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# AIR WAR COLLEGE

## Research Report

SPACE IS A "DIFFERENT" PLACE

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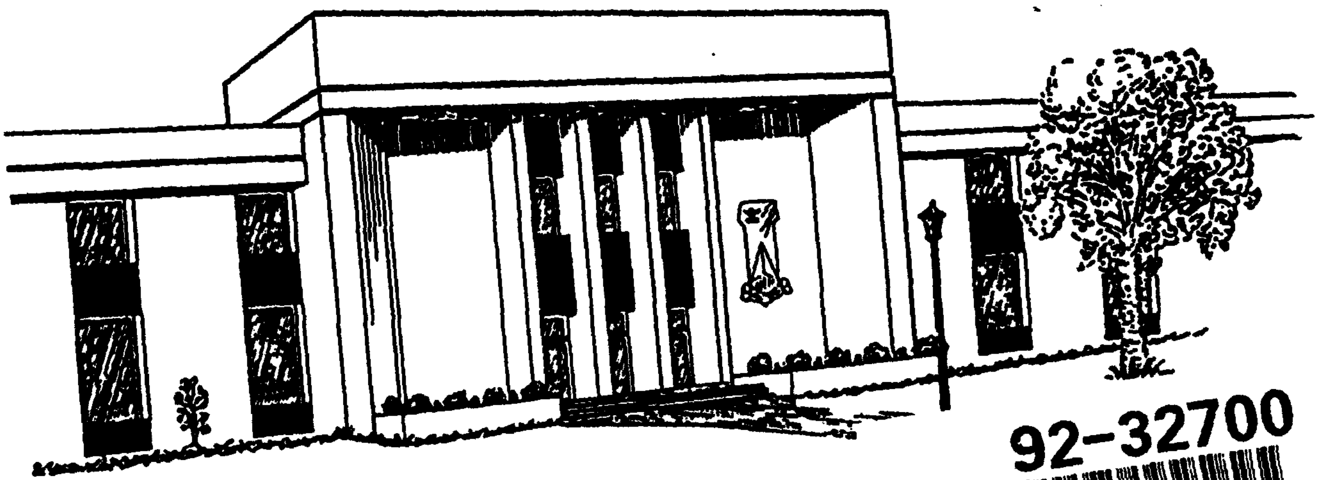

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# SPACE IS A "DIFFERENT" PLACE

by

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## SPACE IS A "DIFFERENT" PLACE

US Air Force policy is that "space is a place,"[1] not a mission, and second, that air and space (aerospace) constitute a single environment. Although Desert Storm was a "watershed event in military space applications,"[2] and some have even called the Gulf war the "first space war," to date this policy remains unchanged.

The US Air Force has implemented this policy in both its organization and doctrine. The creation of the Air Force Space Command translated this policy into Air Force organization. The recently published 1992 edition of the Air Force Manual 1-1, Basic Aerospace Doctrine of the United States Air Force, incorporates this policy into doctrine. In the paragraph above, the first policy component reflects bureaucratic political decisions. The second, although policy, is more an issue of physics than politics and is, therefore, amenable to objective discussion and is the focus of this article.

This analysis is not written to support the establishment of a separate Space Force. It is written because space is becoming increasingly important to successful military operations, but is "the least understood of all military environments."[3] This paper analyzes rationale in AFM 1-1 for treating air and space as a single environment and further examines the nature of the air and space environments through the lens of characteristics of air power (speed, range, flexibility, precision, and lethality).

The purpose in comparing the air and space environments is to help Air Force users of space systems and those making decisions on space systems to avoid the mistake, common even among space advocates, of merely replacing "air" with "aerospace" in discussions of doctrine, requirements, and operations. This linear mindset too easily fosters operational expectations of existing space systems that cannot currently be met, creating an apparent "over-sell" of space capabilities. It also tends to result in statements of future space system requirements that demand too little and do not take into account the full potential of the space environment. As Major General Peter Robinson, Air War College Commandant, recently stated, "Aerospace is not an adequate doctrinal concept <u>if</u> it leads to a blurring or lack of understanding of air and space capabilities."[4] The ultimate goal of this paper is to advance discussion and understanding of space and space systems. The conclusion is not that air and space have nothing in common, but rather that AFM 1-1 does not substantiate its assertion that air and space constitute a single environment.

## AFM 1-1 RATIONALE FOR UNIFIED AEROSPACE ENVIRONMENT

Air Force Manual 1-1 presents several arguments for treating air and space as a single operating environment. The first argument AFM 1-1[5] makes for the unity of aerospace is:

> The aerospace environment has only one distinct boundary - the earth's surface; no lateral boundaries restrict movement within it.[6]

While air and space do share some of the same characteristics with regard to movement and boundaries,[7] there are differences. In any orbital regime, the motion of vehicles is governed, not by control surface deflections, but by Kepler's laws of gravitational physics. The result, using the language of AFM 1-1, is a severe restriction on "lateral movement" in space.

To illustrate these differences, consider the following. In space, a vehicle can continue at high velocities or remain in a fixed position without expending additional energy.[8] In contrast, friction and drag in the atmosphere prevent aircraft from remaining at a constant velocity or hovering without continuous expenditure of energy.

As a second illustration, within the parameters of sink rates, slip, and up and down drafts, an aircraft can fly toward any point of the compass it is directed. A spacecraft orbiting the earth, however, cannot move directly east or west relative to the terrain beneath it, unless the vehicle happens to be in an equatorial orbit.[9]

A related difference between air and space is the relative amount of energy required to maneuver in the two environments. Large amounts of energy are needed to divert an orbiting vehicle from its established orbit. Even small maneuvers perpendicular to the plane of the orbit require such massive amounts of energy as to make them impractical. Smaller, feasible changes within the plane of the existing orbit require extensive time to plan and in some cases (e.g., engine thrusting to de-orbit) require such exactness that the precision of computers is required.[10]

As an illustration, for an aircraft to reverse direction requires only the energy to actuate a control surface deflection associated with executing a turn. However, an orbiting spacecraft reversing direction would consume energy equivalent to that needed to stop its existing velocity, turn its orientation, and then regain its original speed in the opposite direction.[11]

The second argument in AFM 1-1 for the unity of the aerospace environment is that there is no apparent boundary where air ends and space begins.

> The environment extends from the earth's surface toward infinity....The difference between (the) atmosphere and space is obvious but where the transition takes place is not clear.[12]

This approach to rationalize the aerospace concept fails to logically support the conclusion. First, a boundary does not have to be a narrow line to constitute a de facto boundary. The distinction between the sea and the land fluctuates with the tides and wave action, but still constitutes a boundary. Second, the AFM 1-1 statement concedes that there is a boundary, but "where the transition takes place" cannot be determined.

To the contrary, by physical phenomena and administrative practice agreement exists on the boundary between air and space. For practical purposes, above 60 miles altitude friction and drag cease and make "air" craft nonfunctional. By administrative practice, astronaut wings are awarded for excursions above 50 miles.[13]

Third, AFM 1-1 asserts the unity of aerospace by the projected development of a vehicle that will operate in the air and in space.

> Planned development of an aerospace plane to operate both in the atmosphere and space serves to illustrate the continuity of aerospace.[14]

This final argument for air and space as a single environment is not convincing. First, an aerospace plane might be a stronger argument, except it will use different propulsion and control systems in air and in space. A single vehicle that requires multiple means of propulsion and control to operate in air and space is an argument for air and space constituting separate environments, not a single environment.[15] If aerospace were an indivisible, continuous environment, physical phenomena would operate with similar result in all portions of the environment and dual engineering approaches would not be required.

Second, if the existence of an aerospace plane substantiates the continuity of air and space, then other systems argue against traditional distinctions between land, sea, and air. The seaplane operates in both sea and air environments. Special amphibious vehicles operate on water and land. Moreover, both of these examples use a single mode of propulsion, and thereby are stronger support for the continuity of sea-air and sea-land environments, respectively, than is the aerospace plane for the continuity of air and space.

## CHARACTERISTICS OF AIR POWER

Having reviewed the arguments in AFM 1-1 for the continuity of the aerospace environment and found them less than convincing, to what extent are air and space systems similar when viewed through the lens of the characteristics of air power? Figure 1 compares the speed, range, flexibility, precision, and lethality of air and space systems.

Such a comparison of air and space systems highlights a number of differences between the two regimes, with each enjoying certain advantages. Space systems have much higher speeds, employ self-contained propulsion systems, have much longer operational ranges and in many cases greater loiter times. They also have the potential to employ directed energy, laser, and particle beam

Figure 1. AIR AND SPACE COMPARISON

| Characteristics of Air Power: | Air/Aircraft | Space/Spacecraft |
|---|---|---|
| **SPEED** | | |
| * Values | 1,000 mph | 17,000 - 25,000 mph minimum |
| □ Propulsion Mechanism | 1. Aerodynamic lift<br>- Fixed & Rotary<br>2. Atmospheric Combustion | Self-contained<br>- Chemical, nuclear, and solar |
| **RANGE** | | |
| □ Altitude | 0-60 miles | 60 miles plus... |
| □ Distance | Global (with refuel)<br>- hours | Global<br>- 90 minutes<br>Hemisphere<br>- Instantaneous |
| **FLEXIBILITY** | | |
| □ Loiter | Hours | Minutes-Years<br>- Orbit dependent |
| Redirect Path | | |
| * Plan/Execute | Seconds | Days/Weeks |
| □ Scope | 360 degrees | Limited, depends on<br>- Orbit and fuel |
| * Takeoff/Land | | |
| o Factors | Runway length<br>Ground/air conditions | Support infrastructure<br>Air conditions |
| o Locations | Thousands | Launch sites<br>- Only East/West Coast<br>- 14 launch pads ** |
| * Sortie Rate | Several per day | One every 3-6 months |
| * Sortie Generation | Hours | Months-years |
| □ Upgrade Capability | As required | Limited to some software |
| # **PRECISE WEAPON DELIVERY** | Weapon system dependent<br>- Some supported by space systems | None (by treaty) |
| **LETHALITY** | | |
| # Weapon Type | Conventional, CBW, Nuclear | None (by treaty) |
| □ Delivery Mode | Gravity, missile, RPV, Manned, Laser | Gravity, Missile, RPV, Manned, Directed energy Laser, Particle beam |

Differences in Air and Space <u>systems due to:</u>
* Technology
# Political decisions
□ Nature of air and space

** 8 pads East Coast
6 pads West Coast

weapon systems that have their maximum potential in the space environment. Air systems use both lift and propulsion to maneuver, have much faster redirection capability, more takeoff locations, greater sortie rates, shorter generation times, and significantly more flexibility for upgrade or modification of system capabilities.

## IMPLICATIONS OF DIFFERENCES BETWEEN AIR AND SPACE

Currently and for some time to come, space and space systems are different from air and aircraft. Until there are aerospace craft that enjoy the advantages of air and space systems, current operations planning and space system requirements must recognize the differences between air and space. Commanders of current aerospace systems must understand and take into account the unique characteristics of air and space systems if they are to effectively employ aerospace capabilities. Current space systems have some notable operational limitations that are not shared by aircraft. Due to current extended launch response times, only on-orbit assets should be expected to provide space support of near-term operations. Any optimization of on-orbit assets for a specific region of interest should be expected to be measured in months.[16] Military commanders must also take into account the periodic nature of some space access to specific regions. On the positive side, existing space assets may provide access to a region of interest prior to having any in-theater assets deployed and can play a major role in planning force movements and supporting forces enroute to distant theaters of operations.

While care must be taken to avoid raising operational expectations for support of current operations beyond the capabilities of existing space systems, the other extreme must also be avoided. Requirements for future space systems must not stop short of exploring the full potential of the space environment through a linear mindset that equates space with the air environment. Future space systems must fully exploit the unique characteristics of both space and space systems if we are to have effective aerospace capabilities.

It is true that the functions proposed to be performed in space are thus far the same as those accomplished in the air. However, the characteristics of space may dictate different approaches to accomplish these tasks from those used in the air environment. The space environment permits some of these functions to be performed faster, cheaper, or more reliably from space, and it is in these cases that a justification exists for a space capability. In a severely resource constrained fiscal environment, space systems cannot be an end in themselves.

It has been argued that the characteristics that provide a relative advantage for space systems are emplacement (the ultimate "high ground" for unimpeded application of force), pervasiveness (global access and elusiveness against attack), and timeliness (rapid transfer of large amounts of information).[17] Only where these characteristics make a significant difference in mission effectiveness or efficiency is a space capability justified. The point is that merely replacing "air" with "aerospace" is an inadequate approach to stating air and space requirements.

## CONCLUSIONS

There are significant differences between the air and space environments. Evidence cited to the contrary in Basic Aerospace Doctrine of the United States Air Force is not convincing. Some differences between air and space vehicles are due to the limited capabilities of current systems. The majority of the differences, however, are enduring ones due to the nature of space.

Current Air Force policy is to promote the concept of integrated aerospace power. Space is a "place;" but it is a "different" place from the air environment. "Only by recognizing the distinct characteristics of space can the full benefits of military space operations be realized."[18] Concepts that merely replaces "air" with "aerospace" cannot fully exploit the space environment. What is needed is an approach that builds on the heritage of air power, recognizes the differences of the space environment, and fully integrates space into the Air Force mission.

Air Force doctrine asserts "the aerospace environment can be most fully exploited when considered as an indivisible whole."[19] From a scientific viewpoint, there are serious issues with the accuracy of this statement. From an organizational perspective, the validity of the assertion depends on how well, in fact, the United States Air Force "fully exploits" air and space. Errors in employment and misunderstanding of air systems were elements in establishing a separate air service. The U.S. Air Force must avoid making those same errors in space if it is to achieve its stated vision of "building the world's most respected air and space force."[20] (emphasis added)

## ENDNOTES

1. Herres, Robert T., General, USAF, "The Future of Military Space Forces." Air University Review. Winter 1987, p. 42.

2. Canan, James W. "A Watershed in Space." Air Force Magazine, August 1991.

3. Parrington, Alan J., LtCol, USAF. "Toward a Rational Space-transportation Architecture." Airpower Journal. Winter 1991, p. 47.

4. Memorandum to the author, 2 April 1992.

5. AFM 1-1 Volume I asserts the unity of the air and space environments. This analysis evaluates the rationale for this position located in Volume II.

6. AFM 1-1 Vol II, p. 65.

7. In addition to the physical differences, there are also political differences with regard to boundaries in air and space. In the medium of the air, political convention recognizes national sovereignty over airspace. National political divisions require formal approval for overflight of national airspace boundaries. No such political boundaries exist in space. (AFM 1-1 concedes that political boundaries exist in the air, but do not exist in space. It focuses on the earth's surface as the only boundary to aerospace.) Since the 1950s when President Eisenhower's Administration asserted the policy of "Open Skies," space has been recognized as free of political boundaries. The US has consistently demanded the United Nations avoid any political boundaries in space, comparable to the traditional U.S. policy on freedom of the seas.

8. In addition to these conditions occurring in free space (travel outside the effective gravitational pull of any celestial body), they can occur for vehicles at an altitude of approximately 22,300 miles that orbit the earth in the plane of the equator. This orbit gives the appearance of a stationary space vehicle to an observer on the earth.

Additionally, vehicles at the earth-moon libration points remain in a fixed position relative tho the earth and moon without expending additional energy. The earth-moon libration points occur where the gravitational pull of the earth and the moon exactly cancel each other. Analytical models postulate the existence of five libration points, all of which are in the plane of the moon's orbit about the earth. See Collins, John M. Military Space Forces: The next 50 years. Pergamon-Brassey's International Defense Publishers, Inc., New York, 1989, p. 21.

9. This is because the plane of any terrestrial orbit must include the center of gravity of the earth. This is also the reason a vehicle orbiting the earth cannot be in a geostationary orbit and be over either of the earth's poles. Vehicles in geostationary orbits have a ground trace that follows the equator and angular velocity that matches the rotation of the earth. If such an orbit is changed to gain access to higher latitudes in one region (i.e., the orbit plane is inclined), it drops an equal amount below the equator on the opposite side of the orbit and thereby obtains some motion relative to an observer on the earth.

10. Although recent advances in air systems have integrated some use of computers for control purposes, this has been to optimize aircraft capabilities, rather than out of fundamental necessity.

11. The excessive amounts of energy required for such a maneuver are the result of the high velocities involved in orbital travel and that kinetic energy is proportional to the square of velocity. A reversal of the velocity vector for an orbiting object is a special case of accomplishing a change in the inclination of the orbital plane. The change in velocity required to change the orbit plane inclination is given by

$$\Delta V = 2V\sin\frac{\Delta i}{2}$$

Where,

$$\Delta V = \textit{velocity change}$$

$$V = \textit{path velocity (fps)}$$

$$\Delta i = \angle \textit{ of the planes (degrees)}$$

For a 90 degree rotation of the orbit plane inclination, the $\Delta V = V(1.414)$. Approximately 141% of the original velocity would be required to make this change.

For a 180 degree rotation of the orbit plane inclination (a reversal of the velocity vector), the $\Delta V = 2V$. Twice the original velocity would be required.

Until new sources of energy are available, perhaps from harnessing the energy of black holes, such radical movements in space remain in the realm of fiction.

12. AFM 1-1 Vol II, p. 65, 67.

13. Collins, John M. Military Space Forces: The next 50 years. Pergamon-Brassey's International Defense Publishers, Inc., New York, 1989, p. 9.

14. AFM 1-1 Vol II, p. 67.

15. Some air systems have incorporated multiple propulsion modes. An example is the NF-104 rocket and jet aircraft.

16. Hopefully, the next generation launch system (National Launch System) will have launch responsiveness that comes significantly closer to meeting operational requirements.

17. Myers, Kenneth A., Col., USAF and John G. Tockston, LtCol, USAF, "Real Tenets of Military Space Doctrine." Airpower Journal. Winter 1988, p. 59.

18. Myers, Kenneth A., Col., USAF and John G. Tockston, LtCol, USAF, "Real Tenets of Military Space Doctrine." Airpower Journal. Winter 1988, p. 69.

19. AFM 1-1 Vol I, paragraph 2-1, p. 5.

20. From the U.S. Air Force vision statement promulgated by the Secretary of the Air Force Donald Rice and Air Force Chief of Staff General Merrill McPeak.