TRANSITIONING AIR to SPACE

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Abstract

This term paper will cover the construct of U.S. national airspace and some of its respective boundaries. It will cover the existing guidelines for pilots inside the Earth's atmosphere while transitioning these boundaries. The human element will be considered for its limitations with some of the physiological effects of climbing to space altitudes. The limitations of mechanical appliances will also briefly be discussed. In addition, the application of the Space Plane and a need for international space law and policy changes that would allow this technology to flourish. Finally is the need for structure in the current airspace configuration with the addition of space as an extension. Conforming as best as possible to the existing treaties, these amendments must be suitable and acceptable for and by all mankind. Appendices are included to help the reader visualize existing airspace and a simple suggestion by a pilot for the transition from air to space.

1. Established Limits of Airspace

The Webster's dictionary definition of airspace is "the portion of the atmosphere above a particular land area, especially above a nation." In the United States of America the airspace up to the highest altitude inter-atmosphere craft (airplanes) fly is designated in ways that allow for air traffic separation and safe obstacle avoidance parameters. There is a plethora of rules, regulations and standards that must be followed when a pilot transitions through the atmospheric regions that surround mother Earth. For simplicity sake, this paper will describe only the airspace construct, boundaries and the reasons they were implemented. International airspace varies to a certain degree and so this paper will also focus primarily on the construct mainly that of the United States.

Picture the United States and an overlying cross sectional view of the atmosphere above it. Now imagine if you could see various colors and shapes that are designated as classifications of this space. There are six main classifications of airspace known as A, B, C, D, E, and G respectively. While operating in these areas pilots are subject to rules, individual qualifications and aircraft specifications. Looking into the cross section in mind and the multi-faceted operations taking place within, visualize the following:

From the surface up to the next layer are areas known as Class G or (uncontrolled) airspace. Class G typically extends from the surface of the Earth to the floor or bottom of the next overlying airspace classification. Most common and of the next largest in coverage area is Class E (controlled) airspace. This is the airspace where most commercial traffic is located and operations are conducted. The altitude of the Class G (in areas with overlying Class E) is typically up to 700 or 1200 feet Above Ground Level (AGL). In mountainous terrain Class G may extend from the surface to 14,500 feet Mean Sea Level (MSL) to compensate for the higher ground level. If however the terrain becomes higher than 14,500 feet the Class G would be from the surface to 1,500 feet AGL. In any other areas with no overlying Class E the Class G is from the surface to 14,500 feet MSL.

The reader should now have the visualization of the surface, the Class G, and the overlying sections of Class E. See the Earth as Brown, the Class G as Green, and the Class E as Magenta. Everywhere there is a city or town with a major airport, picture these Class E areas. Imagine the Magenta color in layers like an upside down wedding cake from their highest altitude to the ground.

Depending upon the operations and specifics (such as radar) of the particular airport there are the Class D (Centennial for example), Class C (Colorado Springs), and Class B (DIA) classifications. Picture these as upside down wedding cakes of various colors placed over each of the airports in this visualization. Each section of the cake has an altitude specification for its ceiling and its floor. The most center section always extends from the ground to the highest altitude of the cake. The colors represented in this are the actual colors used on pilot Visual Flight Rules (VFR) charts. Like the Class E airspace, the Class C is also Magenta, the Class D is depicted by a blue dashed outline and Class B is a large Blue inverted wedding cake.

With this in mind the reader can see the aircraft leave one airport and climb out of its respective "air cake" and into the Magenta Class E. Climbing higher into the one classification remaining that is the Class A airspace.

Class A airspace starts at 18,000 MSL and extends to Flight Level 600 (FL600), which is 60,000 feet. This covers the majority of the contiguous states and Alaska as well as the area extending 12 nautical miles out from the U. S. coast. Aircraft operating in Class A must be equipped with a transponder having mode C altitude encoding capabilities that allow the aircraft to be tracked by Air Traffic Control (ATC). VFR charts are not used and VFR flight is not allowed in Class A airspace. There are what is referred to as Jet Routes that designate (currently) traffic patterns from 18,000 feet to FL450. The rules that apply to all flights in Class A are designated as Instrument Flight Rules (IFR). The pilots must be instrument rated and on a Federal Aviation Administration (FAA) filed flight plan that gives ATC the exact course route and altitude that is intended for the entire flight.

After the completion of the main portion of the flight the atmosphere craft begins its decent back to the surface of the Earth. The reader can confirm visualization (appendix A) from the decent from Class A through any Class G or E to the desired B, C, or D airports. While understanding volumes more about this airspace and a multitude of other sciences, the skilled pilot with extreme precision and surgical accuracy, through rain, hail, wind and storm, gently places the atmosphere craft on the runway.

1.1 Human Limits

There is much to be explained to understand the physiology of flight both in and above the Earth's atmosphere. Again for simplicity, the basics are in need of explanation only to continue with the visualization of a transition in airspace from inner to outer space. The limits of the human element begin at the surface of the Earth and begin to degrade with the first 5000 feet of altitude gained. Here slight hypoxic effects can be felt as the air begins to thin out with less and less oxygen molecules per volume of air available. For pilots in command of aircraft the Federal Aviation Regulation/Aeronautical Information Manual (FAR/AIM) states for all flights 12,500, 14,000, and 15,000 feet MSL oxygen availability and regulations must be followed. FAR 91.211 (a)(3) "No person may operate a civil aircraft of U.S. registry at cabin pressures above 15,000 feet (MSL) unless each occupant of the aircraft is provided with supplemental oxygen." (FAR/AIM2002)

At altitudes of 18,000 feet and half of the Earths altitude below hypoxic effects can be fatal. Hypoxia (lack of oxygen in the blood) can render an aviator unconscious in less than 30 minutes at this altitude. At 16Km or 9 miles supplemental oxygen is no longer useful. The pilot must wear a pressure suit or the cabin of the aircraft must be pressurized such as with commercial airliners or corporate jets. John F. Graham explains further:

> At 20 Km (12 miles) the outside atmospheric pressure equals the vapor pressure of the human body or about 47 millimeters of mercury. In this environment bubbles of water and other gases begin to form in the body. The bodily fluids begin to literally boil. A pressurized cabin or a pressure suit will protect all occupants of an aircraft at this altitude from this violent condition. At 24 Km (15 miles) an aircraft's pressurization system no longer functions economically. There is so little oxygen and nitrogen at this altitude that it cannot be compressed to protect the pilot, crew, or passengers from the outside elements. Also at this altitude, the ozone layer begins to form in the atmosphere. Even though ozone consists of three atoms of oxygen per molecule, this substance is poisonous to the human body and compressing ozone would poison the cabin and its occupants.

So how does all of this medical information play into the "Transition from Air to Space?" If humans are going to be on board the future craft that transition the atmosphere on a regular basis, the human element and its limitations must be taken into consideration. The author John Graham also gives this explanation of the altitude where space begins for the human body.

> At this altitude (15 miles) the cabin or space suit must have its own pressure and oxygen independent of the outside atmosphere. For the human body space begins at this point because above this altitude a human must carry everything in order for the body to survive. This is probably the doctor's definition of where space begins.

1.2 Mechanical Limits

The conventional jet engine altitude limit is approximately 20 miles or 32Km. Ramjets that operate from the compression of shock waves operate up to about 28 miles or 45Km. After this altitude rockets that create their own oxygen from the oxidizer/fuel mixture must be used. At 50 miles or 81 Km the pilot earns astronaut wings. Besides the shuttle orbiter, only planes such as the X-15 have flown at these altitudes. After 62 miles (100 Km) the aerodynamic control of even the X-15 is lost. Thus this is the altitude where many scientists and engineers recognize the beginning of space. "International law states that there is no definitive point where the atmosphere ends and space begins. The major space powers accept the following definition: Space begins at the lowest perigee attained by orbiting space vehicles." (Graham)

1. Space Laws Application

In consideration of the topic at hand, the transition from the above described airspace, through a not yet defined boundary layer to the vacuum of space, a model for applicable law must be analyzed. For the sake of visualization and an actual real application of present technology, the Space Plane will be used.

There are two types of space plane, the STS (surface to surface) and the STO (surface to outer space). These are air/space craft that can takeoff, enter low earth orbit

(LEO), re-enter and land like conventional aircraft. The STO's main mission will be to carry passengers and equipment to and from the space station while the STS will mimic the Concorde for very fast international flights. Even though the STS does not technically leave the Earth's atmosphere, both planes contain "space objects" and therefore must be categorized the same regarding space law.

> A space object is a body that is able to reach the first cosmic speed or circular speed and more, with the intention of launching that body into earth orbit or beyond, including a series of activities related to that launching as well as an attempted launching. (spacefuture)

2. The Need for Structure

The main legal implications at hand deal directly with the outer space treaty and the convention on international liability for damage caused by space objects of 1972. "The problem is due to the fact that only international, intergovernmental organizations can seek compensation under this convention." (pp. 3) Because of this the present liability would not cover all the persons damaged in an accident of the STO. Finally for this technology to flourish the need for the commencement of meetings and due law process must continue. By implementing proposals for amendments to the conventions and treaties, our nation must lead the world into the next phase of our exploration and exploitation of space. This should begin with international conventions addressing these needs; which include the airspace and transition to space that must also be defined and regulated.

3. Proposed Solution

All scientists, engineers, lawmakers and the like must have some type of map, in whatever form it may be, to begin the visualization necessary to implement change. Appendix B is a drawing that is only a suggestion, but is a place to start. In this the reader can visualize the STO taking off from the depicted airport, transition national and then international (if necessary) airspace, cross the boundary layer that would define the Transition from Air to Space, and move forward with a legacy that to this author, seems to have been left behind.

Conclusion

The reader should now have a basic understanding of the existing national airspace structure. A visualization of the existing boundaries that allow for separation of air traffic and a safe transition from departure to destination should be clear. The human element and physiological limitations that must be considered prior to the addition of additional airspace guidelines have been discussed. Mechanical limitations on air/space craft basics are included as this is imperative to program, design, engineering and continued R & D efforts necessary for operations through these new frontiers. The Space Plane example is a small model of the immediate need for the implementation of new international space laws and treaty modifications. Addressing the liability issue is important but without structure and mutual international agreement for operations to and from space, there can be no accidents for nations and states to be liable for. So with all of this in mind it should be evident that the “Delimitation” between Earth and outer space is most definitely an issue that must be solved in the most expeditious manner. (Granquist)

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