECT did this by virtue of the inherent high reliability of its connectivity protocols; from day one the standard incorporated cognitive spectrum management, before the technology was given that name. This explains DECT's evolutionary path and the consequent maturity of key IoT-related elements of DECT-5G. Figure 3, the DECT Capability Timeline, shows key milestones in its technology and standard evolution, explained in more detail below.

1992	Legacy DECT
1999	IMT-2000
2007	NG-DECT (Next Gen)
2013	DECT Security
2013	ULE (Ultra Low Energy)
2017	HAN FUN (Home Area Network)
2018	DECT Evolution (Low Latency)
2019	DECT 5G - IMT 2020

Figure 3: DECT Capability Timeline

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Capabilities and Roles – DECT's first global role, in 2G, was as a cordless telephone. However, it soon penetrated other markets – data paging/messaging for lone workers and hospitals, defense walkie-talkie applications, wireless microphones/headsets and more. The enhanced capabilities, such as security, multi-year battery life (low energy consumption) and low latency, opened new services, applications and vertical markets.

New Generation DECT – ETSI's 2007 standard updates enabled HD Voice, greater Interoperability, new Internet Services and Over-The-Air product software upgrades [9].

Security Certification – In 2010 DECT Forum proactively introduced security certification for enterprise-like telephony applications as well as integration in the CAT-iq standard for residential cordless VoIP.

Ultra Low Energy and **HANFUN** – Further ETSI DECT standards in 2013 brought a radical reduction in energy consumption with Ultra Low Energy (ULE) [10]. Complemented by the ULE Alliance's Home Area Network FUNctional application layer protocol (HANFUN), ULE has enabled almost 100 different new types of data-centric products, from smart home to industrial. HANFUN's capabilities were extended in 2017. Over 10million ULE devices have been brought to market in a multitude of applications. With a DECT base station in almost every home gateway, and HANFUN supporting vendor interoperability, ULE has unique structural advantages for rolling out IoT services.

DECT-Evolution – The latest DECT chipsets are already delivering down to 1ms latency for sporadic data; for streaming, latency can be traded vs duty cycle enabling, e.g., 4ms for audio streaming. ETSI's DECT-5G IMT-2020 proposals reduce this latency even further.

Rapid, Open Innovation – **openD** [11] is enabling a growing developer community around DECT and ULE with an open source set of APIs that enable DECT & ULE to work seamlessly with existing, mature, prototyping platforms. As DECT-5G chipsets emerge, openD will allow rapid 3rd Party innovation of new products and applications requiring the characteristics targeted by IMT-2020, accelerating ideas and product deployment in the economically important URLLC and mMTC scenarios, across multiple vertical markets.

Interactive Voice – Voice has moved from being a service (telephony), to user interface and is now becoming the application. The DECT industry has addressed this with Smart Speaker products, leveraging its deep expertise in audio compression, microphone and speakerphone technology, and its underlying DSP competence, alongside DECT infrastructures connected to Alexa. The impact of high quality voice/audio for IoT interaction and services in domestic and industrial settings should not be underestimated.

DECT-5G's Further Enhancements to meet the full breadth of IMT-2020 requirements include extensions to DECT's existing multi-level modulation scheme, multi-carrier OFDM, multiple spatial channels and additional latency reduction techniques. Relevant documents detailing the DECT-5G RIT work, termed by ETSI as DECT-2020, may be found in [8], [12] and [13].

DECT was designed to evolve and has continually done so, notably in areas key to the IMT-2020 requirements, such as reliability, robustness and low latency (URLLC)

2.4 Economic Priorities, Industry Realities: Implications for 5G RITs

Deployment Priorities - In many countries, eMBB is expected to be the first service to be deployed. However, in a European context, political goals for both the Digital Single Market (DSM) and Digitizing European Industry (DEI) indicate that URLLC and mMTC have equal importance to eMBB, to upgrade multiple vertical markets, including the priority economic impact areas of manufacturing (Industry 4.0), transport and health.

Industrial Constraints – Many large industries require security of service over 20 year timescales, to align with typical industrial product life cycles. Many also strongly prefer in-house control and autonomy, in preference to outsourcing core business infrastructure, IT and mission critical communications to third parties. DECT uses dedicated spectrum, limited by the technology specification, but without the need for third party operators or licensing. This combination has proved itself in the marketplace as highly attractive for mission critical applications in Industrial Automation, Hospitals and Professional Audio, enabling such markets that need “wired-like” wireless communication. The DECT-5G proposal has been in part motivated and steered by Industry users with such concerns.

Small and Medium Scale Businesses wishing to deploy 5G applications risk being left behind as low priority customers, as major telecom suppliers focus initially on large telco markets and mainstream opportunities. The same risk of being overlooked also exists for vital, but small and niche, manufacturing sectors which have neither the market size nor influence to be significant in the early days of 5G. Simple market economics are likely to result in early 5G solutions being priced outside the range of such companies. This could place such companies, and potentially much of the SME/Mittelstand sector, at a competitive disadvantage, risking long term economic damage. The low cost, simplicity, elegance and openness of DECT-5G offers a route to accelerate and more widely deploy the full 5G scenario benefits for these businesses and sectors, both through existing DECT suppliers and via new market entrants enabled by openD’s innovation ecosystem.

Realization of the economic benefits of 5G requires Radio Interface Technologies (RITs) that meet the needs of Large, Medium and Small businesses, as well addressing companies for whom outsourcing core infrastructure is unacceptable.

System Cost – Dense urban cities require *both* high throughput, to multiple devices, in multiple homes, *and* low data rate, low power and low latency services with mission critical reliability. No single wireless technology can efficiently and cost-effectively support this broad diversity of IoT and smart building use; a “One Size Fits All” solution at a price point for early 5G-IoT roll out remains elusive. This explains the rationale for the ITU’s recommendation [8] for a Set of Radio Interface Technologies, SRIT, an approach that the ITU previously adopted, for different reasons, in its IMT-2000 standards. Leveraging DECT’s capability and industry base is a logical way forward.

Smart Homes & Enterprise – DECT/ULE has traditionally addressed these markets, using its strengths in low power, security, range, robustness and low cost; the evolution to 5G extends this value to new markets. DECT’s latency and energy usage is already close to IMT-2020 targets, with a clear route for DECT-5G to exceed these; improved latency, reliability and reductions in form factor (battery size) will extend the cutting edge of IoT.

A Springboard for Growth – The URLLC and mMTC 5G scenarios are clearly important technology enablers of economic growth, across industry and society. DECT-5G supports a significant and wide range of smart home and multiple local area URLLC and mMTC enterprise and industry scenarios, shown in Figure 2.

DECT's maturity in voice and data, its presence in almost every home gateway and its use in mission critical applications in Industrial Automation, Healthcare, Audio and Enterprise are a powerful springboard for 5G local area IoT and other services

An SRIT comprising 3GPP and DECT-5G RITs can address the full breadth of 5G use cases early and cost effectively, accelerating the market. A complementary approach, focusing on existing strengths, rather than competing, offers a recipe for mutual success. eMBB is the clear initial focus of 3GPP, rightly so given the immediate pressures on existing cellular network capacity, whilst NB-IoT is targeting wide area mMTC. DECT-5G is the logical complement for local, mission critical, Industrial, Medical, SME and other markets, meeting the economic constraints and priorities of Industry and Governments.

DECT-5G as an IMT-2020 RIT will enable earlier rollout of local area mission critical IoT services, such as eHealth and Industry 4.0, accelerating economic growth

Global Deployment – DECT is today deployed globally, with spectrum allocated in >100 countries, Figure 4. Proposed URLLC and local mMTC applications can be supported by DECT-5G within these existing allocations, enabling rapid rollout.

	Freq Band (MHz)	Pk/Avg Tx Power (mW)
EU, Aus	1880-1900	10mW/4mW
Northam	1920-1930	250/100mW
Latam	1910-1930	250/100mW
Japan	1893-1906	240mW
Korea	1788 1791	100mW

Figure 4: DECT Global Usage

Spectrum Evolution – For 5G, the ITU has been working with regional regulators towards global spectrum allocations around 700MHz, 3.4-3.8GHz, 26GHz and higher. In the context of SRITs, DECT-5G will enable a flexible use of available spectrum. This can be achieved by "*carrier aggregation*" (CA) combining dedicated bands for IMT-2020 operation to satisfy the carrier bandwidth demanded by new services. For IMT systems TDD operation is anticipated in the bands 1880-1930MHz, 2300-2400MHz, 2500-2690MHz, 3400-3600MHz and 4800-4990MHz with regional variations. Different technologies will not be able to coexist in the same spectrum.

3 VERTICAL MARKET REQUIREMENTS

Distinct, Yet Similar, Needs - Beyond traditional markets like voice and smart home, IMT-2020 seeks to support multiple vertical industries that go beyond high-speed data, and require machine-type and ultra-reliable low latency communication. ETSI TC-DECT has examined the requirements of many use cases across various vertical markets [12]; whilst distinct requirements exist, many similar needs exist across different markets, which match strongly onto DECT's evolution to date and going forward into the 5G era.

3.1 Media and Entertainment

Market Needs for Media and Entertainment – The Creative Industries provide a significant socio-economic contribution to society. Market needs of this sector reflect its existing, and developing, value-chain – Contribution, Production and Distribution.

- ❖ ***Contribution*** includes Electronic News Gathering from an ENG team for TV news, e.g. live Interviews, involving a cameraman and reporter with handheld microphone. The audio link of the microphone to the video camera employs local area wireless technology (e.g. DECT), with the audio/video (A/V) content delivered via a wide area network (WAN) to the TV studio for further processing including (live) editing.
- ❖ ***Production*** of programs / events is encompassed by the term Program Making and Special Events (PMSE) for which multiple wireless technologies are used today.
- ❖ ***Content Distribution*** happens via broadcast networks and internet-based streaming platforms to the homes, workplaces and mobile devices of end-users.

These processes and their requirements will evolve in the 5G era, as discussed below.

Figure 6: Envisioned 5G Usage for PMSE

Technology Requirements for Media & Entertainment – PMSE requires mobility and quick setup, with a rich set of use cases with widely differing requirements, underscoring the need for adaptability and scalability for 5G solutions. Requirements thus include:

- ❖ ***Deployment Flexibility*** - PMSE deployments may be confined to a local geographical area and may be short-term (hours to weeks) to long-term (months to years) duration. In-ear microphone/headset equipment is also essential; in future this may extend beyond audio to lightweight wearable, integrated A/V, HD/3D devices
- ❖ ***Stringent Requirements*** exist on communication availability and reliability, end-to-end latency, jitter, A/V quality, density of wireless links per site, and synchronicity

- ***Increased Bandwidth*** – arising from growing demand for new, differentiated, services. These include Augmented/Virtual Reality (AR/VR), Remote Presence, 3D audio and other still-emerging immersive experiences
- ***Spectrum Access and Interference Mitigation*** is required to ensure transmission robustness; failures during a live event or production can incur large financial costs.
- ***Continuous Realtime Monitoring of the Network State*** is needed, to act quickly and automatically to avoid interruption of A/V content production, to support efficient root-cause analyses and allow SLA (Service Level Agreement) monitoring if a third-party network operator is involved, to provide the basis for resolving liability disputes
- ***Private Network Deployment and Operation*** within an event location is required by many PMSE operators for security, liability, availability and business reasons. However…
- ***5G Interoperability****,* ie standardized, flexible interfaces, providing seamless handovers and seamless interoperability to/between public/private 5G networks, is critical and underscores the value of an SRIT.

DECT-5G Value for Media and Entertainment – Legacy DECT is extensively used in PMSE today, but not for musicians, due to its latency; professional audio requires end-to-end latencies <3ms to avoid disturbing a musician's performance. DECT-5G overcomes this limitation. DECT-5G will greatly enhance in-home distribution of content from broadcast and internet streaming networks to the homes and devices of end-users.

DECT-5G URLLC will enable a standard technology supporting wireless studio, conferencing, electronic news gathering (ENG), and audio (PMSE) production, with a QoS suitable for audio professionals and hobbyists with professional demands

DECT-5G will enable reliable content distribution within the home, ensuring low-latency and audio synchronicity, and support of immersive 3D, augmented reality (AR) and remote presence applications for home and business

3.2 Enterprise: Healthcare, Hospitality and More

Enterprise Markets – Effective communications are essential, often mission critical, in highly competitive enterprise markets. Despite MNO's, Mobile Network Operators, offering dedicated on-site solutions, with integrated numbering plans and femtocells, DECT has remained the enterprise technology of choice for many reasons. These include its license exempt spectrum (allowing autonomy), its frequency allocation algorithms, excellent voice quality, high reliability, security, ease of deployment, PBX integration and low cost of ownership for small and large businesses. While much of the functionality described below is possible with alternative mobile cellular solutions, DECT has been unique in guaranteeing connectivity in mission critical environments where getting the right message to the addressee is imperative and best efforts will not suffice.

Customised Solutions – For enterprise markets, robust and reliable smartphones are, and are expected to remain, costlier than DECT phones. A substantial share of end-users that require more cost-effective, lightweight and robust handsets based on DECT will continue to exist. Typically, Enterprise DECT manufacturers offer a range of handsets from basic, low cost entry phones to fully fledged robust handsets fitted with alarms to address personal safety, extending to dedicated intrinsically safe handsets (and access points) certified to the ATEX standard for use in potentially explosive environments. Many essential and valuable additional services can be integrated into the DECT facility as required by the customer, including messaging, alarming, location determination, personal safety, etc.; such customization provides tailored functionality, optimized to the market needs of the business, yet at a surprisingly modest Total Cost of Ownership.

Market Needs for Healthcare – Healthcare is a highly demanding work environment, facing big challenges to improve efficiency, patient security and satisfaction. Staff must stay reliably connected anywhere, anytime; every second counts and important decisions are taken on the spot. Optimized communications improve productivity, generate cost savings and create an environment where efficiency and responsiveness foster best possible patient outcomes. The hospital is a mission-critical environment requiring messaging solutions that deliver reliability, scalability, sufficient bandwidth and instant location of people and resources. In addition, to ensure the ongoing safety of patients, caregivers and visitors, healthcare providers must have a contingency plan should an on-site emergency occur; emergency notification solutions must quickly communicate the source and severity of a situation and seamlessly notify personnel and public safety officials for optimal on-site response and wellbeing of all within the facilities. DECT has effectively met all these requirements, evolving to support multi-site hospital campuses with customized messaging, localization and reliable communications.

Market Needs for Hospitality – Staff responsiveness is of the essence for service-oriented businesses. Employee accessibility across the premises translates to improved workflow, staff effectiveness and enhanced service delivery; it can help free up time so staff focus shifts from the necessary to the most important things. In a hotel, for example, when staff can be easily contacted and directed to prioritized activities, the whole organization becomes more efficient, enabling an improved level of service to guests. DECT has for many years met such needs to elevate responsiveness with interfaces and alarm configurations that notify and permit action when timing is critical; DECT's messaging functionality simplifies and expedites communications that don't require a phone call – e.g. maintenance workers can instantly receive alerts on a handset indicating a broken air conditioner or showerhead needing repair.

Market Needs for Emergency Response– Across the enterprise verticals considered, and others, the integration of DECT voice and messaging with building management and safety systems, can enable, capture and process critical events, instantly sending alarm messages to various destinations (pagers, telephone sets, building management systems, fire alarm systems, factory control systems, etc.) with full feedback on delivery results. For example, staff can immediately receive notification of a fire location and instructions to properly facilitate evacuation. Users can initiate an alarm using an emergency call button. Man-down, escape, and no-movement alarms can automatically be triggered by a handset or other user device. In addition, detailed positional information of employees can be polled, to locate staff needing assistance and sending support immediately to the location. Drone control is a further, recently-emerging, requirement.

Technology Requirements for Enterprise Applications – DECT's suitability for today's market requirements is matched by DECT-5G's ability to meet those of tomorrow:

- ***Increased Data Bandwidth –*** Digitalization is driving demand for smartphones in many segments. DECT touchscreen phones using Android are available today, with products/apps customized for specific enterprise markets; DECT-5G can play a key role in extending their capability. In healthcare, for example, Patient Monitors generate alarms, forwarded to DECT handsets; such alarms can contain additional content such as ECG waveforms or other enhanced content. DECT today supports lo-fi video (up to 10 fps); DECT-5G's higher data rates can support more dynamic display of such ECG waveforms, as well as video surveillance for elderly care or psychiatric wards and evolving clinical activities, e.g. new diagnostic body scans. DECT-5G's URLLC capability could also potentially enable remote surgery.
- ***Energy Consumption and Battery Life*** – The small and light-weight nature of DECT messaging devices and pendants worn by patients, residents and staff limits battery size and lifetime, as well as contributing to irregular charging. ULE has driven down power demands, enabling use of small coin cells. DECT-5G could enable new device categories with longer battery life and/or greater functionality in mission critical applications, utilizing the in-built voice capability to enhance spontaneous enterprise communications.
- ***Extended Coverage*** – Hotels, Hospitals, Care Homes, Business Parks, etc., often comprise multiple buildings spread over sites requiring large area coverage and full roaming and handover; guaranteeing seamless coverage in such campus type environments is one of DECT's key USPs. DECT-5G will offer opportunity to system planners to reduce Total Cost of Ownership as well as increase functionality.
- ***Indoor Positioning*** – Within enterprise markets, indoor positioning to track, locate and help to navigate equipment, patients and staff is a growing need; many technologies play a role in this, including DECT. Creation of DECT beacons would provide a low-cost and low energy option support for triangulation or fingerprinting positioning methods that could further enhance DECT-5G enterprise use cases.

DECT-5G Value for Enterprise Markets – DECT today is a powerful, mature technology that delivers essential requirements for customizable, high reliability, indoor communications. Dedicated spectrum, interference-free communication, reliability, ease-of-deployment and security are features that have made DECT today's technology of choice for the enterprise. DECT-5G will support even more diverse use cases, such as those mentioned above whilst leveraging the huge installed base of billions of DECT devices in homes and enterprises across the globe.

DECT-5G offers a smooth evolutionary path for the enterprise – extending today's mission critical applications, in terms of reliability, battery life, low latency and higher bandwidth, whilst retaining low Total Cost of Ownership.

3.3 Smart Homes and Buildings

Market Needs for the Smart Home – The IoT (Internet of Things) carries the promise of improving peoples' lives by connecting "everything" (things), making them accessible through the Internet. The impact will be felt in our homes, offices, factory buildings, on our roads – practically everywhere. In the home, early IoT applications include security, automation, energy control and personal wellbeing; wireless connectivity is the essential enabler of such smart home and building applications. Many technologies are competing to capture this IoT market, but so far there is no single "perfect" technology, capable of providing adequate solutions to the diversity of the application requirements. In today's context ULE, Ultra Low Energy technology, based on the DECT radio, stands out for its reliability, simplicity and for its delivery of advanced features with very low power consumption, its uniquely guaranteed voice quality and secure transmission.

Technology Requirements for the Smart Home – Key requirements for success in the domestic IoT market are reliability and simplicity, convenience, low power and cost.

- ❖ ***Reliability & Simplicity*** – DECT/ULE, with full house and garden coverage (greater range than WiFi), offer simple installation. Alternatives require mesh or repeaters, to forward messages from one device to another, adding complexity and cost, mitigating against simple 'Do-It-Yourself' installation. This is one reason that the smart home market using mesh technologies has been slow to take off. A smart home automation system must work reliably, without interference from Wi-Fi, Bluetooth or similar shared spectrum wireless devices. DECT's dedicated spectrum and cognitive spectrum management algorithms ensure minimal interference. This, combined with long range, ensures a highly reliable and very simple network and installation.
- ❖ ***Convenience*** – The use of a natural voice interface can avoid users needing to learn complex settings and activation sequences for their smart devices. Evolution of the Virtual Personal Assistant (VPA) and Artificial Intelligence in the coming years will see voice emerge as the primary, user friendly, interface in the smart home. VPA requires sustained high quality voice communication. DECT/ULE already delivers secure, reliable and guaranteed two-way High Definition voice communication, to support voice activation via speech recognition and other voice-based use cases; this explains why it already being implemented alongside Alexa in Smart Speakers.
- ❖ ***Low Power Consumption and Cost*** – Mobile phones using Wi-Fi typically require a daily charge, whereas DECT phones last weeks without charging. IoT sensors need to operate for years on small batteries, over 3 years is considered normal. The DECT/ULE protocol was designed to address this need, supporting devices with ultra-low energy consumption and at low cost.

DECT-5G Value for the Smart Home – The number of use cases for IoT in smart homes and buildings is very broad and diverse. Designed for both home and enterprise, DECT/ULE technology effectively addresses a wide range of such use cases in the home and beyond. DECT-5G extends these capabilities, maintaining simplicity and low cost.

DECT-5G support for ultra-reliable, low latency, and machine-type applications will further enable and extend today's smart home capabilities.
Its embedded support for roaming and hand-over enables DECT-5G to provide such services with seamless coverage across a campus of buildings.

3.4 Industrial Applications

Wireless in Industry Today – The high value of manufacturing and, as a consequence, the potential for damage and financial loss from a line-stop on a production line, arising from a communications failure, is why wireless has been little used in manufacturing to date. Technology was unable to guarantee the very stringent demands of such applications; industrial players are conservative and unwilling to experiment. The few existing wireless applications are typically non-critical (e.g. handheld scanners or condition monitoring sensors) or connection of sensors / actuators in harsh or remote environments (e.g. as part of an extended process plant). For such non-critical uses Bluetooth or Wi-Fi technologies are used, or more robust ones such as Wireless HART or ISA 100. Legacy DECT is also often found in factories, mostly for cordless telephony.

Industry 4.0, aka the Industrial IoT (IIoT) reflects fundamental evolution in manufacturing. Driven by the fusion of the classical production techniques with modern Information and

Communication Technologies (ICT), ubiquitous connectivity across all sorts of sensors, actuators and other devices will enable so-called cyber-physical production systems, radically increasing the flexibility, mobility, versatility, ergonomics, productivity and resource efficiency of industrial production. Industrial-grade wireless technologies are needed to overcome the concerns that have prevented widespread adoption of wireless by industry in the past; this has driven the IMT-2020 requirements.

Market Needs of Industry 4.0 – Example envisaged 5G applications include mobile devices, e.g. automated guided vehicles, connected fork lifts, mobile robots, mobile control panels, and classical closed-loop control applications for factory and process automation. For connecting moving or rotating parts, slip rings or cable carriers are used today, but these can be costly devices and require regular maintenance. New human-machine-interfaces, augmented or virtual reality devices, also require wireless connectivity. Wireless enables a new approach to building factories: in future highly modular production units could easily be re-positioned, seamlessly interconnecting and re-configuring themselves in a fully automated manner.

Technology Requirements for Industry 4.0 – No single killer application or use case usually exists today to justify deploying a dedicated wireless network, rather many use cases with variety of diverse and demanding requirements, encompassing all three 5G scenarios (eMBB, mMTC and URLLC). Requirements can be summarized as follows:

❖ ***Industrial-Grade Quality of Service,*** notably latency, reliability and dependability. Many use cases, e.g. closed-loop machine control, involve cyclic communication between a master node (e.g. a programmable logic controller, PLC) and multiple slaves (e.g. sensors or actuators). Data packets are often fixed and small (e.g. 50-250 bytes) with millisecond latency requirements and >99.9999% availability, i.e. a "wire-like" wireless connection requiring exclusive access to spectrum.

- ***Efficient Differentiation of Traffic Flows and Support of Diverse QoS Classes*** Even between just two devices, different traffic flows may exist, e.g. real-time and non-real-time data; such flexibility is important.
- ***Seamless Mobility Support*** is needed to ensure uninterrupted service to connected devices. Lack of this in factories is an existing problem with standard Wi-Fi networks.
- ***Integrated Positioning***, ideally with accuracy <10 cm, so that no separate solution needs to be deployed. Location information is very valuable in the industrial domain and forms the basis for a wide variety of different use cases.
- ***Strong, Integrated Security Mechanisms*** for ensuring confidentiality, authenticity, data integrity and system availability against potentially highly skilled attackers, who may seek to access sensitive production data or to disturb regular factory operations.
- ***Seamless Integration with Existing Communication Technologies***. Machinery and production lines have long lifetimes, up to 10 or even 20 years; further, not every cable will be replaced by a wireless link in the foreseeable future.
- ***Adequate Self-Management Support***. Costs of planning, deployment, operation and maintenance should be minimized and ideally the network should automatically react to potential problems to avoid unplanned downtimes of production facilities.
- ***Continuous Fine-Grained Realtime Monitoring of the Current Network State*** is needed to enable problems to be quickly detected and remedial actions initiated.
- ***Ability to Operate Independently of a Third-Party Network Operator***. Many factories require this for security, privacy, business and liability reasons. Production data can be very sensitive, requiring full control of both data and security mechanisms. A third-party network operator will always charge for his services, adding avoidable costs to the balance sheet. Financial liability, in the event of a production line failure due to a connectivity issue, can be huge; a third-party network operator may be unwilling to accept this liability or would only do so with an unacceptably high service fee.
- ***Worldwide Availability of Suitable Spectrum***. Industrial automation markets are too small to justify geographically specific solutions. Companies with production facilities in different countries, need homogeneity of equipment and solutions across these countries. The particular beauty *(uniqueness)* of DECT is the dedicated spectrum available in many countries, avoiding the need for a third-party network operator; however, some important markets, e.g. China, do not today have an existing allocation.

DECT-5G Value for Industrial IoT – Although DECT-5G alone will not address the requirements of every industry use case, especially bandwidth hungry ones, it is a vital building block when combined with other (complementary) wireless systems. Clearly, seamless mobility has been mastered by DECT right from the outset and the technology represents a very attractive option in terms of cost, reliability and latency.

DECT-5G's biggest potential for Industry 4.0 exists for URLLC-type applications. Its structure is well suited to the important class of cyclic traffic and, with lower latency and higher reliability, it should readily fulfill all corresponding requirements

For Industry, DECT-5G is important, as it enables factories to retain full control, and hence risk management, of their core manufacturing business assets.

4 TECHNOLOGY: THE PATH TO DECT-5G

Technology developments that are enabling DECT-5G fall into two categories, those that have been emerging as DECT has evolved and those external developments which, when combined with DECT-5G, could enable multiple applications across many vertical market. This section provides a deeper dive into the technology empowering DECT-5G.

4.1 Energy Efficiency and Low Power

Legacy DECT / ULE inherently supports high energy efficiency / low power consumption. These capabilities are essential for long lifetime, inaccessible or disposable products and were designed into the legacy DECT/ULE specifications, with features such as:

- ***Scheduled Access*** – allowing power-efficient, duty-cycle based, operation (ULE)
- ***Constant-Envelope GFSK Modulation*** – relaxing linearity requirements, allowing use of power-efficient saturated amplifiers (i.e. lower transmit peak currents) and use of low power radio implementations (i.e. less power in low duty-cycle applications)
- ***Higher Order Modulation Methods*** – permitting shorter air times for higher duty-cycle operation, assuming constant payload (i.e. less average power consumption)
- ***RF Transmit Power Control*** – minimizing the radio footprint of a device, enabling better cell reuse and lower devices power consumption when transmitting

DECT's Network Architecture – To deliver high Quality of Service (QoS), with low power and low latency, a dedicated network is highly preferable to shared network resources. DECT's star topology, compared with mesh or relay approaches, allows:

- ***Improved Power Efficiency*** – controlling transmit power to cover only the local area
- ***Improved Spectrum Efficiency*** – restricting high duty cycle services to local area
- ***High Degree of QoS Control*** – defined by the local network configuration

DECT-5G extends the inherent low power capabilities of legacy DECT technology [14]. Mechanisms incorporated in ETSI's new DECT-2020 specification include:

- ***Even Higher Data Rates*** – enabling shorter air times, lowering average power usage
- ***Faster Synchronization Times*** – reducing the radio scanning windows, lowering power consumption in low duty-cycle operation
- ***Reduced Protocol Overhead*** – flexibly using the A-field, minimizes energy /data bit

Advanced Technology Nodes (smaller chip geometries) will also deliver energy/power savings for DECT-5G (and other RIT) solutions. A 50% smaller node may reduce power consumption by ~2x / ~5x for analog / digital respectively. Low duty-cycle applications may benefit from SOI (silicon on insulator) technology that minimizes transistor leakage currents by isolating the devices from the bulk silicon. Digital consumption is expected to become dominant, as products incorporate more DSP-heavy applications, e.g. CODECs, audio beam-forming and recognition, sensor data processing and on-device AI.

4.2 Interactive Voice & Sound

DECT is strongly rooted in voice and sound, delivering long range, HD audio on battery-operated devices, with high QoS guaranteed through its inherent real-time, mechanisms. DECT-5G will extend these Voice & Sound Capabilities in the home, enterprise and IoT world enabling IMT-2020 to deliver its promise of 5G functionality to new vertical markets. By availing of DECT-5G's inherent backward compatibility to legacy DECT, this can even be achieved using current infrastructure.

DECT-5G will support a full home interactive audio environment. The increased number of duplex channels per fixed part (i.e. concurrent active links) will support dozens of portable parts simultaneously - handsets, headsets, microphones, speakers, intercom and VPAs (Virtual Personal Assistants). A single DECT-5G cell will give simultaneous support enabling all domestic audio devices to 'double up' as phones offering reliable voice calls over IP or other means. DECT-5G's bandwidth per channel will support full band quality music (20-20,000Hz) in a multi-room, multi-speaker configuration.

DECT-5G in the enterprise environment means many more handsets per fixed part, thus lowering system cost and improving voice quality using new codecs (e.g. super wideband). Enterprise voice comes in many forms, from a VoIP phone system with multiple handsets and headsets, to intercom systems for co-working either in-premise or free field.

Adding Voice to IoT devices, e.g. smoke detectors, sirens, smart plugs, can enable new and exciting interactive capabilities, such as:

- ***Voice Queries for Assistance and General Guidance*** (VPA)
- ***Voice Commands for Control and Monitoring*** of smart home or enterprise facilities
- ***Voice Commands for Hands-Free Operation*** of equipment,
- ***Intelligent Voice Prompts***, based on data from other connected IoT sensors
- ***Instant Open Two-Way Voice Channel*** in an emergency scenario

Inherent simultaneous support of voice and data on the same link enables DECT-5G to offer many new possible applications. This is most evident when applications require voice activation to trigger a portable part action in mission critical environments.

Integrated Virtual Personal Assistants – Today's VPAs (Amazon Echo, Google Home, etc.) are revolutionizing how users interact with devices, now moving from "vocal personal assistance" (polling the weather, ordering a pizza, setting appointments), to control their smart home and make spontaneous phone calls. Today's implementation usually consists of a high processing power (remote) server and a voice terminal connected to an IP network, to send the voice to the cloud and to return a response. DECT phones incorporating VPAs are now available. DECT-5G offers an opportunity to efficiently unify home communication and IoT devices and potentially to add intelligence in the fixed part.

Sound Analytics is an emerging technology that uses sound classification for security, monitoring and predictive maintenance, applicable in industry, home and enterprise. Whilst such analysis could be implemented locally on an edge sensor device, in practice, due to power consumption, cost and processing power constraints, it is mainly done today on a local hub or remote server, with the audio transferred over an IP network, like VPAs. DECT-5G can clearly support applications using this technology, providing mature, high fidelity, audio communication. IoT devices equipped with microphones to act as sound sensors, using DECT-5G, can enable products/capabilities such as:

- ***Security & Monitoring*** – Glass break detection, aggression (people shouting), dog barking, a monitored stove, baby crying, fall detection (elderly care or any other abnormal noise in the home…)
- ***Domestic Predictive Maintenance*** – analysis of sounds from stove, refrigerator, pipes, termites, etc., for early detection of malfunction

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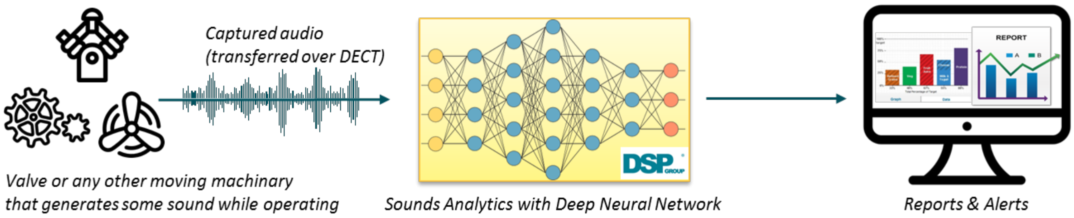
- ***Industrial and Manufacturing Predictive Maintenance*** – analysis of noise from moving parts (valves, rotors, fluid flow, etc.) allowing pre-scheduled monitoring and



downtime

Figure 5: Sound Analytics/AI: Enablers of New Capabilities & Applications

4.3 Product Intelligence, Edge, AI and Networking

In-Field Product Enhancement - DECT's ability to perform Over-The-Air (OTA) software upgrades, introduced with NG-DECT a decade ago, has enabled modest in-field enhancements to end user devices in the home and enterprise. In the DECT-5G era this mature ability to perform secure functionality and performance upgrades of IoT-enabled devices in URLLC and mMTC scenarios is likely to take on new importance and value. Storage and compute functionality is increasingly being deployed at the network edge; we can expect such trends with DECT-5G - in the home, in the enterprise and in the factory.

DECT-5G Hubs can thus be expected to evolve beyond today's base stations / gateways. Whilst processing for VPAs and sound analysis is today performed remotely, in the cloud, AI is progressing fast. Over time we expect AI engines to migrate from the network to reside in DECT-5G hubs, to undertake local analytics, with potential for OTA updates. Dynamic evolution of infrastructure and end devices offers significant value to industrial and enterprise users. However, this could reinforce the desire of some such users wishing to retain full control over their in-house resources, e.g. when upgrading control and monitoring of factory machinery, rather than delegating this to an outside operator.

DECT-5G and 3GPP Interworking – Initial commercial 5G focus, reflecting standards progress, is on the IMT-2020 RITs; however, an equally important element of 5G is the upgrade of network infrastructure to support SDN and NFV, Software Defined Networking and Network Function Virtualization. ETSI DECT-TC is targeting specification of DECT-5G Non-Trusted Access to 3GPP infrastructure for its July 2019 submission to IMT-2020; specification of Trusted Access is expected to follow in 2020, following Rel16 of the 3GPP standards. This will offer a simple service evolution path in the future whereby, as confidence grows, currently cautious industries could move to adopt a full-service network slicing offer from operators, with which today they do not feel comfortable.

4.4 Foundations and Design of DECT-5G

Maturity and Extensibility – The wide range of today's use of DECT, previously described, illustrate how a good technology lends itself to system design, to the benefit of multiple markets. DECT today is far advanced from its early origins, respected and widely used across many Industry verticals. This is an evidence-based demonstration of the motivation and capability of the industry to rise to evolve with market needs. Common features stand out that are shaping the contours of the ETSI DECT-5G specification. DECT-

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5G is rooted in 'Legacy DECT' [14], and its standards evolution, complemented by the ongoing development of its base technologies (chipsets, DSP, RF architectures and components). DECT-5G's evolutionary path, described in section 2.3, explains why it is so strong in terms of URLLC and local area mMTC requirements. DECT-5G will continue to evolve, alongside 3GPP RITs, to deliver new capabilities in years ahead.

DECT-5G builds upon the mature capabilities and evolution of low cost legacy DECT technology. It will support those earlier services and features more efficiently and reliably, as well as delivering the powerful new capabilities of 5G

Legacy Co-existence, Interoperability and Evolution – DECT-5G can share spectrum and existing infrastructure with legacy DECT/ULE products without affecting operation or performance of these devices/systems. DECT-5G uses compatible timeslot, RF channel resolution and procedures for spectrum allocation, awareness and avoidance of packet collision and interference. DECT-5G base stations will simultaneously service both new DECT-5G and legacy DECT devices, allowing a seamless transition to the improved technology without having to replace all installed devices and handsets at once.

Scalable, Multicell Operation, with Seamless Mobility, for extended coverage from single cell to large multicell networks. Interconnection and roaming between networks will be supported as today in legacy DECT. This means scalability from a home, to a building, to a campus or a factory, with seamless roaming (robust make-before-break handover) and interoperability with existing closed wired networks, e.g. in factories.

Range and Location - DECT-5G range is improved, with robust modulation and coding. The OFDM physical layer is designed to deliver good indoor and outdoor coverage. Data bandwidth will gradually decrease at longer ranges. Range extension by use of repeaters is supported. DECT-5G radio technology supports determination of distance between terminals and base stations; a terminal will support location using multilateration, gathering distance information from several base stations in a multicell network.

Worldwide Spectrum, Royalty Free Operation – DECT-5G operates in existing licensed spectrum, providing lower costs through global economies of scale. Spectrum is allocated in two dimensions, timeslots (TDMA) and frequency channels (FDMA). For bandwidth hungry services, consecutive timeslots and multiple frequency channels can be allocated, whilst low bandwidth services can occupy down to half-timeslot and half-channel. The DECT-5G base station allocates the required spectrum, ensuring efficient interworking between different services, such as streaming applications requiring predictable QoS and low latency packet data applications.

Dynamic Channel Allocation from legacy DECT allows equipment deployment without need for any frequency planning or technical radio skills, allowing simple, cost effective, installation. DECT is a cognitive technology, continually responding to its radio environment to find the best channel, optimizing spectrum usage and system capacity. Higher Bandwidth, much greater than legacy DECT, is enabled by additional modulation rate coding schemes and MIMO, in combination with spectrum resource allocation of several timeslots and bonding of multiple RF channels.

OFDM Modulation and Coding (Orthogonal Frequency Division Multiplexing) supports a variety of different modulation and coding rates, allowing optimal adaptation to varying radio conditions. Interference free data transfer for mission critical sensor control and voice/data communication is enabled. The ability to deliver mission critical connectivity, data, alarms and signaling, with/without accompanying voice support, is a central driver of DECT-5G, making it a unique and unreplaceable 5G Local Area technology.

Ultra-Reliable Low Latency will enable economically significant markets. Flexible spectrum and timeslot allocation procedures enable low latency streaming, duplex circuit mode connection and sporadic packet mode data services, all served concurrently on a basestation. Packets are always transmitting at slot boundaries, ensuring low jitter.

Secure Communication – DECT-5G uses state-of-the-art standards for access control, confidentiality and message authenticity. CCM (Counter with CBC-MAC) based on AES provides encryption and per packet authentication. Security keys are private for each device and temporary keys are used for each independent application session.

Vendor Choice and Interoperability – Call control and multimedia configuration features from legacy DECT enable DECT-5G users to benefit from the vendor-independent interoperability and choice associated with the GAP and CAT-iq standards.

Low Energy/Power Consumption, similar to today's DECT implementations, using low duty cycle techniques with wake-up, will enable "always on" battery powered applications

Implementation Cost will be similar to legacy DECT and thus highly attractive compared to comparable mobile cellular implementations. This is mainly due to one (or few) supported frequency bands and a more focused feature set.

IP Termination for integration into common network architectures. The DECT-5G APIs will support both classic DECT application interfaces as well as IPv6.

Open Innovation – DECT's open API approach, openD, will facilitate adoption and innovation of 5G products, by making the technology available to the open innovation community, thereby accelerating adoption and the benefits of 5G.

Operator Independence – DECT-5G can enable operator-independence when a QoS guarantee or independence of external infrastructure are hard requirements, e.g. for a factory network. Such flexibility can reduce dependence on a telecoms operator and save costs for both service provider and end-user, as well as delivering enhanced convenience, safety and security, e.g. through installation of local low cost alarms.

… or Operator Collaboration - Seamless interoperability and roaming with fixed/mobile networks, including 5G WAN and 5G LAN, is however possible if desired. This is the premise of interworking between 3GPP and DECT-5G and bears the promise of seamless end to end services. Today the DECT industry has deployments in, and close relationships with, many verticals, as well as working closely with many Telecom Network Operators. As DECT-5G is deployed and as SDN/NFV becomes proven, so the DECT Industry offers a route for operators to build trust with closed verticals with whom it works.

ETSI Develops and Maintains the DECT Standards, specifying the features and functionality of DECT-5G. This open and publicly available standard will be supported by multiple chipset and equipment vendors. As evidenced by history, the DECT standards, technology and capabilities will continue to evolve beyond 5G.

5 ACCELERATING ECONOMIC, INDUSTRY AND MARKET BENEFITS

5G Promises a Major Economic Stimulus – 5G's benefits to multiple industries are a key driver of the ITU approach to IMT-2020. EU policy has prioritized the economic benefits of ultra reliable low latency services (URLLC), alongside wide area IoT (mMTC) and faster broadband (eMBB). Such services however are still relatively new offerings, having great potential but still largely unknown, untrusted and misunderstood by their potential users (e.g. a manager's possible experience of unreliable wireless IoT at home creates understandable hesitation over hasty adoption of IoT in his enterprise or factory).

DECT-5G Complements 3GPP RITs – DECT's strength as a robust and reliable local coverage solution is widely recognized and appreciated. Many Vertical Markets today rely on DECT for their indoor and campus communications, already using its capabilities for mission critical and safety applications. DECT/ULE's strengths in low energy and latency offer enterprise and industrial markets a simple, easy and low-risk first step into the world of wireless IoT, Industry 4.0 and smart campus environments.

Vertical Industries Trust DECT – Whilst appreciating 5G's potential, many industries, especially those where a communication failure incurs very high costs, such as PMSE or production manufacturing, are not yet confident to outsource control of their core business assets to an independent network operator. A trusted DECT-5G solution provides them a way to begin their 5G journey in a way that enables them to retain control and with which they feel comfortable, and with potential for future evolution.

Quick Deployment to Build Confidence – Today's near-global availability of 1.9GHz DECT spectrum offers a ready launch pad for DECT-5G. Industries that already use DECT for on-site communications can immediately deploy DECT-5G and test for themselves the benefits of 5G capabilities, whilst retaining risks under their own control and without the cost, in time and money, of educating operators in regard to their needs.

5G-WAN / 5G-LAN Interoperability is supported by DECT-5G, enabling companies to explore, experiment and develop in ways that meet their needs, whilst gradually 'enlarging their comfort zone'.

Full 5G Integration – Longer term, SDN/NFV promise the potential of 5G network slicing, enabling network performance to be configured and optimized to the needs of individual verticals and companies. 3GPP is expected to complete relevant standardization issues in its Release 16 specification by early 2020. As standards become finalized and implementations are developed, deployed and become proven and mature, so full network integration and virtualization of DECT-5G on-site facilities can be anticipated.

DECT-5G can accelerate investment, learning and adoption by Vertical Industries. It enables quick 5G service deployment at low cost and risk (under own control). This offers earlier economic benefits for Industry, Society and Governments. Interoperability and full 5G network integration and evolution is supported.

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7 KEY ABBREVIATIONS

BPSK	Binary Phase Shift Keying
CEPT	The European Conference of Postal and Telecommunications
DECT	Digital Enhanced Cordless Telecommunications
eMBB	Enhanced Mobile Broadband
ETSI	The European Telecommunications Standards Institute
FDMA	Frequency Division Multiple Access
GFSK	Gaussian Frequency Shift Keying
HANFUN	Home Area Network Functional Protocol
IMT	International Mobile Telecommunications
IoT	Internet of Things
ITU	International Telecommunications Union, a UN agency
mMTC	Massive Machine Type Communications
OFDM	Orthogonal Frequency Division Multiplexing
QAM	Quadrature Amplitude Modulation
QFSK	Quadrature Frequency Shift Keying
RIT	Radio Interface Technology
SRIT	Set of Radio Interface Technologies
TDMA	Time Division Multiple Access
ULE	Ultra Low Energy
URLLC	Ultra-Reliable, Low Latency Communications

8 ANNEXES

8.1 ANNEX 1 IMT-2020 TECHNICAL REQUIREMENTS, SUBMISSION AND EVALUATION

The ITU-R Document [IMT-2020.TECH PERF REQ] [7] defines IMT-2020 requirements. These aim to make IMT-2020 more flexible, reliable and secure than past IMT standards when providing diverse services in the intended three usage scenarios of (eMBB, URLLC, and mMTC). IMT-2020 defines a RIT (Radio Interface Technology) and SRIT (Set of Radio Interface Technologies). Also defined are five Test Environments (TE),

Technical Performance Requirements are shown in the following table; note that some parameters have slightly different values depending on the usage scenario.

	Usage Scenarios			Key: DL= Downlink UL=Uplink
Requirement	**eMBB**	**mMTC**	**URLLC**	**Target**
Peak data rate	Y			DL: 20 Gbps UL: 10 Gbps
Peak spectral efficiency	Y			DL: 30 bps/Hz UL: 15 bps/Hz
User experienced data rate	Y			DL: 100 Mbps UL: 50 Mbps
5th percentile user spectral efficiency	Y			(Depends on test environment) DL: 0.12 – 0.3 bit/s/Hz UL: 0.045 – 0.21 bit/s/Hz
Average spectral efficiency	Y			(Depends on test environment) DL: 3.3 – 9 bit/s/Hz UL: 1.6 – 6.75 bit/s/Hz
Area traffic capacity	Y			10 Mbit/s/m^2
User plane latency	Y		Y	URLLC: 1 ms eMBB: 4 ms
Control plane latency	Y		Y	20 ms
Connection density		Y		1,000,000 devices/km^2
Energy efficiency	Y			Qualitative measure only
Reliability			Y	1-10^{-5} success for transmitting 32-byte SDU in 1ms
Mobility	Y			(Depends on test environment)
Mobility interruption time	Y		Y	0 ms
Bandwidth	Y	Y	Y	At least 100MHz of aggregated bandwidth of radio spectrum, up to 1GHz for higher freq bands

The Five IMT-2020 Test Environments are:

- **Indoor Hotspot-eMBB** – An indoor isolated environment at offices and/or in shopping malls based on stationary and pedestrian users with very high user density.
- **Dense Urban-eMBB** – An urban environment with high user density and traffic loads focusing on pedestrian and vehicular users.
- **Rural-eMBB** – A rural environment with larger and continuous wide area coverage, supporting pedestrian, vehicular and high-speed vehicular users.
- **Urban Macro–mMTC** – An urban macro environment targeting continuous coverage focusing on a high number of connected machine type devices.
- **Urban Macro–URLLC** – An urban macro environment targeting ultra-reliable and low latency communications.

RIT/SRIT Evaluation – During the IMT-2020 submission and evaluation stage, a RIT must fulfill the minimum requirements for at least three of these test environments; two test environments under eMBB and one test environment under mMTC or URLLC. During later evaluation stages, a RIT/SRIT must fulfill the requirements of all five Test Environments; in general, this means that a RIT does not have to meet all requirements, as long as it is part of an SRIT that does.

The IMT-2020 Submission Process requires that candidates provide technical details and evaluation results (some simulations, some analytical) for submitted RITs. The submission is assessed by one or more Independent Evaluation Groups appointed by the ITU. Final consensus-building and development of the radio interface recommendations is scheduled for 2019/20. Figure 6 shows the detailed ITU-R time-line and process; the roadmap to IMT-2020 approval closely aligns with the goals of the DECT industry at large as well as the workplan of ETSI [13].

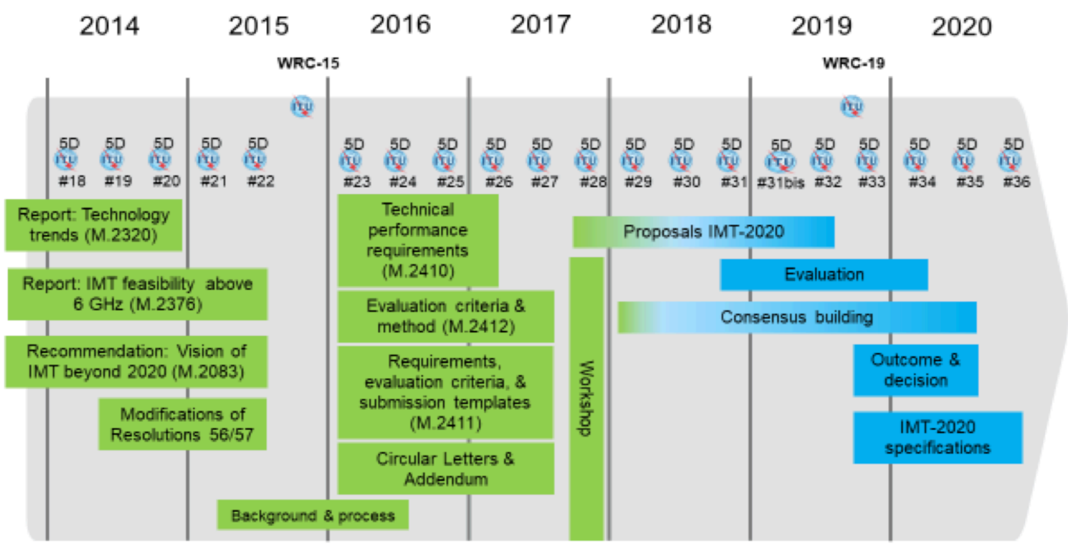

Figure 6: ITU-T WP5D IMT-2020 Timeline

8.2 Annex 2 DECT-5G Technical Parameters

General Approach - The new DECT-5G air interface will coexist with the existing DECT deployments, offering backward compatibility. Therefore, the time frame of 10 ms will be maintained, with the possibility to add shorter sub-frames for low latency operation. For additional robustness in multi-path scenarios OFDMA (Orthogonal Frequency-Division Multiple Access) combined with coding is proposed. The selected parameters provide coexistence of DECT-5G with legacy DECT. A comparison is shown in the table below.

	Legacy DECT	**DECT-5G**
Channel access	TDMA/FDMA	TDMA/FDMA
Time frame	10 ms	10 ms
Nominal slot duration	416.67 µs	416.67 µs
Basic carrier spacing	1.728 MHz	1.728 MHz
Bandwidth	1.728 MHz	Multiples of 0.864 MHz, eg X1, x2, x4, x8, x16, x24, x32, x64, x128, x192, x256 [ie 0.864 MHz to 221.184 MHz]
Carrier type	Single-carrier	Multi-carrier (OFDM)
Modulation configurations	GFSK, BPSK, QPSK, 8-PSK, 16-QAM, 64-QAM	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM
No of Spatial streams	1	1 to 6
Bit-rate	Scalable up to 10 Mbit/s	Scalable up to 10 Gbit/s

Additional DECT-5G technical parameters:

- Physical packets consisting of multiple OFDM symbols
- Nominal sub-carrier spacing is 27 kHz
- Nominal Fourier transformation period is 37.037 µs
- Nominal OFDM symbol duration 41.67 µs
- Packet duration is variable
- Packet transmission starts at half slot boundary
- Packet formats:
  Long Preamble format (6 symbols for synchronization and header), which is an example of a packet using a robust packet level synchronization pattern.
  Short Preamble format (2 symbols for synchronization and header)
  High Efficiency (HE) format (1 symbol for pilot). These packet types enable more efficient communication for certain scenarios, including ‘Low Latency Comms’

8.3 Annex 3 Acknowledgements

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