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Research Paper

Exclusive Studyon Radio Waves Advancement Trend and Future Development of Communication Sector

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Abstract. *Radio wave or more commonly known as radio frequency (RF) is the most used medium of communication in the form of electromagnetic force which transfers information between two or more destinations without physical connection of electrical conductor. Today Radio waves are generated artificially for communication by an electronic device known as transmitter that is connected to an antenna, and that radiates the radio waves. On the other hand, those waves are received by another antenna connected to a radio receiver, and that processes the received signal. Nowadays radio waves are extensively used in modern technology for fixed and mobile radio communication, radar and radio navigation systems, broadcasting, data link, communications satellites, wireless computer networks, command platform, military purpose and other applications. Radio wave is dictating today's civilization as in disguise and something more invisible wave will dictate future civilization beyond our imagination. Present world is the world of communication, where radio wave is playing vital role and become essential part of life. We cannot work in 21st century without extensive use of radio wave, and nowadays in any disaster, pandemic, and natural calamities, communication channels has to be established by using satellite, GEO, LEO or even drones. However, the future world will be unpredicted and more challenging. In future, concept like spaceX, neuro-technology, dark wave radio, quantum-technology, introduction of AI, ML and big data will innovate new and customer friendly communication device along with new business ideas. This is an analytical study on radio frequency and communication technology as a revolutionary subject to globalization and future ahead.*

Key words. *RF, NASA, CNSA, ICT, GPS, GMDSS, LEO, Satellite Stations,*

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I. Introduction

1. It is really astonishing for human is that, total creation process of universe as well as earth in so particular, vast and supper complicated, scientists and philosophers are still working on it and subject remain as never-ending. General people usually ask why the universe was created with more matter than antimatter. Answer lies in the question, why anything exists. The universe we perceive today is made exclusively of matter. There is no explanation for this fundamental asymmetry. When the universe began, the space was full of energy. Since energy can convert into matter and antimatter, as the universe cooled, the energy should have made equal portions of matter and antimatter. We have seen that, in Dan Brown's blockbuster novel 'Angels and Demons' it played a prominent role indeed. Antimatter makes up most of the mass in universe but each of them is theorized to have such a low mass. Because of that anti matter might spread out over kilometers with a speed of light or more. Quantum mechanics contends that every particle behaves like a wave and antimatters are also rippling all around us like a radio wave signal. Antimatter radio consisting dipole antenna and that will also transmit the electromagnetic radio wave produced by an antimatter with an opposite field polarity. Radio of regular matter antenna would still sense the electromagnetic wave with a phase difference of 180 degrees[1] and tuning of the radio has to be exceedingly sharp. Actually invisible radio wave is dictating today's civilization as in disguise and something more invisible wave will dictate future civilization beyond our imagination.

2. Radio-wave is a type of electromagnetic radiation[2] used asa longest wavelengths in the electromagnetic spectrum, typically with frequencies of 300 gigahertz (GHz) and below. [3] At 300 GHz, the corresponding wavelength is 1mm, which is shorter than the diameter of a grain of rice. [4] At 30 Hz the

corresponding wavelength is around 10,000 kilometers (6,200 miles) and that is longer than the radius of the Earth. Wavelength of a radio wave is inversely proportional to its frequency, as its velocity is constant. Radio waves travel in a vacuum like all electromagnetic waves at the speed of light, and in the Earth's atmosphere with a slightly slower speed.[5]Radio waves found naturally as it emitted from lightning or astronomical objects,[6] and are part of the blackbody radiation[7] and that emitted by all warm objects.Radio waves either cover short distance or few meters by using Bluetooth or very long distance or few thousands of kilometers by using deep-space radio communications. Radio wave encompasses various types of fixed, mobile and portable applications, including two-way radios (HF/VHF/UHF) for both Military and Marine purpose like cellular telephones, radar[8] (surveillance/tracking/3D radar[9]) and satellite communication or many new technologies yet to come.More examples of radio wave dependent devices are GPS, GMDSS, satellite television, Geostationary Satellite Station, Low Earth Orbit (LEO)Satellite Stations, etc.[10] Less common technique of achieving radio communication includes electromagnetic wireless technologies; like light, magnetic, or electric fields or sound.However, modern studies and research sectors are working to enhance the lightning fast communication by using unorthodox medium or even uses of antimatter or dark matter concept.

3. Radio waves are radiated by charged particles when they are accelerated.[11] Natural sources of radio waves include radio noise produced by lightning and other natural processes in the Earth's atmosphere,[12]and astronomical radio sources[13] in space such as the Sun, galaxies and nebulas. All warm objects radiate high frequency radio waves (microwaves) as part of their black body radiation.[14] Radio waves are produced artificially by time-varying electric currents, consisting of electrons flowing back and forth in a specially-shaped metal conductor called an antenna.[15] An electronic device called a radio transmitter applies oscillating electric current to the antenna, and the antenna radiates the power as radio waves. Radio waves are received by another antenna attached to a radio receiver.[16] When radio waves strike the receiving antenna they push the electrons in the metal back and forth, creating tiny oscillating currents which are detected by the receiver. From quantum mechanics,[17] like other electromagnetic radiation such as light, radio waves can alternatively be regarded as streams of uncharged elementary particles called photons.[18] In an antenna transmitting radio waves, the electrons in the antenna emit the energy in discrete packets called radio photons, while in a receiving antenna the electrons absorb the energy as radio photons. An antenna is a coherent emitter of photons, like a laser, so the radio photons are all in phase.[19] However, from Planck's relation, the energy of individual radio photons is extremely small, from 10−22 to 10−30 joules.[20] So the antenna of even a very low power transmitter emits enormous numbers of photons per second.[21] Therefore, except for certain molecular electron transition processes such as atoms in a maser emitting microwave photons, radio wave emission and absorption is usually regarded as a continuous classical process, governed by Maxwell's equations.[22]

4. Today’s engineers have speculated that antimatter-powered spacecraft might be an efficient way to explore the universe or a communication device might be communicating with higher speed than light. So, with such great technological advancement, there is a possibility of researchers from National Aeronautics and Space Administration (NASA) and China National Space Administration (CNSA) as they are trying to invent this rare antimatter particle” to bring hyper technological advancement. This is an analytical paper which evaluates and encompasses the chronological development of radio wave and revolution of radio frequency, along with future advancement of communication technology like dark matter, quantum technology and others diversified approach of communication. It will coverhistorical development of radio frequency, revolution of wireless communication,application onmobile communications and satellite communications, unorthodox approach of communication and impact on globalization due to radio based communication and future of communication technology.

ITU, Basic of Radio Frequency (RF) and Tactical Communications

5. The International Telecommunication Union (ITU) is a specialized United Nations organization that drives innovation in information and communication technologies (ICTs) in collaboration with 193 Member States. ITU is dedicated to linking the world. Information and communication technologies are used in practically every aspect of modern life, including commerce, culture, and entertainment, as well as at work and at home. Today, there are billions of mobile phone subscribers, nearly five billion television viewers, and tens of millions of new Internet users each year. Hundreds of millions of people utilize satellite services around the world, whether they are getting directions from a satellite navigation system, checking the weather forecast, or viewing television from remote locations. Every day, millions more people utilize video compression in mobile phones, music players, and cameras.[23] The International Telecommunication Union (ITU) is a specialty branch of the United Nations that works with 193 Member States to push for new ideas in information and communication technologies (ICTs). ITU works to connect people all over the world. Information and

communication technologies are used in almost every part of modern life, including business, society, and entertainment, as well as at work and at home. There are billions of people who use cell phones, almost five billion people who watch TV, and tens of millions of new Internet users every year. Satellite services are used by hundreds of millions of people all over the world, whether they are using a satellite navigation system to find their way, checking the weather report, or watching TV from far away. Millions of people use video compression on their cell phones, music players, and cameras every day.[24] ITU frequency bands include VLF, LF, MF, HF, VHF, and UHF. The radio spectrum is an essential component of the much larger electromagnetic spectrum, which includes not only radio waves but also light, infrared, ultraviolet, and other forms of radiation. Different wavelengths and frequencies indicate that the signals have different properties and can be utilized in a variety of ways, including long-distance radio communication, point-to-point radio communication, radio links that are more secure because they do not travel as far, satellite communications links, and many others.[25] Electromagnetic wave spectrum showing where the radio spectrum is located has been shown in figure 1 below.

6. Different frequencies and spectrum regions may be better suited to one type of radio use than another. These are terms such as LF, MF, HF, VHF and UHF, EHF, and so on, and they represent areas of the radio spectrum or radio frequency spectrum that most people are familiar with. The International Telecommunication Union (ITU) is a multinational body that governs radio spectrum utilization. However, in order to readily refer to different areas of the radio spectrum, the ITU divided the radio frequency spectrum into twelve distinct bands, which are not only numbered 1 to 12 but also given names.[26] The band designations were established when wavelength was the method for measuring the position of the signal in the spectrum; the radio spectrum is depicted in Figure 2 and Table 1 below. As frequency is used today instead of wavelength, the band boundaries are at points equal to 1 x 10n. For instance, the HF portion of the electromagnetic spectrum extends from 100 meters to 10 meters or 3 to 30 MHz These frequencies are specified by the ITU Radio Regulations. There were only nine bands originally, but as usage and prospective usage of the radio spectrum expanded, there are now twelve bands. These ITU frequency bands serve as the fundamental definitions of the various regions of the radio frequency spectrum and are accepted and utilized globally.

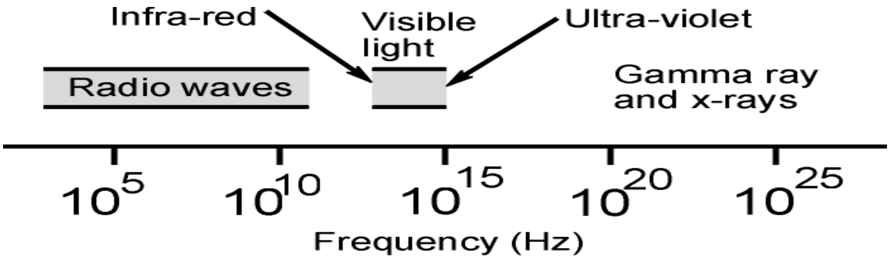

Figure 1: Electromagnetic wave spectrum showing where the radio spectrum is located[27]

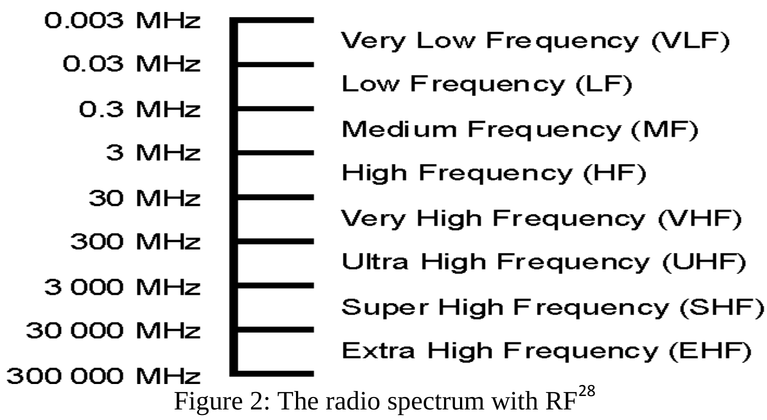

Figure 2: The radio spectrum with RF[28]

7. As we know that, Radio frequency (RF) is the oscillation [29] rate of an alternating electric current or voltage [30] or of a magnetic, electric or electromagnetic field [31] or mechanical system in the frequency[32] range from around 20 kHz to around 300 GHz. This is roughly between the upper limit of audio frequencies[33] and the lower limit of infrared frequencies.[34] These are the frequencies at which energy from an oscillating current can radiate off a conductor into space as radio waves,[35] so they are used in radio technology, among other uses. Different sources specify different upper and lower bounds for the frequency range. Plan for RF receiving and transmitting part for increasing performance of MWSCM for general use. Ant (antenna), Attn

(attenuator), BPF (band-pass filter), CLK (clock), Conv. (converter), IF (intermediate frequency), LNA (low noise amplifier), LNB (low noise block down converter), LPF (low pass filter), PLL (phase locked loop) synthesizer, RF Amp (radio frequency amplifier), β (phase difference) has been shown in a basic diagram below in figure 3.[36]

BAND NAME	ABBREVIATION	ITU BAND NUMBER	FREQUENCY	WAVELENGTH
Extremely Low Frequency	ELF	1	3 - 30 Hz	100000 - 10000 km
Super Low Frequency	SLF	2	30 - 300 Hz	10000 - 1000 km
Ultra Low Frequency	ULF	3	300 - 3000 Hz	1000 - 100 km
Very Low Frequency	VLF	4	3 - 30 kHz	100 - 10 km
Low Frequency	LF	5	30 - 300 kHz	10 - 1 km
Medium Frequency	MF	6	300 - 3000kHz	1000 - 100 m
High Frequency	HF	7	3 - 30 MHz	100 - 10 m
Very High Frequency	VHF	8	30 - 300 MHz	10 - 1 m
Ultra High Frequency	UHF	9	300 - 3000 MHz	100 - 10 cm
Super High Frequency	SHF	10	3 - 30 GHz	10 - 1 cm
Extremely High Frequency	EHF	11	30 - 300 GHz	10 - 1 mm
Tremendously High Frequency	THF	12	300 - 3000 GHz	1 - 0.1 mm

Table 1: ITU radio spectrum bands with their names, wavelengths and frequencies [37]

8. Tactical communications are military communications[38] in which information of any kind, especially orders and military intelligence,[39] are conveyed from one command, person, or place to another upon a battlefield, particularly during the conduct of combat. It includes any kind of delivery of information, whether verbal, written, visual or auditory, and can be sent in a variety of ways. In modern times, this is usually done by electronic means. The earliest way of communicating with others in a battle was by the commander's voice or by human messenger. A runner would carry reports or orders from one officer to another. Once the horse was domesticated messages could travel much faster. A very fast way to send information was to use drums, trumpets or flags.[40] Telegraphs helped theater commanders to move large armies about, but one certainly could not count on using immobile telegraph lines on a changing battlefield.[41] At the end of the 19th century the disparate units across any field were instantaneously joined to their commanders by the invention and mass production of the radio.[42] At first the radio could only broadcast tones, so messages were sent via Morse code.[43] The first field radios used by the United States Army saw action in the Spanish–American War (1898) and the Philippine Insurrection (1899–1902).[44] At the same time as radios were deployed the field telephone was developed and made commercially viable. This caused a new signal occupation specialty to be developed: lineman.[45]

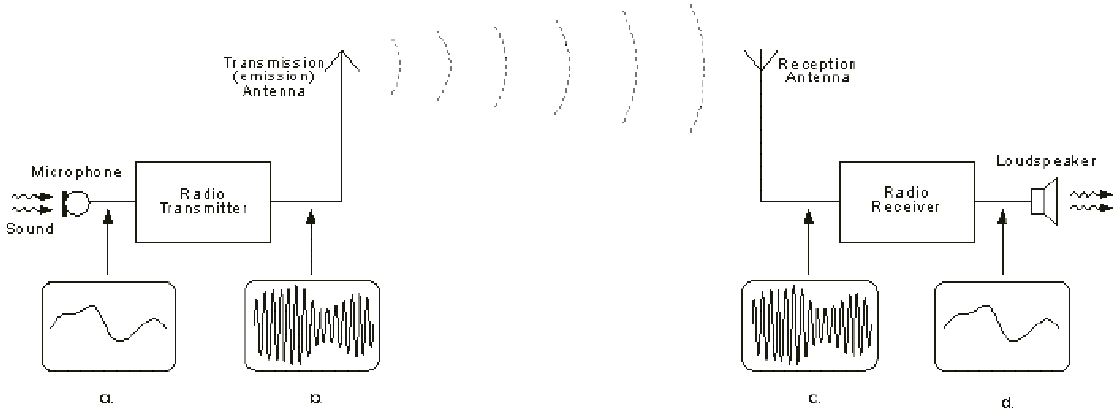

Figure 3: Basic diagram of radio frequency as and transmission and reception (sound radio)[46]

9. Security was a problem. If you broadcast your plans over radio waves, anyone with a similar radio listening to the same frequency could hear your plans. Advances in electronics, particularly after World War II,[47] allowed for electronic scrambling of voice radio. Operational and strategic messages during the war were by text were encrypted with ciphers too complex for humans to crack without the assistance of a similar, high-tech machine, such as the German Enigma machine.[48] Once computer science advanced, tactical voice radio could be encrypted, and large amounts of data could be sent over the airwaves in 'quick bursts of signals'[49] with more complex encryption.[50] Before the electronic age, it was much harder for forces to talk to each other. Messages had to be sent by messengers on horseback or on foot, which took time depending on how far the messenger had to go. Long-distance communication improvements helped the commander on the battlefield because they could learn about any outside force or factor that could affect the way a fight was fought.[51] In tactical communication, the major concerns are the network stability, network redundancy and network security (SRS). A stable network is relatively easy to achieve where communication nodes are distributed in end-to-end structure, for example LAN network using Optical or Ethernet connection, which is practicable in land based data sharing.

10. On the other hand, maritime platforms like warships mostly function as mobile Ad-hoc Network (MANET), where there is no end to end network infrastructure[52]. The same is true for air elements, whose constantly shifting positions at high velocity expose the network to constant connection and disconnection. Even land/army elements become mobile on the battlefield, and tactical communication within the nodes is frequently disrupted. Consequently, network redundancy is a significant challenge in military communication, and in particular tactical communication.[53] Radio communication networks, such as VHF/UHF for limited range and HF for long distance, are frequently insufficient to support tactical communication. Satellite Communication (SATCOM), despite its expense, has gained popularity as a network redundancy solution. In environments with no end-to-end network infrastructure, the incorporation of a hybrid communication system employing Disruption/Delay Tolerant Network (DTN) architecture could therefore be advantageous.[54] The DTN architecture is useful in environments where there is no end-to-end network infrastructure. The ability to forward messages to recipient nodes, taking advantage of node mobility, makes the DTN approach compatible with filling the gaps left by conventional networks[55]. However, all digital tactical communications systems[56] usually have few basic components; those are:

- A Data Source. This could be a sensor system like radar or a human operator entering command and control instructions or manual observations.
- A Data Processing and Display System. This collects coordinate information from the data source(s) and makes sure it meets the standards for release to the tactical About Synthesis offers services in military systems, training, systems and software engineering, technical management, and a wide range of other fields. Our new products and unique support and consulting services make us the first choice for both large and small businesses. The company was started in 1988, and its main goal is to solve common industry problems by combining technical knowledge with easy-to-use software applications. When it gets information, it saves it in local databases so that other integrated systems can use it. It is expected to have a user interface where the tactical communications system's settings can be changed.
- Cryptographic System (optional). The data being communicated is encoded by the cryptographic system, and in some circumstances, pseudo-random transmission characteristics (such as frequency hopping) are also introduced to increase resistance to jamming.

- Communications System. A modem, a radio transceiver, and an antenna are common components of radio frequency systems. The radio transceiver and antenna are obviously unnecessary for landline systems.
- Message set. In order to facilitate the sharing of parametric data, modern digital tactical communications systems use a standard set of messages.

On the other hand, a digital tactical communication system might support the following:

- Single direction data transfer (simplex).
- Two-way data transfer, but transfer in only one direction at any time (semi-duplex).
- Simultaneous two-way data exchange (duplex). Three basic types of connectivity are used.
- Point-to-point. A dedicated link between a pair of units, normally only issued between fixed Command and Control (C2) posts, or from C2 posts to a missile command post.
- Broadcast. Here, a single instrument will transmit data that will be simultaneously received by multiple participants. This is also a simplex transmission by definition, as the data transfer from the broadcasting unit to the recovery unit is unidirectional.
- Networked. This permits all units in the network to communicate with one another. Each transmitting unit can broadcast information to all other units on the network that has the right cryptographic keys, or it can address information to a specific unit, as in a point-to-point link. Data communications between fixed ground locations are supported by media land lines. These can be dedicated copper wires, although they are most commonly fiber optic cables. They are usually part of a multi-route pocket switching network. Satellite Communications (SATCOM) are increasingly being utilized to assist tactical communications, particularly with the emergence of man-portable devices capable of locating, connecting to, and remaining locked in to non-stationary satellites. Radio is most likely the most commonly used medium for tactical communications. Modern radios are dependable, portable, powerful, and simple to encrypt. Military tactical communications radios typically operate in the HF to SHF frequency bands designated by the International Telecommunications Union (ITU), with some very low frequencies used for submarine communications. VHF, UHF, and SHF are limited to line-of-sight (LOS), while some higher frequencies have shorter ranges due to atmospheric water absorption. HF has BLOS capabilities and can be used over great distances or in mountainous terrain, however it is also vulnerable to ionosphere effects.

History and Chronology of Development of Radio Wave

11. Before the invention of radio communication like telegraphy, usually communication has to be established between ships at sea by means of flags, hand signal, symbol, etc. So flags were flown to indicate particular event execution, like Flag BRAVO is flown when a ship is taking on ammunition. In 1864 James Clerk Maxwell projected his theory of electromagnetism by mathematical proofs. He showed that radio and x-rays were all sorts of electromagnetic waves oscillating through free space. Between 1886 and 1888 Heinrich Rudolf Hertz published his experimental result where he was able to transmit radio waves through the air and proved Maxwell's electromagnetic theory.[57] In the last decade of 19th Century Captain Henry Jackson of Royal Navy (RN) conducted an experiment with wireless telegraphy communication between ships in short distances. His work helped RN Ships to acquire front position in global Naval Fleet in the First World War (WWI).Virtually all major British Warships had transmitted and received information by using designated equipment based on this theory. During 1920s and 30s development of radio communication continued and just prior to the Second World War (WWII) rapid development took place in communication equipment design, which laid the fundamental development of today's communication systems.[58] At the beginning of 20th century, RN faces a new set of challenges in the field of communications. There have been astonishingly rapid developments and an enormous amount of investment has been observed in the civil communications (mainly broadcasting) sector. In particular there has been an explosion in the types, quantity and rate of data transmission.[59] Today data are routinely transmitted by fixed radio communication systems. The new techniques and technologies have allowed and continued to drive these communication developments and even filtering back through military sectors."[60]

12. The early history of radio is the history of technology that produces and uses radio instruments by use radio waves.[61] Within the timeline of radio, many people contributed theory and inventions in what became radio.[62]Development of radio began as wireless telegraphy. Wireless telegraphy or radiotelegraphy is transmission of text messages by radio waves, analogous to electrical telegraphy using cables.[63] Before about 1910, the term wireless telegraphy was also used for other experimental technologies for transmitting telegraph signals without wires.[64] Later radio history increasingly involves matters of broadcasting.[65] In an 1864 presentation, published in 1865, James Clerk Maxwell proposed theories of electromagnetism, with mathematical proofs, that showed that light and predicted that radio and x-rays were all types of electromagnetic waves propagating through free space.[66] Heinrich Rudolf Hertz in between 1886 and 1888 has published the

results of experiments wherein he was able to transmit electromagnetic waves (radio waves) through the air, proving Maxwell's electromagnetic theory.[67]After their discovery many scientists and inventors experimented with transmitting and detecting 'Hertzian waves'. It would take almost 20 years for the term radio to be universally adopted for this type of electromagnetic radiation.[68]

13. Maxwell's theory showing that light and Hertzian electromagnetic waves were the same phenomenon at different wavelengths led Maxwellian scientists such as John Perry, Frederick Thomas Trouton and Alexander Trotter to assume they would be analogous to optical light.[69] In 1894, the young Italian inventor Guglielmo Marconi began working on the idea of building long-distance a wireless transmission systems based on the use of Hertzian waves (radio waves), a line of inquiry that he noted other inventors did not seem to be pursuing.[70] Marconi read through the literature and used the ideas of others who were experimenting with radio waves but did a great deal to develop devices such as portable transmitters and receiver systems that could work over long distances, turning what was essentially a laboratory experiment into a useful communication system.[71] By August 1895, Marconi was field testing his system but even with improvements he was only able to transmit signals up to one-half mile, a distance Oliver Lodge had predicted in 1894 as the maximum transmission distance for radio waves. Marconi raised the height of his antenna and hit upon the idea of grounding his transmitter and receiver. With these improvements the system was capable of transmitting signals up to 2 miles (3.2 km) and over hills.[72] This apparatus proved to be the first engineering-complete, commercially successful radio transmission system[73] and Marconi went on to receive British patent 12039, Improvements in transmitting electrical impulses and signals and in apparatus there-for, in 1896.[74]

14. In early radio, and to a limited extent much later, the transmission signal of the radio station was specified in meters, referring to the wavelength, the length of the radio wave. This is the origin of the terms long wave, medium wave, and short wave radio.[75] Portions of the radio spectrum reserved for specific purposes were often referred to by wavelength: the 40-meter band, used for amateur radio, for example. The relation between wavelength and frequency is reciprocal: the higher the frequency, the shorter the wave, and vice versa. As equipment progressed, precise frequency control became possible; early stations often did not have a precise frequency, as it was affected by the temperature of the equipment, among other factors. Identifying a radio signal by its frequency rather than its length proved much more practical and useful, and starting in the 1920s this became the usual method of identifying a signal, especially in the United States.[76] Frequencies specified in number of cycles per second (kilocycles, megacycles) were replaced by the more specific designation of hertz (cycles per second) about 1965. Following development of transistor technology, bipolar junction transistors led to the development of the transistor radio.[77] In 1954, the Regency company introduced a pocket transistor radio, the TR-1, powered by a "standard 22.5 V Battery." In 1955, the newly formed Sony Company introduced its first transistorized radio, the TR-55.[78]It was small enough to fit in a vest pocket, powered by a small battery. It was durable, because it had no vacuum tubes to burn out. In 1957, Sony introduced the TR-63, the first mass-produced transistor radio, leading to the mass-market penetration of transistor radios.[79] Over the next 20 years, transistors replaced tubes almost completely except for high-power transmitters.

15. By the mid-1960s, the Radio Corporation of America (RCA)[80]were using metal–oxide–semiconductor field-effect transistors (MOSFETs) [81] in their consumer products, including FM radio, television and amplifiers. MOSFET is a type of field-effect transistor (FET), most commonly fabricated by the controlled oxidation of silicon. It has an insulated gate, the voltage of which determines the conductivity of the device. This ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals.Metal–oxide–semiconductor (MOS) large-scale integration (LSI) provided a practical and economic solution for radio technology, and was used in mobile radio systems by the early 1970s.[82]In the 1960s VOR systems became widespread. In the 1970s, LORAN became the premier radio navigation system. Then, the US Navy experimented with satellite navigation.[83] In 1987, the Global Positioning System (GPS) constellation of satellites was launched.[84]The development of metal–oxide–semiconductor (MOS)[85] large-scale integration (LSI) technology, information theory and cellular networking led to the development of affordable mobile communications. [86] The Advanced Mobile Phone System analog mobile phone system, developed by Bell Labs and introduced in the Americas in 1978,[87] gave much more capacity. It was the primary analog mobile phone system in North America (and other locales) through the 1980s and into the 2000s.

16. The Telecommunications Act of 1996 was the first significant overhaul in over 60 years amending the work of the Communications Act of 1934.[88] Coming only two dozen years after the breakup of AT&T, the act sets out to move telecommunications into a state of competition with their markets and the networks they are a part of.[89]Up to this point the effects of the Telecommunications Act of 1996 have been seen, but some of the changes the Act set out to fix are still ongoing problems, such as being unable to create an open competitive market. However, a radio-communication service in whichsignals transmitted or retransmitted by space stations are intended for direct reception by the general public.[90] In the broadcasting-satellite service, the term

“direct reception” shall encompass both individual reception and community reception. Artificial intelligence (AI) is likely to have an impact on the radio industry in the future, but the nature and extent of that impact is yet to be determined.[91]AI has the potential to bring many benefits to the radio industry, there are also concerns about the impact that it may have on employment and the role of human content creators in the industry. It's also important to consider that AI algorithms can perpetuate biases and perpetuate existing power structures, and efforts must be made to ensure that they are developed and used in an ethical and responsible manner.

Development of Radio Communication and Contribution to Civilization

17. Radio is an important medium at present day for both tactical and strategic communications especially for military forces. Radio is the only bearer which is capable of providing long range communications. Historically high frequency (HF) radio, very high frequency (VHF), ultra high frequency (UHF) was the only means to communicate beyond the line-of-sight communication. It was widely used by the military since last century. With change of time now Ship-to-shore and ship-to-ship radio communications systems are very useful for long time not only for military but also for merchant vessels. Over the last couple of decades these kind of communication devises like Radar of different types has become the essential part/equipment for modern time. In 1930s the use of radio waves to detect objects beyond the range of sight was first developed into a practical technology by British scientists and engineers. This new equipment, known as radar (Radio Detection and Ranging), would play a major role in WWII and continued today. “Radio waves are used to detect an object at a distance by transmitting a burst of radio energy and measuring the time it takes for the ‘echo’ caused by striking the object to return back to the receiver. The height and bearing (flight direction) of targets can also be identified. By the outbreak of WWII in 1939, a chain of early warning radar stations usually known as Chain Home (CH) Stations, had been built along the south and east coasts of Britain. Radar could identify incoming enemy aircraft from a range of 80 miles and played a crucial role in the Battle of Britain by giving air defenses early warning of German attacks. The CH Stations looks huge as the static installations with steel transmitter masts over 100 meters high. But the invention of the cavity magnetron in 1940, which produced much more powerful radio waves with a shorter wave length, allowed producing far more compact, powerful and sensitive radar units. This gave the Allies an important technological advantage over the Axis forces. Finally new communication equipment was developed rapidly for use in aircraft and ships and in land warfare.”[92]

18. Marine radars are X or S band are used onboard ships to detect other ships and land obstacles, to provide bearing and distance to avoid collision and help navigation at sea. Those are electronic navigation instruments that use a rotating antenna to sweep a narrow beam of microwaves around the water surface surrounding the ship to the horizon, detecting targets by microwaves reflected from them and generating a picture of the ship's surroundings on a display screen. “Radar is a vital navigation component for safety at sea and near the shore. Captains need to be maneuver their ships within feet in the worst conditions and need to be navigate "blind", when there is no visibility at night or due to bad weather. In addition to vessel-based marine radars, either in port or in harbor, shore-based vessel traffic service radar systems are used by harbormasters and coast guard to monitor and regulate ship movements in busy waters. Today, the recent trend is the incorporation of radar with other navigation displays on a single screen, as it becomes distracting to look at several different screens.[93] Therefore, displays can often overlay an electronic GPS navigation chart of ship position, and a sonar display, on the radar display.” This provides a combined view of surroundings and helps captain to maneuver the ship. “In commercial ships, radars are integrated into a full suite of marine instruments including chart plotters, sonar, two-way marine radio, satellite navigation like Global Navigation Satellite System (GNSS), the US Global Positioning System (GPS), and emergency locators like SART. With digital data buses to exchange data, these devices advanced greatly in the early 21st century. Today onboard ships 3D displays allow navigators to see above, below and all around the ship, including overlays of satellite imaging.”[94]GNSS, GPS, ISR (Intelligence Surveillance and Reconnaissance).

19. Military or naval radar systems are used by navies and maritime forces around the world “for surveillance at sea as well as, watching the skies and the water’s surface to detect, identify and track targets and possible threats. Maritime radar provides situational awareness and ISR support, whilst radar-guided missiles can also be used to intercept air and surface targets”[95]. For deeper subsurface inspections, three D (3D) radar provides for radar ranging and direction in three dimensions. In addition to range, the more common two-dimensional radar provides only azimuth for direction, whereas the 3D radar provides elevation. 3D Radars are most useful to weather monitoring, air defense, and surveillance both military and commercial purpose. Steered beam radars guide a narrow beam through a scan pattern to build a 3D picture. “Today’s Doppler weather radar (which uses a parabolic dish) and passive electronically scanned array radar used by the guided missile cruisers, and destroys with the Combat System.[96]Stacked beam radars transmit or receive multiple radio wave

beams at two or more elevation angles. By comparing relative powers of return beam, the elevation of target can be deduced."Good example of stacked beam radar is Air Route Surveillance Radar. In the 1970's AT&T Bell Labs develop cellular systems and continued to drive advancement in technologies, standards and spectral efficiencies with optimum prices which would lead to commercial acceptance. "Huge growth in the consumer sectors during the 1980's and 90's gave rise to the modern wireless mobile services as we know today. From then, until now, human race moved forward and tremendous growth occurred in the telecommunications industry as consumer's demand move faster, on more reliable connectivity. The development from 1G to 4G and now into LTE and beyond to 5G has accelerated the rate of advancement in most technologies."[97]

Mobile Communications and Comfort of Modern Society

20. Mobile Phone or media has focus of many inspiring studies on everyday mass communication changes in the recent few years. The recent development both on the technological and economic side brings further changes to media communication practices. The distinctions between mobile and computer-mediated, as well as between mobile and 'mass communication' have become distorted. Those developments challenge us to enable sustainable empirical research and to develop theoretical concepts that cover communication practices as well as social practices with technologies more deeply.[98] Mobiles have changed the way of communication which has been perceived by humans. Mobile phone is the answer of globalization, and global community. The mobile devices allow speedy communication in all forms and it made the world a smaller place. Rather than just vocal communication from a couple of decades ago, it is not possible to use a mobile device to send location, pictures and videos. Remarkably, they have become flexible in this area with something for all. Mobile phones are a blessing for long-distance relationships, while they help to achieve business tasks even when the whole mass of the Earth is in between. Mobile devices have also become a crucial device in safety, as statistical data reveals that Americans use mobile devices in 74% of the distress calls.[99] Today the use of data link is becoming more popular both business and military sector, because of its safer and secure transmission of data and information.

21. The radio wave technology and telecommunication sector has played the major and leading role in the realization for country like Bangladesh's vision of achieving 'Digital Bangladesh'. Since the industry started to grow, the mobile subscriber base has grown by 82%, from 86.6 million in 2012 to 161.2 million active subscribers in 2019 and that has been shown in figure 1 below. Today country's active mobile subscriber penetration reached a substantial 93.4% from a meager 30.6% in 2008. "The telecom sector is increasingly turning out to be an important sector in terms of economic growth, foreign investment, development of mobile financial institutions, and human development in Bangladesh. The country is now the eighth largest mobile market in the world in terms of subscriber base and is contributing almost 1.8% of total GDP. The telecom providers currently render two major services- voice calls and internet services. Revenue from voice calls is still being the major source of government revenue earning source."[100]

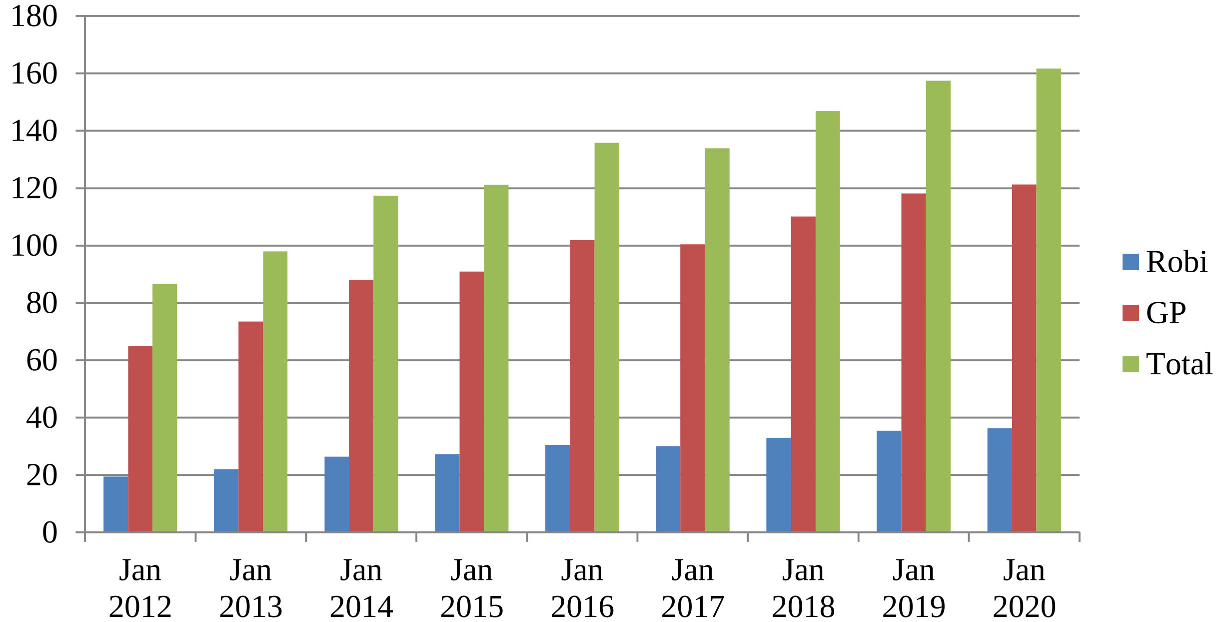

Figure1: Total Mobile Phone Subscribers of Major Operators in Bangladesh[101]

Data Communications and ICT Knowledge Economy

22. Knowledge has appeared as a leading determinant of economic growth and human welfare in 21st century. Knowledge is renovating at the same speedof new technologicaldevelopment and adopted its enhanced productivity to reduce overall cost. Now a day's economic agent obtains and captures relevant market knowledge at a fast pace and in a simple manner so that a quick decision can be made basing on the information at no time.More over people's welfare is also getting facilitated through advancement in medical sciences through knowledge transformation, contributing to increased life expectancy and health quality through preventive, diagnostic and curative measures. Again, "the focus on strengthening the Knowledge Economy (KE) is an integral part of any development strategy. An effective Information Communications Technology (ICT) helps transfer knowledge and facilitates transactions. Bangladesh KE is lagging behind globally and against competitors. As a young economy Bangladesh is still a long way to catching up to the standards of the global KE. The latest available ranking of the Knowledge Economy Index (KEI) prepared by the World Bank puts Bangladesh at the low end of 137 out of 146 countries. Other South Asian countries and competitors, like Vietnam and China, are ranked higher. Bangladesh is still lagging behind in ICT development and progress, in the global context. This is reflected in the global rankings development index done by the International Telecommunications Unit (ITU). The rankings show that as of calendar year 2017, Bangladesh ranks at a low of 147 out of 187 countries" and which has been shown in Figure 2 below.

Global Knowledge Economy Rankings			**ICT Development Index (IDI) 2017**		
Countries	**Score**	**Rankings**	**Countries**	**IDI Score**	**IDI Rankings**
Sweden	9.43	1	Iceland	8.98	1
Singapore	8.26	23	Korea (Rep)	8.85	2
Korea	7.97	29	Switzerland	8.74	3
China	4.37	84	Denmark	8.71	4
Sri Lanka	3.63	101	Sweden	8.41	11
Vietnam	3.40	104	Singapore	8.05	18
India	3.06	110	China	5.6	80
Pakistan	2.45	117	Vietnam	4.43	108
Nepal	1.58	135	Sri Lanka	3.91	117
Bangladesh	1.49	137	India	3.03	134
Myanmar	0.96	145	Nepal	2.88	140
			Bangladesh	2.53	147
			Pakistan	2.42	148
			Central African Republic	1.04	175
			Eritrea	0.96	176

Figure 2: Global KE Rankings and ICT Development Index[102]

23. The decomposition of ICT Development Index (IDI) illustrates that Bangladesh is trailing behind in the sub-index relating to the actual use of ICT services. These comprehensive data is advices that most countries of the world are accelerating faster than Bangladesh to make ICT services available for their citizens. ICT revolution progress can be measured in terms of three indicators: mobile internet subscribers per 100 people; the number of internet users per 100 people; and the percent of bandwidth subscription. Expansion of mobile phone subscriptions has been enormous, growing from a mere 6.4 subscriptions per 100 people in 2005 to 97.3 subscriptions per 100 people in 2018. This is a remarkable progress over a thirteen-year period. A statistics on substantial increase of internet user from 2011 to 2020 is projected in figure3 below, where data has been taken from BTRC of Bangladesh. Submarine cables are the vital and most curial part of global communication infrastructure. As the backbone for Internet and international communications, they carry more than 90% of all global voice and data traffic like telephone conversations, the Internet, emails, television, etc. With the world's bandwidth demand growing rapidly every day, capacity on underwater cable systems will only continue to increase over time, so we can only expect to see investment in submarine cable systems to increase as well. Global submarine cable network has been shown in figure 4 below.

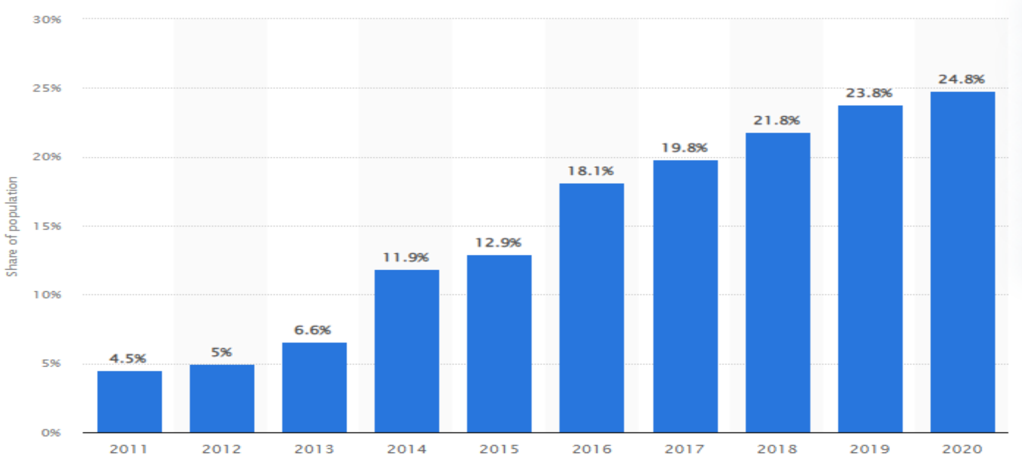

Figure 3: Substantial Increase of Internet User from 2011 to 2020[103]

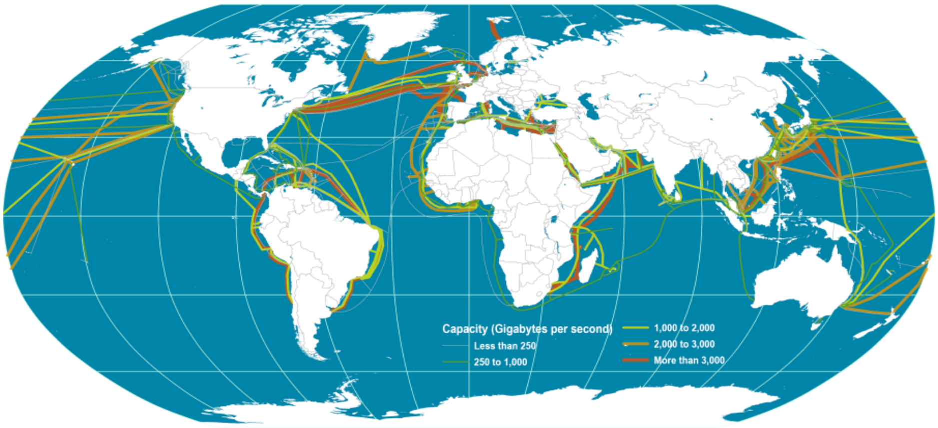

Figure 4: Global Submarine Cable Network[104]

Tactical Data Links (TDLs)

24. Military planning, decision-making, and command and control now necessitate large and expanding amounts of data. National security organizations must increase their ability to rapidly communicate and use massive amounts of information/data in order to improve situational awareness and support increasingly complicated military operations. Furthermore, this information/data is frequently gathered from geographically scattered devices. Tactical data links were created in accordance with particular specifications to facilitate sophisticated data exchange for military engagements. Military operators typically employ tactical data links (TDLs) to communicate important information that is optimized to meet the mission goals of TDL-equipped assets and their associated Information communication Requirements (IERs). The number of interconnected units and systems can be dramatically increased with multi-link operations. As a result, the complexity of the Joint Data Network (JDN) grows, necessitating careful network planning and administration. Link 16 and Link 22 are the most recent and advanced tactical data link networks. Both second-generation data lines were developed to address the shortcomings of first-generation data links. Link 22, for example, was created to replace Link 11. Among other things, it allows for Beyond Line of Sight (BLOS) communication. It was meant to work in more connected environments, complementing Link 16 and enhancing C5ISR capabilities.

25. TDL is a communication standard that employs multiple data channels for the transmission and exchange of tactical data between armed forces. It provides a secure network for military communications. IDM, Link 11, AFAPD, Link 16, Link 22, SADL, JREAP, VMF, and SIMPLE are examples of tactical networks. The network can be chosen based on the requirements of the application and the TDLs developed primarily by the United States and the North Atlantic Treaty Organization (NATO). For instance, Link 16 is utilized for LOS communication. Situational awareness is achieved using SADL. Link 22 is utilized for BLOS communications applications. Through TDL's secure communication military personnel are able to make

accurate decisions in life-or-death situations. Again, this useful high-tech technology integrates readily with a variety of military systems, thereby enhancing their capabilities. Therefore, the defense industry witnessed a surge in the replacement of traditional military communications systems with these real-time, secure links.[105]This aspect will drive TDL market expansion during the next decade. As we all know, the COVID 19 pandemic crisis has resulted in transit limitations and the closure of various production facilities for an extended period of time. These factors contribute to a slow growth rate between 2020 and 2022. TDL market growth, on the other hand, will accelerate in the post-COVID era and in the current global geopolitical environment.

26. Fortune-business-insights predicted that the TDL market will grow from USD 7 billion in 2022 to USD 12 billion in 2029, with a CAGR of 7.7%. When we looked at the world market share by platform, we found that around 42% of the ground platform, 33% of the air platform, and 25% of the sea platform used TDL. The market is divided into air, land, and sea platforms. The air section is expected to grow the most over the next ten years. This growth is because there is more desire. The rise of the segment will be driven by TDL radio for real-time communication between military personnel and the growing number of weapons and military vehicles bought by defence forces that can connect to networks. The Sea Segment is expected to grow a lot, and that will keep happening. This growth is caused by more money being spent on defence and more attention being paid to improving the naval sector because there are more wars going on. This helps the market grow. The marine section is likely to grow as more advanced frigates, destroyers, and other types of warships are made. Link 22 can be used for both LOS and BLOS communications. As the use of UGVs, UAVs, and UUVs for BLOS operations grows, the demand for Link 22 is likely to rise. Again, TDL will be used more in business and commerce in the future.

27. TDL systems are quickly becoming an essential component of modern military operations. It has the unique capacity to transport massive amounts of data quickly; it can manage data communication in critical environments while maintaining dependability and data security. As a result, a wireless hybrid network may be an effective complement to its radio frequency (RF) equivalent. Wireless system co-development can improve system performance in terms of data throughput, dependability, and redundancy for TDL, ensuring its optimal use in military communication systems. Furthermore, it can significantly contribute to secure data sharing within military services, paving the path for C5ISR. Again, efficient localization is critical in many modern applications of Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs), contributing to increased control, safety, and power economy, among other things. The ubiquitous 5G NR (New Radio) cellular network will open up new possibilities for improving the localization of UAVs and UGVs.[106]As we all know, modern armed forces have a lot of interoperability problems with data protocol, data encryption, transmission policy, hardware and software interface protocol, and heterogeneous hardware and software, and standardization of systems or systems (SoS) has become a must. With the use of standard, secure transmission links, any modern military, including those of many developing nations, may be able to close the gap.

Satellite Next Generation Communication

28. GPS is a system. It’s made up of three parts: satellites, ground stations, and receivers. Satellites act like the stars in constellations and we know where they are supposed to be at any given time. The ground stations use radar to make sure they are actually where we think they are. A receiver, like we might find in our phone or in our parents car, is constantly listening for a signal from these satellites. The receiver figures out how far away they are from some of them. Once the receiver calculates its distance from four or more satellites, it knows exactly where we are. From miles up in space our location on the ground can be determined with incredible precision! They can usually determine where we are within a few yards of our actual location. More high-tech receivers, though, can figure out where we are to within a few inches! The ancient sailors of history would be flabbergasted by the speed and ease of pinpointing your location today. The US Department of Defense launched GPS firstly in 1973 and called it NAVSTAR**,** exclusively using it for defence and military purposes with no provision for civilian use. Civilian use was partially and selectively allowed in the 1980s however, it was not until 2000 that it was common practice for the general public’s benefit. A full constellation of 24 satellites was put in orbit till 1995, given that the first prototype satellite was launched by the US Govt in 1978 with 23 more satellites inducted in the following years. Consequently, in 2000, it was made fully functional for public use. The space segment is the constellation of satellites (usually 24 to 32) which moves in a circular orbit around the earth. The GPS system is made up of a total of 27 satellites from which 24 are operative and 3 extra satellites are kept on standby in case of any functional error by the operational 24 satellites.[107] With this expanded constellation 9 satellites are visible at any time which certainly improves the reliability and accuracy.

29. The Global Positioning System (GPS) is a U.S. government satellite-based navigation system that currently consists of at least 24 operational satellites. Satellites act like the stars in constellations and we know where they are supposed to be at any given time. The ground stations use radar to make sure they are actually where we think they are. A receiver, like we might find in our phone or in our parents car, is constantly listening for a signal from these satellites. The receiver figures out how far away they are from some of them. Once the receiver calculates its distance from four or more satellites, it knows exactly where we are. From miles up in space our location on the ground can be determined with incredible precision. They can usually determine where we are within a few yards of our actual location. More high-tech receivers, though, can figure out where we are to within a few inches. The ancient sailors of history would be shocked by the speed and ease of pinpointing our location today.[108] GPS is a system. It's made up of three parts: satellites, ground stations, and receivers. GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription fees or setup charges. The U.S. Department of Defense (USDOD) originally put the satellites into orbit for military use, but they were made available for civilian use in the 1980s.

30. GPS satellites circle the Earth twice a day in a precise orbit. Each satellite transmits a unique signal and orbital parameters that allow GPS devices to decode and compute the precise location of the satellite. GPS receivers use this information and trilateration to calculate a user's exact location. Essentially, the GPS receiver measures the distance to each satellite by the amount of time it takes to receive a transmitted signal. With distance measurements from a few more satellites, the receiver can determine a user's position and display it electronically to measure our running route, map a golf course, find a way home or adventure anywhere in market, shop, hospital, station, etc.[109] Today, GPS is built in to all types of devices, such as smart-watches, satellite communicators, automobiles, boats and more. To calculate our 2D position (both latitude and longitude) and track movement, a GPS receiver must be locked onto the signal of at least three satellites. With four or more satellites in view, the receiver can determine our 3D position (like, latitude, longitude and altitude). Generally, a GPS receiver will track eight or more satellites, but that depends on the time of day and where we are on the Earth. Some devices can do all of that from your wrist.[110] Once our position has been determined, the GPS unit can calculate other information, such as: Speed, Bearing, Track, Trip distance, Distance to destination, Sunrise and sunset times and many more.

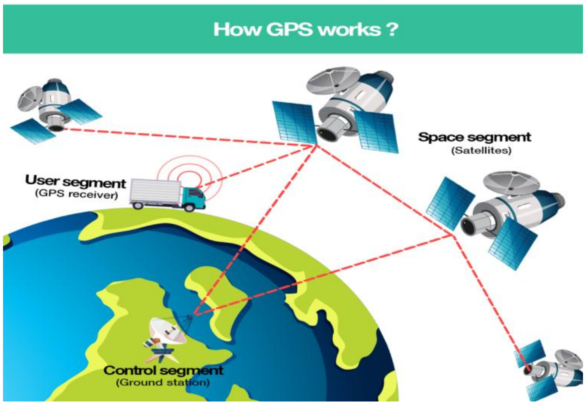

Figure 4: Working principal of GPS[111] and origin of GPS[112]

31. Today's GPS receivers are extremely accurate, due to their parallel multichannel designs. Our receivers are quick to lock onto satellites when first turned on. They maintain tracking locks in dense tree cover or in urban settings with tall buildings. Certain atmospheric factors and other error sources can affect the accuracy of GPS receivers. Garmin GPS receivers are typically accurate to within 10 meters. Accuracy is even better on the water because there are no obstructions to interfere with the signal. [113] WAAS is an extremely accurate navigation system developed for civil aviation. Before WAAS, the U.S. National Airspace System (NAS) did not have the potential to provide horizontal and vertical navigation for approach operations for all users at all locations. With WAAS, this capability is a reality. This capability can improve accuracy to better than 3 meters by providing corrections to the atmosphere and satellite position. No additional equipment or fees are required to take advantage of WAAS satellites.[114] The Federal Aviation Administration (FAA) and the Department of Transportation are developing the WAAS program for use in precision flight approaches. Currently, GPS alone does not meet the FAA's navigation requirements for accuracy, integrity and availability. WAAS corrects for GPS signal errors caused by ionospheric disturbances, timing and satellite orbit errors, and it provides vital integrity information regarding the health of each GPS satellite.[115]

32. At present there are 04 in no global navigation satellite system. Besides them a number of regional satellite systems are also there. Global navigation satellite systems are: NAVSTAR (or GPS) for US, GLONASS for Russia, Galillio for EU and BeiDou-2 for China. Comparison of GPS, GLONASS, Galileo, BeiDou-2 and COMPASS (medium Earth orbit satellites) orbits with International Space Station, Hubble Space Telescope, geostationary and graveyard orbits, and the nominal size of the Earth have been shown in below in figure 5. For this diagram, the 3-dimensional aspect of orbits has been flattened. For instance, the view of the Earth depicted is looking down to the North Pole which makes the orbit representations appear to be equatorial. While this is accurate for geostationary orbits, other orbits listed are actually at significant inclinations. The inclination of Iridium orbits is at 86.4° which is nearly perpendicular to the diagrammed plane. Looking down to the North Pole from this zenith, a polar orbit of 90° inclination would actually appear as a straight line.

33. There are other systems similar to GPS in the world, which are all classified as global navigation satellite systems (GNSS). GNSS is a generic term referring to all satellite navigation systems. Most Garmin receivers track GPS, GLONASS and Galileo, and some regional variations even track BeiDou and QZSS. These are sometimes referred to as multi-constellation receivers since they track and utilize multiple satellite constellations. Generally, we can expect a more reliable solution when we track more satellites. We could be tracking nearly 20 or 30 satellites with newer Garmin products. The 31 satellites that currently make up the GPS space segment are orbiting the Earth about 12,000 miles above us. These satellites are constantly moving, making two complete orbits in less than 24 hours. They travel at speeds of roughly 7,000 miles per hour. Small rocket boosters keep each satellite flying on the correct path. There are some other interesting facts about the GPS satellites.

- The official USDOD name for GPS is NAVSTAR.
- The first GPS satellite was launched in 1978.
- A full constellation of 24 satellites was achieved in 1994.
- Each satellite is built to last about 10 years. Replacements are constantly being built and launched into orbit.
- A GPS satellite weighs approximately 2,000 pounds and is about 17' across with the solar panels extended.
- GPS satellites are powered by solar energy, but they have backup batteries on board in case of a solar eclipse.
- Transmitter power is only 50 watts or less.

GPS is currently deploying Block III as its third-generation satellite.

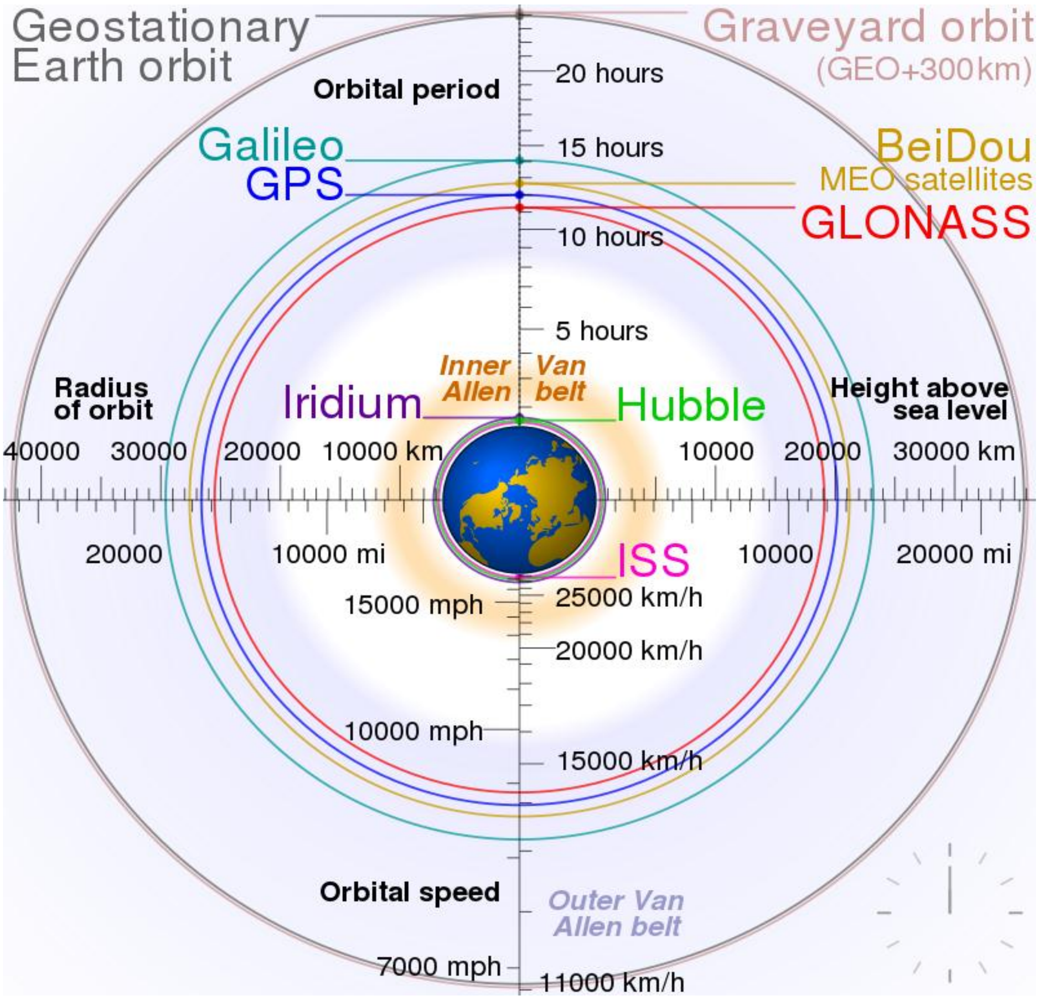

Figure 5: Comparison of navigation satellite in orbits[116]

34. The GPS market size was estimated at USD 37.9 billion in 2017. It is anticipated to progress at a CAGR of 18.4% during the forecast period. Increasing penetration of smart-phones along with rising GPS-enabled vehicles is projected to bolster the growth of the market during the forecast period. Moreover, surging use of social media across developing countries and a high number of mergers and acquisitions between component manufacturers and integrators are poised to stoke the growth of the global positioning systems market.[117] It is expected that the global GPS market will see significant growth in the near future due to increased use in the military, defense, and broad spectrum of civilian applications. The GPS device is used in a wide range of industrial applications and, therefore, has a positive influence on the GPS market. Transport, construction, aerospace, and farming are the GPS system's leading users. The adoption of GPS devices increases the operational efficiencies of these industries and helps cut down the overall operation expenses. Embedded GPS units in passenger vehicles guide travellers through unknown routes in the transportation industry. It is expected that increasing numbers of customers use smartphones with location-enabled services will stimulate market growth in the coming years. The emergence of high-speed mobile data technologies like 4G and 5G promotes the worldwide use of GPS, which is fueling the global market. Stringent policies and licensing, however, are some factors that hinder the growth of the overall market. Based on Deployment, the market is segmented into Consumer Devices, Automotive Telematics Systems, Standalone Trackers, Portable Navigation Devices and Others. Based on Application, the market is segmented into Location-Based Services, Road, Aviation, Marine, Surveying & Mapping and Others. GPS technology can be used in a wide range of applications like road, aviation, location-based services, marine, survey, and mapping.

Dark Matter and Future Radio

35. The universe is the most enigmatic creation of the Almighty or God. Another greatest enigma is how it was created and managed with such strict discipline. Today's wise individuals are aware that there is more mystery than knowledge in the cosmos. One aspect of the universe's expansion was largely understood in the

1990s. It may have an energy density sufficient to halt its expansion and because it to collapse, or it could have an energy density so low that it would never stop expanding. But as time passed, gravity would inevitably slow the expansion. We planned for the universe to slow, even if it had not yet been noticed. The gravitational attraction of all matter in the universe brings it all together. The Hubble Space Telescope[118] (HST) first revealed in 1998 that the cosmos was expanding more slowly than it is now due to observations of extremely far-off supernovae. As a result, contrary to what we previously believed, the universe's expansion has actually been accelerating. Nobody anticipated this and had an explanation for it. There was undoubtedly a reason. Finally, three different types of explanations were developed by scientists and thinkers. Perhaps it was a product of the cosmological constant, a long-forgotten interpretation of Einstein's theory of gravity. Perhaps there was a peculiar type of energy fluid filling the air. Alternately, there might be a flaw in Einstein's theory of gravity, and a new theory might incorporate a field of some sort that causes this cosmic acceleration. What is the most appropriate theory, which theorists are still unsure of? It's interesting that there was a solution, and it was called dark energy. Nothing except mystery surrounds it. According to scientists, dark energy makes up around 68% of the universe. Dark matter, however, makes up around 27% of the universe.[119]Only 5% of the cosmos is made up of the remaining regular matter, including everything else on Earth.

36. The idea that dark energy is a quality of space is one way to explain it. The concept that empty space is not nothing but rather full of something was originally understood by Albert Einstein. Amazing characteristics of space exist, many of which are only now being fully comprehended. The first characteristic that Einstein identified is the ability for new space to be created. Then, a second prediction is made by one interpretation of Einstein's theory of gravity, the interpretation that includes a cosmological constant: empty space can have its own energy. This energy would not be diminished as space expanded because it is a characteristic of space itself. There will be more of this energy of space as more space is created. This kind of energy would lead the cosmos to keep growing as a result. [120] Unfortunately, nobody knows why the cosmological constant should exist in the first place, much less why it would have the precise number necessary to explain the universe's observable acceleration. The quantum theory of matter offers another explanation for how energy is acquired in space. According to this hypothesis, the vacuum is actually filled with transient (virtual) particles that continuously develop and vanish. The calculation used by physicists to determine how much energy this would release into empty space was incorrect, though. The result was 10^{120} times too large. Getting an answer that poorly is difficult. The enigma therefore endures.

37. Dark matter is an invisible substance thought to be five times more widespread in the universe than regular matter. Theoretical analysis dictates that billions of dark matter elements pass through the Earth every second. We don't notice them, as they interact with regular matter only very weakly, through gravity. Researchers around the world have mostly been searching for dark matter particles. However, with the dark matter radio, researchers want to look for dark matter waves. On the other hand large underground detectors are required to detect dark matter particles experimentally. Researchers are anticipating to observe signals from dark matter particles colliding with the detector material. But this only works if dark matter particles are heavy enough to deposit detectable amount of energy during the collision. Peter Graham said, "If dark matter particles were very light, we might have a better chance of detecting them as waves rather than particles. Our device will take the search in that direction." He is a theoretical physicist at the Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, USA.[121] The dark matter radio makes use of a bizarre concept of quantum mechanics known as wave-particle duality: Every particle can also behave like a wave. The dark matter radio will search for particles in a mass range of trillionths to millionths of an electron-volt. It is known to us that one electron-volt is about a billionth of the mass of a proton. This is really problematic, as its range will be in kilohertz to gigahertz frequency band. But on the bright side, dark matter radio will not require any shielding to protect from cosmic rays. Whereas direct detection searches for dark matter particles and it may be operated in underground basement to block out particles falling from space. Researchers are eagerly investigating into dark matter particles now-a-days and planning to conduct their dark matter searches over the next few years around the universe[122]. We are waiting for the future results.

Unorthodox Approach of Communication

38. As per the theory of relativity explained by world famous scientist Albert Einstein's we can think of matter which can travel at a speed of light. Einstein's expressed that mass and energy are equivalent physical entity and can be changed into each other. In the equation $E=mC^2$, where E=kinetic energy of a matter, m=mass of that matter and C=speed of light. On the other hand technology is advancing at its own pace and the differences are quite surprising for both defense and commercial point of view. An astonishing example can be the drawn from thefigure6 as shown below. Picture of latest Webb Telescope (in James Webb Telescope) looks

superficially three dimensional compare with previous Hubble Telescope (looks like 2D picture).In 1928, British physicist Paul Dirac predicted antimatter while trying to combine quantum mechanics. Interestingly, his concept can describe subatomic particles, and Einstein's theory of relativity. Dirac was looking at a solution to an equation that described the movement of an electron traveling near the speed of light. "Just as the equation $x^2 = 4$ can have two possible solutions ($x = \pm 2$), so Dirac's equation could have two solutions, one for an electron with positive energy, and one for an electron with negative energy, according to CERN. Primarily, Dirac was hesitant about sharing his findings. But eventually, he embraced them and said every particle in the universe should have a mirror-image particle that behaved like it but had an opposite charge."

39. Positrons were discovered a few years later by an American physicist Carl Anderson at California Institute of Technology, "who was studying highly energetic cosmic rays that come from space and hit Earth's atmosphere, producing a shower of other particles. In his detector, Anderson witnessed a trace of something with the same mass as an electron but with a positive charge. An editor at the journal Physical Review suggested the name positron for the particle, according to the American Institute of Physics. Dirac and Anderson received the Nobel Prize in physics for their discovery (Dirac in 1933, and Anderson in 1936). "Because putting matter and antimatter together produces energy, engineers have speculated that antimatter-powered spacecraft might be an efficient way to explore the universe[123] or a communication device might be communicating with higher speed than light. Because of these futuristic technological advancement possibility researchers of National Aeronautics and Space Administration (NASA) and China National Space Administration (CNSA) is trying to invent this rare anti matter particle" to bring hyper technological advancement. Neurotechnology is the new concept, which encompasses the method or electronic device which interfaces with the nervous system to monitor or modulate neural activity. Usual design goals for neurotechnologies may "using neural activity readings to control external devices like neuroprosthetics, altering neural activity via neuromodulation to repair or normalize function affected by neurological disorders, or augmenting cognitive abilities. In addition to their therapeutic or commercial uses, neurotechnologies also constitute powerful research tools to advance fundamental neuroscience knowledge. Few examples of neurotechnologies are deep brain stimulation, photostimulation based on optogenetics and photopharmacology, transcranial magnetic stimulation, and brain–computer interfaces, such as cochlear implants and retinal implants." So, future thinking and invention of technologist/engineer will be something new and astonishing. Future world of communication will be beyond our imagination.

Figure 6: NASA Hubble and James Webb Telescope Side by Side Picture[124],[125]

Utilization of Quantum Technology (QT) in Intelligence and Future Warfare

40. Quantum Computers (QCs) have several advantages over classical computers in terms of processing power and speed. On the other hand, QT is an emerging field of physics and engineering based on quantum-mechanical properties, especially quantum entanglement, quantum superposition, quantum tunneling, etc. The second quantum revolution has characterized by scheming individual quantum systems like atoms, ions, electrons, photons, molecules or even quasi-particles are allowing to reach the standard quantum limit to measurement accuracy at quantum scales.[126] Science is increasingly succeeding in taking control of this world. Our society and economic future can be shaped by considerable amounts of capital need to be invested in the research of small but important things. The quantum communication with its inherent secures data transmission to QTs with unimagined processing power and to quantum simulations of chemical reactions and to quantum sensors for medical diagnostics will revolutionize those fields. At present 'engineers are driving the second quantum revolution's wave of metrological possibilities; with the next generations of atomic clocks, even more precise electrical standards and innovative measurement capabilities in medicine as well as engineering fields.[127] To properly understand the potential benefits, we will divide QTs into three categories: 'quantum

computing, quantum networks and communications, and quantum sensing and imaging.' Actually QTs will dominate the future warfare in many aspects.[128]

Figure 7: QT will change our future by introducing new idea like'big brains podcast' 129

41. Quantum computing represents universal programmable QCs, quantum annealers (an imperfect adiabatic computation), and quantum simulators which can provide considerable computational advantage over classical computers. However, despite the common misconception that the exponential increase in processing speed will affect and take over all the classical computers tasks and applications, QCs will definitely be efficient in certain highly complex and challenging computational problems; like quantum simulations, quantum crypto-analyses, faster searching, faster solving of linear or differential equations, quantum optimizations, quantum-enhanced machine learning, etc.[130] The object of quantum networks and communications is to transmit quantum information across various channels, such as fiber-optic lines or free-space communication. The next-generation quantum network, known as QIN or quantum internet, differs in its ability to distribute entangled qubits. In future QIN will offer more services related to security, such as secure identification, position verification, and distributed quantum computing and those are useful in military application. [131]

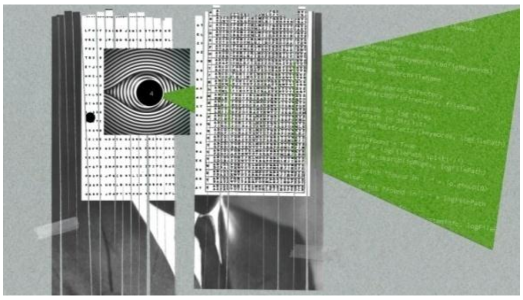

Figure 8: Security Agency spies are trying to shape the future by usingcryptanalysis and QT [132]

42. Quantum sensing aims for more precise measurements of various physical variables such as magnetic or electric fields, gravity gradients, acceleration rotations, and time. Improved time measurements can be used for more precise clocks, quantum inertial navigation, underground and undersea exploration, more effective radio frequency communication, etc. Quantum sensing is the most developed QT, but the effectiveness of deployed sensors is still very uncertain.[133] But, military applications require a portable or mobile solution with low SWaP (size, weight, and power). Again, the spatial resolution of quantum sensors needs to improve, as it is often inversely correlated with sensitivity.[134]In future, detecting a submarine from space may be possible, but using a quantum sensor with a useful degree of precision is unlikely since sufficient spatial resolution will lead to insufficient sensitivity. So, quantum sensing willrevolutionize the future warfare in the field of detection, monitoring and controlling. Future C^5IRS (Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, and Reconnaissance) will be highly influenced by QTs.

43. Quantum imaging is a subfield of quantum optics that is active compared to quantum sensors. We know that for any sensor, the Signal-to-Noise Ratio (SNR) represents the fundamental limit of its sensitivity. But, a significantly higher SNR can be reached using quantum entanglement, as the signal itself may be unrecognizable in the background noise without additional knowledge of entanglement.[135] Quantum imaging can improve the existing technology, such as quantum radars, three-dimensional cameras, around-the-corner cameras, gas leakage cameras, and low-visibility vision devices. Post-Quantum Cryptography (PQC), also

known as quantum-resistant cryptography, is nothing quantum at all but an evolution of the present asymmetric cryptography. PQC relies on more advanced mathematics that is more difficult to compute, even for QCs. In future PQC will be available and resilient against quantum attacks. As example, based on the National Security Agency (NSA of USA) recommendation, the White House published in 2022 a memorandum providing directions for agencies to start the migration to PQC with full implementation by 2035.[136]

44. As in the past with other technologies, defense applications are again the primary drivers of research and development in the field of QT, particularly in the USA and China, mainly in the air and space domains. Actually, QT has promising potential with real transformational aspirations. But, due to its complexity it is still poorly understood by non-specialists and its importance is often exaggerated and hyped. 'Quantum radar is a quantum imaging system that works similarly to classical radar but at the level of individual photons. Theoretically, it offers various advantages such as higher noise resistance, stealth property as extremely low intensity, low probability of detection, and possible target identification. The principles of quantum LIDAR (light detection and ranging) or RADAR were already demonstrated successfully in laboratories. However, space-based quantum LIDAR applications in the optical regime remain viable in the medium-to-long term.'[137] Conversely, more precise quantum or optical atomic clocks can improve the performance of current radars and electronic warfare systems. So, in future warfare in the field of detection and stealth technology, QTs will play a vital role.Free-space quantum communication will be an important channel for future quantum internet and will lead to a higher presence of quantum communication assets in air and space. The situation will change with the arrival of reliable quantum memory and high-rate quantum optics. Then, quantum internet with significant space presence may start to build up after 2030. In the future, there is an opportunity to implement quantum communication with laser communication where significant technological overlap exists. Laser communication would offer high-speed data transfer secured by quantum communication.[138] Quantum communication technology will revolutionize the whole communication system by increasing speed and user friendly application.

45. One of the most interesting applications for QT is Intelligence, Surveillance, and Reconnaissance (ISR). Individual QTs offer various sensing and imaging systems that significantly improve the extant ISR systems.[139] Quantum magnetometers and gravimeters are two good examples. Quantum magnetometers detect magnetic fields, such as local magnetic anomalies or weak biological magnetic signals. Quantum magnetic sensors are under development for detecting metallic objects generating local magnetic anomalies, such as mines, improvised explosive devices, submarines, camouflaged vehicles, and rotating machinery through walls. They can also serve as an alternate method of underwater navigation.[140] So, this technology will revolutionize the underwater and submarine and subsurface warfare. In future detection of submarine may be easier than present. Quantum gravimeters are in under development stage for underground surveillance systems and are already tested for detecting underground structures like caves, tunnels, bunkers, ammunition store, secret military assets, research facilities, missile depots, etc. In future, detection of key points and enemies' important location, as well as precision attack on target places will be easier than before due to better utilization of QTs. So, both types of discussed sensors could be deployed either on airborne systems or on space assets in low Earth Orbit in close future. So, in future QT will be useful tools to dominate space technology and better utilization of space resources.

46. The closest QT to real deployment is the quantum radio-frequency (RF) receiver. 'For military use, quantum RF receivers could enable reception of advanced Low Probability of Intercept/Low Probability of Detection (LPI/LPD) communications and over-the-horizon RF signals, resistance to RF interference and jamming, RF direction finding, and terahertz frequency imaging.'[141] In the future, quantum RF receivers can become the standard RF receiver for multiple systems, such as 5G and the Internet of Things (IoTs). Quantum imaging systems could further serve in Intelligence, Surveillance, Target Acquisition, and Reconnaissance roles. These include all-weather, day-night tactical sensing in long/short-range, active/passive regimes, and stealth detection modes. They can work as low-light or low-SNR vision devices in environments with clouds, fog, dust, smoke, and jungle foliage or at night.[142] So, QTs will ease the future warfare for detection, Intelligence, Surveillance, Target Acquisition, and Reconnaissance process as a whole. Quantum inertial navigation is another relevant technology for the air domain and is analogous to classical inertial navigation but using quantum sensors.[143]'Individual parts are being tested in laboratories and relevant environments with stabilities sufficient for military use. However, creating a complete quantum inertial measurement unit is still challenging. The first users will probably be submarines with the least restrictive SWaP parameters.'[144] In future, we can expect more miniaturization and deployment in planes, drones, and missiles. So, QTs will help for precision targeting and attacking system and may add another dimension in future warfare.

Impact on Globalization by Wave Communication

47. When a disaster strikes it obvious that communication channels might be down. But,if the communication channels can be established using GEO, LEO or even drones then during natural calamity or disaster like COVID-19, communication uncertainty will not arises. At that point communication will play a vital role to sustain world’s economy and to prevent the chaos. The number of broadband users has increased dramatically since the outbreak of Covid-19 pandemic as people had to rely heavily on internet to communicate, work and study. Country like Bangladesh, broadband users becomes more than doubled since February 2020. Bandwidth consumption witnessed a remarkable spike during COVID-19 pandemic. Almost 3,850 Gbps was used in June, up from 1,000 Gbps before the health crisis erupted, according to the BTRC.[145]On the other hand, it compelled the employment market to downsize the organization strength.[146]During the Covid-19 pandemic the number of customers going online to purchase led to a spike in e-commerce transactions. According to Statista, in June 2020 there were almost 22 billion visits to retail sites Interestingly Plus this online behavior shows no signs of slowing down post COVID.[147]

48. Today content comes to us in many forms like, blog posts, videos, podcasts, infographics, ebooks, case studies, newsletters, free tools, even social media status updates.[148] One of the best ways to obtain and retain leads is via a tried and tested method is email. Email is one of the oldest forms of direct marketing and still packs a punch in customer acquisition and retention. From startups to multinational corporations, a great email marketing strategy helps launch successful campaigns. An experienced digital marketer knows that each funnel stage has to be carefully planned. On the other hand, over two-thirds of the world's school-age girls and boys aged 3-17 years (around 1.3 billion children) and 63% of youth aged 15-24 years (around 760 million youth) lack Internet access at home, according to the joint UNICEF/ITU report. Again, globally, 2.2 billion children and young people aged 25 years or under do not have access to the Internet at home. In least developed countries (LDCs), only 22% of households have Internet access at home, compared with 86% of households in developed countries. One of the main barriers to Internet uptake is people's lack of capacity and skills to use online platforms and resources to best advantage.[149]

49. With the pandemic, we have come face-to-face with the future, and we have to start accounting for it. Work Stations has completely transformed today with remote work stations, e-commerce, automation, IoT, Artificial Intelligence (AI), ML, etc. In the postCOVID scenario, it is estimated that every 1 in 16 workers may have to switch their occupations in LDC and developing by 2030. This number is estimated to be even higher in advanced economies.[150] A large number of people have recently become jobless while many more are at the door of unemployment. Particularly, the poor segment of the population who have very small or no saving is the worst victim of the economic meltdown. It is estimated that COVID-19 and ongoing Ukraine crisis has pushed 16.5 million people mainly rickshaw-pullers, transport workers, day laborers, street-vendors, hawkers, construction laborers, service sectors like bank, shop, travel agency, hotel, motel and restaurants workers are severely affected with poverty. Technical education and skilled based work force are the suitable option to solve the unemployment problem for LDC and developing countries. Country needs to change the whole education strategy and policy in line of future advancement of technology; otherwise general mass will remain unemployed. Present world is looking for skilled and technical people and ready to pay high wage. We need to developed skilled manpower. LDC and developing countries should prepare her to phase the future challenges.

50. Digital skills are the key to digital transformation and a significant enabler of each country's digitization. Instilling the necessary skills has become a key part of national digital transformation strategies. Strengthening digital skills will narrow the global digital divide. Among the main reasons why people are not using the Internet in developing countries is the lack of capacities and skills, either to use technologies or to benefit from the information and services available online. Job seekers with digital skills generally have greater success in finding employment. In Europe, nine out of ten future jobs will require digital skills. Today, with social media sites galore, most students are already digital citizens. However, by incorporating technology into the classroom, students can learn how to be responsible in the digital world and with their digital actions. The class becomes a microcosm of the broader digital landscape where students can practice communicating, searching, and engaging with other digital citizens.[151] Utilize educational game websites or apps that offer interactive quizzes, puzzles, and challenges related to the subject matter. This engages students in a fun and competitive environment while reinforcing their learning.[152] However, it’s essential to ensure that students are guided on effectively searching for information, critically evaluating sources, and using technology responsibly. Digital skills are crucial for businesses across industries that want to raise brand awareness, offer great social customer service, generate leads, and increase revenue.[153]

51. On the other hand, as advanced digital skills become more important for employment, some experts foresee a 'talent gap' for workers with or without advanced digital competencies. The growing need for ICT-qualified workers is exacerbated by various socio-economic inequities, such as the lack of Internet access for many people at home. Even before the pandemic, digital skills gaps existed in both developed and developing economies, with different wage levels and job options for workers with basic, intermediate or advanced skills. Green and digital transitions could create about 60 million new jobs worldwide over the next five years (as per European Commission report, 2020). The APEC (Asia-Pacific Economic Cooperation) Closing the Digital Skills Gap survey shows 75% of respondents and comprising employers, government officials and academics and noting a significant skills mismatch, while over half say government agencies have a weak understanding of the digital skills landscape. An estimated 37% of the world's population is still not using the Internet at the end of 2021, according to the ITU data. In developing countries, some 43% of the population remains offline, rising to 73% in the world's 42 least developed countries (LDCs). This stands in stark contrast to the highly digitized economies and societies seen in middle- and higher-income countries.[154]

II. Conclusion

52. Radio Communication is the fastest growing and most vibrant technological areas which have brilliant and bright future. Radio Communication is a method of transmitting information from one point to other, without using any connection like wires, cables or any physical medium.Generally, in a communication system, information is transmitted from transmitter to receiver that is placed over a limited distance. With the help of Radio Communication, the transmitter and receiver can be placed anywhere between few meters to few thousand kilometers. Today's world is the world of communication, where radio wave is playing the very important role and become the part and parcel of life. We cannot think our modern time without the use of radio wave as it is acting as pivoting tool of civilization. By adding matter and antimatter together we may produces some special energy. Today's engineers have speculated that antimatter-powered spacecraft might be an efficient way to explore the universe or a communication device might be communicating with higher speed than light. So, with such great technological advancement, there is a possibility of researchers from NASA and CNSA as they are trying to invent this rare anti matter particle" to bring hyper technological advancement. According to the International Labour Organization (ILO), ICT related industries saw the strongest growth in employment during the pandemic. Demand for communication technology and device as well as digital, IoT, AI and ML skilled workers will continue to grow as the digitization along with smart world accelerates across all industry and science sectors. While digital, automation and economic disruptions could end many current jobs, as well as new jobs will emerge in the field of digital and smart technologies. Future jobs will require digital and smart skills, ranging from basic to advance level of expertise. The new tools, solutions, platforms, and services that have mushroomed since early 2020 will remain part of the new normal in the post-pandemic world. The areas, sectors, and occupations where digitization and smart technology stimulates job creation will inevitably require increasingly advanced digital and smart skills, knowledge, and capabilities. So, for all of those the market of communication technology in general and internet facility in particular is must. High capable satellite only can fulfill such huge requirement. Again, such transition is creating huge investment opportunities in training and skilling. The education, training and learning sectors must expand to fulfill the need.

53. Globalization, digitalization, and smart technology and other mega-trends have sparked changes and that are drastically affecting our working lives and future world. We all should support progress towards Sustainable Development Goals (SDGs) relating to access to quality education, lifelong learning opportunities and good quality jobs for general mass and which need best utilization of communication technology. The discussion and analysis done in this paper will help as expert advice to policy makers, seek to amplify diverse perspectives and ideas in the public debate, and create spaces for cross-sector conversations and collaboration. Actually, it's every individual responsibility as global citizen to build a better world of work for entire humanity. As a result in future we need to develop digital, AI, ML and other digital and smart technical skills which is entirely related to communication technology.Now a day's technology is changing very fast with time and demand of global consumer. The wonderful concept/inventionlike antimatter, dark matter, degenerate matter and exotic matter as well as hyper thinking of modern entrepreneur like Bill Gates, Elon Musk, Mark Zuckerberg, Jack Ma, and the future world will be unpredicted and more challenging. Concept like super capable quantum computation, SpaceX, Neuro-technology, dark wave radio, etc. will invent something new and customer friendly communication device and enhanced new business ideas. Countries like India, Indonesia, Bangladesh, Nepal, with huge population is needed to adapt suitable and viable education and skill development policy and strategy to meet the future challenges. Those countries need to develop more skill and technology friendly workforce for mere survival. Future thinking and invention of technologist/engineer will be something

new and astonishing. Future world of communication will be beyond our imagination. We should prepare new for the future.

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