Mahan on Space Education

A Historical Rebuke of a Modern Error

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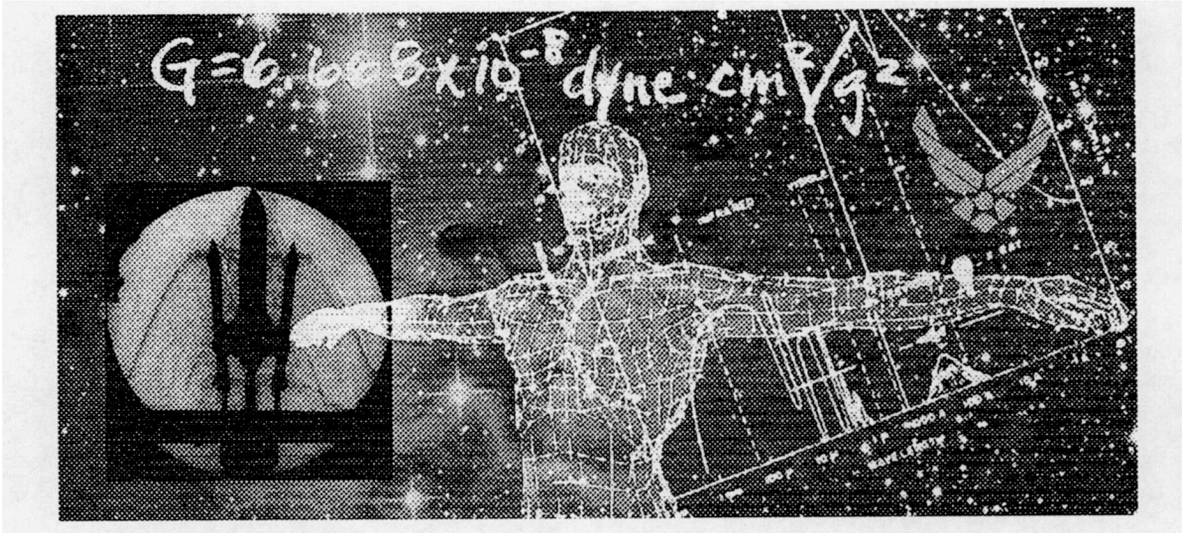
Editorial Abstract: The Air Force has shaped a new space-professional strategy that alters many aspects of career development for the service's space cadre. In this article, Lieutenant Ziarnick posits that the ideas of a nineteenth-century Navy officer and sea-power theorist remain relevant to the development of twenty-first-century space professionals—especially those relating to the ongoing debate of technical versus nontechnical education for officers.



IN RESPONSE TO the *Report of the Commission to Assess United States National Security Space Management and Organization* of 2001 (Space Commission), the US Air Force has shaped a new strategy to guide the development of its space professionals. This strategy changes many elements of career development that guide the operators, scientists, engineers, and program managers who make up the Air Force's "space cadre." A number of aspects of the strategy, such as measurable certification levels and the tracking of an individual's space-related experiences, will undoubtedly prove quite valuable. One item, however, could have serious military implications.

The strategy's new plan for officer certification "desires" that all officers have a "degree relevant to space." Thus, level-one certification (one to 10 years of space experience) calls for a BA/BS degree relevant to space, and level two (10–15 years' experience) requires a relevant master's degree; the plan "highly desires" that individuals seeking level three, the apex of space certification (more than 15 years' experience), hold a space-relevant master's degree.[1] According to the plan, "space relevant" concentrations "include Engineering, Systems Management, Business Administration, Computer Science, Physics, Chemistry, Mathematics, and Space Operations. The rationale for es-

tablishing this 'desirement' is that it allows for the greatest crossflow among the space billets—[acquisitions] to [operations] and vice versa."[2] One notes the absence of the humanities and liberal arts: history, philosophy, English, and political science, among others. At first glance, the plan's desires seem agreeable—even attractive. After all, how could having a technical degree hurt a space professional? As a practical matter, it probably does not. However, it is the wrong question to ask.

Such a preference for technical degrees implies that other studies are irrelevant to military space officership. Indeed, at a briefing on the space-professional strategy attended by the author, the speaker, a lieutenant colonel, explicitly stated that he didn't see how Elizabethan history had any applicability to a military space officer. Thus, one should more properly ask whether only technical study has relevance to military space activities.

Should space officers study engineering or physics to the exclusion of history, philosophy, or other nontechnical fields? An affirmative response could have far-reaching ramifications. If leadership favors technical degrees, it might convince many career-minded young officers or cadets to enter the hard sciences despite their preference for a different academic discipline—or they might discourage others from joining the space forces even though such individuals could make important contributions. Twenty years hence, the lieutenants and captains of today will become the leaders of military space forces. Presumably, if the space-professional strategy works as intended, they will have a substantial technical education but significantly less nontechnical expertise than the current leadership. By expressing a preference for space-relevant degrees and hinting that the type of degree may affect promotions, the space-professional leadership, in effect, has affirmed technical education as the only type suitable for a space officer. But is this true?

Ironically, history informs us that the debate over the merits of a technical versus nontechnical education for officers is not new. At the close of the nineteenth century, another service experienced great changes and confronted the same issue that now stands before the military space force. In 1879, responding to the debate over officer education in the US Navy, Alfred Thayer Mahan (then a lieutenant commander but destined to become a rear admiral and the greatest sea-power theorist in memory) wrote an essay entitled "Naval Education" that is as relevant to our current dilemma as it was to the sea service over a century ago:

> I confess to a feeling of mingled impatience and bitterness when I hear the noble duties and requirements of a naval officer's career ignored, and an attempt made to substitute them for the wholly different aims and faculties of the servant of science. The comparatively small scale on which those duties are now performed, the fancied impossibility of a great war, the pitiful condition of efficiency into which the material of the navy has been allowed to fall, have all helped to blind our eyes to the magnificence of the war seaman's career. . . . No wonder the line officers of the navy are themselves carried away by an amazed humility which dwarfs their own profession.[3]

Admiral Mahan's lamentation of the Navy's degraded status and the depressed state of naval morale at the end of the nineteenth century speaks also to the modern space officer. Much as Mahan's Navy ignored the naval officer, the new Air Force strategy ignores the noble duties and requirements of a space officer in favor of the skills and abilities of an engineer. Are not military space officers more than engineers in uniform? Are we not to lead others in service to the country—and perhaps into battle? Do we truly share more in common with Edison than Nelson, as the strategy suggests? Technical education instills in students the virtues of scientists or engineers. Is that what we want for *all* military space officers?

Indeed, a number of these officers cannot perceive the magnificence of a space warrior's career for many of the same reasons Mahan sensed in his Navy. A "fancied impossibility of a great war" in space permeates the thinking of the Air Force and Space Command, as exemplified in the common belief (oft denied but affirmed through inaction) that space serves merely a supporting role in military operations. Consequently, notions divorced en-

tirely from military experience that elevate nonviolent techniques (e.g., information and electronic warfare) to the totality of space warfare are accepted as gospel, to the detriment of space officers' connection with their fellow land, sea, and air warriors. Thus, the scope of the space officer's military duties becomes considerably less than that of other officers. Unsurprisingly, some are "carried away by an amazed humility which falsely dwarfs their own profession" and attempt to emulate the traits of the closest honorable profession they can relate to—the space engineer. Mahan notes that

> it is necessary, then, to look forward to the end and consider really what you should require a sea officer of the Navy to be. We have actually gotten in the Navy, by constantly adding here a little, there a little, to a pass in which we think that each military sea officer, or to use the technical term, each line officer, should present in his own person a compendium of mathematics including its highest branches, its applications to numerous recondite physical problems, considerable knowledge of the physical and mechanical sciences, and an intimate acquaintance with the arts of the manufacturer; all in addition to a command of his own profession proper. Failing this, so many say, he must descend from the high position occupied by him and his predecessors for these centuries past and become the simple drudge of others whose minds have received a more rigorous and deeper, though often narrower, culture.[4]

Here he describes a belief, commonly held then as well as today, that the officer must be a mathematician, scientist, and engineer as well as a military leader to succeed in his or her duties. That belief lies dangerously close to becoming policy for the military space force.

Did the writers of the new strategy devote sufficient thought to what ideal space officers should be before deciding to make them acquirers (program managers, scientists, or engineers)? Restricting the educational options for these officers seems especially dangerous because we have no clear understanding of the skills they will need in the future. Currently, military space is limited to support operations for terrestrial war fighting. That it will remain so 20 years from now no one knows. Today, the common space-operations officer runs a space or missile system from a computer on a climate-controlled operations floor at a stateside base—and strongly resembles an acquisitions officer. Tomorrow, however, space operators may field true combat weapons systems and actively engage in a fight, perhaps finding themselves in harm's way like their fellow land, sea, and air officers. At this time, we cannot be certain.

It is disconcerting to derive the requirements of the space-operations career field (Air Force Specialty Code [AFSC] 13S), in which the majority of the space cadre resides (as well as a correspondingly large portion of the future leaders of military space), by the entry-level requirements of the acquisitions career field (AFSCs 61, 62, and 63), an important but minority non-war-fighting subset of the cadre. By definition, acquirers obtain new weapons systems and equipment. They require management and engineering skills—the space-relevant skills as determined by the Space Professional Council. Acquiring systems does not equate with operationally exploiting space. We have no indication whatsoever that the "[narrow] . . . culture" of the engineer or manager will prove sufficient for leadership of the military space effort, nor do we have any clear justification for thinking that the acquisitions culture is better for a space officer than any other.

Unfortunately, the space-professional strategy seems to imply that current operations officers without an acquisitions background will ultimately descend from their high position and "become the simple drudge[s]" of those with acquisitions skills, whose expertise we currently deem more important than any other in space. Certainly, acquisition experts will be absolutely essential to the future military space force, and many will become fine commanders. However, the skills of the acquirer, both manager and technical specialist, do not encompass the myriad skills necessary for military effectiveness. Space—even military space—amounts to more than just equations and dollars. Mahan notes that military leadership often fails to grasp this fact:

> Recognizing and dazzled by the stupendous nature of the changes made, and the wonderful things accomplished by the labors of science, those who have had direction of our naval education, or who have exerted influence upon that direction, seem to run away with the idea that every naval officer, having to use these engines of offense or defense which the student or mechanic has put into his hands, should be able to follow out the long train of laborious thought, be familiar with all the practical processes, by which each of these mighty engines has been conceived or produced.[5]

The space-professional strategy undoubtedly has "run away with the idea" that every space officer "should be able to follow out the long train of laborious thought" by which our systems are conceived. It is quite another issue whether or not the writers of the strategy understand the laboriousness of earning a technical master's degree. For instance, the master of engineering degree in space operations (a strategy-approved area of study) from the University of Colorado at Colorado Springs requires classes in astrodynamics, mechanical-systems analysis, spacecraft dynamics, launch-vehicle analysis, systems engineering, and trajectory optimization, among other subjects.[6] Each class requires extensive use of higher mathematics such as differential equations and matrix and linear algebra, as well as advanced principles of mechanics, thermodynamics, and other scientific disciplines. How many current colonels and generals (even in space billets) cringed at beginning calculus or panicked at the sight of their first free-body diagram? Must all space officers become masters of technical concepts rarely encountered in military operations—even in space? Attempting to earn a technical master's degree, especially in light of an active officer's limited time and resources, would almost assuredly require a technical bachelor's degree. Certainly, not every military officer has either the ability or inclination to earn even a technical bachelor's degree. Should this fact make these technically disinclined officers persona non grata in the military space forces?

Interestingly, with such a bachelor's degree, one could begin a career and progress quite far as a spacecraft designer. A senior design engineer often earns a technical master's degree as a terminal degree. Therefore, Space Command wants each officer to become not only a "compendium of mathematics" but also someone qualified to build and design space systems from the ground up. But the mission of the space officer is to exploit space, not build spacecraft. So what kind of education does Mahan think successful officers need?

> The knowledge that is necessary to a naval line officer is simply and solely that which enables him to discharge his many duties intelligently and thoroughly. Any information that goes beyond this point is after all simply culture, which, however desirable in itself, must not be confounded with essentials. This is true although the special culture may be of a kind very closely akin to his profession. For instance the manufacture of ordnance, the intricate questions connected with explosives, have a very close connection with the military part of his business. Yet to say that an exhaustive and exact knowledge of the various processes by which the finished gun and the proved powder are furnished to his hand and of the rapid though gradual advance made in each is necessary, is to occupy ground that is not tenable.[7]

Understanding the universal truth of the first sentence of that quotation is both important to comprehending Mahan's goals for military education and essential to designing a correct scheme of education for military space officers. Oftentimes officers discharge their duties, which include defending their country, by effectively operating their systems, be they rifles, warships, or satellites. Throughout history, military officers have performed their duties admirably without complete understanding of the science behind war machinery. A pilot does not need to know about computational fluid dynamics to understand that pulling back on the stick will cause the aircraft to gain altitude. A soldier does not need skill in advanced chemistry to realize that pulling the trigger on a rifle will fire a projectile. Similarly, a space officer does not need to master the mathematical intricacies of perturbation theory to account for its effects on satellite operations. The scientific principles behind each

operational action are not essential to conducting an operation.

Space operations, however, share much of the culture of space engineering—so much so that Air Force space operations until recently were the express domain of engineering officers under the now-deactivated Systems Command. Mahan warns us that despite the similarity between military operations and engineering cultures, believing that the successful operator must have the same skill set as the successful engineer still confuses culture with essentials. He insists that one need not understand all the scientific underpinnings of modern astronautics to operate a system built on these principles. So how much is truly necessary?

> For the portion of the requisite knowledge, how great an amount of scientific power is required? . . . Some acquaintance with the mechanical powers and the modes of their applications, but scarcely enough to dignify by the name of science. That the knowledge sufficient to run and care for marine steam engines can be acquired by men of very little education is a matter of daily experience.[8]

For example, the operations floor of the 2d Space Operations Squadron proves Mahan's point every day. Although the global positioning system (GPS), a constellation of almost 30 satellites, is undoubtedly one of the most complicated military systems ever produced, very few certified military-operations personnel have earned technical degrees. Satellite vehicle operators, responsible for maintaining the health of spacecraft subsystems and responding to potentially hazardous satellite anomalies, arguably occupy the most highly technical position on the operations crew. But we do not require that they hold technical degrees, and the majority of them do not have engineering or hard-science bachelor's degrees. More tellingly, satellite systems operators—the only crew position in the 2d Space Operations Squadron authorized to generate and transmit commands to a satellite—are young Airmen, often only a few months out of basic training and possessing only high school diplomas. Regardless, the GPS constellation remains one of the most reliable military systems ever fielded, and the satellite vehicle and satellite systems operators consistently demonstrate their competence as crew members.

Even though GPS crews must understand basic principles of orbital mechanics, space dynamics, satellite design, and computer science, they do not need technical degrees to perform their jobs successfully. Skills developed in technical training such as Space 100 (formerly Officer or Enlisted Space Prerequisite Training) and Unit Qualification Training seem to produce fine operators who have no trouble keeping the GPS operational. However, the depth of knowledge obtained in these courses can "scarcely [be dignified] by the name of science." Every other operations unit in Space Command can attest to that fact: "that the knowledge sufficient to run and care for [space systems] can be acquired by men of very little [technical] education is a matter of daily experience." If so, what does Mahan believe the officer should study?

> If I be asked, in my own words, how the English studies or the acquirements of Foreign Languages help a man to handle and fight his ship, I will reply that a taste for these pursuits tends to give breadth of thought and loftiness of spirit. . . . The ennobling effect of such pursuits upon the sentiment and intellect of the seaman helps, I think, to develop a generous pride, a devotion to lofty ideals, which cannot fail to have a beneficial effect upon a profession which possesses, and in its past history has illustrated in a high degree, many of the elements of heroism and grandeur. The necessarily materialistic character of mechanical science tends rather to narrowness and low ideals.[9]

In the final analysis, "breadth of thought and loftiness of spirit" are not qualities essential to an engineer, manager, or operator. An engineer needs mathematic and scientific insight, a manager needs economic and group-dynamic understanding, and an operator needs only a firm understanding of the technical order. However, breadth of thought and loftiness of spirit are essential traits of a military leader—the true definition of an officer.

As an officer with a technical background, when I read astrodynamics texts I feel like an engineer—a functionary. But when I read

Thucydides, Xenophon, and Mahan, I realize what it means to be an officer—a professional student of the art of war. Admittedly, the duties of junior officers are quite functionary, and technical backgrounds may very well make them better operators although we have no indication of this at present. However, officers do not remain mere functionaries for long. When military leadership and an understanding of warfare begin to increase in importance, the "[narrow] . . . ideals" of mechanical science may prove more a hindrance than a help to the officer.

At the level of senior leadership, including positions in the military space field, command decisions become much more than mere equations. Indeed, most of the pressing problems in Space Command today are not technical issues. Such matters as developing effective military space doctrine, applying the art of war to the space medium, and overcoming objections concerning the ethics of military space (including the sickening belief that disabling space systems by killing people on the ground is somehow more "moral" than destroying inanimate spacecraft in orbit) do not require skills of the engineer but those of the philosopher, historian, and military theorist.

The space-professional strategy wrongly emphasizes the functionary over the officer. It is much easier to give officers the technical skill to become successful functionaries in technical schools than to instill a "generous pride" and "a devotion to lofty ideals" essential for great military leaders during a few scant months in professional military education programs. Allowing officers to choose their higher education as they see fit will ensure a healthy balance of all skills necessary for the space officer corps. To deny the importance of the liberal arts to the officer is to undermine the very reasons for the existence of an officer corps. What can we do to secure a healthy balance of skills in Air Force officers yet maintain needed technical proficiency?

> I am persuaded that in our theory of education we have failed in this country to recognize that the progress of the mechanical sciences, and the vast change thereby made in naval vessels and their armaments, as well as in other means of warfare, have made necessary the organization of a corps of specialists.[10]

The space field undeniably needs officers skilled in science, engineering, and program management. Instead of vainly trying to make the space officer an operator, engineer, and manager all in one, the Air Force should focus on developing the best possible individual operators, engineers, and managers.

Air Force–coded scientists and engineers often lament that they very rarely use their degrees. A common notion exists among the science and engineering fields (AFSCs 61 and 62) that Air Force technical specialists do not really "do" science and engineering. Often, the officer technical specialist oversees the real technical work done by civilians and contractors. If our service wishes to ensure that the space cadre has the best technical specialists possible, perhaps it should focus on developing the current AFSC 61 and 62 space officers instead of requiring hard-science master's degrees of all space officers.

Offering technical-specialist space officers the chance to become real engineers and scientists is essential. The Air Force should allow officers especially skilled at research and development to be engineers and scientists in uniform—not simple overseers. Only through hands-on research-and-development opportunities will space technical experts retain and enhance their technical skills. Forcing engineers to take tours as operators or vice versa will do nothing but undermine the specialties of technical experts.

Only by retaining specialties in the space forces can technical experts focus on science and engineering. The promotion schedule for specialties should permit equal advancement opportunities for officers who choose to concentrate entirely on engineering or science as well as specialists who also choose to take operational tours. If the space cadre allows research-minded technical specialists to focus their careers on research without promotion penalty, the military space force will benefit from a stronger technical officer corps. In order to do so, the Air Force must give AFSC 61 and 62 officers the freedom to follow

their interests in service to the military and work alongside civilian researchers rather than remain mere spectators. Filling the entire space cadre with technical specialists will only decrease the depth of knowledge that officer scientists or engineers can achieve since they would incessantly have to leave the lab to serve as operators or managers or attend to any other number of nontechnical details that will monopolize their careers. Instead of magnifying and expanding the roles and opportunities for existing officer scientists and engineers, Space Command has chosen to ask all space officers to fit its mold.

The space-professional strategy's endorsement of technical degrees for all officers springs directly from a passage in the report of the Space Commission:

> Other career fields, such as the Navy's nuclear submarine program, place strong emphasis on career-long technical education. This approach produces officers with a depth of understanding of the functions and underlying technologies of their systems that enables them to use the systems more efficiently in combat. The military's space force should follow this model. In addition, career field entry criteria should emphasize the need for technically oriented personnel, whether they be new lieutenants or personnel from related career fields. In-depth space-related science, engineering, application, theory, and doctrine curricula should be developed and its study required for all military and government civilian space personnel, as is done in the Naval Nuclear Propulsion Program.[11]

This passage makes clear the roots of the Air Force strategy's technical desires; however, it takes on new meaning when put into the context of the report's other findings. Throughout that document, the Space Commission insists that "space is a medium much the same as air, land, and sea" and that the "Department of Defense is not yet on the course to develop the space cadre the nation needs."[12] The commission never states exactly what form the mature space cadre should take, but one can reasonably conclude that the envisioned cadre would not consist of a narrow set of technical specialists but would encompass masters in all aspects—technical and nontechnical—who can exploit the space environment for national-security purposes: "Military space professionals will have to master highly complex technology; develop new doctrine and concepts of operations for space launch, offensive and defensive space operations, power projections in, from, and through space and other military uses of space."[13]

One finds further proof that the commission intends the space cadre to embrace all aspects of military space in its opinions on an independent Space Department: "Near- and mid-term organizational adjustments should be fashioned so as to not preclude the eventual evolution toward a Space Department if that proves desirable."[14] Indeed, the commission made a major recommendation, later adopted, that would lay the foundation for such a department.[15] Therefore, one can reasonably assume that the commission wanted the space cadre to serve as the basis of a separate space service, entrusted with all aspects of the military exploitation of space, much as the Army, Navy, and Air Force are entrusted with exploiting the land, sea, and air mediums.

Thus, one should not conclude from the Space Commission's mention of the Navy Nuclear Propulsion Program that the space cadre *as a whole* should follow this model. Whereas the cadre would exploit the space environment, the Nuclear Propulsion Program is not responsible for exploiting the sea environment—a task entrusted to the Navy. The propulsion program trains only a small subgroup of technical specialists for the larger Navy, most of whom are confined to a warship's engine room, not the bridge. Therefore, to insist that the space cadre follow the propulsion program model is to fatally constrain the development of a robust team of dedicated space professionals. Certainly, none of the established military services has declared that only a person with a technical or business degree is eligible to earn a commission. Leaders know that restricting the officer corps' academic breadth of knowledge to the merely technical would rob the services of many essential skills. Similarly, restricting the space cadre would constitute a deplorable error. What does Mahan advise?

> Do I then undervalue science? Do I ignore the great changes it has made in the appliances and system of naval warfare, or deny the necessity of the service of men thoroughly imbued with its spirits and acquainted with its truths? Not at all, I simply say that while the processes, by which the results of scientific research are obtained, are laborious and difficult, the results themselves, for naval purposes, are instruments easy of comprehension and intelligent use; while the practical use of them, under the varied and often exciting conditions of sea and battle service, calls for other and very different qualities and experience than those of the student or mechanic. Consequently, devotion to science and the productions of the instruments of warfare, from the ship itself downward, should be the portion of a certain, relatively small, class of specialists.[16]

Mahan's conclusion is as relevant to today's military space force as it was to the military sea force of his day. He did not undervalue science or the need for officers skilled in science and engineering—and neither should we. A military organization must have multiple, varied skills in its officer corps. Traditionally, the naval line officer and the operators of the Army and Air Force have provided the "generalists" of the officer corps. Military training courses prepare them to become sailors, pilots, and infantrymen who fight battles with the skills they have learned. After tours of field duty, they then become their service's strategists, theorists, planners, instructors, and leaders. Their academic background often determines the position they fill after operations tours. An infantry officer with an English degree is uniquely suited to become an English instructor at a service academy. The military-historian submariner is academically equipped to become a strategist. Not all military positions are well served by technical degrees.

The military space force is no different than forces in the other services. A history degree may have far more relevance to planning the reorganization of military space than one in astronautics. Education in political science may prove far more necessary than business management for space-power theorists. To accomplish the varied tasks of military space, we need space officers with varied backgrounds. Officers with both a technical and liberal education must form a heterogeneous mix of experts dedicated to American space power. To make all space officers acquirers will deprive the military space force's officer corps of skills essential to the foundation of any military organization. At the end of the nineteenth century, Mahan warned against letting the skills of the engineer overshadow those of the warrior in the officer corps. Rather, he advised strengthening and enhancing specialists while leaving line officers free to study other fields necessary for military officership. At the beginning of the twenty-first century, Space Command has come dangerously close to following the path Mahan fought to avoid. It could gain much by heeding the advice of one of America's greatest military geniuses. ❑

Notes

1. Briefing slides, Peterson AFB, CO, subject: Space Professional Development Road Show, 15 July 2004, https://halfway.peterson.af.mil/spacepro.
2. "Certification Process," Space Professional Development, https://halfway.peterson.af.mil/spacepro/measurable.htm.
3. Lt Cdr A. T. Mahan, "Naval Education," United States Naval Institute *Proceedings* 5 (1879): 349.
4. Ibid., 347.
5. Ibid., 346.
6. "Master of Engineering, Space Operations," College of Engineering and Applied Science, University of Colorado–Colorado Springs, http://mae.uccs.edu/rrappold/moe_space_operations.htm.
7. Mahan, "Naval Education," 348.
8. Ibid., 350.
9. Ibid., 352.
10. Ibid., 346.
11. *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: The Commission, 2001), 45, http://www.defenselink.mil/pubs/space20010111.html.
12. Ibid., 13, 42.
13. Ibid.
14. Ibid., 80.
15. "U.S. interest in space may well ultimately call for the creation of a Space Corps or a Space Department to organize, train, and equip forces for sustained operations in space. For that reason, assignment of Title 10 responsibility to the Air Force by the Congress and its designation as Executive Agent for Space within the Department of Defense is recommended to lay the foundation for such future steps." Ibid., 93.
16. Mahan, "Naval Education," 352.

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