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Space Communication System Based on Radio Signal System and Space Weather Effects on Aircraft Operations

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ABSTRACT

Radio Signal system is a method of transmitting intelligence from one location to another by means of electromagnetic radiation. Communication systems also involve voice transmission and reception between aircrafts and ground. These systems are installed in all types f aircraft so a pilot be given information and directions and may request information from air traffin control centre, control towers and flight service stations. The Solar EUV and Lyman alpha emissions create the ionosphere by photo-ionization, which ionizes neutral atoms producing free ions and electronics. These positively and negatively charged particles are embedded in the neutral atmosphere and form a weak plasma that interacts with radio waves of various frequencies in different ways. Reliable communications are a vital component of safe and efficient air travel. Space weather can be a problem as it drives and perturbs the very regime it creates, the ionosphere. The ionosphere is the key to HF communications for aviation; the lower HF frequencies need the ionosphere to reflect the signal back earthward. This paper explains Space Communication System based on Radio Signal System and Space Weather effects on Aircraft Operations.

Key words: Space, Aircraft Operations, Weather, Radio Signal System

INTRODUCTION

Much of aviation Communication and Navigation is accomplished through a use of High Frequency Radio Waves. Communication by radio was the first use of radio frequency transmission in aviation. The First World War brought about an urgent need for communication. Voice Communication from ground to air and from aircraft to aircraft were established. The World war II injected urgency into a development of aircraft radio communication and navigation Aircraft Navigation systems include – Very High Frequency Unidirectional Range, Instrument Landing system, Distance Measuring equipment, Automatic Direction Finders, Doppler Navigation System, Inertial Navigation System. In airplane operations and all instrument flights, a flight of an aircraft is continuously monitored by air traffic control (ATC). The very high frequency communication systems are employed largely for air traffic.Communication system involves voice transmission and reception between aircrafts and ground. It can be said that a safe aircraft communication is dependent to large extent upon satisfactory performance of communication system, The onboard radio equipments uses different types and size ofantenna's. Each design for their own frequency band. Each of their antenna's of their own characteristics regarding frequency and application and thus location on a spacecraft. The Solar EUV and Lyman

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Space Communication System Based on Radio Signal System

A radio wave is invisible to a human eye. It is electromagnetic in nature and part of a electronic spectrum of wave activity that includes gamma rays, X-rays, ultraviolet rays, infrared waves and visible light rays and radio waves also. Radio waves are directional and propagate out into space at least 186,000 miles per second. The distance they travel depends on the frequency and the amplification of the signal AC sent to the antenna. High frequency (HF) radio waves travel in a straight line and do not curve to follow the earth's surface. Radio waves are types of electromagnetic radiation. Radio wave frequencies vary from 300 GMz to small as 3 Khz. Radio waves travels a speed of light. The atmosphere is filled with these waves. Each wave occurs an specific frequency and has a corresponding wave length. Long wavelengths cover a part of a earth constantly and reflect off a ionosphere and then travel around a world. Shorter wavelengths bend very little and travel on a line of a sight. Basic Radio system components are- an amplifier, a transmitter and receiver [1]. An amplifier is a device that increases strength of a signal. They are found in both transmitters and receivers. A transmitter must increase strength of the signal sent to a antenna so that a electromagnetic Waves will travel a useful distance outward from a antenna. A receiver needs amplifiers because strength of a signal from a antenna is very low and must be increased to enable a signal to be heard. Radio waves produced at these frequencies ranging from 3Hz to 3mHz are jnown as ground waves or surface waves. This is because they follow the curvature of the earth as they travel from the broadcast antenna to the receiving antenna. Ground waves are particularly useful for long distance transmissions. High frequency (HF) radio waves bounce off of the ionosphere layer of the atmosphere. This refraction extends the range of HF signals beyond line-of-sight. Transoceanic aircraft often use HF radios for voice communication.Above HF transmissions, radio waves are known as space waves. Most aviation communication and navigational aids operate with space waves (High frequency radio waves. This includes VHF(30-300MHz), UHF(300MHz-3GHz), and super high frequency (SHF) (3GHz-30GHz) radio waves. VHF communication radios are the primary communication radios used in aviation.They operate in the frequency range from 118.0 MHz to 136.975 MHz. Seven hundred and twenty separate and distinct channels have been designated in the range with 25 kilohertz spacing between each channel. VHF radios are used for communications between aircraft and aircraft and air traffic control (ATC), as well as air to air communication between aircraft. When using VHF, each party transmits and receives on the same channel. Very high frequency communication systems are employed largely for controlling air traffic. To transmit radio waves, an AC generator is placed at the midpoint at the midpoint of an antenna. As AC current builds and collapses in the antenna, a magnetic field also builds and collapses around it [2].

Air Traffic Control for Space Communication System

Air Traffic Control is a service provided by ground based controllers who direct the aircraft on the ground and through controlled Air Space and can provide advisory services to aircraft in non-controlled Air Space. An aircraft uses a range of radio frequencies to navigate its designation and communication its Air traffic control. The Air traffic controllers have access to sophisticated radar systems that provide an overview of a airspace and they have communication tools to coordinate flight paths with aircrew. Very High Frequency communication system is employed largely for controlling air

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traffic. These systems are installed in all types of aircraft so a pilot may give information from air traffic control centres, control towers and flight service stations. On the approach to any airport with two way radio-facilities, a pilot of an aircraft calls the tower and requests information and instructions. So a pilot should rely on Air Traffic Controllers to guide the aircraft through a congested airspace. The pilot in command is the final authority for the safe operation of Aircraft and in emergency he may deviate from Air Traffic System instructions to maintain Safe operation of Aircraft. Air traffic controllers are organized into different groups depending on a handling a distinct portion of a aircraft's flight. The airspace controlled by each group is divided into sectors that are handled by individual controllers. These groups aree organized varies from country to country and depends on the extent of controlled airspace and number of aircraft handled. The entire traffic control system includes with Airport Control, Ground Control, Local Control, and Approach& Terminal Control. If Local Control detects any unsafe condition, a landing aircraft may be told to "Go-Around" and be sequence into the landing pattern by the approach or terminal area controller [3]. The tower controllers are a most visible and important group. From their vantage point on the airport tower, they have a visual overview of all the important parts of a airport tarmac. Tower controllers monitor the air space surrounding a airports and keep tract of approaching and departing aircraft. At well organized airport, they can access also a surface movement radar system to monitor the aircraft. With the use of surveillance radars, they are able to monitor in Air Traffic around the airport. These facilities are called as Terminal Radar Approach Control (TRACON) facilities. In New York where airports are very close to each other, a TRACON facility can service multiple airports. TRACON facilities sequence the aircraft that are coming in to land in order to ensure that the are adequetly separated to minimize any wake turbulence effects. Departure controllers need to take into account that may be flying through their airspace and keep them separated from aircraft landing or taking off. As the aircraft axists TRACON airspace, a facility known as An Area Control Centre (ACC) takes over. These facilities monitor a aircraft's flight which is controlled airspace through remote radar stations. An aircraft may fly control multiple ACC sectors as it files to its designation with each ACC handling off control of the aircraft to the next ACC as it exists the former's airspace [4-5]. Aircraft communication in early times was over a High Frequeny range of Radio Spectrum. Modern Civil Aviation uses the High Frequency and Very High Frequency parts of the spectrum for communication between Aircraft and ATC.

Air Traffic Control and Aircraft Navigation

Radar is an object detection system that uses radio waves to determine a range, angle and velocity of a objects.The RADAR has three major applications in Air Traffic Control- to control air traffic near airports. The Air Survillence RADAR is used to detect and display the aircrafts position in the airport terminals, to guide the aircraft to land in bad weather using Precision Approach RADAR, to scan the airport surface for aircraft and ground vehicle positions [6]. The system consists of transponders, installed in aircraft and Secondary Surveillance Radars(SSRs), and installed at air traffic control facilities. High resolution radar situation displays provide air traffic controllers with aircraft position and flight information. The Primary Surveillance Radar sends a directional pulse into the atmosphere and when the pulses encounter an object it gets reflected back to the radar station. A larger aircraft would be visible at a greater distance than a smaller aircraft due to the larger surface area available for refliecting the radar waves. The Secondary Surveillance Radar system or Air Traffic Control Radar Beacon System (ATCRBS) is comprised of the ATC Radar Installation and a transponder that rides onboard by the aircraft being monitored. With the Primary Surveillance Radar listens for reflected radio signals, the Secondary Surveillance Radar listens for messages from the aircraft's transponder. The Mode S Radar System monitor traffic in air. Aircraft complaint with Mode S provide a operational benefits are unambiguous aircraft identification, improved integrity of surveillance data, improved air

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situation picture and tracking, improvement of safety nets and to handle current and forecast increases in traffic [7]. To navigate a pilot should need these facts- The starting point of departure, the ending point of final destination, the travel direction, the travel distance, the speed of the aircraft, the fuel capacity of the aircraft and the aircraft weight. Aircraft Navigation System includes- VHF Omnidirectional Range (VOR), Instrument Landing system (ILS), Distance Measuring Equipment (DME), Automatic Direction Finders (ADF), Doppler Navigation system (DNS), Inertial Navigation System [8-9]. VOR is very high frequency navigation. VOR enables a pilot to determine the direction of his aircraft from any position to or from- actually giving bearing information. It is a electronic navigation system. VOR receiving system consists of a receiver, visual indicator, antennas, a power supply and frequency selector. ILS operates in the very high frequency portion of the electromagnetic spectrum. The system consists of a runway localizer, a glide slope signal and marker beacons for position location. It enables pilots to conduct an instrument approach to landing if they are unable to establish visual contact with the runway. DME indicates the slant range between the aircraft and the ground station. It is for constant visual indication of the distance the aircraft is from a ground station. It automatic gains control and constant duty cycle operation. The transponder operates in the band 962-1213 MHz. An ADF is a marine or aircraft radio navigation instrument that automatically and continuously displays a relative bearing from a ship or an aircraft to a suitable radio station. ADF receivers are normally tuned to aviation or marine. In case of ADF radio receivers equipped with directional antennas. DNS automatically and continuously computes and displays ground and drift angle of an aircraft without a aid of ground stations, wind estimates or true air speed data.INS derives altitude, velocity and heading information from measurement of a aircraft's accelerations. It is used on large aircraft as a long range navigationaid.

Table 1: Classification of Navigation system according to the Frequency range

Navigation System	Frequency's	Con's
VOR	108-117.95 MHz	**multiple ground stations to cover large areas**
ILS	90Hz, 150Hz, 108-111.975 MHz, 328.6-335.4Mhz	**sensitive to obstructions, complex**
NDB/ADF	190-535 kHz	**Susceptible to atmospheric and terrain bounce**
DME	**1025-1150 MHz**	**Replacing with GPS**

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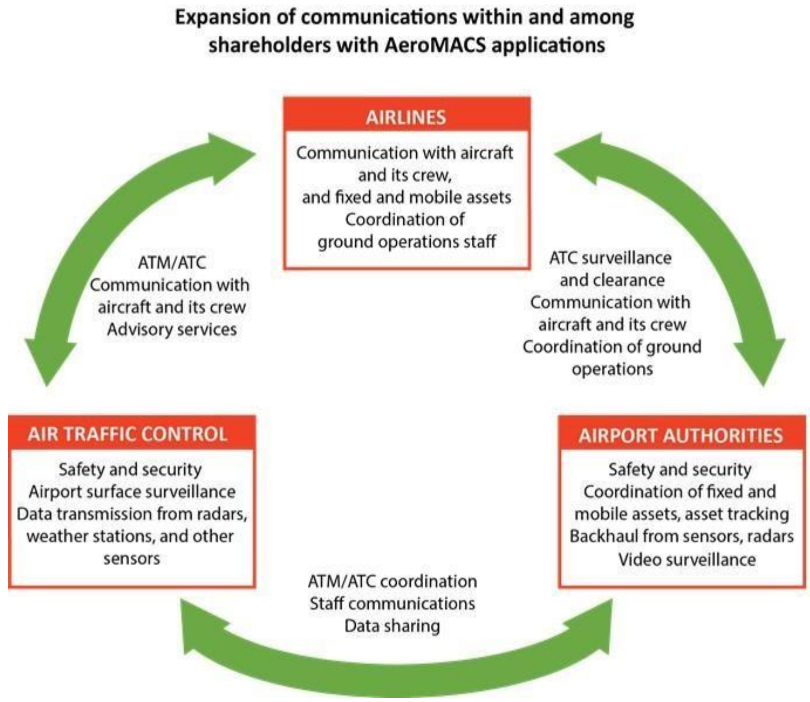

Figure 1: Air Traffic Control System

Effects of Space Weather on Aircraft Operations

Reliable communications are avital component of safe and effiecient air travel. Space Weather can be a problem as it drives and perturbs the very regime it creats, the ionosphere. The ionosphere is the key to HF coomunications for aviation: the lower HF frequencies need the ionosphere to reflect the signal back earthward. For satellite communications the higher satellite frequencies that must pass through the ionosphete may suffer loss of power or frequency stability. The solar EUV and Lyman apha emissions create the ionosphere by photo ionization, which ionizes neutral atoms producing free ions and electrons. These positively and negatively charged particles are embedded in the neutral atmosphere and form a weak plasma that interacts with radio waves of various frequencies in different ways. Since the sun is a variable star, its output can vary over a wide range of time scaled- solar flares, solar protons- as well as the long term over the eleven year solar cycle, with EUV. This solar variability necessitates a level of understanding and procedural flexibility to enable optimal communications at all times. As the impacts on HF are different from those on SATCOM, and as the types of impacts vary spatially, it is helpful to describe each condition- HF low-mid latitude; HF high latitude and polar region; SATCOM low mid altitude, SATCOM high latitude and polar region-individually. HF communications at low mid latitudes are used by airlines during trans-oceanic flights and routes where line -of-sight VHF communication is not an option. HF enables a skip mode to send a signal around the curvature of earth. HF communications on the dayside can be adversely affected when a solar flare occurs and its photons rapidly alter the electron density of the lower altitudes of the ionosphere, causing fading, noise, or a total blackout. Usually these disruptions are short lived- tens of minutes to a few hours – so the outage ends fairly quickly. HF communications at high latitudes and polar regions are adversely affected for longer periods, sometimes days, due to bad space weather. The high latitude and polar ionosphere is a sink for charged particles, which alter the local ionization, provide steep local ionization

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gradients to deflect HF radio waves as well as increase local absorption. The near vertical magntic field lines allow particles to reach low altitudes Normal auroral processes include electron precipitation; solar radiation storms and energetic protons; and fro the dayside region, solar flare photons can add a further unwanted ioization source. Operationally, HF is the primary means of radio communications above approximately degrees latitude. This is because the VHF range of the ATC facilities is exceeded and SATCOM communications are often impossible north of degrees. Normal SATCOM options are via satellites in orbit over the equator, but contact with these satellites is lost because the satellite is occulted by the limb of earth from the region near the poles. Polar orbital communications satellites are an increasingly viable option for polar flights but most airlines are not equipped to use these polar orbiting satellites. Polar satellites are not fully immune to a different suite of space weather effects. A description of those issues follows in this document [10-11].

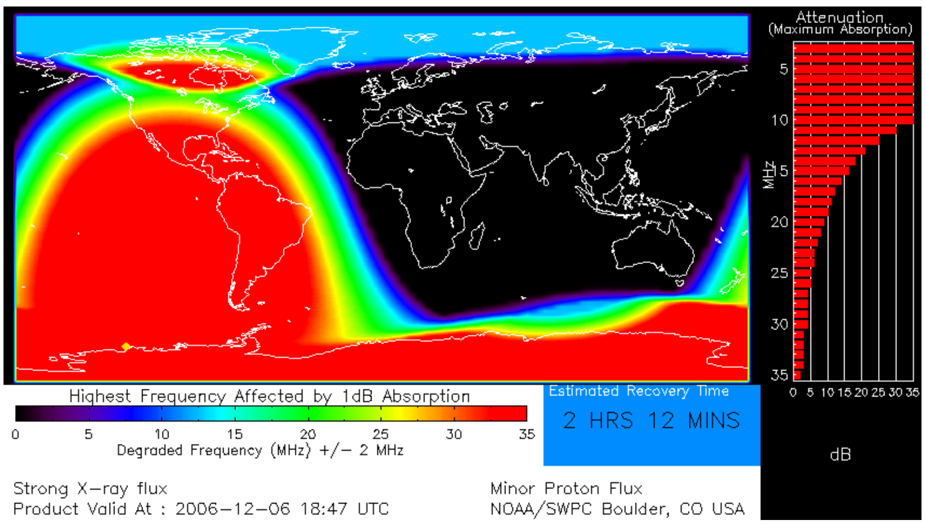

Figure 2: The global D-Region Absorption depicts the D-region at high latitudes where it is driven by particles (sollar radiation storm) as well as low latitudes

SATCOM Signals pass through the bulk of the ionosphere and are a popular means of communicating over a wide area. The frequencies normally used for satellite communications are high enough for the ionosphere to appear transparent. However, when the ionosphere is turbulent and non homogeneous, an effect called scintillation, a twinkling in both amplitude and phase is imposedupon the transmitted signal. Scintillations can result in loss of lock and inability for the receiver to track a Doppler shifted radio wave. In the quatorial region, approximately 10 degress either side of the geometric equator, seven scintilations can cause SATCOM signal degradationand blackout, for periods from sunser to near midnight in local time. Thee scintillations become more severe in the solar maximum era and also have a seasonal dependency. At middle latitudes, SATCOM can be impacted during very strong space weather storms as occurred in October- November of 2003. Reports of poor or lost SATCOM were made by various operators, and ground based GPS receivers documented the difficulty of receiving a transionospheric UHF signals, even at the generally middle latitudes. Measurements showed "ionospheric walls" of TEC with very severe ionization gradients These severe ionospheric conditions will likely again hamper SATCOM during the next maximum of solar activity, expected to be centered around 2013. SATCOM in the high latitude and polar regions is also affected by scintillations in the ionosphere. But unlike the amplitude scintillations that most commonly occur nearer the equator, it is phase scintillations that are the issue here. Phase irregularities cause similar loss of lock and fading issues for

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the receiver, and occur at their greatest severity during geomagnetic and ionospheric storms. Very low level phase scintillations are a common occurrence and do not pose a significant threat for SATCOM [12].

CONCLUSION

The Communication systems involve voice transmission and reception between aircrafts and ground through Air Traffic Control system, Radar and Antenna. These systems are installed in all types of aircraft so a pilot may be given information and directions and may request information from air traffic control centre and flight service stations. . For satellite communications the higher satellite frequencies that must pass through the ionosphere may suffer loss of power or frequency stability. Since the sun is a variable star, its output can vary over a wide range of time scales- solar flares, solar protons- as well as the long term over the eleven years solar cycle, with EUV. This solar variability necessitates a level of understanding and procedural flexibility to enable optical communication at all times.

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