Tishk International University
Engineering Faculty
Mechatronics Engineering Department
AVIONICS

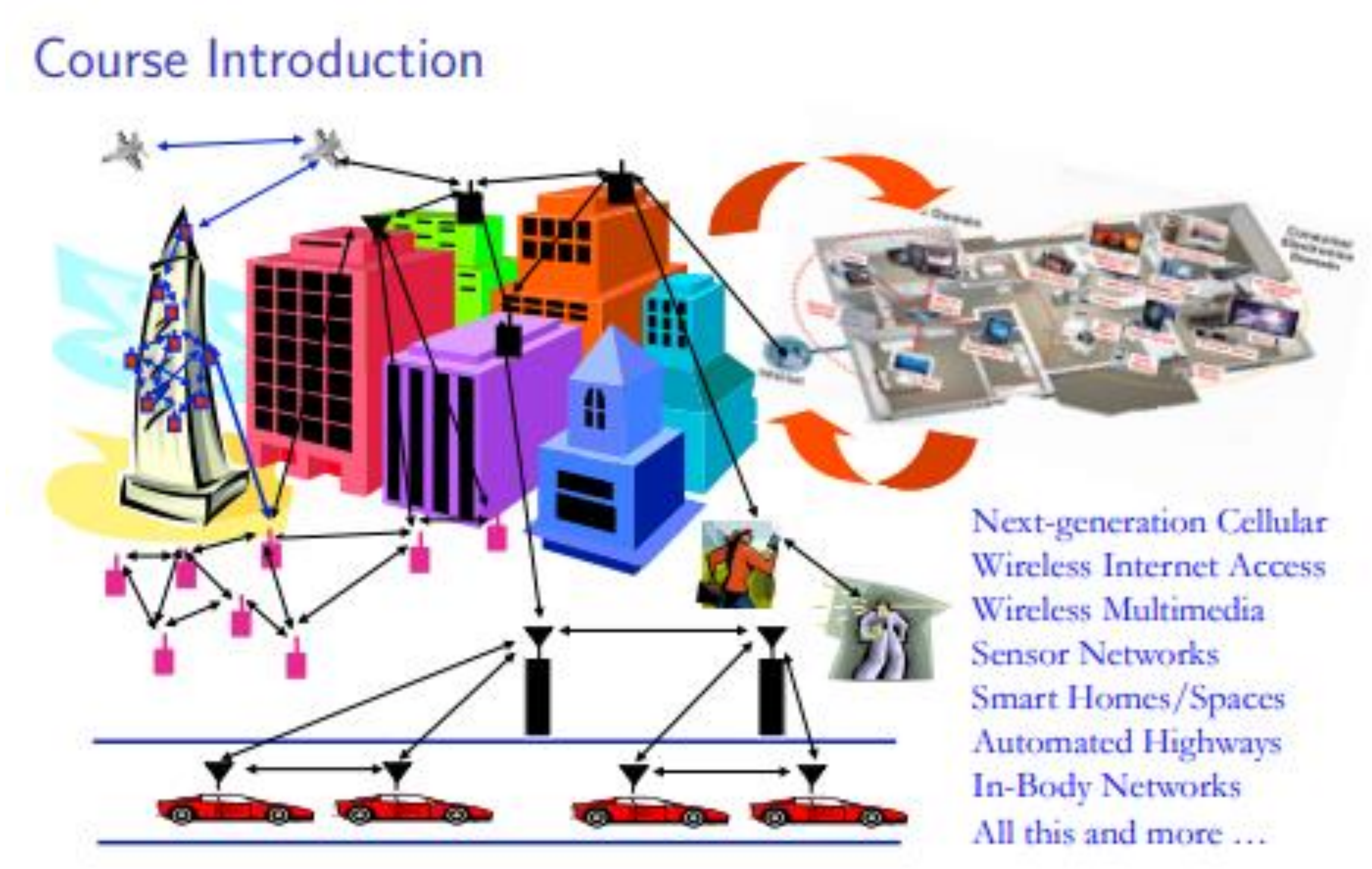
TOPIC: Introduction to Avionics Radio Systems

Week14_Lecture13

4th Grade- Spring Semester 2022-2023

Instructor: Prof.Dr. Qaysar Salih Mahdi

Introduction Communication Systems



Early Communication Systems

Telegraph

1830, Joseph Henry

1832, Pavel Schilling

1837, Samuel B. Morese, Morse code

1844, What Hath God Wrought

Telephone

1876, Alexander G. Bell (“Watson come here; I need you.”) 1888, Strowger stepper switch

1915, US transcontinental service (requires amplifiers)

Wireless telegraphy

1895, Jagadish Chandra Bose builds radio transmitter

1896, Marconi patents radio telegraphy

1901, Marconi, first transatlantic transmission

Radio

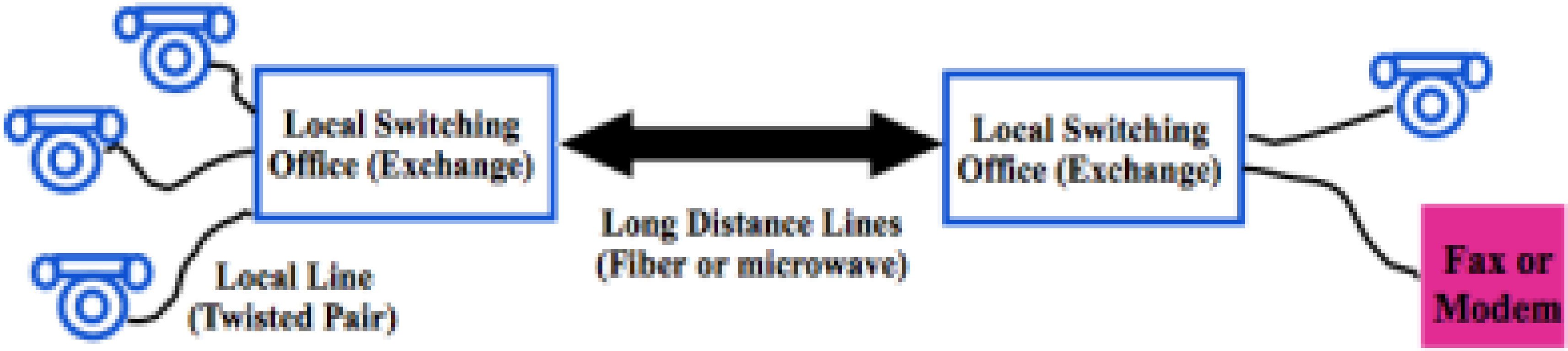
1906, Reginald Fessendend, first broadcast

1920, first commercial AM radio station (Montreal XWA → CINW)

Communication Systems Today

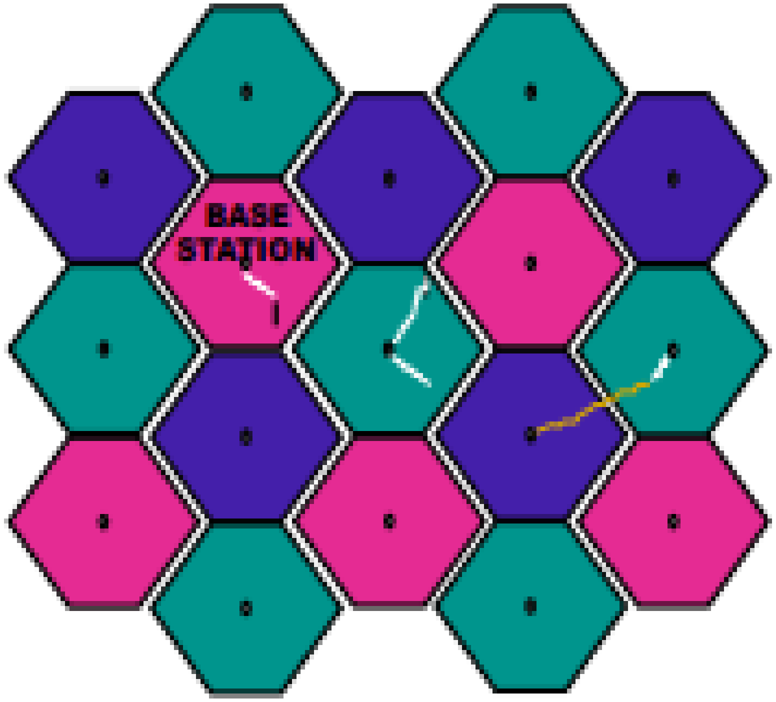
Public Switched Telephone Network (PSTN) for voice, fax, modem
Radio and TV broadcasting
Citizens' band radio; ham short-wave radio
Computer networks (LANs, WANs, and the Internet)
Satellite systems (pagers, voice/data, movie broadcasts)
Cable television (CATV) for video and data
Cellular phones
Bluetooth
GPS
Many others..

PSTN Design



- Local exchange
  - Handles local calls
  - Routes long distance calls over multiplexed high-speed connections
- Circuit switched network tailored for voice
- Faxes and modems modulate data for voice channel
- DSL uses advanced modulation to get 1.5-6.0 Mbps

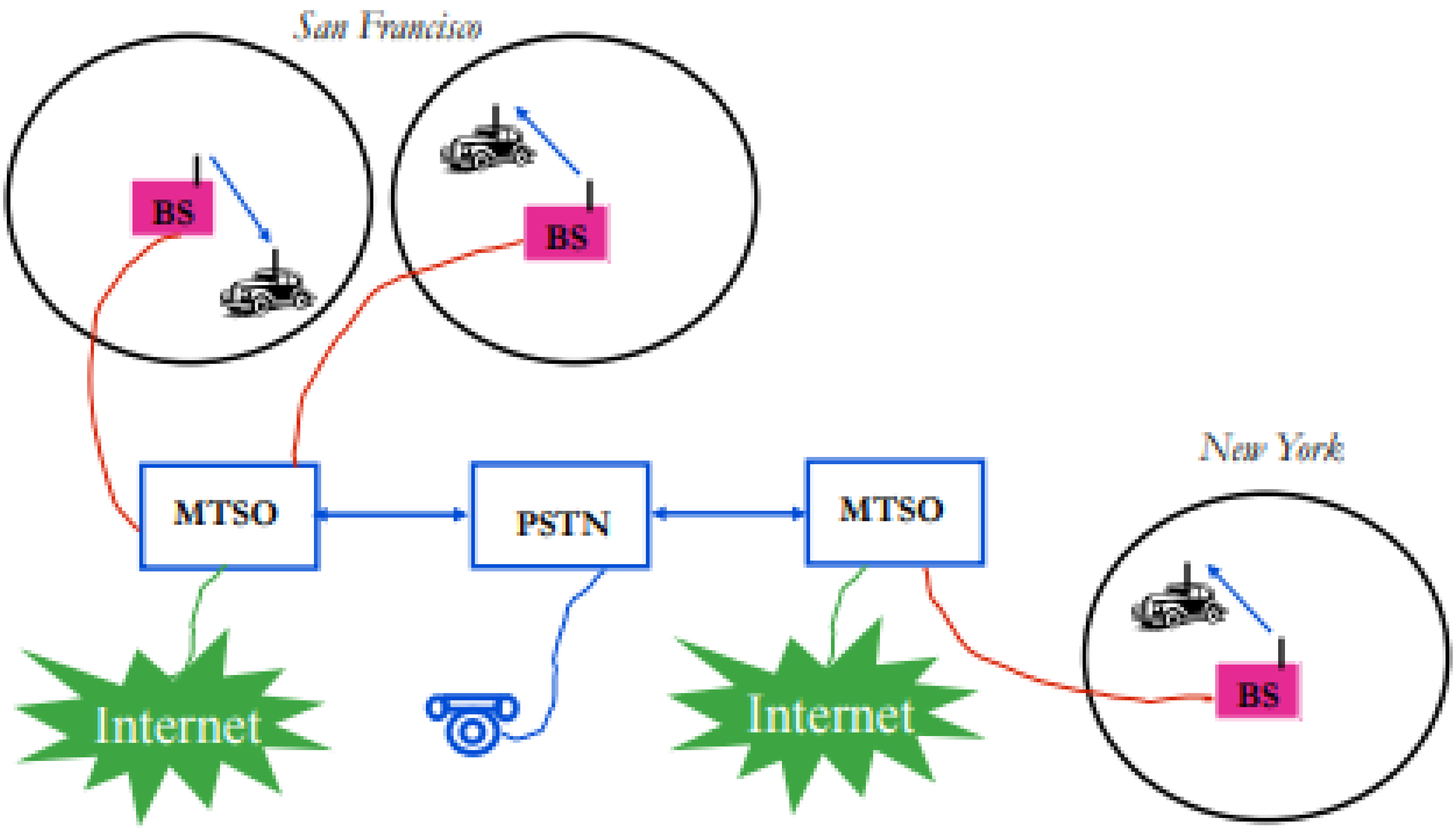
Cellular System Basics



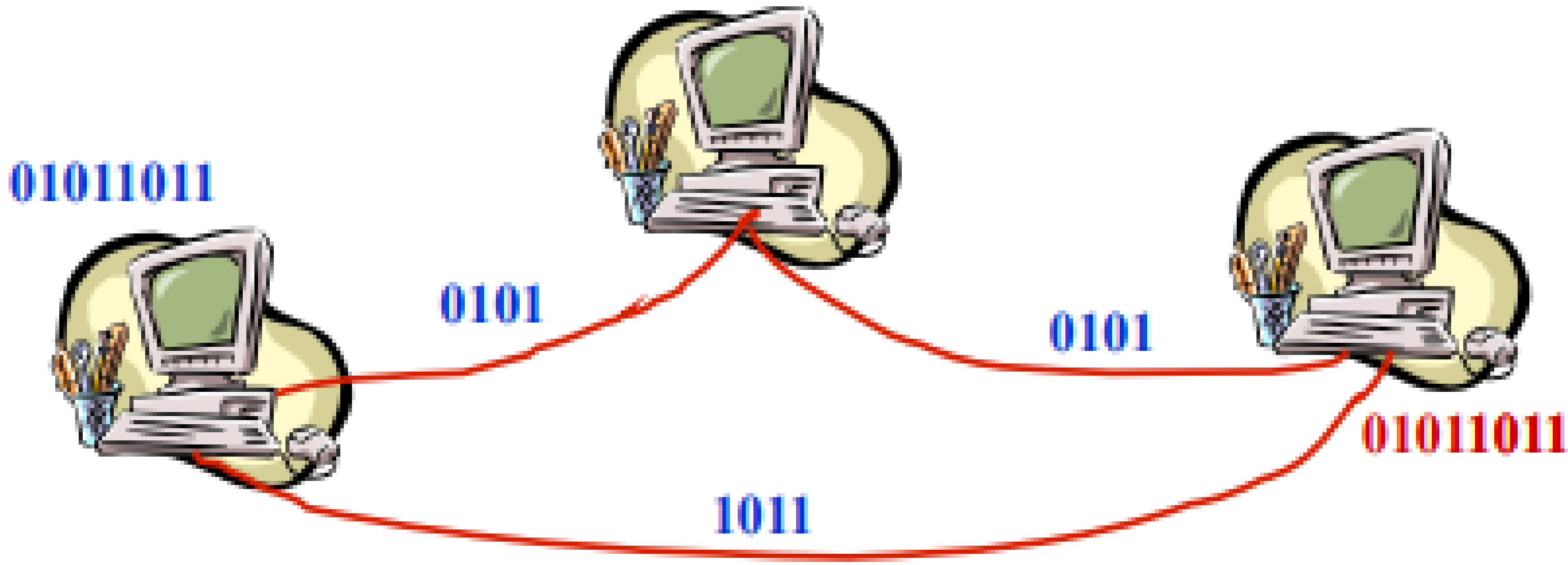
- Geographic region divided into hexagonal cells[1]
- Frequencies/timeslots/codes are reused at spatially-separated locations. (Analog systems use FD, digital systems use TD or CD.)
- Co-channel interference between same color cells
- Handoff and control coordinated through cell basestations

Cellular Phone Backbone Network

Mobile telephones depend on the PSTN — except for mobiles within the same MTSO (mobile telephone switching office)

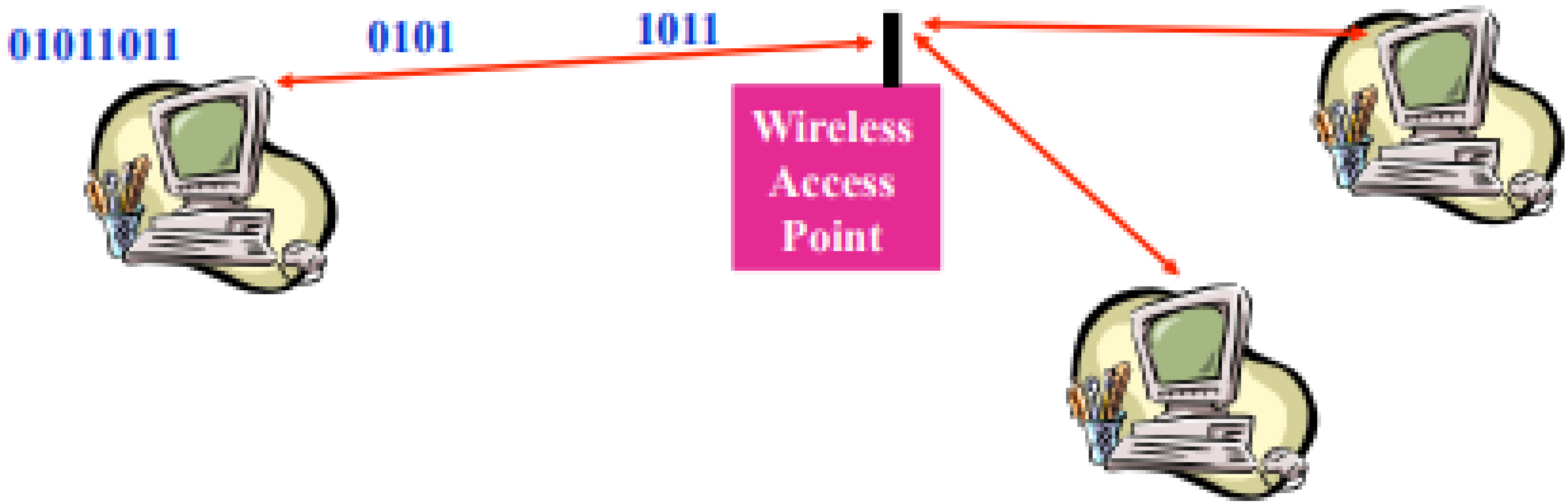


Local Area Networks (LAN)



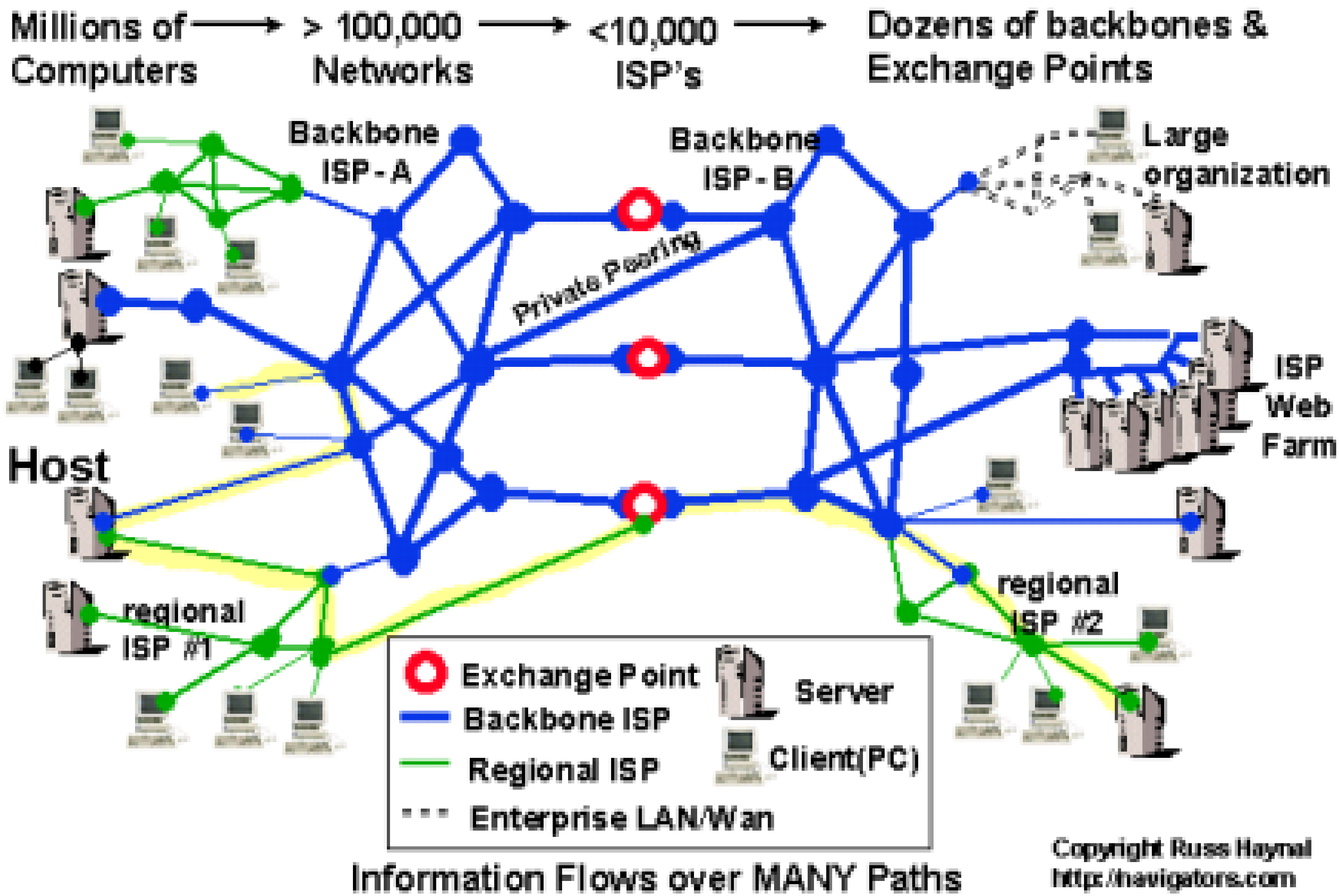
- "Local" means every computer can hear every other computer
- Packet switching instead of circuit switching (no dedicated channels)
- Data is broken down into packets
- Originally proprietary protocols; e.g., Ethernet was a collaboration between Intel, DEC, and Xerox. (DEC?)

Wireless Local Area Networks (WLAN)

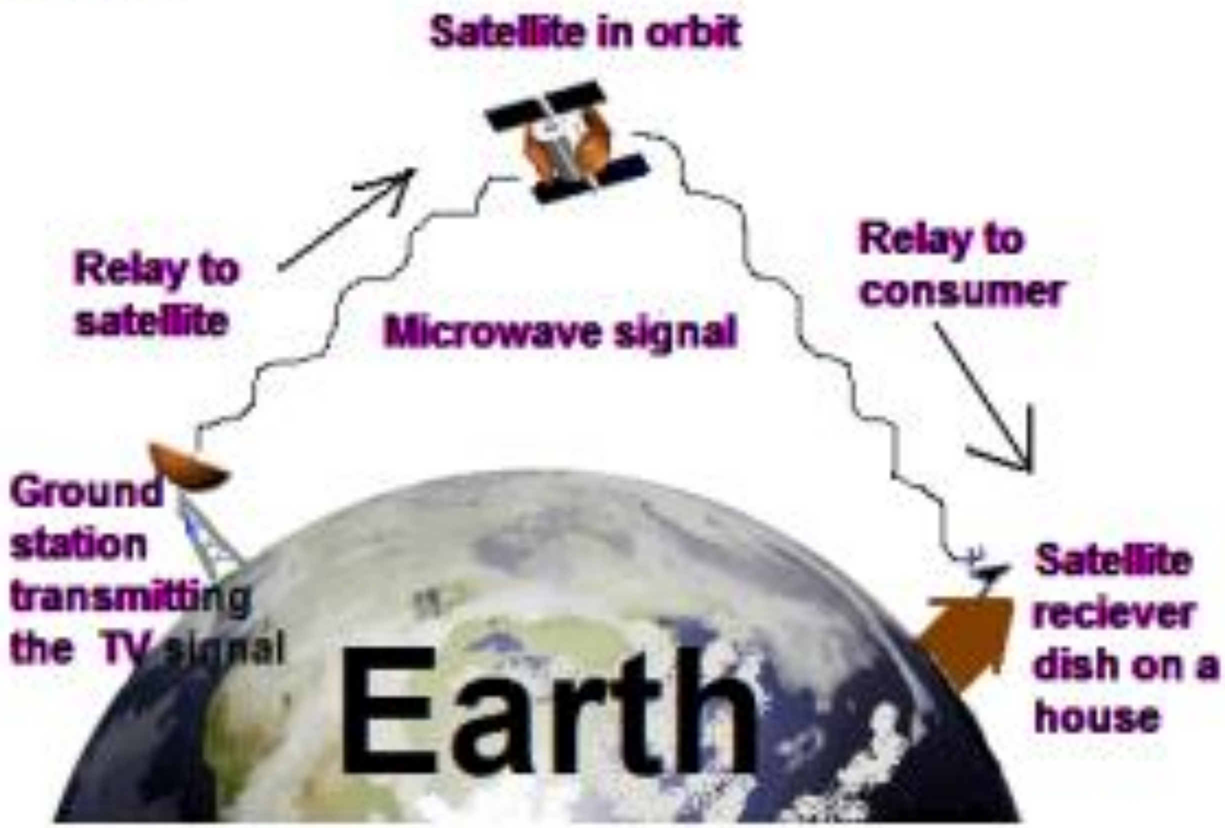


- WLANs connect "local" computers (100m range) to an access point
- As with LANs, data is broken down into packets
- Channel access is shared (random access)
- Access protocols for WLANs are much more complex than for LANs
- Backbone Internet provides best-effort service (no QOS guarantee)

Wide Area Networks; the Internet



Satellite Systems



- Satellites cover very large areas
- Different orbit heights: GEOs (39000 Km) versus LEOs (2000 Km)
- Optimized for one-way transmission, such as radio (XM, DAB) and television (SatTV) broadcasting
- Latency (round trip delay) can be a problem

Bluetooth

- Ericsson, 1994, named for King Harald Blåtand Gormsen
- Intended as replacement for cables, such as RS-232
  Now used for input devices, cell phones, laptops, PDAs, etc.
- Short range connection (10–100 m)
- Bluetooth 1.2 has 1 data (721 Kbps) and 3 voice (56 Kbps) channels, and rudimentary networking capabilities

Avionic Radio Communication

Avionic Radio Communication: Developing an understanding of radio communications begins with the comprehension of basic electromagnetic radiation. Radio waves belong to the electromagnetic radiation family, which includes x-ray, ultraviolet, and visible light — forms of energy we use every day. Much like the gentle waves that form when a stone is tossed into a still lake, radio signals radiate outward, or propagate, from a transmitting antenna. However, unlike water waves, radio waves propagate at the speed of light.

We characterize a radio wave in terms of its amplitude, frequency, and wavelength (Figure 1-1).

Radio wave amplitude, or strength, can be visualized as its height ─ the distance between its peak and its lowest point. Amplitude, which is measured in volts, is usually expressed in terms of an average value called root-mean-square, or RMS.

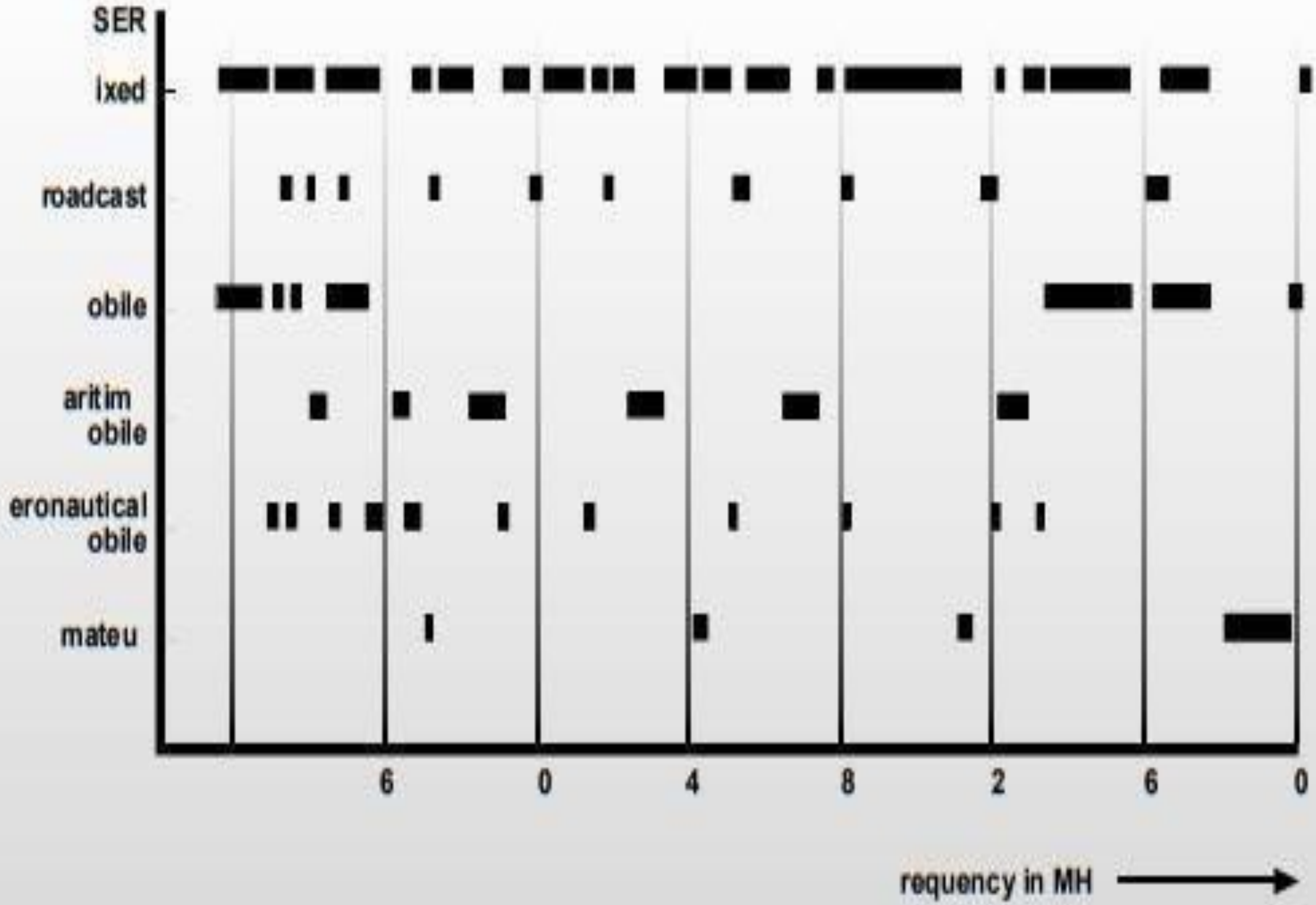
The frequency of a radio wave is the number of repetitions or cycles it completes in a given period of time. Frequency is measured in hertz (Hz); one hertz equals one cycle per second. Thousands of hertz are expressed as kilohertz (kHz), and millions of hertz as megahertz (MHz). You would typically see a frequency of 2,182,000 hertz, for example, written as 2,182 kHz or 2.182 MHz.

Radio wavelength is the distance between crests of a wave. The product of wavelength and frequency is a constant that is equal to the speed of propagation. Thus, as the frequency increases, wavelength decreases, and vice versa.

Since radio waves propagate at the speed of light (300 million meters per second), you can easily determine the wavelength in meters for any frequency by dividing 300 by the frequency in megahertz. So, the wavelength of a 10-MHz wave is 30 meters, determined by dividing 300 by 10.

The Radio Frequency Spectrum In the radio frequency spectrum (Figure 1-2), the usable frequency range for radio waves extends from about 20 kHz (just above sound waves) to above 30,000 MHz. A wavelength at 20 kHz is 15 kilometers long. At 30,000 MHz, the wavelength is only 1 centimeter.

The High Frequency (HF) Band: The HF band is defined as the frequency range of 3 to 30 MHz. In practice, most HF radios use the spectrum from
1.6 to 30 MHz. Most long-haul communications in this band take place between 4 and 18 MHz. Higher frequencies (18 to 30 MHz) may also be available from time to time, depending on ionospheric conditions and the time of day (see Volume One, HF Technology).



SER
ixed
roadcast
obile
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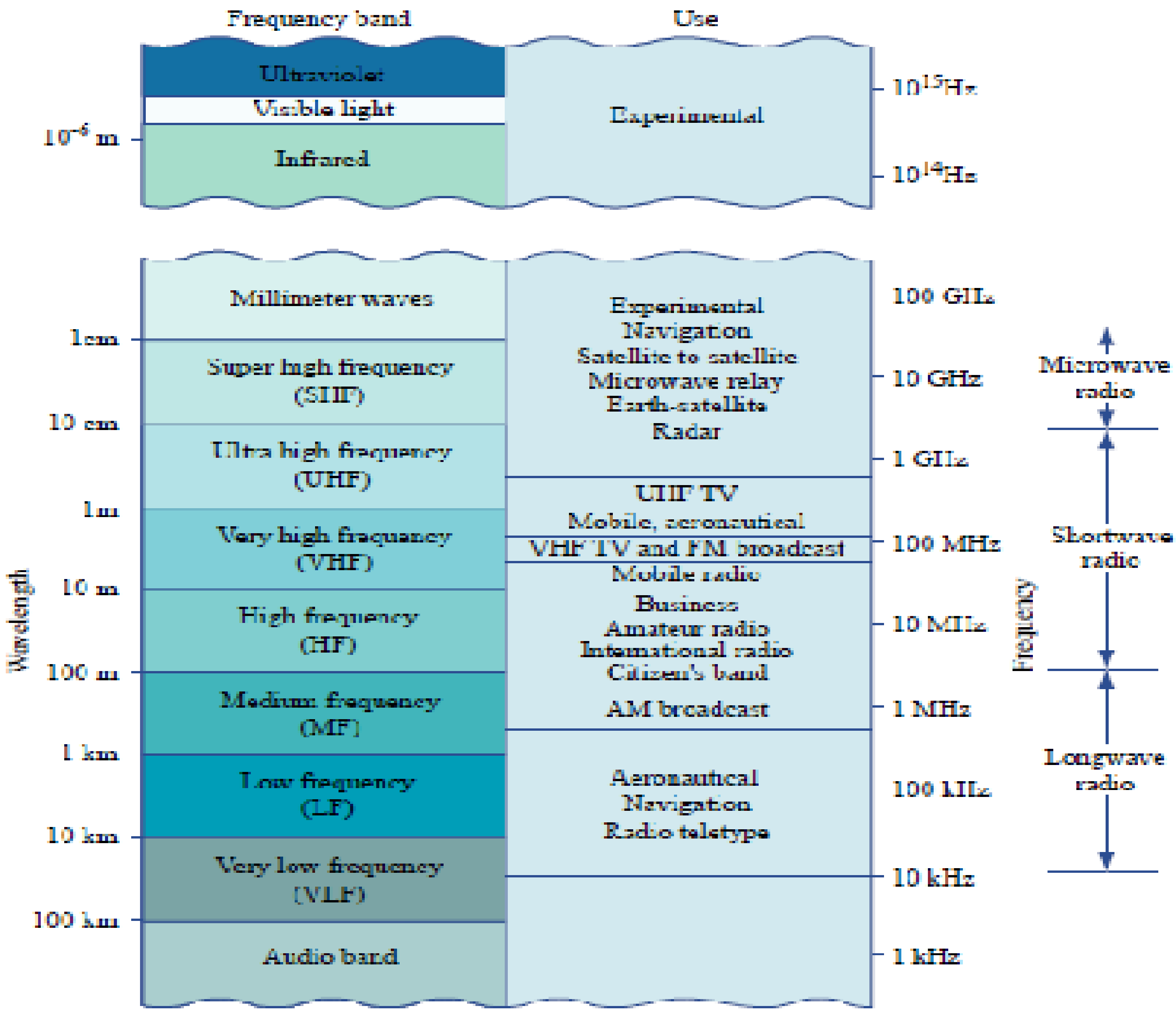
eronautical
obile
mateu
6
0
4
8
2
6
0
requency in MH

Very High Frequency (VHF) Band

The VHF frequency band is defined as the frequency range from 30 to 300 MHz. From the previous discussion about the relationship between frequency and wavelength, it should be noted that VHF wavelengths vary from 10-meters at the low end to one meter at the high end. This means that the size of antennas and tuning components used in VHF radio are much smaller and lighter than those of HF radios. This is a big advantage for manpack radios.

Frequency spectrum



Frequency range for wireless electromagnetic channels.

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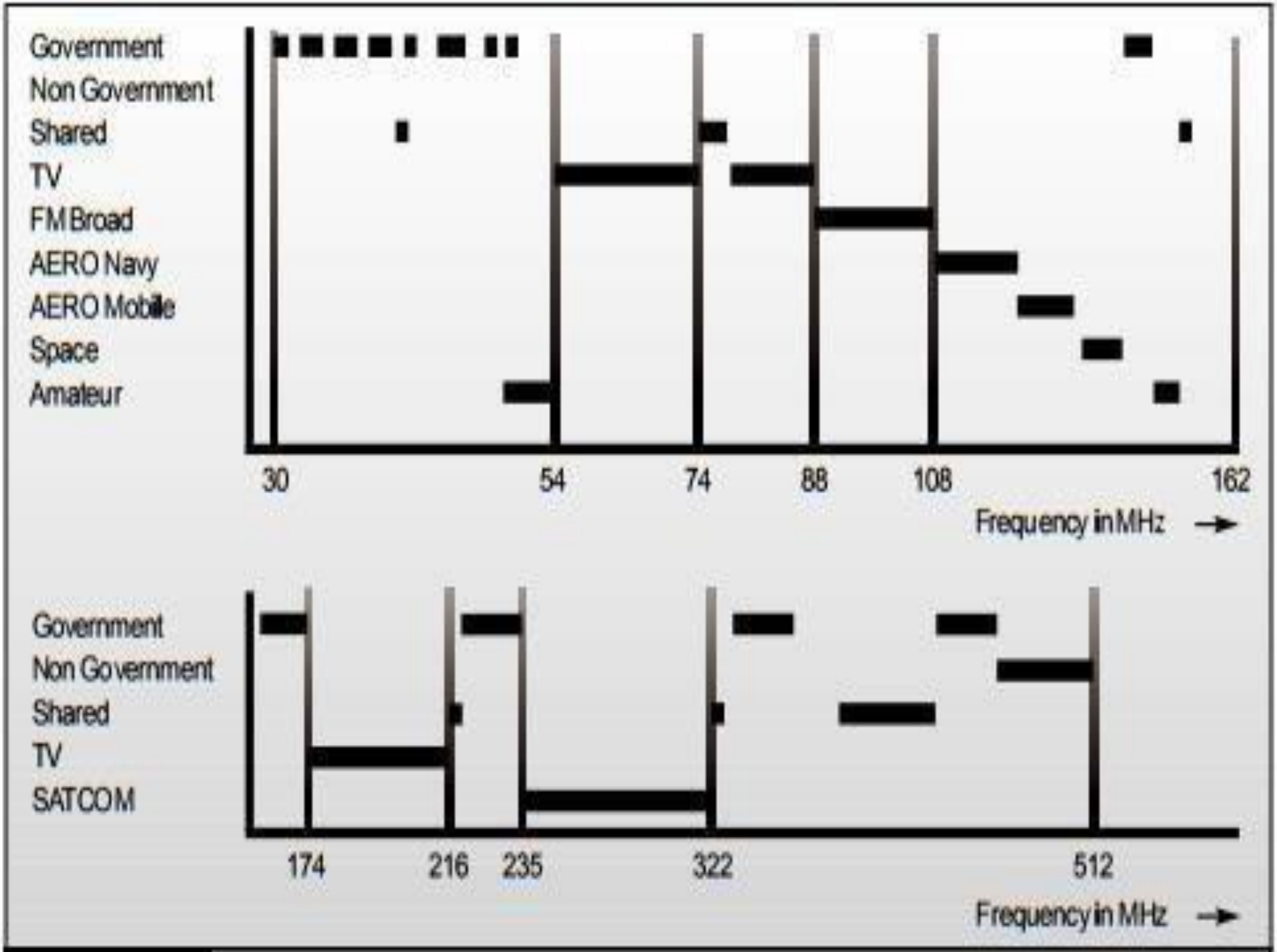
Frequency Allocations: Within the HF spectrum, groups of frequencies are allocated to specific radio services — aviation, maritime, military, government, broadcast, or amateur. Frequencies are further regulated according to transmission type: emergency, broadcast, voice, Morse code, facsimile, and data. International treaty and national licensing authorities govern frequency allocations. Frequencies within the VHF/UHF bands are similarly allocated (Figure 1-4).



Government
Non Government
Shared
TV
FM Broad
AERO Navy
AERO Mobile
Space
Amateur
30
54
74
88
108
162
Frequency in MHz
Government
Non Government
Shared
TV
SATCOM
174
216
235
322
512
Frequency in MHz

Ultra High Frequency (UHF) Band

The UHF band goes from 300 MHz to 2450 MHz, although TACSAT man pack UHF radios do not utilize frequencies above 512 MHz.

The wavelengths associated with 300 to 512 MHz range from one meter to 0.58 meters (58 centimeters).

The very small antennas required for these wavelengths make them ideal for use on high-speed aircraft.

Modulation The allocation of a frequency is just the beginning of radio communications. By itself, a radio wave conveys no information. It’s simply a rhythmic stream of continuous waves (CW). When we modulate radio waves to carry information, we refer to them as carriers. To convey information, a carrier must be varied so that its properties — its amplitude, frequency, or phase (the measurement of a complete wave cycle) — are changed, or modulated, by the information signal.

Modulation

- Digital signals must be transmitted as analog waveforms
- Baseband signals
  – Signals whose frequency components are concentrated around zero
- Passband signals
  – Signals whose frequency components are centered at some frequency fc away from zero
- Baseband signals can be converted to passband signals through modulation
  – Multiplication by a sinusoid with frequency fc

The simplest method of modulating a carrier is by turning it on and off by means of a telegraph key. In the early days of radio, On-Off keying, using Morse code, was the only method of conveying wireless messages. Today’s common methods for radio communications include amplitude modulation (AM), which varies the strength of the carrier in direct proportion to changes in the intensity of a source such as the human voice (Figure 1-5a). In other words, information is contained in amplitude variations. The AM process creates a carrier and a pair of duplicate sidebands — nearby frequencies above and below the carrier (Figure 1-5b). AM is a relatively inefficient form of modulation, since the carrier must be continually generated.

The majority of the power in an AM signal is consumed by the carrier that carries no information, with the rest going to the information-carrying sidebands. In a more efficient technique, single sideband (SSB), the carrier and one of the sidebands are suppressed (Figure 1-5c). Only the remaining sideband, upper (USB) or lower (LSB), is transmitted. An SSB signal needs only half the bandwidth of an AM signal and is produced only when a modulating signal is present.

Thus, SSB systems are more efficient both in the use of the spectrum, which must accommodate many users, and of transmitter power. All the transmitted power goes into the information-carrying sideband.

One variation on this scheme, often used by military and commercial communicators, is amplitude modulation equivalent (AME), in which a carrier at a reduced level is transmitted with the sideband. AME lets one use a relatively simple receiver to detect the signal.

Another important variation is independent sideband (ISB), in which both an upper and lower sideband, each carrying different information, is transmitted. This way one sideband can carry a data signal and the other can carry a voice signal.

Frequency modulation (FM)

Frequency modulation (FM)

is a technique in which the carrier's frequency varies in response to changes in the modulating signal

(Figure 1-5d). For a variety of technical reasons, conventional FM generally produces a cleaner signal than AM, but uses much more bandwidth. Narrowband FM, which is sometimes used in HF radio, provides an improvement in bandwidth utilization, but only at the cost

signalquality. It is in the UHF and VHF bands that FM comesintoitsown. RememberthattheHF bandis generally defined as occupying the spectrum from 1.6 MHzto 30 MHz. This is a span of only 28.4 MHz. The VHF band covers thespan of from 30 MHzto 300 MHz, which is a span of 270 MHz; nearly 10 times the span of HF. This extra room means that a channel bandwidth of 25 kHz is used to achieve high signal quality.

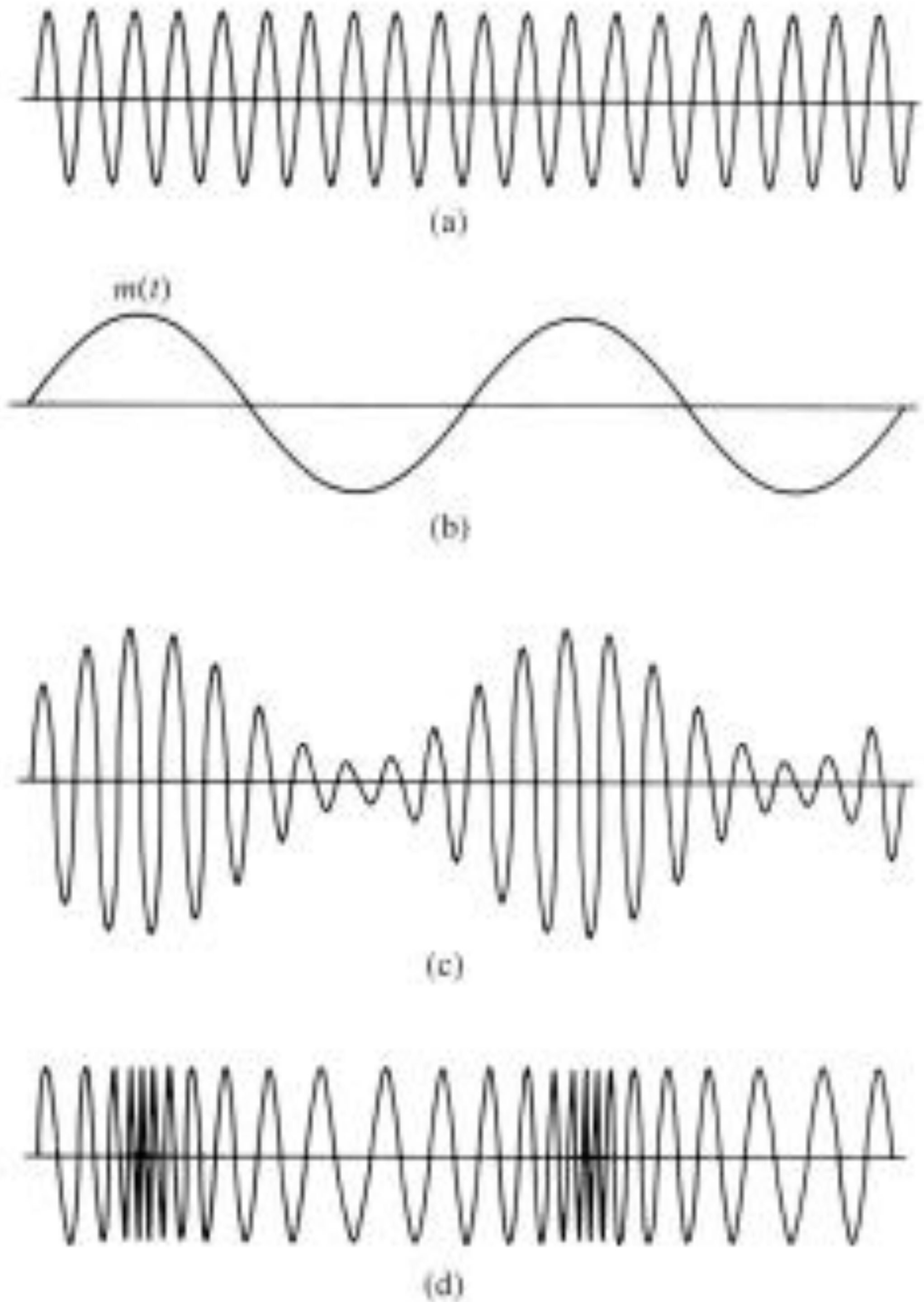
AM and FM Modulation

(a) Carrier

(b) Signal

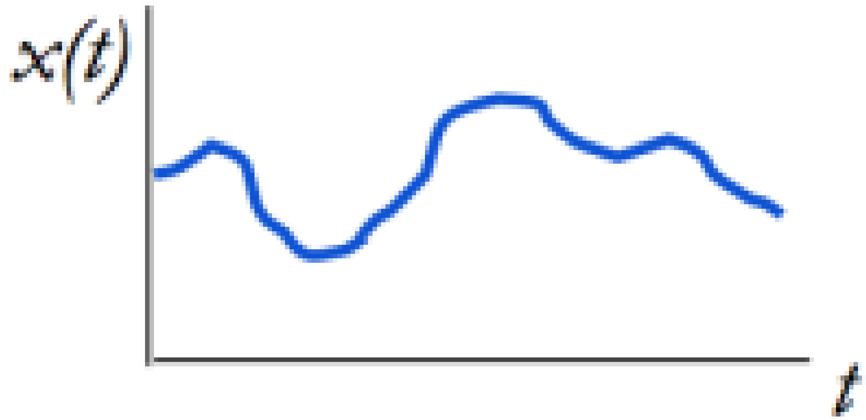
(c) Amplitude modulated

(d) Frequency modulated

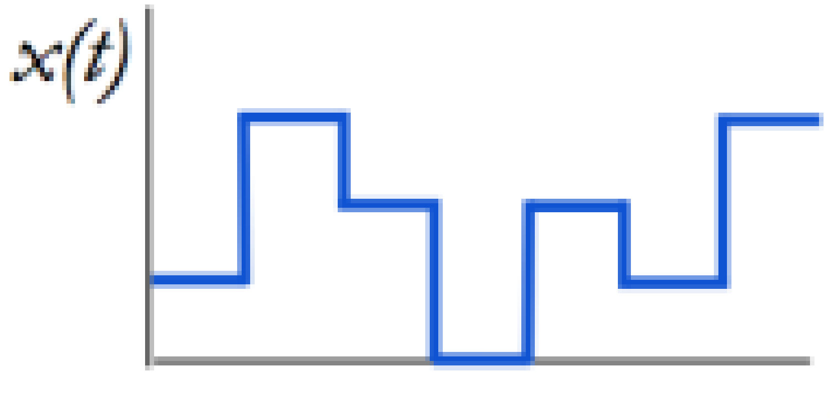


Analog vs. Digital Systems

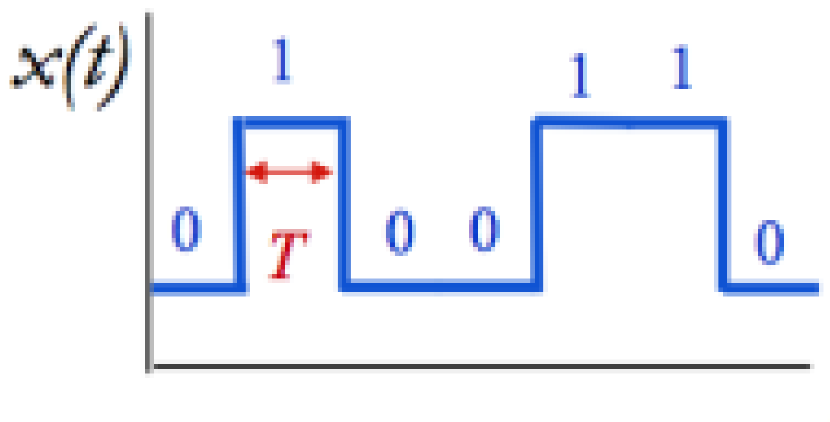
- Analog signals
  Values varies continously



- Digital signals
  Value limited to a finite set
  Digital systems are more robust



- Binary signals
  Have 2 possible values
  Used to represent bit values
  Bit time T needed to send 1 bit
  Data rate $R = 1/T$ bits per second

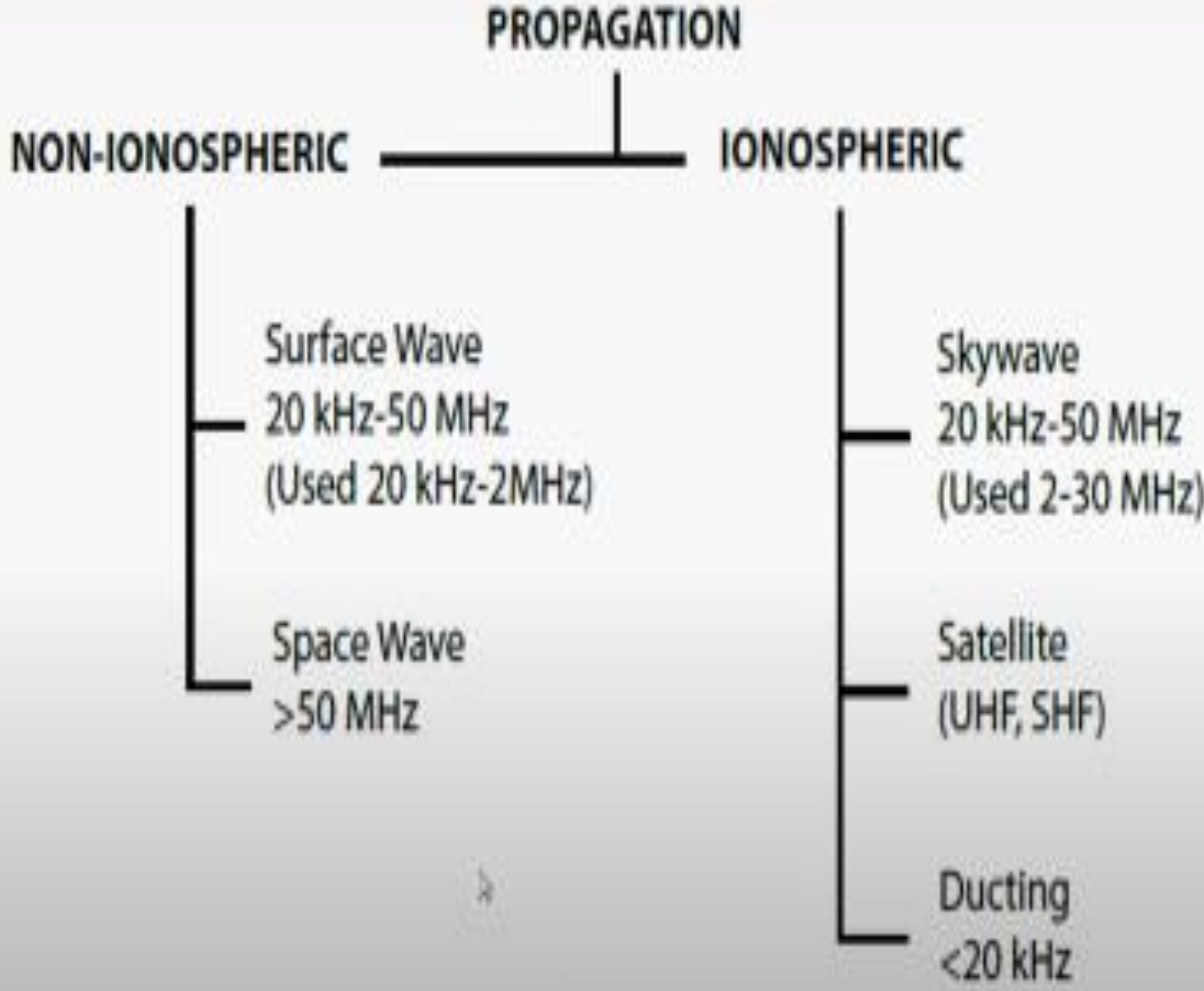


Radio Wave Propagation

describes how radio signals radiate outward from a transmitting source. The action is simple to imagine for radio waves that travel in a straight line (picture that stone tossed into the still lake). The true path radio waves take, however, is often more complex.

There are two basic modes of propagation: ground waves and sky waves. As their names imply, ground waves travel along the surface of the earth, while sky waves "bounce" back to earth.

Figure 1 shows the different propagation paths for radio waves. Ground waves consist of three components: surface waves, direct waves, and ground-reflected waves. Surface waves travel along the surface of the earth, reaching beyond the horizon. Eventually, the earth absorbs surface wave energy. The frequency and conductivity of the surface over which the waves travel largely determine the effective range of surface waves. Absorption increases with frequency..

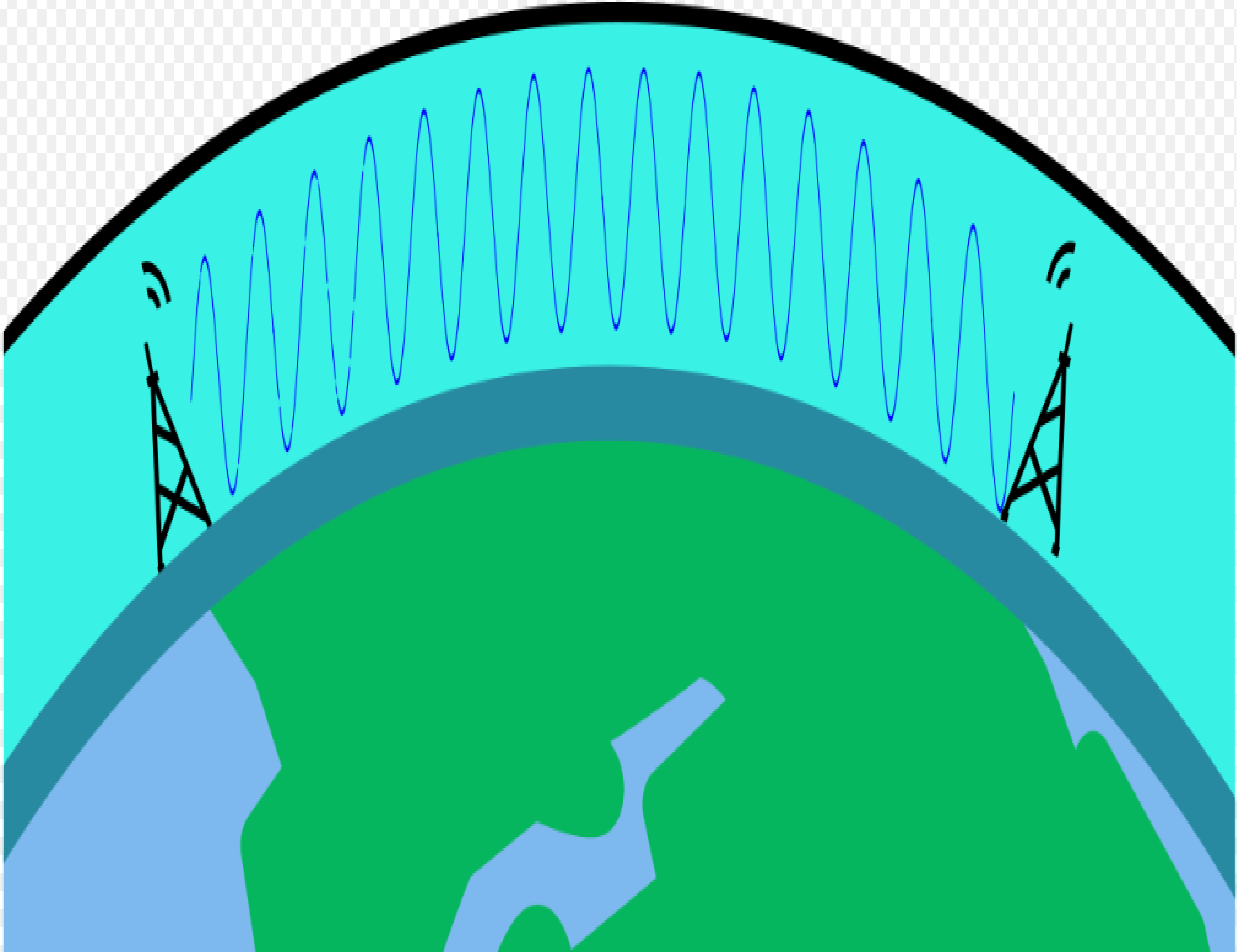

PROPAGATION
NON-IONOSPHERIC
IONOSPHERIC
Surface Wave
20 kHz-50 MHz
(Used 20 kHz-2MHz)
Space Wave
>50 MHz
Skywave
20 kHz-50 MHz
(Used 2-30 MHz)
Satellite
(UHF, SHF)
Ducting
<20 kHz

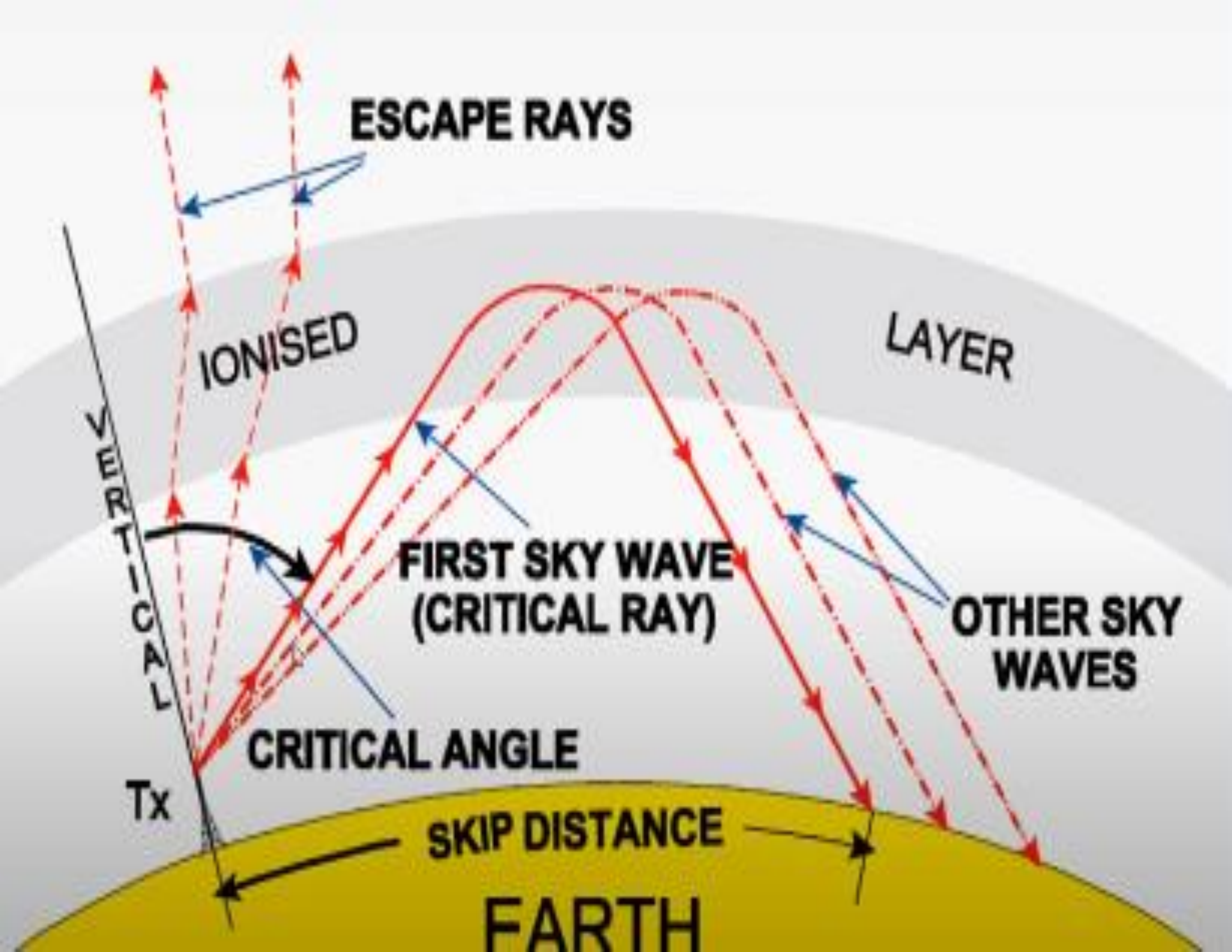
Transmitted radio signals, which use a carrier traveling as a surface wave, are dependent on transmitter power, receiver sensitivity, antenna characteristics, and the type of path traveled. For a given complement of equipment, the range may extend from 200 to 250 miles over a conductive, all-sea- water path. Over arid, rocky, non-conductive terrain, however, the range may drop to less than 20 miles, even with the same equipment.

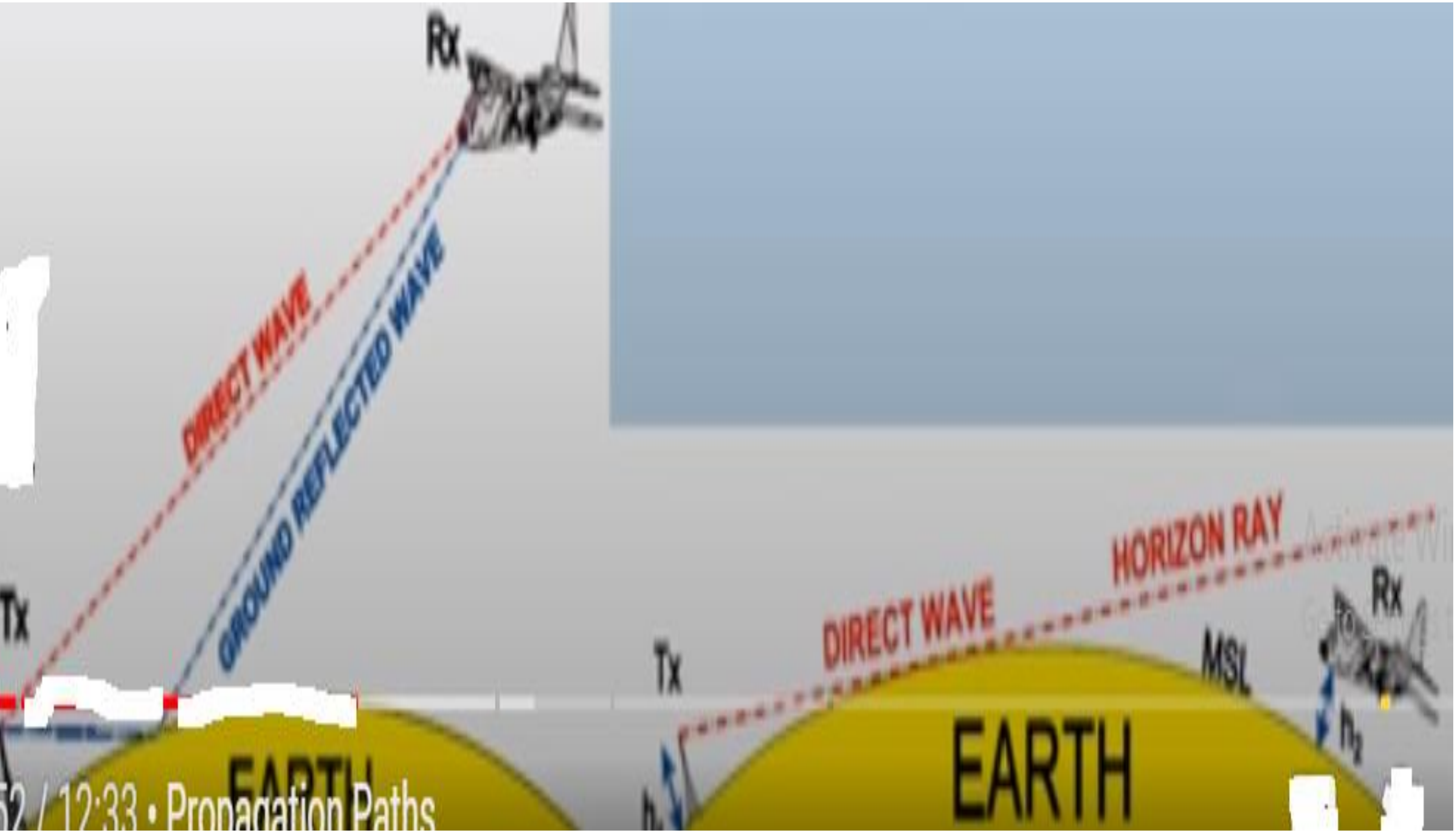
Direct waves travel in a straight line, becoming weaker as distance increases. They may be bent, or refracted, by the atmosphere, which extends their useful range slightly beyond the horizon. Transmitting and receiving antennas must be able to “see” each other for communications to take place, so antenna height is critical in determining range. Because of this, direct waves are sometimes known as line-of-sight (LOS) waves. This is the primary mode of propagation for VHF and UHF radio waves. Ground-reflected waves are the portion of the propagated wave that is reflected from the surface of the earth between the transmitter and receiver.

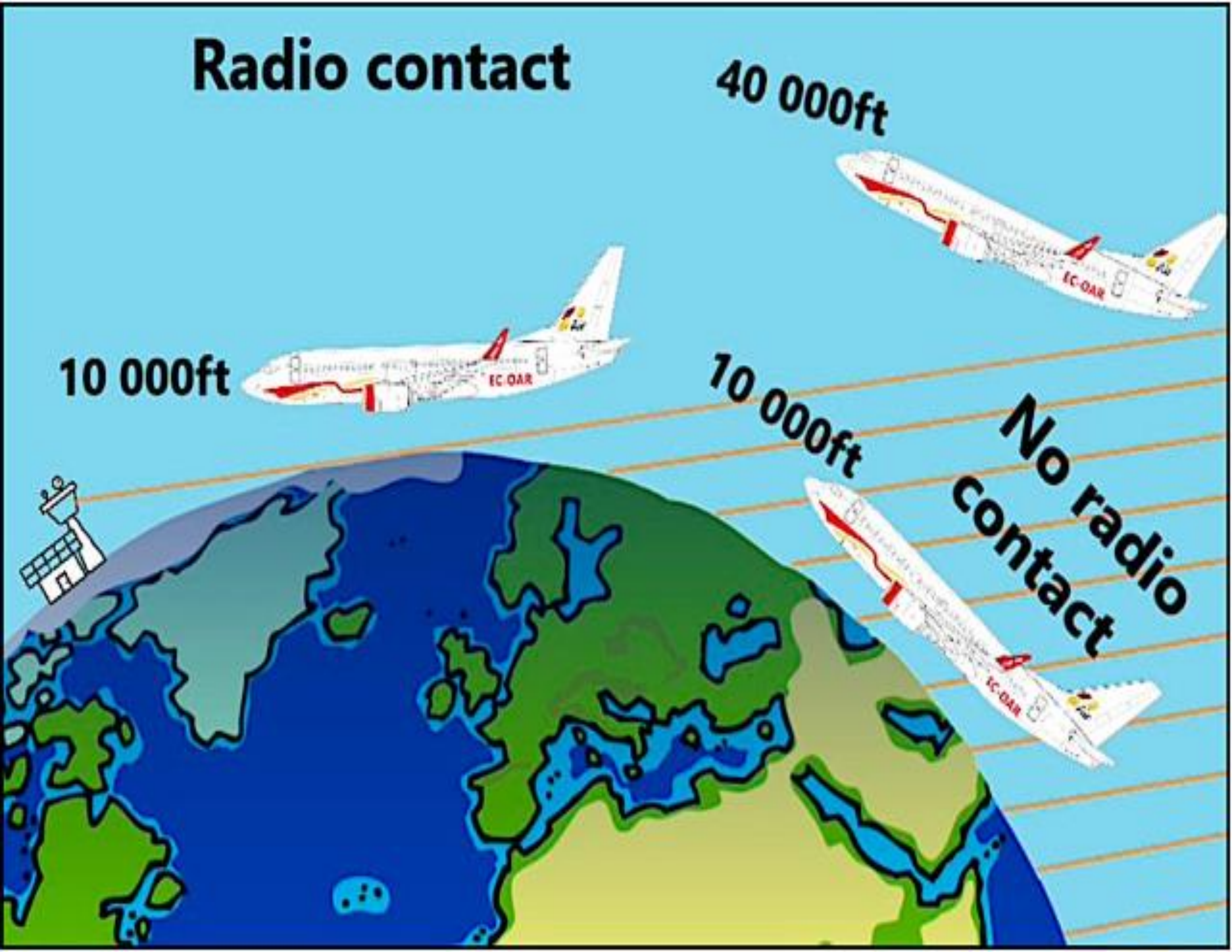
Sky waves make beyond line-of-sight (BLOS) communications possible. At frequencies below 30 MHz, radio waves are refracted (or bent), returning to earth hundreds or thousands of miles away. Depending on frequency, time of day, and atmospheric conditions, a signal can bounce several times before reaching a receiver


SURFACE WAVE
Tx
Rx
EARTH




ESCAPE RAYS
IONISED
LAYER
VERTICAL
FIRST SKY WAVE
(CRITICAL RAY)
OTHER SKY
WAVES
CRITICAL ANGLE
Tx
SKIP DISTANCE
EARTH


Rx
DIRECT WAVE
GROUND REFLECTED WAVE
Tx
EARTH
52 / 12:33 • Propagation Paths
HORIZON RAY
DIRECT WAVE
Rx
MSL
Tx
EARTH


Radio contact
40 000ft
10 000ft
10 000ft
No radio contact
EC-OAR
EC-OAR
EC-OAR

Contents

Aircraft travel from one place to another at a height of 11km; some of them, even at the speed of sound, therefore, it is necessary to have a communication channel between them and their surroundings. This medium is the radio.
It was invented by an electronics engineer called Guillermo Marconi in 1901, two years previous to the Wright brothers' first ever flight. Radio is indispensable to aviation.
But how does it work? How is the radio used in aeroplanes? Here's what we tell you.

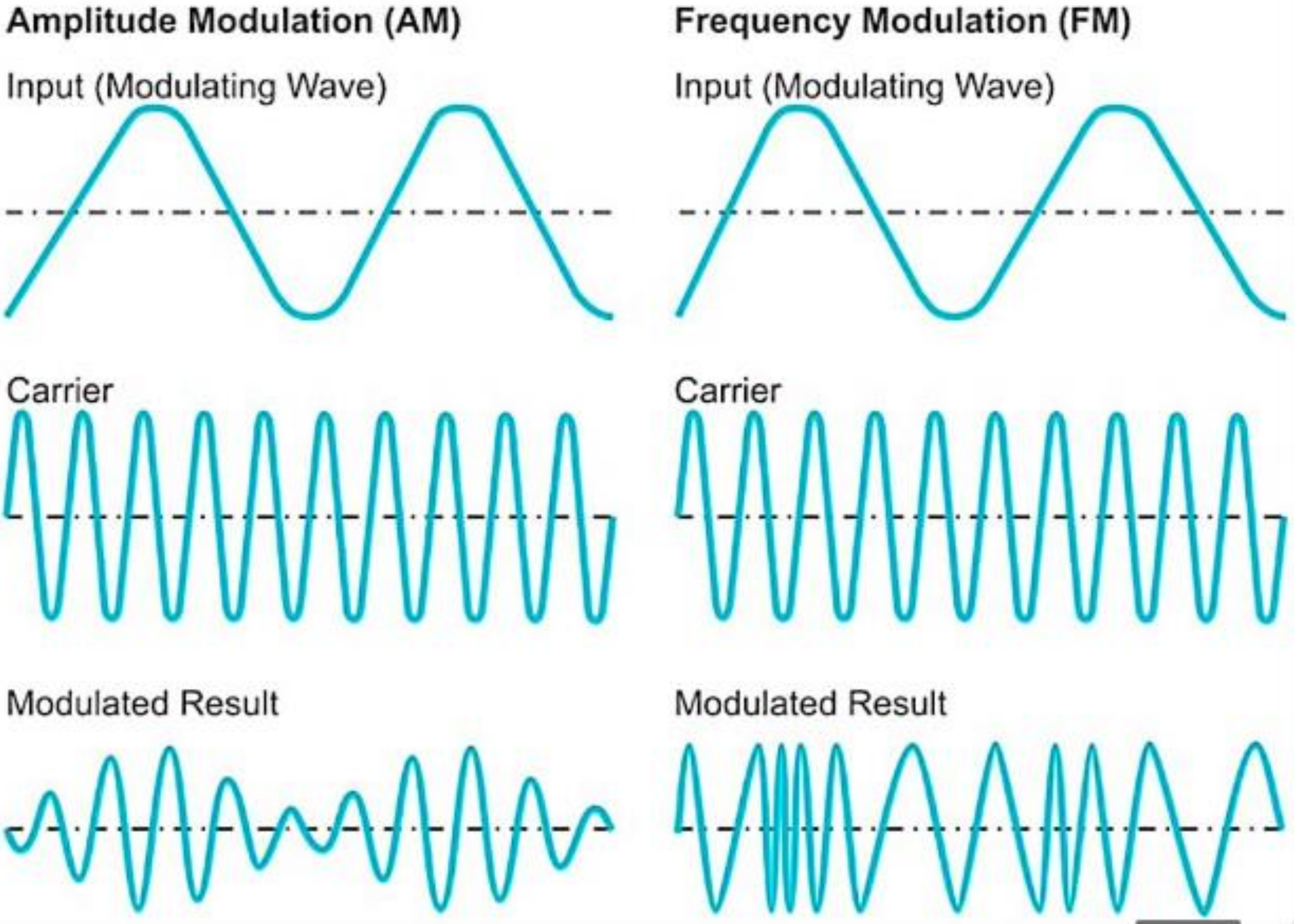
How does radio works

Radio is based on the transmission of electromagnetic waves to the atmosphere. These waves travel at the speed of light (300 thousand kilometres per second) and form a specific pattern.

Basically, the radio transmitter converts our voice to electrical signals.

Afterwards, the aerial transmitter converts those signals to electromagnetic waves and broadcasts them into space.

Finally, the radio receptor decodes the waves and sends them back to their original pattern, recovering the information and generating the audio once again.


Amplitude Modulation (AM)
Input (Modulating Wave)
Carrier
Modulated Result
Frequency Modulation (FM)
Input (Modulating Wave)
Carrier
Modulated Result

RADIO WAVE CHARACTERISTICS

A radio wave has two main characteristics, frequency and wave length.

•Its frequency is the number of complete cycles per second, i.e., the number of complete waves the receptor can capture. The unit of measure for frequency is the Hertz (Hz) and it is represented by f.

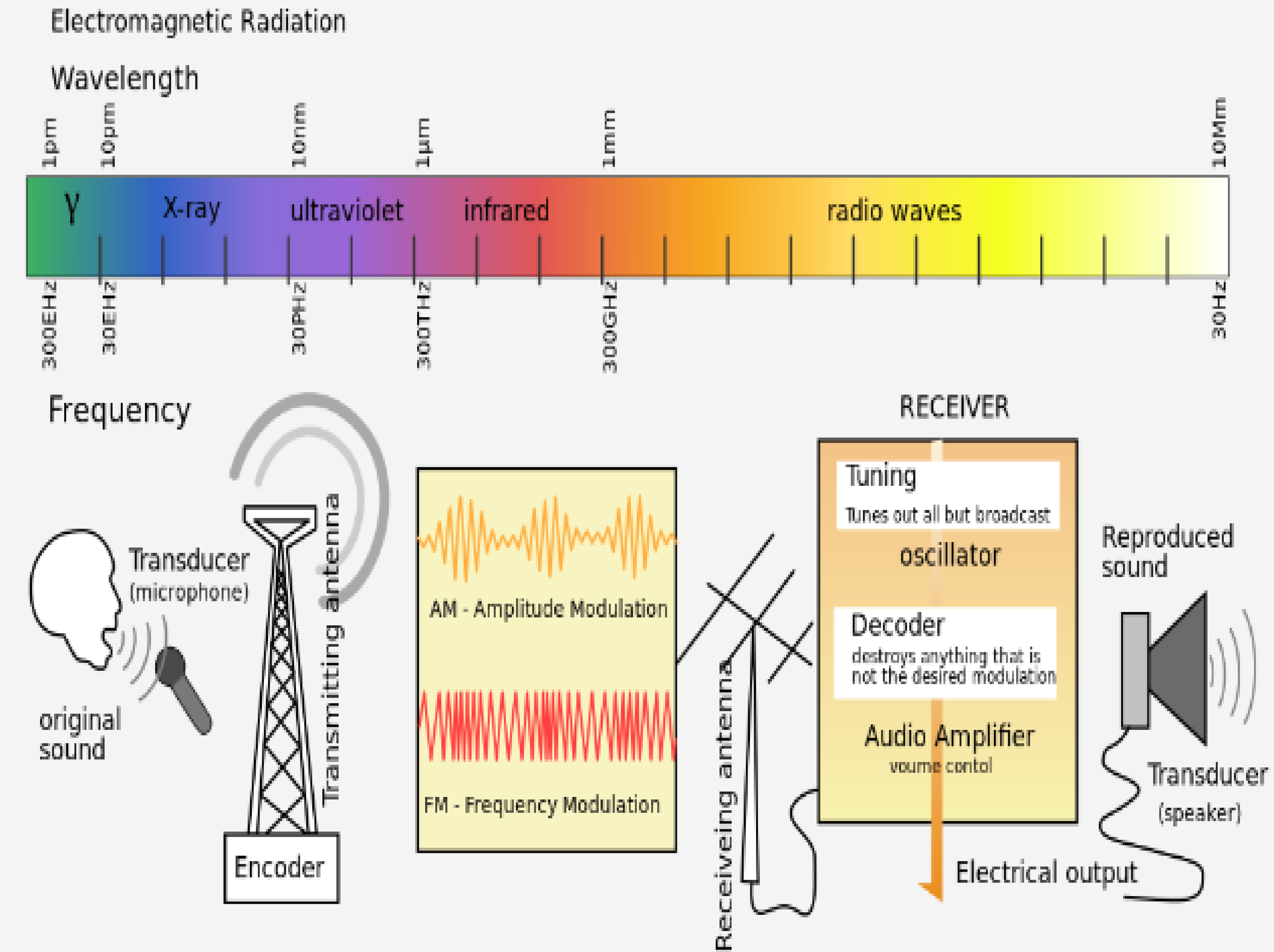
•The length of wave is the distance between two crests of the wave. A high frequency means small lengths of wave and vice versa. The unit of measure is the meter (m) and it is represented by the Greek letter, lambda λ.

Wave Modulation

According to its function, there are two methods of modulation of radio waves: amplitude modulation (AM) and frequency modulation (FM).

In aviation, radio works with the AM method or amplitude modulation. It uses less bandwidth and is the first one ever used; however, it is also the one which is mostly affected by interference and hence has a poorer audio quality.

FM or frequency modulation is what is used daily when we play the radio in our cars and enjoy the latest hits.


Electromagnetic Radiation
Wavelength
1pm
10pm
10nm
1µm
1mm
10Mm
γ
X-ray
ultraviolet
infrared
radio waves
300EHz
30EHz
30PHz
300THz
300GHz
30Hz
Frequency
Transducer
(microphone)
original sound
Transmitting antenna
Encoder
AM - Amplitude Modulation
FM - Frequency Modulation
Receiveing antenna
RECEIVER
Tuning
Tunes out all but broadcast
oscillator
Decoder
destroys anything that is not the desired modulation
Audio Amplifier
voume contol
Electrical output
Reproduced sound
Transducer
(speaker)

Radio Spectrum

Abbreviation	Frequencies
VLF - Very Low Frequency	3-30 kHz
LF - Low Frequency	30-300 kHz
MF - Medium Frequency	300-3000 kHz
HF - High Frequency	3-30 MHz
VHF - Very High Frequency	30-300 MHz
UHF - Ultra High Frequency	300-3000 MHz
SHF - Super High Frequency	3-30 GHz
EHF - Extremely High Frequency	30-300 GHz

FREQUENCIES USED IN AVIATION

In aviation we do not use all the frequencies for the same purpose:

•Instrumental landing system (ILS) uses frequencies reserved for this:
from 108MHz to 112MHz.

•From 108MHz to 118MHZ: these frequencies are used for VOR navigation.

•VHF Communication uses frequencies from 118MHz to 137MHz.

Communication between longer distances uses other frequencies such as HF.

Range of radio communication in aviation

VHF frequencies propagate in a straight line through the atmosphere but are limited by the line of sight, i.e., the waves do not follow the curvature of the Earth.

This is the reason why It is necessary to install signal repeaters in the surface of our planet

Additionally, pilots can make use of a formula to find out if they are within sufficient range to talk to the station they are contacting.

→ Range in nautical miles = 1.23 x ($\sqrt{h1}$ + $\sqrt{h2}$), h1 being the height of the airplane and h2 the height of the station, both expressed in feet.

In-flight connectivity

In recent years, IFE has been expanded to include in-flight connectivity—services such as Internet browsing, text messaging, cell phone usage (where permitted), and emailing. In fact, some in the airline industry have begun referring to the entire in-flight-entertainment category as "IFEC" (In-Flight Entertainment and Connectivity or In-Flight Entertainment and Communication).

The airline manufacturer Boeing entered into the in-flight-connectivity industry in 2000 and 2001 with an offshoot calledConnexion by Boeing. The service was designed to provide in-flight broadband service to commercial airlines; Boeing built partnerships with United Airlines, Delta, and American. By 2006, however, the company announced it was closing down its Connexion operation. Industry analysts cited technology, weight, and cost issues as making the service unfeasible at the time.

The Connexion hardware that needed to be installed on an aircraft, for example, weighed nearly 1,000 pounds (450 kg), which added more"drag" (a force working against the forward movement of the plane) and weight than was tolerable for the airlines.

Since the shuttering of Connexion by Boeing, several new providers have emerged to deliver in-flight broadband to airlines—notably Row 44, OnAir and AeroMobile (who offer satellite-based solutions), and Aircell (which offers air-to-ground connectivity via a cellular signal).

In the past few years, many US commercial airlines have begun testing and deploying in-flight connectivity for their passengers, such as Alaska Airlines, American, Delta, and United. Industry expectations were that by the end of 2011, thousands of planes flying in the US will offer some form of in-flight broadband to passengers. Airlines around the world are also beginning to test in-flight-broadband offerings aswell.

Satellite and internal telephony

Some airlines provide satellite telephones integrated into their system. These are either found at strategic locations in the aircraft or integrated into thepassenger remote control used for the individual in-flight entertainment. Passengers can use their credit card to make phone calls anywhere on the

ground. A rate close to US$10.00/minute is usually charged regardless of where the recipient is located and a connection fee may be applied even if the recipient does not answer. These systems are usually not capable of receiving incoming calls. There are also some aircraft that allow faxes to be sent and the rate is usually the same as the call rate, but at a per page rate. Some systems also allow the transmission of SMS.

More modern systems allow passengers to call fellow passengers located in another seat by simply keying in the recipient's seat number.

Data communication

IFE producers have begun to introduce Intranet type systems. Virgin America's and V Australia's *RED* Entertainment System allows for passengers to chat amongst one another, compete against each other in the provided games, talk to the flight attendants and request, and pay for in advance, food or drinks, and have full access to the internet and email.

Wi-Fi

Several airlines are testing in-cabin wi-fi systems. In-flight internet service is provided either through a satellite network or an air-to-ground network. In the Airbus A380 aircraft, data communication via satellite system allows passengers to connect to live Internet from the individual IFE units or their laptops via the in-flight Wi-Fi access.

Boeing's cancellation of the Connexion by Boeing system in 2006 caused concerns that inflight internet would not be available on next-generation aircraft such as Qantas' fleet of Airbus A380s and Boeing Dreamliner 787s. However, Qantas announced in July 2007 that all service classes in its fleet of A380s would have wireless internet access as well as seat-back access to email and cached web browsing when the Airbuses started operations in October 2008. Certain elements were also retrofitted into existing Boeing 747-400s.[29]

Sixteen major U.S. airlines now offer Wi-Fi connectivity service on their aircraft. The majority of these airlines use the service provided by Gogo Wi-Fi service. The service allows for Wi-Fi enabled devices to connect to the Internet. Delta currently has the most Wi-Fi equipped fleet with 500 aircraft that now offer in-flight Wi-Fi.[30]

Mobile phone

As a general rule, mobile phone use while airborne is usually not just prohibited by the carrier but also by regulatory agencies in the relevant jurisdiction (e.g. FAA and FCC in the US). However, with added technology, some carriers nonetheless allow the use of mobile phones on selected routes.

Emirates became the first airline to allow mobile phones to be used during flight. Using the systems supplied by telecom company AeroMobile, Emirates launched the service commercially on 20 March 2008.[31] Installed first on an Airbus A340-300, AeroMobile is presently operating on Emirates A340, A330, and B777 aircraft.[32] Emirates planned to roll out the system over their entire fleet by 2010.

ACARS data Communication Systems

ACARS (an acronym for aircraft communications addressing and reporting system) is a digital datalink system for transmission of short messages between aircraft and ground stations via airband radio or satellite. The protocol was designed by ARINC and deployed in 1978, using the Telex format. More ACARS radio stations were added subsequently by SITA.

History of ACARS

Prior to the introduction of datalink in aviation, all communication between the aircraft and ground personnel was performed by the flight crew using voice communication, using either VHF or HF voice radios. In many cases, the voice-relayed information involved dedicated radio operators and digital messages sent to an airline teletype system or successor systems.

Further, the hourly rates for flight and cabin crew salaries depended on whether the aircraft was airborne or not, and if on the ground whether it was at the gate or not. The flight crews reported these times by voice to geographically dispersed radio operators. Airlines wanted to eliminate self-reported times to preclude inaccuracies, whether accidental or deliberate. Doing so would also reduce the need for human radio operators to receive the reports.

In an effort to reduce crew workload and improve data integrity, the engineering department at ARINC introduced the ACARS system in July 1978, as essentially an automated time clock system. Teledyne Controls produced the avionics and the launch customer was Piedmont Airlines. The original expansion of the abbreviation was "Arinc Communications Addressing and Reporting System".[2] Later, it was changed to "Aircraft Communications, Addressing and Reporting System". The original avionics standard was ARINC 597, which defined an ACARS Management Unit consisting of discrete inputs for the doors, parking brake and weight on wheels sensors to automatically determine the flight phase and generate and send as telex messages. It also contained a MSK modem used to transmit the reports over existing VHF voice radios. Global standards for ACARS were prepared by the Airlines Electronic Engineering Committee (AEEC). The first day of ARINC operations saw about 4,000 transactions, but ACARS did not experience widespread use by the major airlines until the 1980s.

Early ACARS systems were extended over the years to support aircraft with digital data bus interfaces, flight management systems, and printers.

System description and functions

ACARS as a term refers to the complete air and ground system, consisting of equipment on board, equipment on the ground, and a service provider.

On-board ACARS equipment consists of end systems with a router, which routes messages through the air-ground subnetwork.

Ground equipment is made up of a network of radio transceivers managed by a central site computer called AFEPS (Arinc Front End Processor System), which handles and routes messages. Generally, ground ACARS units are either government agencies such as the Federal Aviation Administration, an airline operations headquarters, or, for small airlines or general aviation, a third-party subscription service. Usually government agencies are responsible for clearances, while airline operations handle gate assignments, maintenance, and passenger needs.

The ground processing system

Ground system provision is the responsibility of either a participating ANSP or an aircraft operator. Aircraft operators often contract out the function to either DSP or to a separate service provider. Messages from aircraft, especially automatically generated ones, can be pre-configured according to message type so that they are automatically delivered to the appropriate recipient just as ground- originated messages can be configured to reach the correct aircraft.

The ACARS equipment on the aircraft is linked to that on the ground by the datalink service provider. Because the ACARS network is modeled after the point-to-point telex network, all messages come to a central processing location to be routed. ARINC and SITA are the two primary service providers, with smaller operations from others in

ACARS messages may be of three broad types:

- Air traffic control messages are used to request or provide clearances.
- Aeronautical operational control
- Airline administrative control

Control messages are used to communicate between the aircraft and its base, with messages either standardized according to ARINC Standard 633, or user-defined in accordance with ARINC Standard 618.[5] The contents of such messages can be OOOI events, flight plans, weather information, equipment health, status of connecting flights, etc.

OOOI events

A major function of ACARS is to automatically detect and report the start of each major flight phase, called OOOI events in the industry (out of the gate, off the ground, on the ground, and into the gate).[6] These OOOI events are detected using input from aircraft sensors mounted on doors, parking brakes, and struts. At the start of each flight phase, an ACARS message is transmitted to the ground describing the flight phase, the time at which it occurred, and other related information such as the amountoffuelonboardortheflight originanddestination. These messages are used to track the status of aircraft and crews.

Flight management system interface

ACARS interfaces with FMS flight management systems, acting as the communication system for flight plans and weather information to be sent from the ground to the FMS. This enables the airline to update the FMS while in flight, and allows the flight crew to evaluate new weather conditions or alternative flight plans.

Equipment health and maintenance data

ACARS is used to send information from the aircraft to ground stations about the conditions of various aircraft systems and sensors in real-time. Maintenance faults and abnormal events are also transmitted to ground stations along with detailed messages, which are used by the airline for monitoring equipment health, and to better plan repair and maintenance activities.

Ping messages

Automated ping messages are used to test an aircraft's connection with the communication station.[7] In the event that the aircraft ACARS unit has been silent for longer than a preset time interval, the ground station can ping the aircraft (directly or via satellite). A ping response indicates a healthy ACARS communication.

Manually sent messages

ACARS interfaces with interactive display units in the cockpit, which flight crews can use to send and receive technical messages and reports to or from ground stations, such as a request for weather information or clearances or the status of connecting flights. The response from the ground station is received on the aircraft via ACARS as well. Each airline customizes ACARS to this role to suit its needs.

Communication details

ACARS messages may be sent using a choice of communication methods, such as VHF or HF, either direct to ground or via satellite, using minimum-shift keying (MSK) modulation.

ACARS can send messages over VHF if a VHF ground station network exists in the current area of the aircraft. VHF communication is line-of-sight propagation and the typical range is up to 200 nautical miles at high altitudes. Where VHF is absent, an HF network or satellite communication may be used if available. Satellite coverage may be limited at high latitudes (trans-polar flights).

Role of ACARS in air accidents and incidents

In the wake of the crash of Air France Flight 447 in 2009, there was discussion about making ACARS an "online-black-box" to reduce the effects of the loss of a flight recorder. However no changes were made to the ACARSsystem.

In March 2014, ACARS messages and Doppler analysis of ACARS satellite communication data played a very significant role in efforts totrace Malaysia Airlines Flight 370 to an approximate location. While the primary ACARS system on board MH370 had been switched off, a second ACARS system called Classic Aero was active as long as the plane was powered up, and kept trying to establish a connection to an Inmarsat satellite every hour. The ACARS on the Airbus A320 of EgyptAir flight 804 reported "irregularities" to ground staff on three separate occasions, which led tothree emergency landings, in the 24 hours prior tothe aircraft's crash into the Mediterranean Sea on May 19, 2016, which killed all 66 persons on board. The specific nature of the irregularities was not explained, but at each instance the aircraft was given clearance to continue its flight.

THANK YOU