



ITU-APT Foundation of India (IAFI)¹

AWG-29 meeting invited APT members for further inputs so as to complete the APT Report on Emerging Critical Applications of IMT for Industrial, Societal and Enterprise Users at the AWG-30 meeting.

In this contribution IAFI provides some editorial updates to the working document from AWG-29 in document AWG-29/TMP-12 rev 2 so as to complete the report in AWG-30 meeting.

IAFI also recommends that this report may be completed and approved at the AWG-30.

¹ ITU-APT Foundation of India (IAFI) is an Affiliate member of APT. Details of IAFI can be seen at itu-apt.org

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW APT REPORT ON EMERGING CRITICAL APPLICATIONS & USE CASES OF IMT FOR INDUSTRIAL, SOCIETAL AND ENTERPRISE USAGES

1. Scope- This new APT Report on new/emerging critical applications & use cases of IMT-Advanced and IMT-2020 for industrial, societal and enterprise usages, addresses the capabilities of IMT and its use cases, for Non Public networks (NPN)

2. Introduction

The integration of information technology (IT) to build an automated, agile and intelligence driven manufacturing and services industry will require high speed mobile connectivity. Today's industries, society and enterprises generate and use a huge amount of data in real time, which is moved and consumed at enormous rates so as to harness the advantages of digital technologies. Until now, connectivity has remained a critical barrier in order to realize the full potential of what is collectively known as Industry 4.0.

A new generation of private mobile broadband networks is emerging to address real-time reliable wireless communication requirements in the operations of industries and critical infrastructure. Users of NPN networks include government entities, private enterprises, public utilities and local communities. Today's industrial automation is powered by ICT technology and this trend will increase manifold with advent of new IMT technologies such as 3GPP New Radio (NR), leading to increased business efficiencies, improved safety and enhanced market agility. Industry 4.0 enables industries to fuse physical with digital processes by connecting all sensors, machines and workers in the most flexible way available. Tethering them to a wired network infrastructure is expensive and, ultimately, it will limit the possible applications of Industry 4.0. Industrial grade private wireless can provide a flexible and cost-effective way to implement a wide range of Industry 4.0 applications. Current IT based automation solutions are well adapted for day-to-day business communications but are limited in reliability, security, predictable performance, multiuser capacity and mobility, all features which are required for operational applications that are business or mission critical. Similarly, applications in mines, port terminals or airports require large coverage area, resilient/direct mode and isolated operations and challenging environments, which so far only two-way land mobile mission critical radio technology could meet. In both mining and port terminals, remotely operated, autonomous vehicles, such as trucks, cranes and straddle carriers that are used for requiring highly reliable mission critical, mobile data communications. Efficiencies of these types of users, can be enhanced substantially by supplementing the mission critical voice communications with high-quality video and data support which is likely to become available from Releases 17/18 onwards in 3GPP IMT-2020. Report ITU-R M.2291 provides details of support provided by 3GPP IMT and IMT-2020 for meeting these requirements.

The emergence of ultrafast mobile broadband technologies across low mid bands and in higher millimeter wave frequency bands provides manufacturers with the ability to deploy using common IMT platforms across multiple bands including licensed, lightly licensed and shared access spectrum. This flexibility and technology convergence enables much needed reliable connectivity solutions, enabling critical communications for wireless control of machines and manufacturing robots, and this will unlock the full potential of Industry 4.0. Taking manufacturing, with thousands of factories with more than 100 employees, as an example, typical business cases revolve around controlling the production process, improving material management, improving safety, and introducing new tools. Fortunately, 5G is available across

multiple bands and is being designed and developed to support deployment and use case configurations for private wireless networks to support Industry 4.0. The time is ripe for many industries to leverage private and captive mobile broadband to increase efficiencies and automation.

Apart from manufacturing, many other industries are also looking at IMT-2020 (5G) as the backbone for their equivalent of the Fourth Industrial Revolution. The opportunity to address industrial connectivity needs of a range of industries, including diverse segments with diverse needs, such as those in the mining, port, energy and utilities, automotive and transport, public safety, media and entertainment, healthcare, and education industries, among others.

Some recent trial of IMT in port operations demonstrated the “New Radio” capabilities such as ultra-reliable low-latency communication (URLLC), enhanced mobile broadband (eMBB) and network slicing with the use of 5G to support traffic light control, AR/VR headsets and IoT sensors mounted on mobile barges and provides countless possibilities to improve efficiency and sustainability in seaports and other complex and changing industrial environments. Similarly, in mining exploration sites, the drilling productivity could be substantially increased through automation of its drills alone and the use of real time video analytics for operating and controlling machines remotely. Additional savings from increased usage of equipment could also lead to lower capital expenditures for mines (CapEx) as well as a better safety and working environments for their personnel

3. Acronyms, Terms and Definitions

AGV: Automated Guided Vehicle

AP: Access Point

AR: Augmented Reality

DER: Distributed energy resources

eMBB: Enhanced mobile broadband

IoT: Internet of things

mMTC: Massive Machine Type-Communication

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NPN – Non Public Network – An IMT network which provides service to a specific set of user(s) but does not provide service to the general public

Pubic IMT network: An IMT network which provides services to the general public

SDWAN: Software-defined wide area network

4. References

[1] APT/AWG/REP-67: APT survey report on authorized/licensed shared access as a national solution to access spectrum for IMT

[2] Question [ITU-R 262/5](#) – Usage of the terrestrial component of IMT systems for specific applications.

[3] Recommendation [ITU-R M.2083](#) – Framework and overall objectives of the future development of IMT for 2020 and beyond.

[4] Report [ITU-R M.2440](#) – The use of the terrestrial component of International Mobile Telecommunications (IMT) for Narrowband and Broadband Machine-Type Communications.

[5] Report [ITU-R M.2441](#) – Emerging usage of the terrestrial component of International Mobile Telecommunication (IMT).

[6] Report [ITU-R SM.2404](#) – Regulatory tools to support enhanced shared use of the spectrum.

[7] Report [ITU-R SM.2405](#) – Spectrum management principles, challenges and issues related to dynamic access to frequency bands by means of radio systems employing cognitive capabilities.

5. Required capabilities of IMT for critical applications.

IMT is the root name that encompasses IMT-2000, IMT-Advanced, and IMT-2020 collectively. IMT-2000 was to support data transmission rates of up to 2Mbps for fixed stations and 384 Kbps for mobile stations.

At Radiocommunication Assembly (RA-12), in Geneva, on 16-20 January 2012, consensus on ‘IMT-Advanced’ was reached to expand the IMT Radio Interface family by establishing the new IMT-Advanced standard. Initially peak data rates of 100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for IMT-Advanced systems.

In early 2012, ITU-R embarked on a programme to develop “IMT for 2020 and beyond”, setting the stage for 5G research activities that were emerging around the world. In September 2015, ITU-R finalized its “Vision” of IMT for 2020 5G mobile broadband connected society”. IMT-2020 use cases can be grouped into three classes: enhanced mobile broadband (eMBB), massive machine-type communication (mMTC), and ultra-reliable and low-latency communication (URLLC). There will be use cases that may not fit into one of these classes. For example, there may be some applications that require very high reliability but with latency requirements that are not as low as 1 millisecond.

Industrial, societal and enterprise users of private networks have use cases that are not readily or not fully supported by public networks. The reasons to deploy private networks include:

- Coverage: By deploying private networks users can ensure coverage at their facilities or locations. This is necessary when the locations have no or poor coverage by public networks. For example: in remote locations in mines or farming areas; indoor locations in schools, campus, factories, warehouses, power utilities, etc.)
- Capacity: Private networks provide exclusive access to available capacity. They can be configured to specific capacity demands (e.g., support high- definition video streaming)
- Control: Operators of private networks can determine which users connect, how resources are utilized and how traffic is prioritized. They also have control over the security of their data and can ensure that sensitive information remain within their premises.

6. Use cases/applications

6.1 Manufacturing

Even the most advanced factories of today still largely depend on inexpensive unlicensed wireless networks that have several drawbacks, such as interference in dense settings and complex fixed connections that are difficult to manage in large industrial settings. While the unlicensed spectrum is freely available, it is severally limited in quality of service (QoS) and support for mobility. In smart manufacturing, such networks cannot support the mobile

requirements of automated guided vehicles (AGVs) or even some of the faster moving arms of robots. It also does not support low power requirements of sensors and other IoT devices. Further, it cannot support the high density of sensors, devices, robots, workers and vehicles that are operating in a typical manufacturing plant.

6.2 Transportation/ Logistics

Provision of efficient, comfortable, and safe transportation using artificial intelligence under the platform of 5G/IMT 2020 network, ensuring wireless connection and automatic driving via perception, the decision as well as control. The feature would enable video/images capturing conditions of the road and roadside facilities, V2V, road infrastructures, and real time communication.

The logistics enterprise distributes goods to customers according to the number of orders. The customer number for a route is uncertain, and the vehicle route must be determined in order to optimize transportation cost.

Figure 1



6.3 Construction

Remote management management/safe operation of the vehicles and machines, autonomous operation and synchronization between the construction industry vehicles. In order to tackle the challenge of automating the construction industry through those aspects related to the construction process that may benefit from the use of 5G/IMT 2020. Different wireless technologies have been proposed for IoT implementation in the construction sector. The proposed wireless technologies can be classified into long-range networks, short-range networks, and cellular networks.

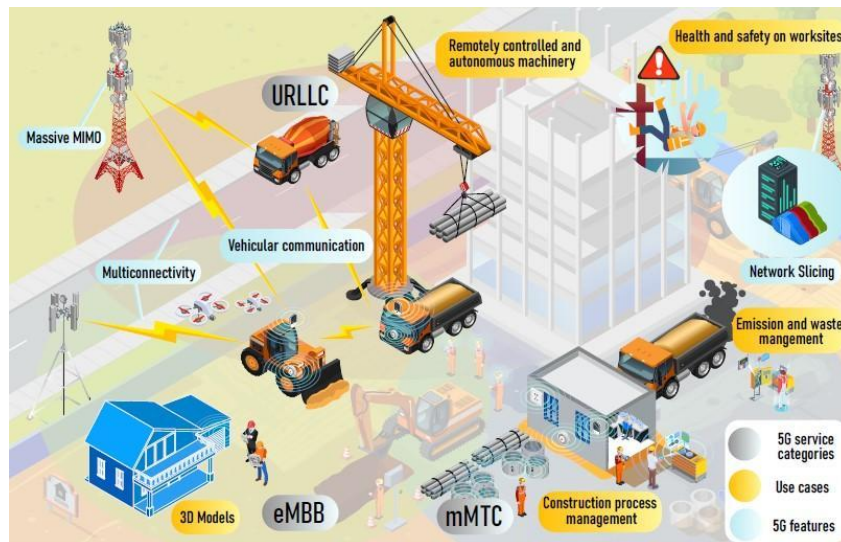
Long-range network such as LoRA or Sig Fox are characterised by providing low-power communications and a wide coverage radius, in the order of tens of kilometres. This type of technology provides the low power consumption of devices thanks to the efficient use of the bandwidth. However, these technologies might not be able to respond to all the requirements of this sector leading to the dependence on 5G/IMT2020

Examples of construction use cases are:

- Remotely controlled & Autonomous Machinery: Incorporation of autonomous machinery such as robotic operators or self-driven cranes and remotely controlled machinery such as bulldozers or excavators at worksites. These elements gather information from their environment such as video images or physical parameters through the use of sensors in real time. Based on the information collected, the actions to be performed by this machinery are decided. In the case of autonomous objects, the decision-making process is usually performed by the machine itself or by a control centre.

Remotely controlled and autonomous machinery are considered in the field of communications as mission-critical applications. In these types of applications, it is of vital importance to have a fast communication between the machinery and the decision-making entity. Fatal accidents may occur if the communication fails or if there are delays in the reception of the data. Thus, the main challenges posed by this use case are: the need to transmit and receive information at very low latency, between 1 and 10 ms, the high availability of the services, higher than 99.9999%, the reliability in the communication, and the need for a secure link. Here the data collected by the machinery is in the form of video induced with high bandwidth with a minimum data rate of 10 Mbps per connected machine.

Figure-2



6.4 Healthcare

One of the factors that set to contribute majorly in medicine and healthcare and add value to the life of the patient is with the introduction of 5G/IMT2020. IMT 2020 would not only come with significantly increased bandwidth, it would also be incredibly responsive due to low latency.

5G/IMT2020 advances in ultra-reliable low latency (URLLC), massive machine type communication (mMTC) and enhanced mobile broadband (eMBB) will be the way forward to provide health care services delivery across multiple applications.

Provision of flexible and convenient wireless connections to accommodate the health industry such as continuous provision of wide area coverage for ambulances sensors, home patients or in-hospitable equipment, assets as well as personnel management and monitoring.

Mission-critical medical functions, such as remote surgery, require high reliability and availability with latency intervals that are down to a few milliseconds; monitoring devices and wearable medical equipment will require long battery life comparatively low data rate transmission.

Enhanced mobile broadband applications, such as high-resolution imaging and video conferencing hold the potential to be used for diagnostic purposes. IMT 2020 will enable these requirements and bring consistent, reliable user experiences to improve medical care. The lower the latency requirements of a specific health application, the larger the bandwidth needed to send a given amount of data.

Examples of Healthcare use cases: -Wireless use cases wherein there is location of equipment (asset tracking)

-Connectivity of devices for data entry (e.g., tablets, laptops)

-Automated collection of biometric health data for patients (IoT)

-Remote surgery (long term objectives, which create precedents in AR/VR ‘assisted surgery’)

6.5 Mines

The development of mining is a gradual development process from mechanization to automation, digitization and intelligence. With the rapid advancement of industry digitization, the uplink demands of mining have gradually increased. Based on the IMT system, the digital transforming of the mining can be better carried out and the mining use cases will be fully developed.²

For any mine operator primary goals of deploying a communication solution can be summarized in the following:

- Prevent failures/breakdowns/unplanned downtime
- Enhance worker safety
- Improve efficiency
- Reduce energy consumption
- Meet environmental requirements

The modern mine is crowded with vehicles and machines performing a variety of tasks, both on the surface and underground: trucks, drills, trains, wheel loaders, and robots designed for specific tasks are all typical examples. Mines are high-risk environments, and the ability to move people and equipment from one place to another is key, given that certain areas can take a considerable time. The ability to move driverless equipment into place quickly, say following a blast, is a potential time-saver when people are not permitted into the area until fumes have cleared. Benefits like this, combined with the fact that mines are typically found in remote locations, have led the mining industry to become an early adopter and developer of remote machine operation.

Examples of mining use cases³:

-Intellectual mining production which is supported by IMT system in mining and production provides real-time transmission and interaction of data such as high-definition video surveillance, working conditions of devices, operating parameters and scheduling commands, various environmental indicators etc. This is followed by through the data analysis and devices control of intelligent centralized platform, the remote monitoring and control of working

² Source: ITU-R Document 5D/1064

³ Source: ITU-R Document 5D/1064

devices in mining and even realize unmanned mining and improve the production efficiency and the safety production level.

-Intelligent inspection in mine this is supported by IMT system and high accuracy positioning technology in mining, to meet the needs of intelligent inspection the real-time interaction of positioning and information of personnel and environmental monitoring data collection could be realized to meet the massive high-definition video data transmission requirements of environmental monitoring and safety protection and provide intelligent safety warnings for the entire mine and the entire process.

-Intelligent operation and maintenance based on AR which is supported by IMT system, the AR intelligent operation and maintenance systems have the function of real time data collection, real time positioning, multimedia interaction with voice and video proximity detection and tele-diagnosis. The device failure in mining could be located quickly with the help of AR equipment when the equipment is abnormal.

6.6 Oil Refineries

The Oil industry has been undergoing a tectonic shift and has been a pioneer in the adoption and deployment of technology. In the past, the oil and gas industry did not have data throughput needed to conduct real time monitoring in the field. The oil and gas sector operate hazardous production facilities.

With the advent of 5G/IMT 2020, it will become easier to monitor activities going inside the facility through a distance in real time via the remote operation of equipment as well as monitoring of leaks which are the routine applications, when it comes to inspection, servicing in an oil refinery.

Remote operation is highly applicable to this industry, but to fully reap the potential benefits, equipment must remain functional without the need for regular on-site maintenance, and this can be completed through remote operation which leads to a reduction in the need for people to work in hostile environments along with frequent maintenance visits which would negate this benefit.

Examples of Oil refineries use case:

- Higher efficiencies & reduced costs, since oil refineries produce vast amount of data, this data is waiting to be utilized, leading to information being produced on the equipment at the speed of milliseconds, henceforth leveraging this data productively is imperative. This can be achieved by 5G/IMT2020 & edge computing by enabling richer communication with the field workers by providing an augmented reality hard hat technician who bridges real-time advice on how to fix a piece of machinery, getting the job done safer & faster.

-Leakage detection & prevention ensuring steady use of equipment and reducing the chances of malfunctions. This can be achieved through sensors which are deployed capable of collecting information about unwanted gas leaks to avoid losses of human as well as other inf 5G will enable long distances communication – transmitting sensor data from remote offshore locations to onshore facilities for centralized monitoring in an efficient way. Advantage of 5G mobile network over existing communication technologies like Wi-Fi and 4G is the higher data transmission rate, lower end-to-end latency, ability to connect massive number of connection points, and consistent quality of experience.

6.7 Container Ports

Container ports are essential hubs of modern transportation and international trade, although the struggle to fully integrate automated systems into supply chain logistics. Container ports need an overhaul to reduce operational delays caused by vessel and truck congestion.

The 5G/IMT 2020 slice for the control unit needs to have a very high reliability as a failing connection to the central road traffic control management would stop the proper operation of the traffic light. This will lead to the improvement of port traffic management with a reliable and resilient network. Better traffic flow: Intelligent Transport system (ITS) Traffic light control, traffic lights are connected to the port's central road traffic control management through the 5G mobile network with a dedicated network slice. For the testbed, an existing traffic light control unit is equipped with the necessary 5G modem which supports network slicing.

Examples of Container Ports use cases:

-Every new traffic light in the port area is connected via fibre, and every modification requires considerable efforts to update or replace the corresponding underground cables. This also applies to the installation of new traffic control units (traffic lights, measurement equipment etc.).

-Improve port operations through Virtual/ Augmented reality applications for the port's engineering team, connected via mobile broadband. The 5G slice for the AR/VR-device should provide a high data throughput to enable a fast delivery of documentation and pictures or video material.

-Mobile sensors on barges for emissions measurement which leads to mobile sensors on barges for emission measurements. Environmental measurement sensors installed on ships which provide real-time data on the current air quality in the port area. The used prototype environmental sensor and control units, which generate a data stream of raw measurement data, are connected to the data Centre through the 5G/IMT 2020 mobile network with a dedicated network slice. The processing of the raw measurement data takes place within the data center.

6.8 Enterprises

5G/IMT 2020 introduces new enabling ways to work and solve traditional business challenges, organizations have long wanted a flexible and secure connectivity option for the enterprise.

Examples of Enterprises use cases:

-Fiber Alternative- IMT 2020 offers fiber-like bandwidth and latency capabilities but with significantly shorter deployment time as there is no need to lay cables to the office/branch. With this advantage, 5G can be positioned as a comparable alternative to fiber for the enterprise data network, provisioned much faster and acting as the primary business-grade solution. IMT 2030 can also be used as a primary connectivity for enterprises in their branch network, especially in cases where fiber deployment is challenging (e.g., rural areas). The technology can also enable enterprises to deploy an ad-hoc mobile branch for event exhibitions within a short timeframe.

-SD-WAN Evolution- With the possibilities around IMT 2020 around network slicing, there are other emerging areas for businesses such as the ability to set bandwidth and throughput preferences as well as quality of services/class of service for a WAN through network slicing. Along with the ability to logically partition networks, creates new environments compared with what has been possible to date through any previous fixed or mobile-based capability. Networks can be purpose-built for the use case (e.g., ultra-low latency and security) to be more responsive to the application and IT environments they support.

-Private Wireless Networks- There are a growing number of enterprises deploying sensors and remote equipment in private wireless networks. These highly customized networks require a secure environment, high bandwidth and remote deployment. For example, mission-critical communications for public safety require a dedicated network to minimize cybersecurity threats

6.9 Utilities

Utilities are representative public sector verticals, which reflect a huge group of organization interested in deploying their own private LTE and eventually private IMT networks. Therefore, it is imperative to deploy new applications that enable the utility to collect and use data from a wide variety of grid assets, including smart meters, gas sensors, voltage regulators, distributed energy resources (DER's) and drones. Other initiatives involve the rollout of new or enhanced workforce management, safety or other applications that connect to vehicles and field workers.

In both cases, utilities are depending on these initiatives to help them to release important organizational objectives including lower operation costs, improved grid safety and reliability, better customer engagement and more renewable energy generation. For these initiatives to succeed, connectivity with strong cyber security is essential.

Utilities facilities consist of expansive territories, stretching across hundreds and thousands of square miles. All potential IMT networks activities may impact power generation and delivery to consumers, with a sharp focus on outage prevention and/or fast outage recovery.

Examples of Utilities use case:

- Smart Grid- Means that the digital technology that allows for two -way communication between the utility and its customers, and the sensing along the transmission lines is what makes the grid smart. Smart grid should consist of controls, computers automation and new technologies and equipment working together,

- Distribution Automation (Volt/Var Optimization and Circuit Reconfiguration) this refers to digitized management of the electricity distribution network, leading to conservation Voltage reduction (CVR) mode.

- Cyber-Security- It is a critical requirement and consists of strong access control for personnel and devices, and active monitoring of all networking activities to prevent and protect against malware. Increased automation of grid networks, as well as dependance of large user communities and critical infrastructure on electricity has huge implications on cyber-security requirements of smart grids.

- Situational awareness- Includes detecting and correcting outages in the most optimal way possible. Early detection of location and cause of outage requires intelligent connectivity of devices as well as extensive telemetry and analytics.

6.10 Retail

In store experience augmentation which will in new customer experiences (such as Magic mirror) that help in the search for latest apparel and provide recommendations and customizations, this will help notifying the sale people or robots to fetch different items leading to enabling of face-to-face virtual assisted shopping with in-store AR enabled customer care who are able to access graphic-rich product information and support the consumer.

It also holds potential to help brick-and-mortar retail stores engage better with their customers and offer them integrated, personalized and immersive shopping experiences. Modern retail logistics are heavily reliant on internet-based functions such as package tracking, inventory distortion.

Retailers can also improve consumer labelling, in order to provide extreme personalization to consumers targeted with the right products and experience that will ensure the sale. Although this requires retail analytics technology to collect structured and unstructured information of a specific shopper and translate into actionable insight so that there is flow of recommendations. The data-driven insights provide customized and relevant services to the consumers such as real-time shelf displays, predictive inventory, and real-time integration of external data sources.

Examples of Retail use case:

1) Network strategy- Increasing their bandwidth to drive new applications and do more in their stores leveraging existing and new investments when 5G is ubiquitous. The 4G LTE and LTE Gigabyte-class cellular networks can address some of the use cases with emerging technologies and continue to be used for offloading network traffic and failover for years to come. Retailers can continue to use these networks even as they move down the path toward 5G.

2) Enterprise private network or SD-WAN (Software Defined Wide Area Network) as one of the enabling technologies to deliver a high-quality network experience tailored to the retailer while managing the transition to a complete end-to-end 5G infrastructure delivery. Network slicing for different retail groups for extreme personalization and targeting products or services

3) Mobile Edge Computing (MCE) Infrastructure Strategy- Edge computing strategy will play a critical role for retailers in 5G. The MCE can complement 5G Infrastructure in areas such as shopping malls. 5G and edge computing will remove the bottlenecks that exist today and widen the pipes in dense environments for information to flow in real-time.

6.11 Local community

6.11.1 Connected schools

During the (Covid-19) pandemic, to curb local transmission of Covid-19 infection within communities, some governments had to close their schools and implement home-based remote learning for their students. This raised a new challenge in the form of ensuring all students have online access to learning materials, instructors, and support.

In the USA some schools have risen to the challenge by deploying their own private broadband networks to bridge the digital divide and provide Internet service to students who are learning remotely, enabling students to access online learning programs from their own homes.

7. Regulatory and Security Aspects.

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7.1 Spectrum access (allocation/assignment) for local private networks

Increased use of local (small cell) private network deployments can expand wireless capacity within existing spectrum resources.

New spectrum allocation mechanisms may be needed to grant spectrum access to local area private networks to enable spectrum sharing by multiple networks operating in a portion of an IMT band.

Spectrum access mechanism to enable spectrum sharing and deployment of local area private network which have been implemented or being planned include:

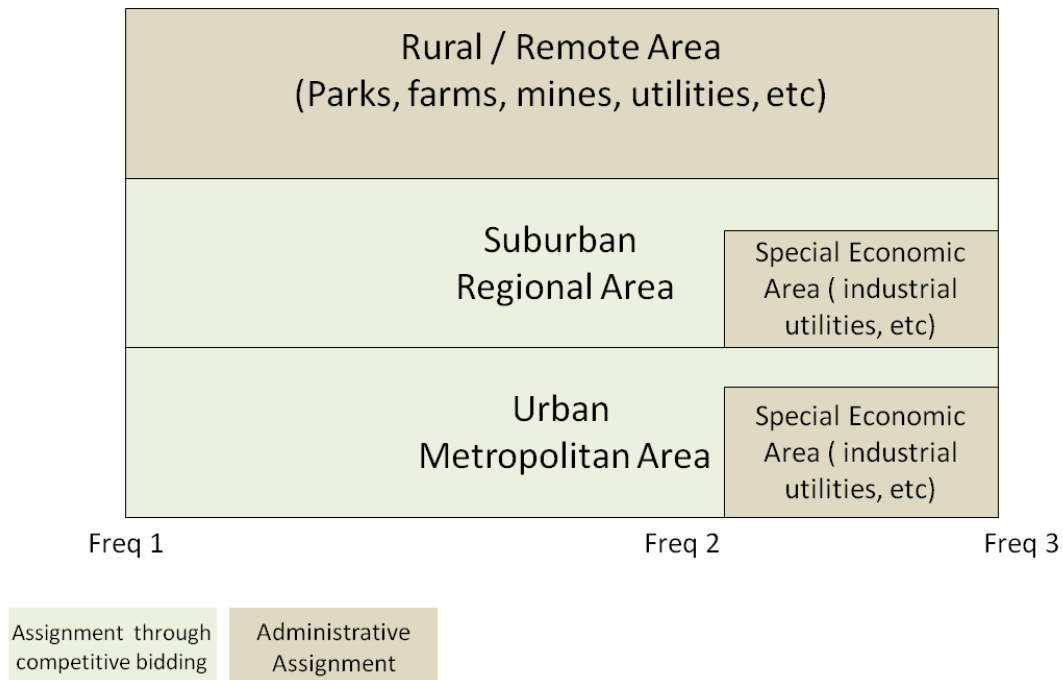


Figure 2: Assignment by competitive bidding in urban, suburban areas; administrative assignments in rural & special economic areas.

7.1.1 Localized Area and Geographically restricted Administrative assignments

A process whereby a part of a band or parts of a number of bands that are being harmonized for IMT is made available for local area licensing for private broadband versus the remaining part for typical wide area or nationwide licensing targeting commercial carriers. Depending on the frequency band of choice, the higher the band is, the smaller the area licensing can be considered. This would help enterprise customers to have rights to operate within a specific jurisdiction such as a land for a farm, seaport, airport, mining, school or enterprise industrial facility to be assigned frequencies to deploy NPN IMT based systems on a geographically limited and technically coordinated basis. Such users would be allowed through an administrative process to acquire the spectrum and operate it within the area of interest with minimal requirements on synchronization, power level and defined power flux density (PFD) limits. A number of administrations have opted for such scenarios where they award parts of mobile bands to commercial carriers nationwide or for large areas and reserve part of the band for local licensing to encourage enterprise customers to invest in advanced IMT technologies and owning their infrastructure with spectrum rights in bands that are protected from harmful external interference. The argument in favor of such licensing is that commercial carriers and enterprise and private users can benefit from the proliferation of infrastructure and device ecosystem and the commercialization of IMT based COTs for their industrial and societal applications that are geographically limited. The regulator would study the application for license and suggest technical and coordination arrangements to facilitate optimized use of the band, encourage innovation and advanced digital transformation while balancing the interest of commercial carriers and needs of private users.

IMT IDENTIFIED / 3GPP BAND



START FREQUENCY

END FREQUENCY

Figure 1: Assignment for local NPN by splitting a typical IMT band between nationwide or wide area licensing for commercial carriers and local assignments for private broadband.

9.1.2 Apparatus Administrative assignments

Administrative assignments, also known in some administrations as apparatus licensing, is a traditional method of assigning frequencies such as those to narrowband private land mobile radio (PLMR) systems⁴ in a number of countries. This method of assignment can be facilitated by establishing geographic zones: e.g., metropolitan, suburban and rural; and designating the frequency bands and zones in which spectrum licenses are issued through a first-come-first-served and use it or lose basis or even enable competitive bidding (e.g., auction) with small local areas if the demand exceeds supply. For example, a frequency band may be designated for spectrum auction in metropolitan and suburban areas, with a sub-band designated for special economic areas, and administrative assignments to apply to the whole band in areas/ zones not covered by competitive bidding assignment. (See Figure 1)

9.1.3 Dynamic spectrum access

DSA which stands for the possibility of a radio system implementing cognitive radio systems (CRS) capabilities to operate on a temporary or unused/unoccupied spectrum and to adapt or cease the use of such spectrum in response to the users of the band.

Cognitive Radio System is defined as a radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained.

Annex 1 includes examples of Dynamic Spectrum Allocation (DSA) methods adopted by some countries

10. Spectrum Aspects

⁴ Conventional and trunked land mobile radio systems such as analog FM, APCO P25, DMR and TETRA

Frequency Bands identified for IMT (MHz)	Footnotes identifying the band for IMT in the Radio Regulations	Available Bandwidth (MHz)
	Region 3	
450-470	5.286AA	20
470-698	5.296A	228
694/698-960	5.313A, 5.317A	262
1 427-1 518	5.341C, 5.346A	91
1 710-2 025	5.384A, 5.388	315
2 110-2 200	5.388	90
2 300-2 400	5.384A	100
2 500-2 690	5.384A	190
3 300-3 400	5.429F	100
3 400-3 600	5.432A, 5.432B, 5.433A	200
3 600-3 700	-	100
4 800-4 990	5.441B	190
24 250-27 500	5.532AB	3250
37 000-43 500	5.550B	6500
45 500-47 000	5.553A	1500
47 200-48 200	5.553B	1000
66 000-71 000	5.559AA	5000

Table 1: Frequency bands allocated to Mobile Service and Identified for IMT IN REGION 3,

10.1 IMT Frequency Bands

NPN IMT networks need to operate in the frequency bands identified for IMT in order to benefit from the economies of scale of the global IMT ecosystem. The choice of which frequency band(s) to use for local area networks is determined at the national level.

11. Summary

This new APT Report on new/emerging critical applications & use cases of IMT-Advanced and IMT-2020 for industrial, societal and enterprise usages, addresses capabilities of IMT and use cases, in particular for Non Public Networks (NPN) which may be designed for local-area coverage or virtual private networks on a public mobile operator network. This report is critical for today's industries, society and enterprises which generate and use a huge amount of data in real time, which is moved and consumed at enormous rates so as to harness the advantages of digital technologies. Until now, mobile connectivity has remained a critical barrier in order to realize the full potential of what is collectively known as Industry 4.0.

A new generation of private mobile broadband networks is emerging to address real-time reliable wireless communication requirements in the operations of industries and critical infrastructure. Users of NPN networks include government entities, private enterprises, public utilities and local communities.

The emergence of ultrafast mobile broadband technologies across low mid bands and in higher millimeter wave frequency bands provides manufacturers with the ability to deploy using common IMT platforms across multiple bands including licensed, lightly licensed and shared access spectrum. This flexibility and technology convergence enables much needed reliable connectivity solutions, enabling critical communications for wireless control of machines and manufacturing robots, and this will unlock the full potential of Industry 4.0. Taking manufacturing, with thousands of factories with more than 100 employees, as an example, typical business cases revolve around controlling the production process, improving material management, improving safety, and introducing new tools. Fortunately, 5G is available across

multiple bands and is being designed and developed to support deployment and use case configurations for private wireless networks to support Industry 4.0. The time is ripe for many industries to leverage private and captive mobile broadband to increase efficiencies and automation.

Apart from manufacturing, many other industries are also looking at IMT-2020 (5G) as the backbone for their equivalent of the Fourth Industrial Revolution. The opportunity to address industrial connectivity needs of a range of industries, including diverse segments with diverse needs, such as those in the mining, port, energy and utilities, automotive and transport, public safety, media and entertainment, healthcare, and education industries, among others.

Annex 1

Examples of Dynamic spectrum Allocation methods adopted by various Countries

1. Citizens Broadband Radio Service (CBRS)

In USA, the FCC established the Citizens Broadband Radio Service (CBRS) and created a three-tiered access and authorization framework to accommodate shared use of the band 3550-3700 MHz. Access and operations is managed through the use of an automated frequency coordination system, called Spectrum Access System (SAS).

The three tiers are made up of :

1st tier: Incumbent Access. Existing primary operations including authorized federal users and Fixed Satellite Service (FSS) earth stations. Federal users, e.g., Maritime Radars, will be protected from harmful interference from the CBRS users through geographic exclusion zones as well as dynamic blocking of CBRS use. FSS use will be protected by coordination zones around earth station installations, where CBRS use may be excluded or carefully monitored and regulated.

2nd tier: Priority Access License (PAL) users, such as mobile operators and other private entities such as enterprises can seek to receive priority authorization to operate within designated geographic areas based on census tracts and protected from harmful interference from the other 2nd tier users as well as 3rd tier General Authorized Access (GAA) users. Such PAL users are authorized using geographically delineated licenses that have 1-year terms and can be extended for up to 5 such terms.

3rd tier: General Authorized Access (GAA). Entitled to seek authorization from the SAS to use the spectrum on opportunistic basis and is not entitled to license guarantees or interference protection from other users. Users within certain Contained Access Facilities (CAF) such as hospitals, public safety buildings and local government buildings can reserve up to 20 MHz of spectrum from the GAA pool and need not seek 2nd tier status. These CAF can additionally restrict or deny third party use of the same spectrum within their premises.

The SAS is a cloud-based system and employs a database of all CBRS Service Devices (CBSD), including their tier status, geographical location, and other pertinent information from an environmental sensing capability (ESC) to coordinate channel assignments, manage potential interferences and authorize access to available shared spectrum. The ESC is a sensor network that detects transmissions from Department of Defense radar systems and transmits that information to the SAS. SASs will coordinate operations between and among users in the three tiers of authorization.